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Physical Activity and Exercise: Recent Advances and Current Challenges

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This article presents an overview of major developments in physical activity and exercise for health promotion and disease prevention during the past 10 years. The importance of physical activity to physical and mental health was increasingly recognized. Assessment methods appropriate for diverse population groups were developed, and understanding of correlates of regular physical activity improved. Many studies focused on moderate activity that can be integrated into people's everyday lives. Research in community, school, and health care settings demonstrated that interventions based on cognitive–behavioral theories can change physical activity. Nevertheless, physical activity remained at low levels in most population subgroups throughout the past decade. Psychologists can make important contributions to efforts to address this ongoing challenge to public health.

The past decade has been a rewarding time to be involved in physical activity promotion and research. During the 1990s, there were a number of developments indicating the study of exercise and physical activity had reached a new level of scientific sophistication and importance in public health. Accumulating evidence of the effects of activity on health encouraged national organizations and public health agencies to formulate new position statements and recommendations to guide the public, health care providers, exercise professionals, researchers, and policy makers. New technology improved assessment and interventions. There is still, however, much to be learned and much to do. Low levels of physical activity continue to be a major public health challenge in almost every population group of developed countries. This article presents an overview of some of the major developments during the past 10 years and of current challenges for psychologists interested in physical activity, behavioral medicine, and public health.

Current Recommendations for Physical Activity and Health

In 1995, the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC) published new recommendations for physical activity and health (Pate et al., 1995). Although previously published statements had emphasized regular endurance exercise of sufficient intensity to improve and maintain cardiovascular fitness, the new recommendations were designed to help Americans find a way to make healthy physical activity part of today's lifestyles. To appreciate the significance of the new guidelines, it is helpful to take a brief look at their history (U.S. Department of Health and Human Services, 1996). In 1978, the ACSM published guidelines on the frequency (3 to 5 days per week), intensity (60% to 90% of maximum heart rate reserve), duration (15 to 90 min per session), and type of exercise (rhythmic use of large muscle groups in activities like running or swimming) needed for cardiorespiratory fitness and optimal body composition. These guidelines became widely known and interpreted, not only as a guide to cardiovascular fitness promotion but also as a statement of the requirements for exercise for good health in general.

By the early 1990s, there was growing recognition of the value of moderate-intensity physical activity for health, and it was evident that only a small percentage of adults were willing or able to engage in regular vigorous exercise consistent with the 1978 guidelines. The ACSM had updated its guidelines in 1990, adding a recommendation to include resistance training and recognizing that activities of moderate intensity may reduce the risk of chronic disease even if they do not improve cardiovascular fitness (ACSM, 1990). New research had also shown that an accumulation of short (8–10 min) active periods over the course of a day could approximate the benefits from a sustained period of activity (Pate et al., 1995). This new scientific evidence and the desire to provide recommendations that could be realistically achieved by the general public resulted in the new CDC–ACSM recommendation that "every U.S. adult should accumulate 30 min or more of moderate-intensity physical activity on most, preferably all, days of the week." (Pate et al., 1995, p. 402) Examples of moderate intensity activity include walking briskly (3–4 miles/hr; 4.8 km–6.4 km), general calisthenics, painting and home repair work, lawn mowing with a power mower, washing windows, and other heavy cleaning in the home.

Later in 1995, a National Institutes of Health (NIH) Consensus Development Conference was convened that produced an NIH Consensus Statement on Physical Activity and Cardiovascular Health (1996). Despite continuing controversy about the importance of vigorous, higher intensity activity for protection against coronary heart disease, the NIH panel endorsed a recommendation of at least 30 min daily of moderate intensity activity for children and adults. The NIH statement also recommended wider use of cardiac rehabilitation, including physical activity and exercise training.

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The most important publication of the decade for physical activity, the first Surgeon General's *Report on Physical Activity and Health* (U.S. Department of Health and Human Services, 1996), was released just in time for the 1996 Olympics. Only time will tell if this report leads to an eventual impact on public health as significant as that of the first Surgeon General's report on tobacco and health released in 1964. The report concludes that moderate-level activity has significant health benefits but that vigorous activity should be also be encouraged for those who are able and willing to increase the intensity of their effort. The report emphasizes endurance exercise and does not cover the use of exercise as therapy/rehabilitation.

Other important activity statements, recommendations, and updates have been published during the past 10 years. The American Heart Association in 1992 declared physical inactivity one of the major risk factors (along with smoking, hypertension, and high cholesterol) for coronary heart disease (Fletcher et al., 1992). In 1994, an International Consensus Conference on Physical Activity Guidelines for Adolescents issued a recommendation for adolescents to be physically active every day and to engage in three or more 20-min sessions of moderate to vigorous activity each week (Sallis & Patrick, 1994). Although the new Healthy People 2010 leading health indicator for adolescent physical activity and fitness calls for 20 min of vigorous activity three times a week (U.S. Department of Health and Human Services, 2000), other groups have recommended at least 60 min per day for youth because of the rising prevalence of obesity (Cavill, Biddle, & Sallis, 2001). The CDC issued guidelines for school and community programs for promoting physical activity in youth in 1997 (CDC, 1997). The ACSM (1998b) published a new position on recommendations for cardiorespiratory and muscular fitness and flexibility in healthy adults in 1998. The ACSM (1998a) also published a position on exercise and physical activity in older adults. This document noted the importance of appropriate activity to maintaining functional abilities and preventing falls as well as to promoting psychological and cognitive function.

Health Benefits of Physical Activity and Exercise

Research on the association of physical activity and health outcomes during the 1990s underscored the health risks faced by a society that has been successful in engineering the necessity for physical activity out of most people's daily lives (Stuart & Davis, 1972). The 1996 Surgeon General's *Report on Physical Activity and Health* (Report; U.S. Department of Health and Human Services, 1996) included an extensive review of the effects of physical activity and exercise on health. Major conclusions from this review are very briefly summarized in this section.

Taking into account all different causes of death, moderate to high physical fitness was associated with lower mortality than was low fitness. Higher levels of activity and fitness were protective in older as well as younger populations, and in longitudinal studies, people who become more fit over time reduced their risks in comparison with those who remained at low levels of fitness. Heart disease is still the number one cause of death, and the findings on physical activity conveyed a clear message. Risk of cardiovascular disease mortality decreases with increased physical activity and fitness. There was substantial evidence for an inverse dose-response association between physical activity and coronary heart disease as a specific outcome. The relationship between physical activity and stroke, which is the third leading cause of death in the United States, was not yet clear. Observational and experimental studies supported the benefit of physical activity for lowering blood pressure.

There is growing interest in studying physical activity and cancer, which is the second leading cause of death in the United States. Observational data and plausible biologic mechanisms provided evidence for a protective effect of physical activity on colon cancer (but not rectal cancer). Evidence for effects on other cancers, including breast and prostate cancers, was too limited or too inconsistent to allow conclusions at the time of the publication of the Surgeon General's Report. Observational studies strongly suggest a protective effect of physical activity on the development of non-insulin-dependent diabetes mellitus, and plausible mechanisms have been identified.

Observational data in humans and experimental studies in animals also have indicated physical activity is important to maintaining healthy joints. Physical activity can help control pain and other symptoms in people who have already developed osteoarthritis, but it can also enhance the risk of developing osteoarthritis in a joint that has been injured. Physical activity in early life builds stronger bone mass and protects against osteoporosis by maintaining healthy bone in middle and later adult years. Exercise designed to improve endurance, strength, and balance can help prevent falls and fractures in older adults.

Cross-sectional studies have shown that more active people are less likely to be obese, but prospective studies that allow inference of cause and effect relationships between activity and weight change were inconclusive at the time of the Report's (U.S. Department of Health and Human Services, 1996) publication. In general, studies have shown that people lose more weight with a combination of diet and exercise and do not lose significant amounts of weight with exercise alone. Exercise does not always increase appetite enough to offset added energy expenditure. Resistance as well as endurance activities should be encouraged for weight management.

A growing body of epidemiologic research on adults suggests that people who are more active have lower levels of anxiety and depression symptoms. The Surgeon General's Report concluded that experimental studies have demonstrated that exercise is an effective intervention for depressed and anxious mood. Biologic mechanisms have been proposed, but many researchers believe that psychosocial aspects of activity, such as increased social contact, perceived mastery, or distraction from daily stressors, may contribute to the beneficial effects. There is some evidence of a dose–response relationship between level of physical activity and depressive symptoms; however, evidence of increased depression from studies of overtraining in athletes suggests that the relationship may be curvilinear. The degree to which mental health benefits of exercise are linked to cardiorespiratory fitness is still undetermined. In general, studies with individuals without clinically significant mental health problems and studies with other types of mental health problems, such as psychosis, substance abuse, and cognitive impairments, have been inconclusive or too limited to allow conclusions.

Research on the health benefits of exercise has continued to advance since the publication of the Surgeon General's Report (U.S. Department of Health and Human Services, 1996); space

limitations here preclude comment on all of the significant publications. However, because work on the psychological benefits of exercise may be of particular interest to psychologists and other mental health professionals, a few recent studies will be highlighted here as examples of research approaches in this area. In a laboratory study that varied the duration of acute bouts of exercise with moderately fit college women, Rejeski, Gauvin, Hobson, and Norris (1995) found that exercise for 10, 25, or 40 min produced more improvement in affect than did an attention control condition. Notably, the women's pre- and during-exercise affective states predicted a significant amount of the variance in postexercise affect. Rejeski and colleagues (Gauvin, Rejeski, & Norris, 1996; Gauvin, Rejeski, & Reboussin, 2000) subsequently used experience-sampling methods to study positive and negative affect in relation to acute bouts of vigorous physical activity in women living in the community. Averaged across women, the observational data confirmed that affect improved after physical activity, but it improved particularly in women who felt worse before exercising. In addition, the new data demonstrated that the affect improvement was above what could be predicted by diurnal trends and day of the week.

Findings from another study of exercise in community-residing women (Stetson, Rahn, Dubbert, Wilner, & Mercury, 1997) examined the relationship between exercise adherence and perceived stress, with exercise as the dependent measure. During weeks of high perceived stress, women exercised less, were less satisfied with their exercise, and had lower self-efficacy for meeting future exercise goals. These findings suggest that perceptions of stressful events and cognitive reactions to missed exercise may play a significant role in exercise adherence and relapse. In a clinical trial setting, a study of exercise and diet interventions for hypertension yielded additional evidence that exercise training produces favorable effects on cardiovascular reactivity to mental stress (Georgiades et al., 2000). Results for participants treated with exercise or exercise combined with diet were similar to the improvements typically observed with pharmacologic therapy.

New studies on the effects of exercise as an intervention for clinical depression also merit special mention. For example, Blumenthal et al. (1999) have recently published the results of a controlled trial of endurance exercise (walking or jogging three times a week), antidepressant medication (sertraline), or their combination for older adults who met diagnostic criteria for major depressive disorder. After 16 weeks, all three groups had clinically significant improvements in depression scores. After 10 months, remitted participants in the exercise-only group had significantly lower relapse rates than participants in the medication groups (Babyak et al., 2000). Exercising on one's own during the follow-up was associated with a reduced risk of relapse. These results are an impressive addition to the existing literature suggesting that exercise can be an effective alternative to antidepressant medicine.

Salmon's (2000) recently published review summarized findings on the beneficial psychological effects of exercise on anxiety, depression, and stress. He proposed that these can all be at least partially understood as stress adaptation responses resulting from exercise training. Salmon's review called attention to many as-yet-unanswered questions and hypotheses that can be tested. For example, he proposed that the long-term protective benefits of exercise training may actually depend on its initial unpleasantness and that the social and other rewards that some believe are critical to the psychological benefits of exercise may be unimportant. Salmon argued strongly for more research on exercise effects in clinical populations, such as individuals with panic disorders.

There is also new evidence that exercise training can improve at least some aspects of cognitive function. In a study examining exercise and other components of an intensive rehabilitation program for older adults with chronic obstructive lung disease, only patients who had exercise training improved on measures of verbal fluency (Emery, Schein, Hauck, & MacIntyre, 1998). In a study with healthier older adults, Kramer et al. (1999) evaluated cognitive functioning in 60–75-year-old men and women randomized to either aerobic (walking) or strength/toning exercise. After 6 months, aerobic training participants showed significant improvement, relative to the comparison group, on measures involving switching between tasks, distractor-interference effects, and reaction time for stopping. Kramer et al. argued that exercise that increases aerobic fitness may selectively improve cognitive processes involving frontally mediated activities such as planning, scheduling, inhibiting, and working memory. With the growing elderly population, the effects of exercise on cognitive functioning continues to be a critical area for additional research effort.

Theories and Models for the Study of Physical Activity and Exercise

A variety of theories and models have influenced the research and writings on physical activity during the past decade. Learning theory, social–cognitive theory, and relapse-prevention model concepts are still widely used in developing effective multicomponent intervention programs (Baranowski, Anderson, & Carmack, 1998; Dubbert & Stetson, 1999; Sallis & Owen, 1999). The transtheoretical model achieved new prominence in the design of physical activity promotion interventions during the 1990s. Careful elaboration and testing of the model's application to physical activity by Marcus and her collaborators (Marcus et al., 1992; Marcus, King, Bock, Borelli, & Clark, 1998; Marcus, Rossi, Selby, Niaura, & Abrams, 1992) has created a solid scientific foundation for its use by others. Theories of reasoned behavior and planned behavior have also received more attention in recent studies of physical activity (Courneya, 1995; Godin, 1994; Rosen, 2000). None of the current theories and models is sufficient for understanding and changing physical activity for health. In a review of 45 intervention studies based on behavioral theories, Baranowski et al. (1998) concluded that the ability of theory to predict outcomes in physical activity studies was very limited. These authors argued for more research on mediating variables to improve understanding of whether theory-based interventions are producing intended effects. They also suggested that prediction might be improved if researchers focused on limited classes of physical activity performed in specific situations, such as walking during lunch break or taking stairs instead of the escalator at a shopping mall.

In a recent essay, Epstein (1998) reminded physical activity researchers and interventionists that both inductive (empirical) and deductive (model testing) approaches contribute to knowledge and that a combination of approaches is probably the best way to ensure continued progress. Epstein and his colleagues (Epstein et

al., 1995; Epstein, Kilanowski, Consalvi, & Paluch, 1999; Epstein, Paluch, Gordy, & Dorn, 2000) have been conducting innovative laboratory studies and clinical trials guided by behavioral economics or behavioral choice theory. This approach is likely to have far-reaching effects on future interventions in physical activity because it can help us understand why people choose sedentary rather than physically active behavior and what has to change to make physical activity more attractive.

Recent reviews have classified important theoretical constructs for physical activity in terms of types of variables or levels of application (intrapersonal–individual, interpersonal–social, and physical environmental; Sallis & Owen, 1999; U.S. Department of Health and Human Services, 1996). Understanding physical activity behavior and building more effective interventions require attention to all three of these dimensions. In a thoughtful analysis of reasons why theoretically based interventions in physical activity and other health behaviors have sometimes yielded disappointing results, Winett (1995) argued that psychologists' traditional focus on intrapersonal and interpersonal variables has led to relative neglect of environmental variables and program implementation issues. He encouraged adopting more of a social-marketing framework that adapts the successful approaches used in commercial settings. The Surgeon General's Report (U.S. Department of Health and Human Services, 1996) and other recent reviews (Sallis & Owen, 1999) similarly have encouraged greater attention to environmental (e.g., institutional, organizational, and community level) variables in future research.

Current Status of Physical Activity Participation and Adherence to Guidelines

Reports from national health surveys during the past decade confirmed what many parents already knew: Today's children and adolescents spend large amounts of time watching television and engaging in other sedentary behaviors that are associated with increased risk of obesity (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998). In general, studies from developed countries suggest that less than 50% of adolescents are sufficiently active (Stone, McKenzie, Welk, & Booth, 1998). Participation in physical education classes at school has continued to decline. In a 1997 survey, 64% of adolescents reported 20 min of vigorous activity at least three times a week (U.S. Department of Health and Human Services, 2000). Studies using objective measures, however, have shown as few as 10% of youth engaging in activity for at least 10 min at a time (Armstrong & Van Mechelen, 1998). Recent studies in the United States have shown minority youth to be less active than non-Hispanic Whites, but it is not clear to what extent these findings could be explained by socioeconomic status (Sallis & Owen, 1999).

A recent comprehensive review of more than 100 studies of child and adolescent physical activity (Sallis, Prochaska, & Taylor, 2000) evaluated associations with demographic, biological, psychological, behavioral, social, and environmental variables. For children, this review found consistent positive associations between physical activity and male gender, overweight parents, intent to be active and preference for activity, healthy diet, previous physical activity, access to programs/facilities, and time spent outdoors. Consistent inverse associations were found for perceived barriers. For adolescents, consistent positive associations were found for male gender, White ethnicity, perceived activity competence, intent to be active, community sports, sensation seeking, parent and others' support, sibling physical activity, direct help from parents, and opportunities to exercise. Inverse associations were found for increasing age, depression, and sedentary activity after school and on weekends. Findings from a recent national telephone survey of children and parents (Sallis, Prochaska, Taylor, Hill, & Geraci, 1999) found three variables with strong and consistent relationships with children's physical activity across age–gender subgroups: afternoon time for sports and physical activity, enjoyment of physical education, and family support for physical activity.

Analyses of physical activity survey data in adults during the past decade have also provided a more richly detailed picture of who is active at different intensities and in different settings. The proportion of the U.S. population over age 18 who reported engaging in light to moderate physical activity at least 5 days per week has remained at about 25% since 1990, and the prevalence of those reporting insufficient activity was about 45% (CDC, 2001). Fewer still, only 16% to 17%, reported engaging in vigorous physical activity. About 25% of all adults reported *no* leisure time physical activity. Significant differences by ethnic and age groups and between states (Bolen, Rhodes, Powell-Grner, Bland, & Holtzman, 2000; National Center for Health Statistics, 1999) may provide clues to variables that control level of participation.

It has been observed for many years that leisure time physical activity is most prevalent among younger, male, better educated, White adults with higher incomes (U.S. Department of Health and Human Services, 1996). The recently reported finding of a higher prevalence of physical inactivity among rural Americans than those living in urban settings (CDC, 1998) may have been surprising to people holding stereotypical views of life on the farm. Although rural residents are older, poorer, and less educated, the rural–urban differences remained after statistical adjustment for these variables. Occupational activity was not included in these analyses.

Addressing a large at-risk population that has not been adequately studied in the past, King, Castro, et al. (2000) have described the results of a national telephone survey of women over age 40. Care was taken to adequately sample American Indian, Asian American, African American, and Hispanic women for comparison with White women. The survey addressed personal and environmental factors and included physical activity at work and around the home, as well as during leisure time. For the sample as a whole, less education, perceived lack of energy to exercise, perceived poor health, lack of others exercising in the neighborhood, and lack of hills in the neighborhood were associated with inactivity. In contrast to other recent survey data (CDC, 1999), neighborhood safety did not emerge as a predictor of activity in this sample.

Surveys that ignore occupational activity may underestimate activity for some population groups that report little leisure activity. For example, recently published analyses from a 1990 survey (CDC, 2000b) showed that approximately one half of adults with no leisure time physical activity had reported at least 1 hr per day of hard physical activity at work. Occupational activity was greater for minorities and for those with less than a high school education and decreased with age. In the future, more attention to measurement of activities at home (including child care, cleaning, and

gardening), at work, and at play will help provide a more accurate method of identifying those individuals who are inactive in all settings and most at risk.

People 50 years and older are the most sedentary population group, and by age 75, one in three men and one in two women engage in no regular physical activity (U.S. Department of Health and Human Services, 2000). Even among those who are engaging in some activity, studies have suggested that encouraging further physical activity modification could increase health benefits. For example, surveys of walking—which is popular among women and older people—have found that many who walk for exercise do so fewer than 5 days a week and/or for fewer than 30 min at a time (CDC, 2000a; Dubbert, Meydrech, Kirchner, Cooper, & Bilbrew, 2001). Although chronic disease and disability contribute to the lower activity of older people, a number of studies have revealed that there are many variables besides health that have important influences on physical activity participation. Believing in the value of physical activity, perceiving fewer barriers, and having higher self-efficacy for physical activity participation are important psychosocial determinants (consistent predictors) of activity in adults of all ages (King, Rejeski, & Buchner, 1998). Program factors (being able to exercise on one's own at home vs. in a class or group) and advice and support from the primary health care provider are also important for elders (Simons-Morton, Calfas, Oldenburg, & Burton, 1998).

Advances in Assessment of Physical Activity

Physical activity measures using different methods (e.g., self-report, observer ratings, accelerometer, cardiorespiratory fitness) are typically only moderately correlated at best. Each method has its strengths and limitations, and researchers and practitioners need to consider what is most important for their purposes when making a choice of assessment methods. There has been considerable activity in development and validation of several important physical assessment methods during the past 10 years, and space does not permit a detailed discussion here. However, the Surgeon General's Report (U.S. Department of Health and Human Services, 1996) and a more recently published text on physical activity and behavioral medicine (Sallis & Owen, 1999) both provided excellent reviews of physical activity measurement concepts and methods. Another recently published text (Duda, 1998) gave coaches, teachers, and researchers a comprehensive review of exercise and sport psychology instruments. A 1997 special issue of *Medicine and Science in Sports and Exercise* (Pereira et al., 1997) included a collection of widely used physical activity questionnaires. Special issues of *Medicine and Science in Sports and Exercise* (Montoye, 2000) and *Research Quarterly for Exercise and Sport* (Wood, 2000) on assessment of physical activity, both published in 2000, are rich sources on conceptual discussion and state-of-the-art methods.

For adults, increased attention to moderate and to lifestyle activity during the 1990s enhanced the value of the Seven-Day Physical Activity Recall (PAR; Blair et al., 1985) as a self-report measure. The PAR, which elicits information on time spent in moderate and vigorous physical activity during the past week, was among 10 instruments validated in the Study of Activity, Fitness, and Exercise (Jacobs, Ainsworth, Hartman, & Leon, 1993). Recent clinical trials of interventions to increase activity in sedentary healthy adults (Dunn et al., 1999) and middle-aged primary care patients (Blair et al., 1998) have used change in daily energy expenditure estimated from the PAR as primary outcomes.

For children, validity of physical activity recall is related to older age and shorter recall periods (Sallis, Buono, Roby, Micale, & Nelson, 1993). Two new recall instruments for children assess activity from the previous day: the Past Day Physical Activity Recall (Weston, Petosa, & Pate, 1997) and the Self-Administered Physical Activity Checklist (Sallis et al., 1996). Both of these instruments separate recall for during- and after-school activity; both also assess time spent in sedentary behaviors.

Although it is difficult for many people to accurately recall routine activities, studies during the past decade have shown that it is possible to obtain reliable assessments of physical activity in the home setting (Brownson et al., 1999). The newly developed Kaiser Physical Activity Survey (Ainsworth, Sternfeld, Richardson, & Jackson, 2000), designed specifically to assess activity in women, has a section addressing child and elder care, cooking and cleaning, grocery shopping, and garden and yard work. This instrument has demonstrated good reliability and shown moderate correlations with cardiorespiratory fitness and estimates of energy expenditure obtained from monitoring of physical activity with accelerometers. Self-report measures for the elderly had been relatively neglected until recently, but there are now several adequate measures (Washburn, 2000). The Community Healthy Activities Model Program for Seniors (CHAMPS), a new physical activity questionnaire developed by Stewart et al. (2001) to assess outcomes with community-residing older adults, has been used in several settings with English-speaking and Spanish-speaking participants. This instrument can be administered in about 10 to 15 min by questionnaire or interview, has good psychometric properties, and yields estimates of energy expenditure that are sensitive to community-based interventions.

Concerns about the cardiovascular and other risks associated with physical activity create barriers to research and exercise promotion, especially in the elderly. Medical providers who want to encourage physical activity in these higher risk individuals, but who find the current guidelines for exercise stress testing vague, confusing, and prohibitively costly, may find recent practical recommendations helpful (Gill, DiPietro, & Krumholz, 2000). Walking tests, which permit standardized, submaximal, and well-tolerated assessment of fitness while requiring minimal time and resources, have a good safety record even among symptomatic cardiac rehabilitation patients (Bittner, Sanderson, Breland, Adams, & Schumann, 2000). The 6-min-walk test correlates as predicted with measures of functional ability (Harada, Chiu, & Stewart, 1999), can be sensitive to increased physical activity, and predicts mortality and morbidity (Bittner et al., 1993). The functional-fitness test battery (which includes the 6-min walk along with several other activities related to independent everyday life functioning) is designed for use with older adults in community settings, does not require medical supervision, has very good reliability and validity (Rikli & Jones, 1999a), and is normed for several older age groups (Rikli & Jones, 1999b).

Motion sensors are now being used with increasing frequency to obtain objective records of physical activity in children (McMurray, Harrell, Bradley, Webb, & Goodman, 1998), young adults (Jakicic et al., 1999; Nichols, Morgan, Sarkin, Sallis, & Calfas, 1999), and older adults (Fehling, Smith, Warner, & Dalsky, 1999).

Accelerometers currently in use can store data on activity in unsupervised settings for up to several weeks, depending on the frequency of sampling. Despite advances in the technology, there are still significant limitations besides the costs and effort required for use of this method of assessing physical activity. For example, data obtained during a variety of activities, including walking, jogging, stair climbing, and cycling, suggest a need for caution in interpreting intensity/caloric expenditure results (Fehling et al., 1999; Jakicic et al., 1999; Nichols et al., 1999). Inexpensive electronic pedometers (step counters) have also become very widely used during the past few years. Evaluation studies suggest they provide good estimates of daily step counts, but there is no simple way to translate step counts to public health physical activity guidelines (Welk et al., 2000).

Interventions to Promote Physical Activity in Home and Community Settings

Physical activity interventions have been extensively reviewed in the Surgeon General's Report (U.S. Department of Health and Human Services, 1996) and in a recent special issue of the *American Journal of Preventive Medicine* (Blair & Morrow, 1998). In addition, an excellent comprehensive quantitative synthesis of 127 studies from the physical activity intervention literature was published (Dishman & Buckworth, 1996). In this review, analyses weighted by sample size indicated that interventions based on principles of behavior modification and delivered to healthy people in the community can have moderately large effects (equivalent to increasing success from a rate of 50% to 70% or more). The most effective interventions involved unsupervised, low-intensity, leisure physical activity and used mediated approaches. Another recent review by a National Heart, Lung, and Blood Institute Working Group (Marcus et al., 2000), which examined evidence on maintaining physical activity change, found relatively little data on activity change beyond the 6 months after initiation of interventions. This is clearly an important priority for future research.

The quality of physical activity intervention research has continually improved through the past decade. Recently published studies have been generally characterized by stronger designs, larger numbers of more ethnically varied participants, multicomponent interventions, and follow-up for a year or more. Discussion here focuses on a few studies that exemplify state-of-the-art methodology with different target populations and physical activity goals.

The Child and Adolescent Trial for Cardiovascular Health (CATCH; McKenzie et al., 1996) involved more than 5,000 students in Grades 3, 4, and 5 in 96 schools and had the goals of increasing moderate and vigorous physical activity during physical education and out of school and increasing fitness. Like several other studies with children in schools, CATCH also had a nutrition component, and the intervention involved changes in physical education classes and classroom curricula. CATCH increased activity during physical education and increased out-of-school vigorous physical activity in intervention schools. A 3-year follow-up of eighth graders who participated in CATCH in the fifth grade found the intervention students maintained a higher level of activity (Nader et al., 1999).

Sports Play and Recreation for Kids (SPARK; Sallis et al., 1997) was used to assign more than 900 students to intervention or control conditions within seven schools. SPARK evaluated a physical education and behavioral self-management curriculum, with some physical education classes taught by experts and others by teachers trained by the project. Both types of intervention physical education classes increased the amount of moderate and vigorous physical activity during class. SPARK students also showed improved physical skills (McKenzie, Alcaraz, Sallis, & Faucetter, 1998).

Epstein et al.'s (2000) most recently published study targeting sedentary behavior change randomized 90 families with obese children to a comprehensive behavioral weight control program with the physical activity component targeting either increasing physical activity or decreasing sedentary activity. Participants self-monitored time spent in these types of activity and received incentives for targeted change. Accelerometer readings were correlated with self-reported time in physical activity. Both groups lost weight, and both groups had similar increases in physical activity, showing that these alternative approaches are both effective methods of changing behavior. The investigators noted that physical activity behavior changes were better maintained after 2 years than the weight-change outcomes.

Telephone interventions have consistently proved to be effective methods of increasing physical activity in targeted groups. Lombard, Lombard, and Winett (1995) studied the effects of frequency (once a week vs. every 3 weeks) and content of phone contact (specific feedback about the participant's performance vs. a less structured "how's the walking going?" approach) on adherence to a goal of walking at least 20 min a day at least 3 times per week. Survival analyses over 6 months of follow-up revealed the university women participants walked more if they received frequent, weekly prompts, but there was no significant effect for content of the calls. These findings suggest that inexpensive prompts that do not require intensive tracking of performance by individual participants can be effective, at least for short-term activity increases.

In adults, a study by Marcus, Bock, et al. (1998) illustrates the use of individual, motivationally-tailored printed intervention materials delivered through repeated mailings. The individualized messages were generated by a computer expert system programmed to deliver counseling messages on the basis of participant data and developed by psychologists using concepts from social–cognitive, decision-making, and the transtheoretical models. Control participants received standardized self-help materials published by the American Heart Association. Both groups reported increases in physical activity after 6 months, with significantly greater increases in the tailored intervention group.

Project Active (Dunn et al., 1998, 1999) involved 235 healthy adult men and women in a randomized clinical trial that compared a lifestyle physical activity program with a structured exercise program. The lifestyle participants met on a frequent basis for 6 months to learn cognitive–behavioral skills to help them find ways to accrue at least 30 min of moderate or higher intensity physical activity on most days. The structured exercise group received a free membership to a state-of-the-art exercise facility with an exercise leader. After 6 months, participants in both groups increased their average self-reported energy expenditure in physical activity on the PAR and showed improved fitness with treadmill testing. After 2 years, both groups continued to report increased energy expenditure, but the lifestyle group had more moderate intensity and the structured group had more vigorous intensity

activity. Fitness, blood pressure, and body fat were also improved in both groups. This study demonstrated that a lifestyle intervention approach could be as effective as structured exercise in increasing activity and health benefits.

CHAMPS demonstrated the effectiveness of a unique, well-designed program for promoting physical activity in older residents living in two government-subsidized (low income) congregate housing facilities (Stewart, 2001; Stewart et al., 1997). Instead of requiring all participants to follow the same exercise program, the intervention encouraged them to try one or more activities available in their community that were suited to their interests, abilities, income, and transportation resources. Those who were already somewhat active were encouraged to choose a complimentary activity for a more balanced exercise program. The intervention group was more active than the comparison group throughout the intervention phase. The exercise intervention was also associated with improvements in self-esteem, and those who initiated and successfully maintained a new physical activity reported improvements in anxiety, depression, and overall psychological well-being.

Continuing their timely and innovative contributions to studies of diet and physical activity change, Jeffery, Wing, Thorson, and Burton (1998) evaluated the effects of providing personal trainers and monetary incentives for supervised walking for weight control program participants. Having a trainer and receiving incentives, as single interventions, resulted in significantly greater attendance at the walking sessions. Use of both interventions together almost tripled attendance. Weight loss was, however, not significantly enhanced by the improved exercise adherence, perhaps in part because even the best group only completed about 50% of their prescribed walks.

There has been increasing interest in the possibility that physical activity promotion interventions delivered through health care settings may be one answer to the problem of how to change sedentary lifestyles (Simons-Morton et al., 1998). Several randomized clinical trials have been conducted. The Provider-Based Assessment and Counseling for Exercise (PACE) Program found increased walking and motivation for exercise in healthy adults 6 weeks after a few minutes of physician counseling, followed by one phone call (Calfas et al., 1996). The Physically Active for Life (PAL; Goldstein et al., 1999) study evaluated a medical office-based physical activity intervention involving 5 min of physician counseling, a mailed manual, and a follow-up visit for 355 older adults in 24 practices. After 6 weeks and 8 months, motivation for exercise was increased, but self-reported activity did not differ between intervention and control patients. PAL's authors concluded that older adults may need more intensive intervention to understand and retain counseling information.

The Activity Counseling Trial (ACT; Writing Group for the Activity Counseling Trial, 2001), a 24-month multisite randomized trial of physical activity counseling for 874 sedentary 35–75-year-old primary care patients, compared two counseling conditions differing in program staff time and resources with a control condition in which patients only received advice to exercise from their providers. Although provider advice was considered the standard of care, it should be noted that the attention given to physical activity in the control group was probably considerably greater than in most health care settings today. One counseling group received written materials, mail-back cards, feedback sheets, videos, and personal counseling. The most intensive counseling intervention added personal follow-up counseling sessions, regular phone calls from the counselor, and ongoing classes. After 2 years, women receiving either of the two interventions were more fit than those who only received provider advice; men's fitness did not differ between groups. Seven-day physical activity recall did not differ between groups for either gender. The investigators concluded that advice is an appropriate intervention for men, but women should be offered counseling to help them increase their physical activity.

The Strong for Life trial of a resistance training program for older adults with functional limitations (Jette et al., 1999) conducted the intervention entirely through home visits, with participants using videotapes as a guide for elastic band exercises. Behavioral strategies including goal setting and monitoring were used in the intervention. Therapists maintained contact by means of mail-back diaries and phone contacts. This trial achieved excellent adherence (almost 90% of exercise sessions completed) and researchers found strength improvements at 6 months. In one of many outstanding contributions during the past decade, King and her collaborators described the results of a community-based trial comparing endurance and strength exercise (Fit & Firm) with a stretching and flexibility (Stretch & Flex) intervention. Participants in both groups achieved excellent adherence, especially for the home sessions (King, Pruitt, et al., 2000); fitness outcomes were somewhat different between the two groups as expected. Notably, participants in the Stretch & Flex program also reported favorable changes in body pain after 1 year. Another trial involving elderly primary care patients with chronic illness, the Seniors Telephone Exercise Primary Care Study (STEPS; Dubbert, Cooper, Kirchner, & Meydrech, 2001), encouraged home-based walking programs. More than half the patients began walking, but those who received a combination of automated and personal phone calls from a nurse interventionist walked more often during the follow-up period than those who received no follow-up phone calls.

Exercise and Sport Psychology

The content of this and previous articles of this series (Dubbert, 1992; Martin & Dubbert, 1982) has emphasized physical activity promotion for disease prevention and rehabilitation. Although this continues to be a major focus for psychologists interested in exercise, an increasing number are also using their research and practice skills to improve athletic performance in individuals and teams. A recently published comprehensive volume on exercise and sport psychology (Van Raalte & Brewer, 1996) includes contributions by many leaders in this field. Another recently published book on exercise and sport psychology (Hays, 1999) described how to combine psychotherapy with exercise, using many clinical vignettes as well as referencing available literature.

Conclusions and Future Directions

The previous sections summarized some of the more important developments in physical activity and exercise during the past 10 years. What has been called a "paradigm shift" away from the previous emphasis on vigorous training for cardiovascular fitness toward moderate lifestyle activity stimulated continuing contro-

versy while creating opportunities for new intervention approaches (Dunn, Andersen, & Jakicic, 1998). The importance of physical activity to both quality and quantity of life was recognized by official statements of several professional groups and national public health guidelines. Study of physical activity and mental health, which had in previous decades often been characterized by more speculation than science, advanced through well-controlled studies of the effects of acute bouts of activity and extended exercise training. Understanding of the psychosocial and environmental correlates of regular physical activity versus sedentary lifestyles also improved for many population groups. Assessment methods more suitable for gender, age, and ethnic subgroups were developed. Standards for future physical activity promotion intervention studies were raised to a new level, as several large and influential trials with children and adults were published or initiated. Both qualitative and quantitative reviews concluded that interventions based on cognitive–behavioral theory are effective in changing physical activity behavior.

The Surgeon General's *Report on Physical Activity and Health* (U.S. Department of Health and Human Services, 1996) and subsequent literature have provided ample justification for the continued emphasis on physical activity in the recently released Healthy People 2010 objectives (U.S. Department of Health and Human Services, 2000). For 2010, physical activity is once again the first health indicator listed. There are specific objectives (a) to increase the proportion of adolescents who engage in vigorous physical activity 3 or more days per week for 20 min or more per occasion and (b) to increase the proportion of adults who engage in regular, preferably daily, moderate physical activity at least 30 min per day. Yet how will these objectives be reached? The modest physical activity improvement objectives of the Healthy People 2000 were not met; and there are no indications of reversal of the secular trends that have contributed to decreasing physical activity in the population at large. The final comments here will highlight some of the major challenges and opportunities for the new decade.

Research in the genetics of health and behavior and brain development and function may provide valuable new insights for understanding physical activity behavior choices and effects. For example, such research may improve understanding of the decrease in physical activity with age (Ingram, 2000; Sallis, 2000), why some people get more physical as well as psychological benefits from physical activity than others, and to what extent these are modifiable. We need to find out what the best times are to intervene with children, adolescents, and adults to prevent obesity and how early experience with physical activity influences attitudes and behavior later in life. We want to see how the brain changes when people are physically active and how these changes are associated with mental health and cognitive function.

Although there is now considerable evidence for benefits of physical activity and/or exercise training for disease prevention or rehabilitation, dose–response relationships remain poorly understood for many of the conditions that have been studied. Physical activity is a complex behavior that varies in mode (type) of activities and duration of individual bouts, occurs at varying frequencies, and can be performed at different intensities in different settings. Laboratory and observational studies are needed to further elucidate the relationships of these dimensions of activity to desired health benefits. The potential of using exercise and physical activity in a scientific manner to promote mental health should inspire continued efforts to understand the biological, psychosocial, and cognitive mechanisms (Dubbert, 1992). There is need for more research on activities other than endurance exercise (e.g., strength training, flexibility exercises). This is particularly important for elderly individuals, our fastest growing segment of the population, and a group at high risk for impaired mobility and loss of independence because of insufficient activity (King, Rejeski, & Buchner, 1998a). There is also as yet very little empirical evidence about the extent to which physical activity can facilitate other lifestyle changes, such as smoking cessation and dietary change (Marcus et al., 2000).

Researchers should continue to improve measures appropriate to ethnic and cultural minorities, women, youth, and older populations so that they do not overburden participants, yet remain reliable and valid. Technological advances will likely aid progress in this area, with better and less expensive activity monitors and palm-top computers to facilitate accurate real-time data collection. We need to find ways to assess the impact of environmental and policy level interventions, such as providing walking–biking trails and safe playgrounds. Intervention research should use fully randomized or the strongest feasible designs and consistently use the valid measures that are now available.

The rapid growth of electronic communications will undoubtedly allow creative new intervention methods and strategies. Researchers and practitioners should carefully consider the successes and failures of previous studies using mediated interventions. In their review, Marcus, Owen, Forsyth, Cavill, and Fidinger (1998) concluded that print- and telephone-based interventions are effective, at least for short-term physical activity change. Matching intervention content on participant characteristics such as motivational readiness improves their effectiveness. Unfortunately, mass media approaches such as radio and television have not produced physical activity behavior change despite good recall. Findings from interventions targeted to underserved populations have been mixed thus far, suggesting a need for creativity and improved tailoring so the audience feels the message is relevant to them.

Success in achieving population physical activity change objectives seems unlikely unless researchers and interventionists heed advice to pay more attention to the physical and psychosocial environment in which choices to be active or sedentary occur. At the simplest levels, better understanding of neighborhood and family/friend support for exercise and physical activity is needed. For example, a successful intervention for weight management that involved recruiting people with their friends and providing social support interventions during the treatment program might be adapted to improve adherence to physical activity and exercise (Wing & Jeffery, 1999). Lasting change at the environmental level will, however, require changing families, schools, workplaces, organizations, and communities, and using theoretical models and strategies that may be unfamiliar to psychologists trained primarily in individual clinical methods (Sallis, Bauman, & Pratt, 1998). Psychologists can join their skills to those of others with complementary training in public health and organizational change to build the interdisciplinary teams needed to tackle these complex objectives (Sallis et al., 1998). With this kind of collaboration and continuing innovation, the next decade may be equally as rewarding as the past 10 years for physical activity and exercise promotion and research.

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