

# Behavioral Science Research in Diabetes

## Lifestyle changes related to obesity, eating behavior, and physical activity

RENA R. WING, PHD  
MICHAEL G. GOLDSTEIN, MD  
KELLY J. ACTON, MD, MPH, FACP  
LEANN L. BIRCH, PHD  
JOHN M. JAKICIC, PHD

JAMES F. SALLIS JR., PHD  
DELIA SMITH-WEST, PHD  
ROBERT W. JEFFERY, PHD  
RICHARD S. SURWIT, PHD

Lifestyle factors related to obesity, eating behavior, and physical activity play a major role in the prevention and treatment of type 2 diabetes. In recent years, there has been progress in the development of behavioral strategies to modify these lifestyle behaviors. Further research, however, is clearly needed, because the rates of obesity in our country are escalating, and changing behavior for the long term has proven to be very difficult. This review article, which grew out of a National Institute of Diabetes and Digestive and Kidney Diseases conference on behavioral science research in diabetes, identifies four key topics related to obesity and physical activity that should be given high priority in future research efforts: 1) environmental factors related to obesity, eating, and physical activity; 2) adoption and maintenance of healthful eating, physical activity, and weight; 3) etiology of eating and physical activity; and 4) multiple behavior changes. This review article discusses the significance of each of these four topics, briefly reviews prior research in each area, identifies barriers to progress, and makes specific research recommendations.

*Diabetes Care* 24:117–123, 2001

In November 1999, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) conducted a conference on behavioral science research in diabetes. One of the conclusions of this conference was that further research is needed on lifestyle changes related to obesity and physical activity, because these factors play such a major role in the prevention and treatment of diabetes. The purpose of this review article is to identify key research topics related to lifestyle

changes and briefly discuss the significance of each topic, key research to date, and barriers to progress, and then to make specific research recommendations on the topic. Future issues of *Diabetes Care* will include articles on other important areas of behavioral science research in diabetes that were presented at the NIDDK conference, including psychological and behavioral disorders (e.g., depression) and broader health system approaches to behavior change.

From Miriam Hospital (R.R.W., J.M.J.), Brown University, and the Department of Psychiatry and Human Behavior (R.R.W.), Brown Medical School, Providence, Rhode Island; the Pharmaceuticals Division (M.G.G.), Bayer Corporation, West Haven, Connecticut; the Indian Health Service Diabetes Program (K.J.A.), Albuquerque, New Mexico; the Department of Human Development and Family (L.L.B.), Pennsylvania State University, State College, Pennsylvania; the Department of Psychology (J.F.S.), San Diego State University, San Diego, California; the Department of Medicine, Division of Preventive Medicine (D.S.-W.), University of Alabama, Birmingham, Alabama; the Division of Epidemiology (R.W.J.), School of Public Health, University of Minnesota, Minneapolis, Minnesota; and the Department of Psychiatry and Behavioral Sciences (R.S.S.), Duke University Medical Center, Durham, North Carolina.

Address correspondence and reprint requests to Rena R. Wing, PhD, Director, Weight Control and Diabetes Research Center, Brown University/Miriam Hospital, 164 Summit Ave., Providence, RI 02906. E-mail: rwing@lifespan.org.

Received for publication 7 March 2000 and accepted in revised form 24 May 2000.

**Abbreviations:** CHD, coronary heart disease; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Type 2 diabetes is increasing at an alarming rate. There are currently 16 million Americans with diabetes, but it is projected that within 10 years, there will be 23 million Americans with this disease. The increase in prevalence is associated with the aging of the population, the dramatic rise in the prevalence of obesity, and a more sedentary lifestyle.

Type 2 diabetes disproportionately affects minority populations, including African-Americans, Hispanics, Native Americans and Alaska Natives, Asian-Americans, and Pacific Islanders. Risk factors for diabetes that are specific to these populations include genetic, behavioral, and lifestyle factors (1). In the past, type 2 diabetes occurred primarily in individuals >40 years of age. However, the increasing prevalence of childhood obesity has led to a marked increase in type 2 diabetes in adolescents and young adults (2).

A large number of epidemiological studies show that obesity and a sedentary lifestyle are independently related to the chances of developing diabetes. Data from the Nurses' Health Study suggest that the lowest risk of diabetes occurs in individuals who have a BMI <21, with increasing prevalence seen as obesity levels increase (3,4). Similarly, there is a dose-response relationship between physical activity and risk of diabetes (5,6), and equivalent energy expenditure from walking and vigorous activity appears to confer comparable benefits with respect to reduction in risk of diabetes (7).

In addition to epidemiological data, several intervention studies have suggested that weight loss and increased physical activity may help prevent or delay the development of type 2 diabetes in those at high risk for this disease (8,9). Given these data, the National Institutes of Health has launched a major multicenter clinical trial—the Diabetes Prevention Program—to determine whether lifestyle or pharmacological intervention (namely metformin) is effective in preventing conversion from impaired glucose tolerance to type 2 diabetes (10).

Similarly, there are a number of studies indicating that weight loss and exercise may

help in the treatment of diabetes. Weight loss and exercise have both been shown to decrease insulin resistance, a major physiological defect related to the development of diabetes, and to improve glycemic control (11,12). These interventions also ameliorate hypertension and lipid abnormalities and thus may contribute to reduction in risk of coronary heart disease (CHD) in individuals with type 2 diabetes (12).

Given that behaviors (namely diet and physical activity) are among the strongest risk factors for type 2 diabetes (1) and a key aspect of its treatment, it is important that behavioral research focus on how best to change these behaviors. Four key areas have been identified for future research related to lifestyle modification.

## **ENVIRONMENTAL FACTORS RELATED TO OBESITY, OVEREATING, AND PHYSICAL INACTIVITY**

### **Why is this topic significant?**

As noted above, differences in lifestyle appear to be related to the differential rates of diabetes and obesity across cultures and within our own culture over time (13). These differences in behavior may, in turn, reflect differences in the macroenvironment. Evidence indicating the importance of the environment is seen, for example, in studies comparing Pima Indians, who live in rural Mexico and follow a traditional Pima lifestyle, with Pima Indians living in Arizona, who consume a Westernized diet and are more sedentary (14). Despite the apparent similarity in genetic background of these two Pima communities, the Mexican Pimas have markedly lower rates of obesity and diabetes than the Arizona Pimas. Many other examples of the negative effects of Westernization on eating and exercise, and subsequent risk of obesity and diabetes, are available (15).

Likewise, environmental changes in the U.S. may be leading to the increasing prevalence of obesity (16). It has been suggested that Americans live in an environment rendered unhealthful by their easy access to energy-dense foods and an increasing number of devices (e.g., television remote controls) that reduce their energy expenditure. Modifying this environment through population-wide changes in eating and physical activity may help prevent obesity.

Currently, most interventions for obesity are conducted at the level of individual

patients. Overweight individuals are encouraged to join weight loss programs. Given the epidemic level of obesity in our country, such approaches to the problem may not be the most cost-effective (17). A more global public health approach may be needed.

Environments affect the entire population exposed to them. By affecting policies of companies, government agencies, and other organizations whose decisions influence many people, it may be possible to change the unhealthful environment and thereby change obesity at a population level. In addition, the fact that the current environment is not conducive to healthful eating and activity may explain the poor maintenance seen in most physical activity and nutrition programs. Such educational programs and individual-level treatments will have limited effectiveness when the environment makes it hard to follow the recommendations—i.e., it is hard to follow a healthful diet if grocery stores do not make healthful foods abundantly and consistently available at reasonable prices. Differences in access to healthful foods and opportunities for physical activity may be one of the factors related to the prevalence of obesity in individuals of lower socioeconomic status (16,18). Thus, an important new direction for behavioral research is to study ways to change the macroenvironment and thereby change eating behavior and physical activity.

### **Prior research**

Correlational data have suggested that environmental factors influence physical activity and eating. For example, Cheadle et al. (18) found strong correlations between fat intake and the percent of local grocery store shelf space devoted to low-fat versus regular milk and meat. Similarly, both the amount of exercise equipment in the home (19) and the density of physical activity facilities in the neighboring community (20) have been associated with adult physical activity levels. The physical activity level of children has been shown to be related to characteristics of their neighborhood environments (21,22).

There have also been small-scale intervention studies suggesting that changing the price or availability of foods in cafeterias or vending machines may influence whether people purchase these items (23,24). Environmental manipulations, including signs to promote the use of stairs rather than elevators (25), have also been effective in changing physical activity pat-

terns. A recent study by Andersen et al. (26) suggests that there may be important differences between ethnic groups in the impact of such environmental manipulations. Signs advocating the use of stairs for cardiovascular health or for weight control increased Caucasians' but not African-Americans' use of stairs. Of particular note are the studies by Ellison et al. (27,28) showing that changes in the food supply in boarding schools are well tolerated and can lead to improvements in physiological risk factors.

Whereas these studies investigating specific manipulations of the environment have tended to show positive effects, there are several large community interventions and school-based approaches that relied mainly on educational programming, which had much more limited effects on eating behavior, eating activity, or obesity (29–31). Thus, actually changing the environment may be far more effective than trying to educate the public to deal with an unhealthful environment.

### **Barriers to progress**

To date, there has been little research on the environmental factors related to eating and physical activity. Such research will require conceptual work to determine what the key variables are and how best to change them; it will also require new methods for measuring these environmental variables and consideration of cultural factors that may influence the results. Environmental variables may be inherently difficult to study because they are ubiquitous; the most important variables may be widespread, such as television advertisements, car use, presence of fast-food outlets, and availability of palatable energy-dense foods. People may also resist environmental changes in these domains. Small-scale projects are needed to learn how to intervene on environmental variables.

### **Research recommendations**

• **Theoretical and epidemiological research.** Because this is a new area of research, conceptual work is needed to identify the most important environmental and policy influences on eating and physical activity behaviors. Identifying such influences will require input from scientists, public health experts, marketing researchers, and policy makers. Development of objective psychometrically sound measures of environmental characteristics related to eating and physical activity is also needed, again requiring collaboration across diverse

fields. Correlational studies are needed to document associations between environmental and policy variables and behaviors. These studies would generate hypotheses regarding which variables have the most influence on eating and physical activity, and examine the interactions between environmental factors and cultural and socioeconomic differences in the populations.

• **Intervention studies.** Small focused interventions are needed to examine the effect of specific environmental manipulations on outcomes (i.e., eating behavior, physical activity, and biological end points). Strategies for changing the home environment (e.g., access to television), other controlled environments (e.g., boarding schools, university dormitories, and summer camp), and the broader neighborhood community should be developed. Changes in the environment to increase access to healthful food and physical activity and to reduce both the financial and behavioral costs of such behaviors should be evaluated. Similarly, it is important to examine ways to decrease access to undesirable behaviors, such as limiting the availability of unhealthy snack foods in school settings or limiting the number of hours of television viewing. It is important to determine whether environmental interventions have similar effects on different ethnic or socioeconomic groups. Studies focusing on the acute effect of environmental change on behavior could be modest in scope; those intended to affect biological end points would need to be more extensive in scope and duration.

## **ADOPTION AND MAINTENANCE OF HEALTHFUL EATING, PHYSICAL ACTIVITY, AND WEIGHT**

### **Why is this topic significant?**

As noted earlier, both obesity and physical inactivity are risk factors for diabetes, and the reduction or elimination of such factors appears to be related to prevention and management of this disease. In addition, CHD is the major cause of mortality for individuals with diabetes (11). Both physical activity and weight loss have been shown to reduce blood pressure, improve serum lipid levels, and positively affect other CHD risk factors (11). Thus, development of more effective strategies for adoption and maintenance of healthful eating, physical activity, and body weight would be significant for the prevention and treatment of both diabetes and CHD.

### **Prior research**

Behavioral approaches to obesity were first introduced during the 1970s and have become increasingly popular in the management of diabetes. Programs that combine diet, exercise, and behavior modification have been shown to be most effective over the short term (11). Currently, a patient entering such a behavioral program will lose 20 lb on average (~10% of their weight) over the course of 20–26 weeks (32). Alternative approaches to the delivery of the intervention (e.g., through use of computers or correspondence) have been explored (33,34). Although these approaches have typically produced smaller weight loss than face-to-face programs, they may increase the proportion of the population that is willing to participate in weight control interventions.

Longer-term maintenance of weight loss after participation in weight control interventions is less successful. At the 1-year follow-up, patients have typically regained ~30% of their initial weight loss (32); the few studies with 3- to 5-year follow-up suggest that most patients are back to baseline by this time (35). The most consistent predictors of long-term maintenance of weight loss are increased physical activity and adherence to self-monitoring. Continued treatment contact also appears to improve long-term maintenance of weight loss (36).

There have been a number of studies applying behavioral weight control approaches to type 2 diabetic patients (37). These studies have suggested that improvement in glycemic control and reduction in CHD risk factors are related to the magnitude of weight loss, but even modest weight reduction of ~10% of body weight appears to improve a patient's glycemic control, blood pressure, lipids, and quality of life (38–40). There is some evidence that diabetic patients are less successful in maintaining long-term weight loss than people without diabetes (41), a result perhaps due to metabolic differences between these two groups. Thus, continued efforts are needed to develop behavioral weight loss interventions that will increase the percentage of diabetic patients who are able to lose and maintain weight losses of at least 10% of initial body weight.

Behavioral research on physical activity started more recently and has taken a more community-oriented, less clinic-based approach (42,43). The focus has been on developing strategies to increase the proportion of individuals who adopt physical

activity and the proportion that will maintain activity for the long term. Frequent contact by phone and print has been found to help promote activity, along with development of personalized messages matched to the participants' readiness to change their behavior (44,45). Several studies have also documented the impact that physicians can have by recommending and "prescribing" exercise to their patients (46–49). Emphasis has gradually shifted to home-based, rather than clinic-based, physical activity interventions (50,51), and the accumulation of 150 min/week of moderate-intensity physical activity through multiple short bouts of exercise (52) and/or incorporation of lifestyle activity within one's daily routine (53).

### **Barriers to progress**

Development of effective strategies for long-term maintenance of any behavior change has proven to be difficult. To develop more effective long-term interventions, it is necessary to understand better what motivates continued adherence to lifestyle change. Since research on long-term maintenance requires large sample sizes and long periods of time, developing reliable intermediate end points would allow for evaluation of intervention strategies in a more condensed time frame. Better ways to assess energy intake and expenditure would allow investigators to focus interventions more directly on the behaviors related to body weight.

### **Research recommendations**

• **Research directly focused on maintenance.** Currently, the major problem in the field is the difficulty of ensuring long-term maintenance of behavior change (54). Therefore, concerted efforts are needed to better understand why maintenance is so difficult and how long-term outcomes can be improved. Aspects of maintenance meriting further attention include the following: the nature and frequency of intervention contact, novel methods of promoting self-monitoring and social support, methods of sequencing or matching treatment to relevant individual characteristics, the level of physical activity that should be recommended, and theoretical constructs that may promote long-term adherence. It is recommended that there be a focus on long-term maintenance within the context of existing large-scale trials, such as the Diabetes Prevention Program and the Study of the Health Outcomes of Weight Loss.

• **Increased understanding of motivation.** Research is needed to understand better what motivates people to initiate changes in diet and physical activity and what sustains engagement in these behaviors for the long term. Recognition of cultural differences in the attitudes about ideal body weight, obesity, and physical activity will be important in this research.

• **New approaches to providing treatments.** Research is needed that moves beyond traditional clinic-based models and explores other avenues for intervention with the goal of increasing both the number of people who attempt to lose weight and the long-term effects on body weight. New approaches include church-based interventions and interventions in the primary care setting. Since many individuals who change diet or physical activity do so on their own (i.e., without participation in formal programs) (55), it is important to examine ways to facilitate such efforts, such as using computer-based Internet interventions.

## ETIOLOGY OF EATING AND PHYSICAL ACTIVITY BEHAVIORS

### Why is this topic significant?

To develop approaches to treatment and prevention, it is important to have some understanding of the etiology of obesity and the factors involved in the development of eating and physical activity habits. This understanding is particularly relevant to the growing problem of childhood obesity.

The prevalence of childhood overweight has increased dramatically over the past 2 decades, nearly doubling by some estimates (56,57). Childhood overweight is particularly common in minority groups, such as African-Americans and Hispanics. With this increased prevalence of childhood obesity has come a startling increase in the prevalence of type 2 diabetes in children and adolescents (2).

Childhood obesity is also significant because of its psychosocial costs (58,59). In a recent study (59), overweight adolescent females, followed for 7 years, were found to complete less schooling, to be less likely to get married, and have lower income than their normal-weight peers.

Obesity in childhood often continues into adulthood. However, the more common path to obesity in adulthood is to be normal weight as a child and gradually gain weight during adulthood (60). High-risk periods for weight gain include the

time period of 25–34 years of age and the time periods surrounding menopause (61). Pregnancy can also be a high-risk time period for a subset of women (62).

Although weight gain and obesity are clearly due to problems in energy balance, it is still unclear whether this is due to high dietary intake, a low level of physical activity, or both. Secular changes in dietary patterns (e.g., increased reliance on fast foods and increased portion sizes) and physical activity (e.g., decreased playtime and increased use of television as a child-care strategy) may contribute to these changes. A better understanding of the process by which children establish their eating and physical activity preferences and the changes that occur with age will facilitate development of more effective approaches for prevention and treatment of obesity.

### Prior research

Research on the etiology of eating and physical activity has pointed out the important influence of parents in the development of children's food preferences, dietary intake, and activity patterns (63). Parent-child relationships in nutrient intake appear to be related more to shared environment than to genetics and appear stronger for mother-child pairs than father-child pairs (63,64).

Young children appear to regulate their energy intake quite accurately. That is, if they are fed a high-calorie preload, they will eat less during a subsequent meal than if they had been fed a low-calorie preload. However, over time, children become less accurate at such regulation (65). These changes may be due to environmental and familial influences. For example, older children are more responsive to the influence of portion size (65). Moreover, mothers who report more control over their children's eating behavior have children who regulate their energy intake less successfully. Recent work suggests that parents shape their children's eating behavior through their feeding practices (66), but also through the foods they offer to their children and through direct modeling.

The strongest predictor of dietary intake is food preference; people tend to eat what they enjoy. Such preferences appear to be in part innate and in part responsive to early feeding experiences (67). Although preference for sodium has been shown to change with repeated exposure to low-sodium foods, it is unclear whether preference for dietary fat can be changed by consuming a low-fat diet (68).

There have been more than 100 studies of physical activity patterns in children and more than 300 studies in adults (21,22). Most are correlational and have examined demographic, psychological/emotional, behavioral, social/cultural, and environmental correlates of physical activity. Significant associations have been found in all domains. Children appear to be the most active segment of the U.S. population, with physical activity levels declining from the age of 6 years on (69). Decreases in physical activity during adolescence are dramatic. Among adults, sedentary behavior is more prevalent for women, the less educated, the poor, and ethnic minorities (70).

Research has shown that obesity aggregates within families. Interventions for childhood obesity that target both the child and the overweight parent appear most successful (71). In a series of studies, Epstein et al. (72) have shown that family-based interventions for overweight children aged 8–12 years produce improvements in obesity that are maintained through 10 years of follow-up.

To date, there have been few studies designed to prevent obesity. Jeffery and French (73) found little benefit over 3 years of a low-intensity intervention for weight gain prevention. In contrast, a more intensive intervention to prevent weight gain and lipid changes during the menopausal transition was quite effective through 5 years of intervention (45).

### Barriers to progress

Research on etiology of obesity is hampered by the inability to accurately assess intake (i.e., total calories, macronutrient intake, and patterns of intake) and physical activity (i.e., overall amount of activity, its intensity, and the patterns of activity). Self-report measures of these parameters are subject to many biases (74). In addition, there have been few theoretically based studies of the etiology of obesity. Environmental, cultural, and policy influences have not been systematically investigated, and most studies have not been designed to be relevant to intervention. Few studies have focused specifically on prevention of weight gain.

### Research recommendations

• **Longitudinal research.** Longitudinal research is needed to identify risk and protective factors for childhood overweight and for weight gain during adulthood. These designs should include samples that allow comparisons across racial and ethnic

groups. Research designs should include measures of physical activity, energy expenditure, and food intake and should assess aspects of the environment related to eating and exercise behavior (e.g., the portion of meals eaten away from home and the environmental opportunities for activity). For studies of children, particular attention to the family environment is needed; this will allow for examination of how genetic and environmental factors interact to produce overweight or weight gain. Once longitudinal data (with measures at multiple time points) are available, new statistical techniques, such as growth-curve multilevel modeling, can be used to identify predictors that may constitute risk and protective factors and that predict differing growth trajectories. An important longitudinal issue is to determine how and when childhood behaviors carry over to adulthood.

- **Research on development of preferences for foods and activities.** Research is needed that describes the factors involved in the acquisition of food and physical activity preferences. What are the biological and environmental influences that shape eating and physical activity preferences? How stable are these preferences over time, and what strategies can be used to modify these preferences?

- **Intervention studies.** Research is needed to determine how to prevent the development of obesity in children and reduce obesity in those children already affected. It is unclear whether there are certain ages that are most conducive to effective intervention (e.g., ages 8–12 years) and what strategies are most effective in modifying diet and activity patterns. Similarly, interventions are needed to prevent the decrease in physical activity that occurs during adolescence and to examine the impact of such interventions on weight change and other health-related parameters in young adults (75). Interventions to prevent weight gain and the development of obesity during adulthood are also needed.

## MULTIPLE BEHAVIOR CHANGES

### Why is this topic significant?

The treatment regimen for individuals with diabetes is extremely complex. The regimen includes both lifestyle components (i.e., diet and physical activity) and typically pharmacological components (i.e., oral medication and insulin). Patients must monitor their blood glucose and use this

information to adjust and coordinate eating, physical activity, and medication doses. In addition, many patients with diabetes have other comorbidities, including hypertension and hyperlipidemia, and thus must integrate their diabetes self-care with self-care of these other diseases. The treatment regimen also involves regular visits to physicians or other health care providers and screening and treatment for diabetes-related conditions (e.g., eye screenings and foot care). Tobacco use or excessive alcohol use further complicates the task of behavior change.

It remains unclear how best to integrate these multiple behavior changes. This issue is important within lifestyle behaviors (e.g., is it best to start with diet and add exercise, or start with exercise and add diet, or do both concurrently?) and is made even more complex when medication is added to the treatment regimen. Which behaviors are synergistic and which negatively affect each other remains unclear. What is the optimal role of the health care clinician in sorting out priorities for behavior change?

### Prior research

Previous research has suggested that the combination of diet and physical activity is more effective for long-term weight loss maintenance and improved glycemic control than either intervention alone (11). Physical activity may also act as a catalyst for other behavior changes; individuals who are more active often consume healthier diets and smoke less (76).

The positive impact of the combination of diet plus exercise contrasts with other examples in which the combination of two behavioral goals produces less change in each of the behaviors. In treatment of hypertension, for example, patients who are instructed to follow a low-sodium diet and lose weight are less adherent to either of these changes than when they are introduced separately (77).

Smoking cessation programs have examined the effectiveness of including other lifestyle behaviors within the program to address concerns about weight gain after smoking cessation. Studies combining smoking cessation with a weight loss intervention have been relatively unsuccessful (78), whereas a recent study combining smoking cessation with physical activity appears promising (79). There is also evidence that targeting alcohol consumption and smoking enhances abstinence rates for both behaviors (80).

To date, there has been little research on how best to combine lifestyle and pharmacological treatments to maximize compliance to both regimens and increase overall effectiveness (81). With the increased interest in drug treatment of obesity, such research clearly will be of significance.

### Barriers to progress

Clinically, the major barrier to the combination of lifestyle modification and pharmacological treatment relates to the different specialty groups that focus on each approach. Although physicians feel competent to prescribe medication, they have little or no experience with lifestyle intervention. The lack of time the physician has available for each patient in primary care settings poses another barrier to use of lifestyle intervention. Conversely, the behaviorists who are most expert at lifestyle intervention are not qualified to prescribe drugs.

From a research perspective, a major barrier is the complexity of the study design required for investigation of multiple behavior changes. Such studies require large sample sizes and relatively long duration.

### Research recommendations

- **Research on multiple lifestyle changes.** Research is needed to determine which lifestyle interventions act synergistically with each other and which combinations are less effective. Although it is often assumed that modification of multiple lifestyle factors will enhance prevention and treatment efforts for diabetes, research in other areas (e.g., smoking plus weight loss) suggests that targeting multiple behaviors may, in some cases, have a negative impact on treatment. Therefore, it is important to compare the effects of targeting a single lifestyle factor, sequencing of several lifestyle factors, or targeting multiple factors simultaneously. Whether physical activity has a special role as a catalyst for other lifestyle behavior changes deserves specific attention.

- **Research combining lifestyle and pharmacological treatment.** Research is needed to develop strategies to maximize the effectiveness of the combination of lifestyle and pharmacological treatments. Such research should be multidisciplinary and examine lifestyle plus medication approaches for treatment of obesity, diabetes, and other CHD factors. Questions related to the timing of the two approaches, the impact of patient preference or choice (versus clinicians' choice) regarding these two modalities, and ways to train physi-

cians and other clinicians in the use of lifestyle approaches within clinical settings deserve attention.

**CONCLUSIONS** — Given the strong association between lifestyle behaviors and the prevention and treatment of type 2 diabetes, it is important that greater research attention be directed at issues related to the development of healthful eating and physical activity habits and strategies for modifying unhealthy behaviors. The focus should be on ways to change eating and physical activity behavior both from an individual perspective and a broader environmental perspective.

## References

- Rewers M, Hamman RF: Risk factors for non-insulin-dependent diabetes. In *Diabetes in America*. National Diabetes Data Group, Ed. Bethesda, MD, National Institutes of Health, 1995, p. 179–220
- Pinhas-Hamiel O, Dolan L, Daniels S: Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. *J Pediatr* 128:608–615, 1996
- Colditz GA, Willett WC, Stampfer MJ, Manson JE, Hennekens CH, Arky RA, Speizer FE: Weight as a risk factor for clinical diabetes in women. *Am J Epidemiol* 132:501–513, 1990
- Carey VJ, Walters EE, Colditz GA, Solomon CG, Willett WC, Rosner BA, Speizer FE, Manson JE: Body fat distribution and risk of non-insulin-dependent diabetes mellitus in women: the Nurses' Health Study. *Am J Epidemiol* 145:614–619, 1997
- Manson JE, Nathan DM, Krolewski AS, Stampfer MJ, Willett WC, Hennekens CH: A prospective study of exercise and incidence of diabetes among US male physicians. *JAMA* 268:63–67, 1992
- Manson JE, Rimm EB, Stampfer MJ, Colditz GA, Willett WC, Krolewski AS, Rosner BA, Hennekens CH, Speizer FE: Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. *Lancet* 338:774–778, 1991
- Hu F, Sigal R, Rich-Edwards J, Colditz G, Solomon C, Willett W, Speizer F, Manson J: Walking compared with vigorous physical activity and risk of type 2 diabetes in women. *JAMA* 282:1433–1439, 1999
- Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, Hu ZX, Lin J, Xiao JZ, Cao HB, Liu PA, Jiang XG, Jiang YY, Wang JP, Zheng H, Zhang H, Bennett PH, Howard BV: Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: the Da Qing IGT and Diabetes Study. *Diabetes Care* 20:537–544, 1997
- Eriksson KF, Lindgarde F: Prevention of type 2 (non-insulin-dependent) diabetes mellitus by diet and physical exercise. *Diabetologia* 34:891–898, 1991
- Diabetes Prevention Program Research Group: Design and methods for a clinical trial in the prevention of type 2 diabetes. *Diabetes Care* 22:623–634, 1999
- NHLBI Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: the evidence report. *Obes Res* 6 (Suppl. 2):51S–210S, 1998
- Maggio CA, Pi-Sunyer FX: The prevention and treatment of obesity: application to type 2 diabetes (Review). *Diabetes Care* 20:1744–1766, 1997
- Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL: Overweight and obesity in the United States: prevalence and trends. *Int J Obes* 22:39–47, 1998
- Ravussin E, Valencia ME, Esparza J, Bennett PH, Schulz LO: Effects of a traditional lifestyle on obesity in Pima Indians. *Diabetes Care* 17:1067–1074, 1994
- Zimmet PZ, McCarty DJ, deCourten MP: The global epidemiology of non-insulin-dependent diabetes mellitus and the metabolic syndrome. *J Diabetes Complications* 11:60–68, 1997
- Hill J, Peters J: Environmental contributions to the obesity epidemic. *Science* 280:1371–1374, 1998
- Jeffery RW: Population perspectives on the prevention and treatment of obesity in minority populations. *Am J Clin Nutr* 53:1621S–1624S, 1991
- Cheadle A, Psaty B, Diehr P, Koepsell T, Wagner E, Curry S, Kristal A: Evaluating community-based nutrition programs: comparing grocery store and individual-level survey measures of program impact. *Prev Med* 24:71–79, 1995
- Jakicic JM, Wing RR, Butler BA, Jeffery RW: The relationship between presence of exercise equipment in the home and physical activity level. *Am J Health Promot* 11:363–365, 1997
- Sallis JF, Hovell MF, Hofstetter CR, Elder JP, Hackley M, Caspersen CJ, Powell KE: Distance between homes and exercise facilities related to frequency of exercise among San Diego residents. *Public Health Rep* 105:179–185, 1990
- Sallis J, Prochaska J, Taylor W: A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc* 32:963–975, 2000
- Sallis J, Owen N: *Physical Activity and Behavioral Medicine*. Thousand Oaks, CA, Sage Publications, 1999
- French S, Jeffery R, Story M, Hannan P, Snyder M: A pricing strategy to promote low-fat snack choices through vending machines. *Am J Public Health* 87:849–851, 1997
- Jeffery RW, French SA, Raether C, Baxter JE: An environmental intervention to increase fruit and salad purchases in a cafeteria. *Prev Med* 23:788–792, 1994
- Brownell KD, Stunkard AJ, Albaum JM: Evaluation and modification of exercise patterns in the natural environment. *Am J Psychiatry* 137:1540–1545, 1980
- Andersen R, Franckowiak S, Snyder J, Bartlett S, Fontaine K: Can inexpensive signs encourage the use of stairs? Results from a community intervention. *Ann Intern Med* 129:363–369, 1998
- Ellison R, Capper A, Stephenson W: Effects on blood pressure of a decrease in sodium use in institutional food preparation: the Exeter-Andover Project. *J Clin Epidemiol* 42:201–208, 1989
- Ellison R, Capper A, Goldberg R, Witschi J, Stare F: The environmental component: changing school food service to promote cardiovascular health. *Health Educ Q* 16:285–297, 1989
- Taylor CB, Fortmann SP, Flora J, Kayman S, Barrett DC, Jatulis D, Farquhar JW: Effects of long-term community health education on body mass index: the Stanford Five-City Project. *Am J Epidemiol* 134:235–249, 1991
- Jeffery RW: Community programs for obesity prevention: the Minnesota Heart Health Program. *Obes Res* 3 (Suppl. 2):+283S–288S, 1995
- Winkelby M: The future of community-based cardiovascular disease intervention studies. *Am J Public Health* 84:1369–1372, 1994
- Wing RR: Behavioral approaches to the treatment of obesity. In *Handbook of Obesity*. Bray G, Bouchard C, James PT, Eds. New York, Marcel Dekker, 1997, p. 855–873
- Jeffery RW, Hellerstedt WL, Schmid TL: Correspondence programs for smoking cessation and weight control: a comparison of two strategies in the Minnesota Heart Health Program. *Health Psychol* 9:585–598, 1990
- Leermakers EA, Anglin K, Wing RR: Reducing postpartum weight retention through a correspondence intervention. *Int J Obes* 22:1103–1109, 1998
- Wadden TA, Sternberg JA, Letizia KA, Stunkard AJ, Foster GD: Treatment of obesity by very low calorie diet, behaviour therapy, and their combination: a five-year perspective. *Int J Obes* 13:39–46, 1989
- Perri MG, McAllister DA, Gange JJ, Jordan RC, McAdoo WG, Nezu AM: Effects of four maintenance programs on the long-term management of obesity. *J Consult Clin Psychol* 56:529–534, 1988
- Wing RR: Behavioral treatment of obesity: its application to type II diabetes. *Diabetes Care* 16:193–199, 1993
- Wing RR, Koeske R, Epstein LH, Nowalk MP, Gooding W, Becker D: Long-term

- effects of modest weight loss in type II diabetic patients. *Arch Intern Med* 147:1749–1753, 1987
39. Goldstein DJ: Beneficial health effects of modest weight loss. *Int J Obes* 16:397–416, 1992
  40. Kanders BS, Blackburn GL: Reducing primary risk factors by therapeutic weight loss. In *Treatment of the Seriously Obese Patient*. Wadden TA, Van Itallie TB, Eds. New York, Guilford, 1992, p. 213–230
  41. Guare JC, Wing RR, Grant A: Comparison of obese NIDDM and nondiabetic women: short- and long-term weight loss. *Obes Res* 3:329–335, 1995
  42. King AC, Haskell WL, Taylor CB, Kraemer HC, DeBusk RF: Group- vs. home-based exercise training in healthy older men and women: a community-based clinical trial. *JAMA* 266:1535–1542, 1991
  43. Marcus BH, Owen N, Forsyth LH, Cavill NA, Fridinger F: Physical activity interventions using mass media, print media, and information technology. *Am J Prev Med* 15: 362–378, 1998
  44. Marcus BH, Emmons KM, Simkin-Silverman L, Linnan LA, Taylor ER, Bock BC, Roberts MB, Rossi JS, Abrams DB: Evaluation of motivationally tailored vs. standard self-help physical activity interventions at the workplace. *Am J Health Promot* 12:246–253, 1998
  45. Simkin-Silverman LR, Wing RR, Boraz MA, Meilahn EN, Kuller LH: Maintenance of cardiovascular risk factor changes among middle-aged women in a lifestyle intervention trial. *Women's Health Res Gend Behav Policy* 4:255–271, 1998
  46. Calfas KJ, Long BJ, Sallis JF, Wooten WJ, Pratt M, Patrick K: A controlled trial of physician counseling to promote the adoption of physical activity. *Prev Med* 25:225–233, 1996
  47. Goldstein M, Pinto B, Marcus B: Physician-based physical activity counseling for middle-aged and older adults: a randomized trial. *Ann Behav Med* 21:40–47, 1999
  48. Pinto B, Goldstein M, Marcus B: Activity counseling by primary care physicians. *Prev Med* 27:506–513, 1998
  49. Wee C, McCarthy E, Davis R, Phillips R: Physician counseling about exercise. *JAMA* 282:1583–1588, 1999
  50. Perri MG, Martin AD, Leermakers EA, Sears SF, Notelovitz M: Effects of group-versus home-based exercise in the treatment of obesity. *J Consult Clin Psychol* 65: 278–285, 1997
  51. Dunn AL, Marcus BH, Kampert JB, Garcia ME, Kohl HW, Blair SN: Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial. *JAMA* 281:327–334, 1999
  52. Jakicic JM, Wing RR, Butler BA, Robertson RJ: Prescribing exercise in multiple short bouts versus one continuous bout: effects on adherence, cardiorespiratory fitness, and weight loss in overweight women. *Int J Obes* 19:893–901, 1995
  53. Andersen R, Frankowiak S, Snyder J, Bartlett S, Fontaine K: Effects of lifestyle activity vs. structured aerobic exercise in obese women: a randomized trial. *JAMA* 281:335–340, 1998
  54. Jeffery R, Drewnowski A, Epstein L, Stunkard AJ, Wilson GT, Wing RR: Long-term maintenance of weight loss: current status. *Health Psychol* 19:5–16, 2000
  55. Klem ML, Wing RR, McGuire MT, Seagle HM, Hill JO: A descriptive study of individuals successful at long-term maintenance of substantial weight loss. *Am J Clin Nutr* 66:239–246, 1997
  56. Troiano R, Flegal K: Overweight children and adolescents: descriptions, epidemiology, and demographics. *Pediatrics* 101:497–504, 1998
  57. Ogden C, Troiano R, Briefel R, Kuczmarski R, Flegal K, Johnson C: Prevalence of overweight among preschool children in the United States. *Pediatrics* 99:E1, 1997
  58. Millis J, Andrianopoulos G: The relationship between childhood onset obesity and psychopathology in adulthood. *J Psychol* 127:547–551, 1993
  59. Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH: Social and economic consequences of overweight in adolescence and young adulthood. *N Engl J Med* 329: 1008–1012, 1993
  60. Williamson DF, Kahn HS, Remington PL, Anda RF: The 10-year incidence of overweight and major weight gain in US adults. *Arch Intern Med* 150:665–672, 1990
  61. Wing RR: Changing diet and exercise behaviors in individuals at risk for weight gain. *Obes Res* 3 (Suppl. 2):277S–282S, 1995
  62. Keppel KG, Taffel SM: Pregnancy-related weight gain and retention: implications of the 1990 Institute of Medicine Guidelines. *Am J Public Health* 83:1100–1103, 1993
  63. Perusse L, Reich T, Rice J, Bouchard C: Familial resemblance in energy intake: contribution of genetic and environmental factors. *Am J Clin Nutr* 47:629–635, 1988
  64. Oliveria S, Ellison R, Moore L, Gillman M, Garrahe E, Singer M: Parent-child relationships in nutrient intake: the Framingham Children's Study. *Am J Clin Nutr* 56: 93–98, 1992
  65. Rolls B, Engell D, Birch L: Serving portion size influences 5-year-old but not 3-year-old children's food intake. *J Am Diet Assoc* 100:232–234, 2000
  66. Johnson S, Birch L: Parents' and children's adiposity and eating styles. *Pediatrics* 94: 653–661, 1994
  67. Drewnowski A, Kurth CL, Rahaim JE: Taste preferences in human obesity: environmental and familial factors. *Am J Clin Nutr* 54:635–641, 1991
  68. Mattes R: Fat preference and adherence to a reduced fat diet. *Am J Clin Nutr* 57:373–381, 1993
  69. Stone E, McKenzie S, Welk G, Booth M: Pre-school to college-aged physical activity intervention studies: review and synthesis. *Am J Prev Med* 15:298–315, 1998
  70. Dishman RK, Sallis JF: Determinants and interventions for physical activity and exercise. In *Physical Activity, Fitness, and Health*. Bouchard C, Shephard RJ, Stephens T, Eds. Champaign, IL, Human Kinetics, 1994, p. 214–238
  71. Epstein LH: Family-based behavioural intervention for obese children. *Int J Obes* 20 (Suppl. 1):S14–S21, 1996
  72. Epstein LH, Valoski A, Wing RR, McCurley J: Ten year outcomes of behavioral family based treatment for childhood obesity. *Health Psychol* 13:373–383, 1994
  73. Jeffery R, French S: Preventing weight gain in adults: the Pound of Prevention Study. *Am J Public Health* 89:747–751, 1999
  74. Lichtman SW, Pisarska K, Berman ER, Pestone M, Dowling H, Offenbacher E, Weisel H, Heshka S, Matthews DE, Heymsfield SB: Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *N Engl J Med* 327: 1893–1898, 1992
  75. Marcus B, Dubbert P, Forsyth L, McKenzie TL, Stone EJ, Dunn A, Blair SN: Physical activity behavior change: issues in adoption and maintenance. *Health Psychol*, 2000
  76. Wankel L, Sefton J: Physical activity and other lifestyle behaviors. In *Physical Activity, Fitness, and Health Campaign*. Bouchard C, Shepard R, Stephens T, Eds. Champaign, IL, Human Kinetics, 1994, p. 530–550
  77. The Hypertension Prevention Trial Research Group: The Hypertension Prevention Trial (HPT): three-year effects of dietary changes on blood pressure. *Arch Intern Med* 150:153–162, 1990
  78. Hall SM, Tunstall CD, Vila KL, Duffy J: Weight gain prevention and smoking cessation: cautionary findings. *Am J Public Health* 82:799–803, 1992
  79. Marcus BH, Albrecht AE, King TK, Parisi AF, Pinto BM, Roberts M, Niaura RS, Abrams DB: The efficacy of exercise as an aid for smoking cessation in women: a randomized controlled trial. *Arch Intern Med* 159:1229–1234, 1999
  80. Hughes J: Clinical implications of the association between smoking and alcoholism. In *Alcohol and Tobacco: From Basic Science to Policy* (NIAAA Research Monograph 30). Fertig J, Fuller R, Eds. Washington, DC, U.S. Government Printing Office, 1995, p. 171–181
  81. Wadden TA, Berkowitz R, Vogt RA, Steen SN, Stunkard AJ, Foster GD: Lifestyle modification in the pharmacologic treatment of obesity: a pilot investigation of a potential primary care approach. *Obes Res* 5:218–226, 1997