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Special Issue: Obesity in Louisiana

Preface

Poor nutrition, physical inactivity and the associated excess body weight are now considered the second leading cause of preventable death in the United States. Three-hundred thousand individuals die of conditions linked to obesity each year in this country. On average, overweight reduces the lifespan of Americans by 4 years in nonsmokers and obesity by about 7 years. This costs American taxpayers 117 billion dollars.

Louisiana ranks seventh among the 50 states in the prevalence of obesity as assessed by phone interviews but is consistently in the worst five states in national surveys in which body height and weight are actually measured. The full impact of the current obesity epidemic on the health care system and the Louisiana economy will be felt five to ten years from now. Indeed, obesity is associated with several morbidities whose global burden is considerable. There is irrefutable evidence that obesity is a risk factor for type 2 diabetes, hypertension, heart disease, stroke, orthopedic problems, several cancers, behavioral problems, psychiatric disorders, poor quality of life, loss of autonomy and premature death. Doing nothing should not be an option in any state but particularly in the state of Louisiana as the overall lifestyle and environment is among the most obesogenic on this continent.

The severity of the obesity problem in Louisiana was recognized in 1998 when the Louisiana Legislative created the Louisiana Council on Obesity Prevention and Management (Obesity Council). The diverse and committed membership of the council includes professionals in the fields of health and education, including staff from the Louisiana Department of Health and Hospitals, the Louisiana Department of Education, Pennington Biomedical Research Center, and other healthcare organizations. In 2001, the Obesity Council presented recommendations for the future role of the Obesity Council as well as a plan to address this critical problem to the Louisiana Legislature. One of the recommendations relates to the dissemination of information concerning obesity throughout the State

The increase in the prevalence of excess weight is driven by a poor diet and a sedentary lifestyle. State, parish and city officials as well as architects and urban planners need to recognize that many of the decisions that they take contribute to the creation of an obesogenic environment. The absence of sidewalks and bike paths, the total reliance on the automobile, a poorly developed public transport system, and the poor accessibility to well designed stairs in comparison to escalators and elevators in public and corporate buildings are among the factors that diminish the opportunities to expend calories and prevent weight gain (in addition to the many other benefits of being physically active).

Louisianians have a well established reputation as food-loving people. Unfortunately, over time, while the unique features of the local cuisine may have been maintained, portion sizes have increased dramatically. This is undoubtedly one of the major culprits in the ongoing epidemic of overweight and obesity. It has reached a point where it is often difficult for the health conscious to find reasonable meal alternatives in restaurants. The food industry needs to be involved for this epidemic to be brought under control.

The purpose of this supplement is to gather information from health care providers, researchers, and individuals interested in the health of the citizens of Louisiana as we seek possible solutions to this epidemic in our state. It brings together many useful pieces of this complex problem. However, several topics could not be addressed in the context of an issue of the Journal. The global burden of diseases associated with obesity and the demographics and etiology of the disease are far reaching and beyond the scope of this publication.

John N. Udall, Jr., MD, PhD
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The Obesity Epidemic: Incidence and Prevalence

Larry S. Webber, PhD and Ariane L. Bedimo-Rung, PhD

Obesity is a major public health problem in the United States and in Louisiana in particular. The prevalence of both overweight and obesity has increased in the past two decades. National studies and studies conducted in Louisiana in adults and children have shown that overweight and obesity are related to conditions such as hypertension, diabetes, stroke, and insulin resistance syndrome. Obesity tracks over time, with obese children and adolescents being more likely to become obese adults. Numerous intervention models to modify eating and exercise behaviors have been conducted with children in Louisiana and have shown that it is possible to reduce fat and saturated fat intakes and increase the amount of moderate to vigorous daily physical activity. More research is needed, however, in both health education programs and environmental influences if we are to be effective in making the necessary changes in eating and physical activity habits of children, adolescents, and adults to reduce the prevalence of obesity.

Obesity is a complex, multi-factorial chronic disease that is the second leading cause of preventable death in the United States. Among adults, it substantially elevates the risk of developing conditions such as hypertension, type 2 diabetes, heart disease, stroke, gallbladder disease, and some cancers, while increasing the severity of disease associated with arthritis and other musculoskeletal problems. Among children and adolescents, obesity increases the risk of high cholesterol, hypertension, and diabetes. While genetic factors and health conditions both contribute to obesity in the population, the tendency toward obesity is greatly fostered by the environment. A lack of physical activity combined with high-calorie, high-fat, and low-cost foods is responsible for at least 300,000 deaths annually. Only tobacco use causes more preventable deaths in the United States.[1] The estimated annual cost of obesity and overweight in the United States is about $117 billion.[1] Moreover, obesity is a source of stigmatization and discrimination in society.

Obesity for adults is defined as a body mass index (BMI) greater than or equal to 30, and overweight as a BMI greater than or equal to 25. Obesity (or overweight) for children is defined as a BMI at or above the sex- and age-specific 95th percentile BMI cut points from the 2000 CDC growth Charts: United States.

NATIONAL STUDIES

NHANES

The National Health and Nutrition Examination Survey (NHANES) is a program of studies begun in the early 1960s to assess the health and nutritional status of adults

CME Information

Target Audience

"The Obesity Epidemic: Incidence and Prevalence" is intended for primary care physicians and nurses, endocrinologists, gastroenterologists, diabetologists, cardiologists, and surgeons interested in obesity.

Educational Objectives

After reading the article, the healthcare provider should know the prevalence of obesity in the United States and Louisiana. The healthcare provider should also be aware of national problems that have documented the prevalence of obesity and know that some of the intervention models that have been developed and tested in Louisiana.

Credit

The LSMS Educational and Research Foundation designates this educational activity for a maximum of 1 category 1 credits toward the AMA Physician's Recognition Award. Each physician should claim only those hours of credit that he/she actually spent in the educational activity.

Disclosure

Dr. Webber has nothing to disclose.
Dr. Bedimo-Rung has nothing to disclose.

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and children in the United States. Using interviews and physical examinations, a nationally representative sample of about 5000 persons is surveyed each year. Results from these surveys indicate that the prevalence of overweight and obesity changed little between the early 1960s and 1980.[2] Findings from the 1988-94 survey, however, showed substantial increases in obesity among adults. Estimates from the 1999-2000 survey indicate that overweight and obesity have continued to rise with 65% of adults overweight and with 31% obese.

The prevalence of obesity in US adults varies by sex, race, and ethnicity. In the 1999–2000 survey, 28% of men and 34% of women were obese. The prevalence of obesity among men differed little by racial and ethnic group; however, among women, non-Hispanic black women had a higher prevalence of obesity than did non-Hispanic white women. In 1999–2000, one-half of non-Hispanic black women were obese.[2]

Among children and adolescents, the percent overweight increased after the mid-1970s. Estimates from the 1999–2000 survey indicate that about 15% of children and adolescents were overweight. The increase in overweight prevalence is highest among non-Hispanic black and Mexican-origin adolescents. More than 23% of this subpopulation were overweight in 1999–2000.[3]

BRFSS

The Behavioral Risk Factor Surveillance System (BRFSS) is a telephone survey established by the CDC in 1984 to collect state-level prevalence data of the major behavioral risks among adults associated with premature morbidity and mortality. It differs from NHANES in that it collects self-reported data on obesity, rather than objectively examining respondents. The 2002 BRFSS survey showed that 22.2% of the US population was obese; however, there was little difference in the obesity rate among men (23%) and women (21.4%).[4] When examining age groups, the highest prevalence of self-reported obesity was for those between 55 and 64 years old (27.3%) and those between 45 and 54 years old (27.7%). African Americans were the most obese racial/ethnic group at 31.0%, followed by Hispanics at 22.1% and Whites at 20.7%. Other correlates of obesity include income less than $15,000/year (27.7%) and less than a high school education (26.2%).

Louisiana compares unfavorably to the rest of the country. According to the 2002 BRFSS, Louisiana has the fourth highest prevalence of obesity in the US, at 25.5%, following Mississippi, South Carolina, and Alabama.[5] By gender, 25.6% of men and 25.4% of women are obese.[6] Individuals in the 55-64 and 45-54 age groups are the most obese, at 31.9% and 31.6% respectively. Among racial/ethnic groups in Louisiana, African Americans have the highest prevalence of obesity at 35.1%, followed by Whites at 21.6% and Hispanics at 18.8%. Other correlates of obesity in Louisiana include income less than $15,000/year (34.3%) and less than a high school education (33.8%).

YRBSS

The Youth Risk Behavior Surveillance System (YRBSS) was developed in 1990 to monitor health risk behaviors among youth and adults in the United States. Conducted every two years, it includes national, state, and local school-based surveys of representative samples of 9th through 12th grade students. The national survey, conducted by CDC, provides data representative of high school students in public and private schools in the United States. The state and local surveys, conducted by departments of health and education, provide data representative of the state or local school district. The YRBSS 2001 survey, also containing self-reported data, showed that nationwide, 10.5% of high school students were overweight.[7] Male students (14.2%) were more likely than female students (6.9%) to be overweight. African American and Hispanic students (16% and 15.1%, respectively) were more likely than White students (8.8%) to be overweight. This ethnic difference holds for both male and female students. African American female students (14.6%) are more likely than Hispanic female students (8.8%) to be overweight.

Youth in Louisiana do not fare any better than adults compared to national averages. In the 2001 YRBSS, 13% of high school students in Louisiana (excluding New Orleans) were overweight, including 17% of male students and 9.8% of female students.[5] In New Orleans, statistics are also alarming; 13.4% of students are overweight, with 14.3% of males and 12.7% of females overweight.

THE BOGALUSA HEART STUDY

The Bogalusa Heart Study is one of the preeminent programs studying the early natural history of atherosclerosis. Beginning in 1973, periodic cross-sectional surveys of all children took place. Data collected included measures of height, weight, skinfolds, cholesterol and its fractions, triglycerides, glucose, insulin, blood pressure, diet, and behavior.[8-10] These data were collected on infants, school-age children, and young adults. Longitudinal cohorts were formed to examine trends over time and interrelations for most of these parameters. The population in Bogalusa is biracial; about 2/3 of the subjects are Caucasian and 1/3 of the subjects are African American.

In recent years, one focus has been the study of determinants and correlates of obesity. Using cut points from national studies, about 11% of the children 5 to 17 years old who were examined between 1973 and 1994 are considered overweight, with a greater prevalence in more recent years.[11] Overweight children were 2.4 times as likely to have an elevated level of serum cholesterol, 2.4 times as likely to have an elevated diastolic blood pressure, 3.0 times as likely to have elevated low density lipoprotein (LDL) cholesterol, 3.4 times as likely to have

low high density lipoprotein (HDL) cholesterol, 4.5 times as likely to have elevated systolic blood pressure, 7.1 times as likely to have elevated triglycerides, and 12.6 times as likely to have elevated fasting insulin. Approximately 58% of the overweight children had at least one cardiovascular risk factor at adverse levels.[11]

Data collected in Bogalusa also show that African American girls, similar to adult women, were 1 to 3 kg heavier than similarly aged white girls, when adjusting for height, particularly after age 13 years.[12] Hypercholesterolemia is also associated with increased relative weight in girls.[13] BMI increased more in hypercholesterolemic girls than in the non-hypercholesterolemic girls during 6 years of follow-up; a result not found in boys. Increased relative weight is associated with a deleterious effect on blood lipids.

Secular trends in the prevalence of obesity have been noted. Two cohorts of girls ages 8 to 17 years were measured.[14] The first cohort was measured in 1978-79, and the second cohort was measured in 1992-94. The second cohort was heavier than the first at all ages except for African American girls aged 12-13 years. In particular, subscapular skinfold thickness was increased at all ages. The onset of menarche occurred at an earlier age in the second cohort compared with the first cohort, both in African American girls (11.4 vs 12.3 years) and white girls (11.5 vs 12.3 years). Thus, the secular trend toward early onset of menarche may be a result of increasing obesity. Early onset of menarche may be a risk factor for adult disorders such as cardiovascular disease and breast cancer; hence, increasing obesity is becoming a major public health problem.[15]

Significant differences exist within racial groups concerning body image perception in relation to overweight status among young adults.[16] African Americans are almost twice as likely as whites to perceive their body image negatively, regardless of their actual BMI, whereas those currently employed or with a higher education were less likely to have a poor body image. This has important implications in designing culturally sensitive intervention programs.

Obesity plays an important role in the development of hyperinsulinemia.[17] In a longitudinal study of children followed up as adults 15 years later, there was a significant positive trend between baseline body mass index and incidence of hyperinsulinemia at follow-up independent of race, gender, and baseline insulin value. Childhood obesity is also related to adult levels of other cardiovascular risk factors.[18] About 77% of the obese children remained obese as adults 17 years later. The relationships between childhood overweight levels and adult adverse risk factor levels were more consistent for those at elevated weights as children.

The prevalence of insulin resistance syndrome (syndrome X) is common in adults. A study in Bogalusa was conducted to examine the relative contribution of childhood adiposity and fasting insulin to the adult risk of developing syndrome X.[19] A total of 745 subjects, initially 8-17 years old, were followed for about 12 years. The proportion of adults who developed clustering of BMI, fasting insulin, blood pressure, and either an elevated cholesterol to HDL-cholesterol ratio or elevated triglycerides to HDL cholesterol ratio increased across childhood BMI and insulin. Childhood obesity thus is an important predictor of developing syndrome X. In a study of 271 children with and 805 children without a parental history of coronary artery diseases (CAD) who were followed for 18 years, BMI, triceps, and subscapular skinfold thickness were consistently higher from childhood to adulthood in the offspring with affected parents.[20] During childhood, insulin levels were lower in the offspring with affected parents; however, after age 20 these offspring had higher levels of fasting insulin. Offspring at high risk for CAD develop excess body fatness beginning in childhood and then later manifest hyperinsulinemia in young adulthood.

Obesity during childhood and continuing into adulthood was related to carotid intima—media thickness (IMT) by age 35 years.[21] In 513 men and women who had BMI and triceps skinfold thickness (TSF) measured during six different times as children and young adults, adult IMT was associated with both BMI and TSF, with magnitudes of associations with childhood adiposity comparable to those with adult levels of BMI and TSF. Interestingly, IMT levels did not become elevated among overweight children who were not obese in adulthood or among thinner children who became obese adults. This emphasizes the adverse, cumulative effects of childhood-onset obesity that persist into adulthood.

Eating patterns and dietary quality may be related to obesity in children.[22] Total energy intake of children has remained about the same for the past three decades, but the proportion of energy from fat has decreased while that from carbohydrates and protein has increased. Children are increasing their intakes of fruits, fruit juices, sweetened beverages, snacks, condiments, and cheese. Other dietary changes that may help explain the increase in adiposity include the number of meals eaten in restaurants, increased portion sizes, snacking, and meal-skipping. Consumption of sweetened beverages, sweets, meats, and total consumption of low-quality foods was positively associated with overweight status in 10-year-old children whose diets were assessed using 24-hour recalls.[23]

INTERVENTION MODELS

A number of intervention models have been developed and tested with children in Louisiana. Some were funded by the National Institutes of Health and were part of national multi-center trials. Summarized below are several of these trials. Also included is a detailed description of the dissemination of one of the trials to a school district in central Louisiana. Although some of the inter-

ventions were developed to prevent the onset of cardiovascular risk factors at adverse levels, most were directed towards improving eating and exercise behaviors. These trials form the basis for potential programs to prevent the onset of overweight and obesity.

DISC

Often prevention studies are aimed at the entire population. This is a reasonable approach, particularly when a large portion of the population exhibits a risk factor or risk behavior at adverse levels. It has become clear that prevention of cardiovascular diseases, obesity, and other conditions must begin during childhood when risk behaviors are first established. One important correlate of obesity is elevated low-density lipoprotein (LDL) cholesterol. Early evidence from the Bogalusa Heart Study[24] and other studies of children [25-26] showed that levels in children track much as they do for adults. The Dietary Intervention Study in Children (DISC) was a controlled clinical trial to examine the safety and efficacy of dietary intervention to reduce LDL cholesterol.[27] Children from Louisiana and five other sites in the United States participated. Children with LDL cholesterol levels between the 70th and the 99th age- and sex-specific percentiles were randomized to either a usual care group or to an intervention group in which the diet provided 28% of energy from total fat, less than 8% from saturated fat, and less than or equal to 9% from polyunsaturated fat. After three years of intervention, cholesterol intakes were lower in the intervention group than in the usual care group. In addition, LDL cholesterol decreased in the intervention group by 15.4 mg/dl but only by 11.9 mg/dl in the usual care group. One of the conclusions from the study is that it is possible to make these changes in children to lower LDL cholesterol moderately while maintaining adequate growth and well-being. Although there were no differences in mean weight or mean BMI between the two groups, this is an example of a low fat diet that is often advocated for overweight or obese children. There was no component in the intervention to increase daily physical activity, however.[27]

Health Ahead/Heart Smart

Health Ahead/Heart Smart was a cardiovascular health promotion program for children in grades K-6 and was originally implemented in four schools in one parish in Louisiana.[28] Intervention components included comprehensive health screening and questionnaire administration, classroom and physical education curricula, parent programs, school lunch modification, volunteerism, and teacher training. The program successfully reduced serum total cholesterol, increased selection of healthier school lunches, and improved health knowledge.[29] The program has been disseminated to numerous elementary schools in the New Orleans and Washington Parish areas. The Heart Smart Family Health Promotion was a school-based clinical model for cardiovascular risk reduction for high-risk children and their parents.[30] Significant positive eating changes, improvement in children's 1-mile run/walk times, parent increases in leisure physical activity and health knowledge, and reductions in blood pressure and triglyceride levels were observed. Positive trends were a decrease in adult serum total cholesterol of 19 mg/dl and decreased children's diastolic blood pressure of 10 mm Hg. The Family Health Promotion was then disseminated as a family cardiovascular health promotion program at Fort Polk, Louisiana.31

Gimme 5

A Fresh Nutrition Concept for Students (Gimme 5) was a National Cancer Institute (NCI)-funded 5-a-day program to increase dietary consumption of fruits and vegetables among New Orleans high school students.[32] Twelve schools participated in the study, and support for the program was obtained from businesses, local/state organizations, and community groups. Interventions included an extensive and successful school media/marketing campaign, student workshops, meal and snack modification, and a parent support program. Impact measures indicated that the cohort was aware and accepting of media activities while fruit and vegetable knowledge and daily intake significantly increased in students in intervention schools compared to students in control schools.[33]

CATCH

One school-based intervention model that was developed and thoroughly evaluated during the last decade of the 20th century was the Child and Adolescent Trial for Cardiovascular Health (CATCH).[34] CATCH is the largest school-based health promotion research program funded by the National Heart, Lung, and Blood Institute, one of the National Institutes of Health. The program was implemented in four states (California, Louisiana, Minnesota, Texas) with a Data Coordinating Center in Massachusetts. The model was developed and pilot tested as Phase I (1987-1991) and implemented as Phase II (1991-1994). Additionally, the cohort of children first identified in 1991 were followed as Phase III (1994-97) and Phase V (2000-02). In addition, a study of institutionalization of the program within the elementary schools (Phase IV) was conducted from 1997-1999.

The study design involved the random assignment of 24 schools at each CATCH site into 14 intervention schools and 10 control schools. The intervention, which lasted for three school years, consisted of classroom curricula, alterations to the school food service program (*Eat Smart*), enhancements to physical education classes (CATCH-PE), and (in half of the intervention schools) family programs geared to promoting healthier eating and physical activity behaviors. The CATCH intervention was able to modify the fat content of school lunches, increase moderate to vigorous physical activity during

physical education class, and improve eating and physical activity behaviors in children during the three school years.[35] The percentage of energy from fat fell significantly more in intervention schools (38.7% to 31.9%) than in control schools (38.9% to 36.2%). The number of minutes of moderate to vigorous physical activity during physical education class increased more in intervention schools than in control schools. Self-reported daily energy intake from fat was reduced in children from intervention schools (32.7% to 30.3%) compared to children from control schools (32.6% to 32.2%). Similarly, children from intervention schools reported more daily vigorous activity (58.6 minutes) than children from control schools (46.5 minutes). Blood pressure, body size, and cholesterol measures did not differ significantly between the two groups.

Three years after the intervention ended, these behavioral changes persisted into early adolescence for self-reported dietary and physical activity behaviors.[36] The differential between the intervention and the control group was diminished, however. The daily energy intake from fat was 30.6% in the intervention group and 31.6% in the control group. The difference in self-reported daily minutes of vigorous activity declined from 13.6 minutes in 5th grade to 8.8 minutes by 8th grade.

Results for schools and students in Louisiana that participated in CATCH were similar to those for the national study.

CATCH: LEARNING AND LIVING HEALTHY LIFESTYLES

In 1999, after meeting with officials from The Rapides Foundation and with the Superintendent of Schools in Avoyelles Parish, a grant application was funded by The Rapides Foundation to implement CATCH in the six public elementary schools in Avoyelles Parish. This provided the opportunity to disseminate an effective and well-evaluated intervention model to a new school district. The intervention consisted of several components.

Staff Development—One of the important aspects of CATCH is staff development and training to orient teachers, physical education specialists, and food service staff to the program. During Fall 2000, two separate one-day training sessions were held, one for CATCH-PE and a second for the CATCH classroom curricula for third through fifth grades. During Fall 2001 and again in Fall 2002, two half-day booster sessions were conducted, one for CATCH-PE and one for classroom curricula. During these sessions, the teachers shared experiences and exchanged ideas on classroom techniques and integration activities.

The initial *Eat Smart* training for the Director of Food Service for Avoyelles Parish Schools and all food service managers and workers was conducted in November 2000 at the Avoyelles School Board Office to introduce the *Eat Smart* Nutrition Program and to present the *Eat Smart* Guidelines. The program involves four major intervention areas:

1. Menu Planning—Guidelines provided information on how to adapt existing menus to be lower in fat and sodium.
2. Food Purchasing—Offered guidelines for choosing government commodities and products from commercial vendors that are lower in fat and sodium.
3. Food Preparation—Guidelines for modifying recipes and food preparation techniques that will be lower in fat and sodium.
4. Program Promotion—Marketing the *Eat Smart* program in the school.

During Fall 2001 and Fall 2002, *Eat Smart* booster sessions were conducted at the Avoyelles School Board Office to review and reinforce the program. School recipes were reviewed to assist in the selection of additional *Eat Smart* guidelines for the school. Program promotion ideas were discussed and a promotion program was developed for each school.

Materials—In Fall 2000, all teachers received the original CATCH curriculum teacher manuals, black line master copies of student workbooks, and various teaching supplies for each curriculum. All teachers received copies of the CATCH-PE Activity Box and Guidebook for grades K-5. Although not a "curriculum" in the strict sense, the CATCH Activity Box and Guidebook provides ideas and activities for enhancements to current physical education standards and practice. Stopping elimination games, increasing the equipment-student ratio, and using appropriate group sizes are just a few of the key principles encouraged in CATCH-PE. Supplemental materials such as aerobic and step-aerobic videos, mileage challenge posters, pedometers, and the Louisiana Physical Education Standards were also provided to all schools.

At the initial *Eat Smart* training, each school received a copy of the *Eat Smart* Manual, a guidelines poster, and a whip for defatting ground beef. At the Fall 2001 booster session, each school received a copy of the new USDA recipes while at the Fall 2002 booster session, each school cafeteria received the 2nd edition of the *Eat Smart* manual.

Throughout the three years of the program, Tulane staff provided on-site support through visits to each school. Tulane staff answered questions, provided feedback, and provided additional materials as needed. Between on-site visits, Tulane staff maintained contact with teachers through e-mail and telephone.

Evaluation—The System of Observing Fitness in Teaching (SOFIT) was used at four time points to monitor the progress of the effects of CATCH-PE on the amount of moderate to vigorous physical activity during PE class.[37] PE lessons were observed in two-to-four classes at two times at least four weeks apart at each school. Class size averaged 39 students and the mean lesson

length was 25 minutes. Team teaching occurred in 47% of the lessons observed and half of the lessons were conducted indoors. While warm-up activities were almost always included (70%), cool-down activities happened less often (13%). Appropriate group sizes were observed 90% of the time and activities were conducted safely most or all of the time in 84% of the lessons. An adequate child-to-equipment ratio was observed in 87% of the lessons.

An important part of CATCH-PE is to increase the amount of time students are moving and actively engaged in physical activity. In comparison to baseline data collected in Fall 2000, all schools increased the proportion of lesson time spent in moderate to vigorous physical activity (MVPA). In Fall 2000, the percent of lesson time in MVPA was 35.9% while in Spring 2003, the percent of lesson time in MVPA increased to 48% (Figure 1). Healthy People 2010 calls for all students to be engaged in MVPA for at least 50% of lesson time. Two out of the six schools exceeded the 50% criteria with three schools coming close with 41% to 46%.

Training, materials, and on-site support promoted strategies to make each lesson more activity dense (more MVPA); hence, there was considerable attention given to minimizing time spent in management during the lesson. Compared to baseline, the average of all schools showed improvement in minimizing time in management tasks such as distributing equipment, forming groups, and giving directions. At baseline, 29.4% of physical education class time was spent on management activities. By Spring 2003, this was reduced to 23.4% of class time, a change of about 6.0%.

Four key components contributed to successes in CATCH- PE and increased the likelihood of CATCH-PE being sustained. These were 1) an openness and willingness of the teachers towards a new program; 2) active and enthusiastic participation in yearly teacher workshops and boosters; 3) yearly stipends for school equipment; 4) time (3 years) to grow familiar with program philosophy and activities.

During Fall 2000, prior to the initial *Eat Smart* training, one week's menus and recipes were collected and analyzed from each school in order to estimate the amount of fat, saturated fat, and sodium in school meals. Menus and recipes were entered into the NutriKids Data System for analysis. To track the implementation of *Eat Smart* guidelines in menu planning, food purchasing, and food preparation, an additional one week's worth of menus and recipes was collected and analyzed in a similar manner from each school during Spring 2001, Spring 2002, and Spring 2003. The percent of energy from total fat decreased from 32.5% to 30.2%, near the 30% recommended by the US Department of Agriculture (USDA) (Figure 2). Energy from saturated fat decreased from 10.7% to 9.2%, below the 10% recommended by the USDA. (Figure 3).

By the third year, each school had incorporated *Eat Smart* guidelines into daily meal service operation. Some of the guidelines that were successfully implemented included baking chicken and French fries instead of frying, defatting ground beef, eliminating fat and bacon added during food preparation, eliminating fat brushed on top of rolls, serving more fresh fruit instead of prepared desserts, serving more lower fat vendor items, purchasing 1% low fat milk instead of 2% fat milk, and using the new USDA recipes. Because many of the *Eat Smart* guidelines have become 'routine' in the cafeterias, it is likely that the guidelines will continue to be implemented.

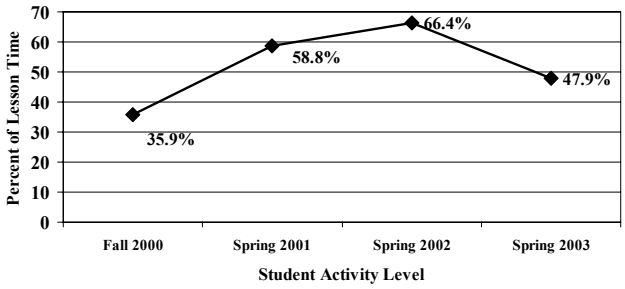

Figure 1. Percent of Physical Education Lesson Time in Moderate to Vigorous Activity. The percentage increased from 35.9% at baseline in Fall 2000 to 48%, near the 50% recommended by Healthy People 2010.

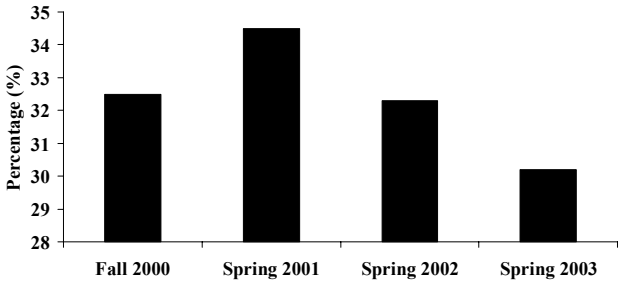

Figure 2. Percent of Energy in School Lunch from Total Fat. The percentage decreased from about 32.5% at baseline in Fall 2000 to near the 30% recommended by the United States Department of Agriculture.

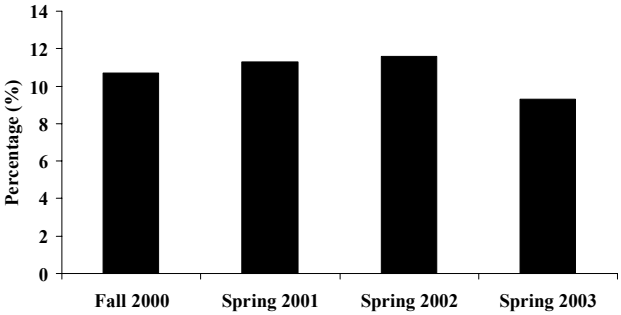

Figure 3. Percent of Energy in School Lunch from Saturated Fat. The percentage decreased from 10.7% at baseline in Fall 2000 to 9.2%, below the 10% recommended by the United States Department of Agriculture.

CONCLUSION

Obesity, a major public health problem, begins in childhood. The prevalence has increased sharply during the past two decades. National data indicate that the proportion of adults who are overweight is greater for men than for women and increases with age up until about 75 years when there is a decrease in the proportion overweight and obese. Overweight and obese individuals also concomitantly exhibit many adverse characteristics such as hypertension, hyperlipidemia, hyperinsulinemia, and diabetes. Perhaps one of the most serious consequences of the increase in obesity, particularly among children and adolescents, has been the increase in type 2 diabetes.[38] Prior to the last decade, this disease was almost never diagnosed during childhood. In recent years, however, there has been a dramatic increase in type 2 diabetes in obese adolescents. Type 2 diabetes is likely to continue increasing since the prevalence of obesity is increasing in the United States.[39] The long-term consequences of this problem are only beginning to be noted as these adolescents grow into adulthood and become at risk for cardiovascular diseases.

Overweight and obesity result from a positive energy balance with caloric intake exceeding caloric expenditure. Excess energy intake is stored as fat in adipose tissue. The mechanisms that lead to a positive energy balance and result in obesity are complex and include multiple genetic and environmental factors. In recent years, prime concern has focused on environmental factors like diet and physical activity, both of which are modifiable behaviors. There have been numerous studies in adults with varying degrees of success. Maintaining weight loss is a challenge for most adults.

There have been several studies in children and adolescents in Louisiana that have targeted physical activity or eating behaviors. Most of these have been conducted in a single location and have included small sample sizes. There have been relatively few large community- and school-based multi-site intervention studies that were carefully designed to target eating and physical activity behaviors in children and adolescents. Children in Louisiana have participated in two of the largest of these studies, DISC and CATCH. The former evaluated a model to change eating behaviors in children with elevated LDL cholesterol while the latter evaluated a model to change both the behaviors in children as well as the entire school environment. The CATCH program focused primarily on changes in school lunches, changes in classroom and physical education curricula, and targeting parents and families. In recent years, the CATCH materials have been made available for dissemination to interested schools and districts.

Future work should include adults as well as children. Eating and physical activity are social behaviors that involve the entire family unit. Future work should also address the design of communities in the promotion of physical activity and improved health. Guidelines from the CDC and the American College of Sports Medicine currently include recommendations to increase physical activity by using environmental and policy approaches; that is, creating or enhancing access to places for physical activity and targeting interventions at the community level.[40-42] A growing number of studies show that people in activity-friendly environments are more likely to be physically active in their leisure time. Some research already exists showing that people with access to recreational facilities, a variety of built and natural facilities, safe places to walk near their homes, and attractive surroundings exercise more.[43-47] More work is needed.

Dietary changes at the macro level are also needed. Not only do we need to intervene in schools, but we must not neglect other environments such as homes, food stores, neighborhoods, workplaces, restaurants, and shopping malls.[48-49] The availability and promotion of quality foods such as fruits and vegetables in neighborhood grocery stores, the placement of vending machines and fast food outlets, portion sizes, and pricing are all areas in which interventions are necessary in the fight against obesity. The media's role in promoting unhealthy choices must also not be neglected.

This type of environmental change research necessitates transdisciplinary collaboration between the medical and public health communities and partners in urban planning, parks and recreation, transportation planning, the food industry, city government, and the media. It is the responsibility of all members of the community to improve the eating and physical activity habits of children, adolescents, and adults.

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CME QUESTIONS

To earn CME credit, read the preceding CME article and complete the registration, evaluation, and answer form on page S76. Mail or fax the registration, evaluation, and answer form to the Educational and Research Foundation. Answers must be postmarked or faxed prior to December 31, 2005. Participants must attain a minimum score of 75% to receive credit.

For each question, choose the one answer that is most correct.

1. Which of the following are national studies which address health and obesity?
   a) National Health and Nutrition Examination Survey (NHANES)
   b) The Behavior Risk Factor Surveillance System (BRFSS)
   c) The Comprehensive American Dietary Survey (CADS)
   d) Both a and b
   e) Both b and c

2. True or False. Total energy intake of children has remained about the same for the past three decades, but the portion of energy from fat has decreased while the that from carbohydrates and protein has increased.

3. True or False. In the year 2001, the Youth Risk Behavior Surveillance System (YRBSS) documented that 6% of high school students in Louisiana (excluding New Orleans) were overweight.

4. True or False. Childhood obesity is not an important predictor of the insulin resistence syndrome (syndrome x).

Genetic and Physiological Factors in Obesity

Steven R. Smith, MD and Eric Ravussin, PhD

Body weight is determined by the interaction of the genetic makeup of an individual and the environment in which that person is living. The control systems that regulate body weight are numerous and include signals from fat that travel to the hypothalamus where cognitive and internal signals are integrated. The integration of these signals involves a complex array of neuropeptides, neurotransmitters and structural circuits. These circuits regulate appetite, intake and energy expenditure. Recent studies demonstrate that the theory of a thrifty genotype is probably correct. Some people are more susceptible to our obesogenic environment than others. Some people are able to overwhelm their genetics by voluntarily increasing energy expenditure and decreasing food intake; a feat that is rarely accomplished and requires a Herculean effort. As we better understand the environmental, genetic, physiological, and behavioral aspects of obesity, we will undoubtedly develop better strategies and therapies for obesity.

Body weight, like blood pressure and heart rate, is regulated by a series of physiologic control systems involving the CNS, sympathetic nervous system, and hormones, many of which emanate from the adipose tissue. The regulation of body weight is extremely precise. Small alterations in daily energy balance cumulate to result in large changes in body fat stores over time. Also, like the cognitive control systems that interact with brain stem systems to regulate blood pressure, the intake of food is regulated by 'higher' centers in the brain that register sensory signals for the appearance, smell, mouth 'feel', and taste of foods. Because of this obvious connection between the hedonics (pleasure) of foods and intake, the public wisdom is that food intake (and therefore body weight) is under cognitive control. Studies performed in the 1960s and 70s, using microablation of discrete nuclei in the hypothalamus, proved that food intake *is* under precise physiological control.

The corollary to the prevailing wisdom of 'low willpower ' as a cause of obesity is that if people would only exercise more 'willpower' then we would all be thin and healthy. This view, commonly espoused by both thin and heavy physicians, ignores a growing body of evidence that the control systems that serve to regulate body weight are more effective in some individuals as compared to others. These simplistic views serve as the soil for the growth of negative feelings and attitudes towards obesity. The negative stereotypical views of the obese, historically, in the current media/cinema, and yes, in the minds of physicians, distract us from our role to prevent and cure diseases. Obesity is a chronic disease, whether judged from the standpoint of personal suffering endured by affected individuals or by the cost to public health systems and societies. Make no mistake: even if you don't believe that obesity is a disease, the epidemic of obesity is leading this nation towards unprecedented numbers of patients with diabetes and other diseases. We can all agree that the ravages of diabetes deserve our attention; so does obesity. A recent study estimated the total cost of obesity in the US at $238 billion dollars per year in 1999. In Louisiana, we spend $1.3 million per year on the health costs of obesity. Clearly, preventing and treating obesity would have a significant effect on the cost of healthcare in the United States.

We must discard the view of 'impaired willpower' and instead address the problem at hand from the same perspectives that we view other diseases. Does this mean we can blame all of our woes on our genes? Obviously not. Changing the obesogenic environment into a healthier environment is a laudable goal. Our schools are an obvious place to start. Other opportunities exist in the workplace and in our cities. In contrast to the view of obesity as a result of two of the seven deadly sins 'gluttony' and 'sloth', the more appropriate view is that obesity is the result of a) environmental pressures (an obesogenic environment) and b) genetic susceptibility.

The purpose of this review is to make the reader aware of the interactions between genetic and physiological control systems and our obesity-promoting environment. As a side effect, we hope to remove the negative stigma surrounding the treatment of the obese patient and the physicians that care for the obese patient, and redirect our efforts towards more effective prevention and treatment of obesity

HOW MUCH OF OBESITY IS GENETICALLY DETERMINED?

Although lifestyle and environmental influences on obesity are readily accepted, it is now recognized that human obesity has an important genetic component as well. Obesity is characterized by a strong familial aggregation pattern. However, except for some rare Mendelian disorders, the vast majority of obese patients do not exhibit a clear pattern of Mendelian inheritance. Despite the large number of studies on the familial aggregation and the

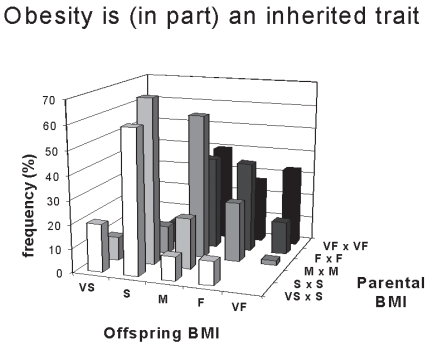

Figure 1. Parental BMI makes a strong contribution to the body weight of offspring. In a classic study of the genetics of body weight, Davenport showed that the offspring of obese parents were more likely to be obese than the offspring of thin parents. Later studies in monozygotic twins showed an even stronger impact of genetics on body weight. This led to the concept of the heritability of body fatness. (Very slender=VS; Slender=S; Medium=M; Fat=F; Very Fat=VF)

heritability of the obesity phenotypes, there is no unanimity among researchers regarding the importance of genetic factors. A more complete review of these questions can be found elsewhere, but a brief summary of the main findings is presented here.[1, 2]

More than 75 years ago, C. B. Davenport described the first comprehensive attempt to understand the role of inheritance in human body mass for stature.[3] Among his findings, normal weight parents sometimes have obese adult offspring. He also observed the converse: obese parents frequently have normal weight adult descendants. In the aggregate, his study demonstrated quite convincingly that BMI values were more similar among family members than among unrelated persons (Figure 1).

The level of heritability has been considered in a large number of twin, adoption and family studies. The level of heritability is simply the fraction of the population variation in a trait (e.g., BMI) that can be explained by genetic transmission. Results obtained by a number of investigators indicate that the heritability estimates depend on how the study was conducted. For instance, studies conducted with identical twins and fraternal twins or identical twins reared apart have yielded the highest heritability levels with values clustering around 70% of the variation in BMI. In contrast, adoption studies have generated the lowest heritability estimates, of the order of 30% or less. Family studies have generally found levels of heritability intermediate between the twin and the adoption study reports. A few investigations have included all or most of these kinds of relatives in the same analysis, and they have concluded that the heritability estimate for BMI in large sample sizes was between 25 and 40 percent.[4]

The risk of becoming obese when a first-degree relative is overweight or obese can be quantified using a statistic called the lambda coefficient (l). Lambda is defined by the ratio of the risk of being obese when a biological relative is obese compared to the risk in the population at large, i.e. the prevalence of obesity.[5] Estimates of l for obesity based on BMI data were recently reported.[6-8] Data obtained from 2,349 first-degree relatives of 840 obese probands and 5,851 participants of the National Health and Nutrition Examination Survey III (NHANES III) revealed that the prevalence of obesity (BMI > 30) is twice as high in families of obese individuals than in the population at large.[7] Moreover, the risk increases with the severity of obesity in the proband. Thus, the risk of extreme obesity (BMI > 45) is about eight times higher in families of extremely obese subjects. More recently, using data from 15,245 participants aged from 7 to 69 years from the 1981 Canada Fitness Survey, it was shown that the familial risk of obesity was five times higher for relatives in the upper 1% distribution of BMI than in the general Canadian population.[8] However, the latter study suggested that the familial risk was not due entirely to genetic factors as the spouse of a proband was also characterized by an elevated risk.

Several obesity-related Mendelian disorders are also known, and the loci for several of them have been mapped. The latter are summarized in the latest annual human obesity gene map and include the Prader-Willi Syndrome, the different loci for the Bardet-Biedl Syndromes, the Wilson-Turner Syndrome and many others. Once again, these syndromes in which obesity is only one of the clinical manifestations are not very prevalent and cannot explain the magnitude of the obesity problem in our present environment. About 40 Mendelian disorders have been described so far.[9, 10]

A few single-gene mutations causally related to obesity have been detected in a small number of people. Mutations with strong effects were found in the leptin receptor gene, the leptin gene, the pro-opiomelanocortin gene, the prohormone convertase 1 gene.[11-15] Agonist and antagonist peptides of the melanocortin MC4 receptor have been developed and cause the expected effect on feeding, i.e., decrease and increase, respectively. Finally, humans with functionally impaired melanocortin MC4 receptors are obese.[16-19]

More information can be found in a recent review on the genetics of obesity in animals and humans [20] and online at http://obesitygene.pbrc.edu//.

HOW CAN 'GENETICS' ACCOUNT FOR THE OBESITY EPIDEMIC IN THE US?

Thrifty genes in an obesogenic environment

As shown in Figure 2, the prevalence of obesity in the US (and in most other "westernized" countries) is increasing at an alarming pace. Closely behind this trend, an epidemic of type 2 diabetes is lurking. This increase in the BMI of the population is occurring in a time frame

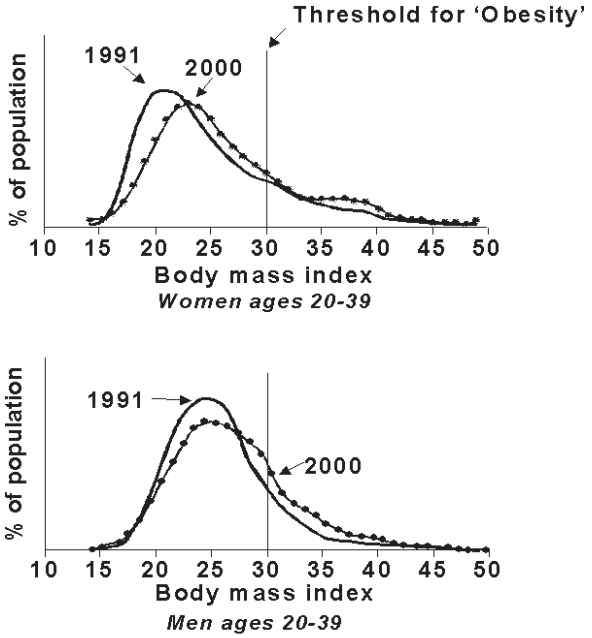

Figure 2. Trends in body fatness as measured by the Body Mass Index from US government epidemiological data. Body mass index has increased over the last 100 years with a rapid rise in the prevalence of BMI's greater than 30kg/m^2 in the last 25 years. Note that the shape of the distribution of BMI has changed over just 10 years. The increasing skewness to the highest BMIs is an alarming trend, as the dangerous comorbidities of obesity are more likely in these BMI ranges. This change in distribution can be interpreted in several ways including 'thrifty' genes and assortative mating. See text for a more detailed discussion of these trends. Figure redrawn from Friedman, 2003.[51]

where 'classical' evolutionary biology tell us that our 'genetic makeup' could not have changed. It has been argued that this is evidence for an environmental effect and that genetic factors, although interesting, could not possibly contribute to such a rapid epidemic. Several lines of evidence and reasoning make this simplistic conclusion untenable. First, examine closely the shape of the distribution of BMI in Figure 2. Note that the left side of the distribution is relatively fixed. In other words, the number of individuals with a BMI less than 20 doesn't change very much. The entire distribution of BMI's measured in 1991 does not simply shift rightward to higher BMI's, rather the shape of the distribution changes with an increase skewness toward individuals in the higher BMI categories. These 'super-obese' individuals, although not rare in 1991, are becoming more frequent.

There has been considerable speculation concerning the reasons why the human genome could harbor genes predisposing to positive energy balance and obesity at such a high frequency if one takes the genetic epidemiology estimates of heritability at face value. The most frequently stated theory is that of the "thrifty genotype hypothesis," which is essentially as follows: during mankind's history, individuals and populations have evolved in restrictive environments in which food was not very abundant and required much physical work to obtain.[21] Hence, survival mechanisms have evolved to confer a protection against periods of food scarcity. The "thrifty genotype hypothesis" states that evolution in such a restrictive environment has progressively (or through genetic bottlenecks) selected for a "thrifty genotype," conferring survival advantages in periods of famine but resulting in liabilities in an affluent environment.[22, 23] The hypothesis is not unreasonable, since the abundance of food and the lack of the necessity for physical exercise to acquire food are fairly recent phenomena.

These unknown susceptibility genes make some individuals more efficient at storing energy in times of famine, but predisposes them to store excess body fat in time of plenty. This kind of 'diet by gene interaction' is an attractive explanation for the change in the shape of the distribution of BMIs and is supported by experimental data in rodents. For example, inbred strains of mice differ in their propensity to become fat when fed a high fat diet but not a bland diet. This suggests that differences in genetic makeup are subtle when diet is bland and low in dietary fat and have an enormous effect on body weight when diet is palatable and high in fat.[24] Some of these genes have been mapped and at least one gene has been identified.[25] Strong evidence for this same phenomenon comes from recent studies where the overexpression of *a single gene* can block the development of 'syndrome-X' in a mouse. Again this gene had minimal effect when the mice were fed a standard laboratory chow, but a profound effect when the animals were fed a palatable high fat diet.[26]

Although the evidence in humans is less complete, several clinical studies point out that the thrifty genotype is present in humans. Often-cited examples of such populations include the aboriginal populations of Australia, navigators of the Pacific Islands, and the Pima Indians of the United States, who were typically exposed to alternating periods of "feast" and famine. About 600 to 1000 years ago the Pima Indians of Arizona were separated from a genetically similar tribe, now in Northern Mexico. The Arizona Pima Indians in the United States adopted some aspects of a Western diet (specifically high fat foods) and acquired a 'Western' sedentary lifestyle since they no longer had to work to produce food like their cousins to the South. Along with this change in lifestyle came the highest rate of obesity and diabetes in North America.[27] In the Mexican Pima population, with the attendant manual labors of food production and a diet enriched in basic carbohydrate nutrients, obesity and diabetes are virtually unheard of. These two groups, both presumably harbor susceptibility gene(s) that are only evident when food is abundant and physical activity levels are low.

People differ in their 'resistance' to gain weight during periods of overfeeding. In a remarkable study by Bouchard et al subjects were overfed by 1000 kcal per day. There was a marked variability in the amount of weight gained, ranging from 4.3 to 13.3 kg and as noted

previously, evidence for a genetic contribution to the propensity to gain weight.[28] In another study by Levine et al subjects were overfed by 1000 kcal per day for 8 weeks.[29] There was a marked variability in the amount of weight gained, ranging from 1.4 to 7.2 kg that could not be accounted for by changes in resting energy expenditure. Interestingly, inter-individual differences in the amount of 'non-exercise activity thermogenesis' (NEAT) or 'fidgeting', accounted for a large portion of this variability. There is some evidence that NEAT, also known as spontaneous physical activity (SPA), is an inherited trait in lower animals such as worms, flies, and mice and accounts for a large portion of the total daily energy expenditure.[30]

One implication of the "thrifty genotype hypothesis" is that it should not be surprising to observe that highly industrialized populations are now struggling with the problem of obesity due to rapid changes in environmental conditions. This has led to a second hypothesis which states that obesity in our present environment is an "essential" condition, and only those with fewer obesity susceptibility genes (the former non--survivors in times of famine) are able to resist our "obesogenic" environment and remain normal weight without conscious effort.[31] Such hypothesis implies that pharmacological treatment will probably be the only way to help most obese people in our environment. Alternately, the environment could (and should) change.

An alternate explanation for at least a part of the skewness to the right of the distribution is 'assortative mating'. This phenomenon, where individuals with similar body weight marry and produce similar offspring, has been supported by at least two detailed studies.[8, 32] This process would favor concentration of 'obesity predisposing genes' and might lead to super-obese individuals. (Reexamine the figure from Davenport showing that children from two obese parents were almost always obese, even before the destructive changes in our environment!) The concentration of obesity susceptibility genes might make these individuals super-sensitive in our 'obesogenic' environment.

Lastly, it is possible that non-classical 'genetic' or structural mechanisms such as maternal environment/nutritional environment might alter the development of obesity.[33] Fetal programming, as the result of an altered maternal-fetal physiological system, might produce a feed-forward mechanism to alter metabolism in offspring of obese women.[34, 35] As another and graphic example, deficiency of the adipose tissue derived hormone leptin at a critical period in murine fetal development prevents synaptic 'hard-wiring' of the hypothalamic arcuate nucleus, a key weight control circuit. This structural abnormality cannot be rescued by giving the hormone later in development.[36, 37] These provide examples of *how* maternal nutrition might influence the metabolism and body weight in the children. Identification of these patients is not known, however selection of therapy may be different due to potential structural changes.

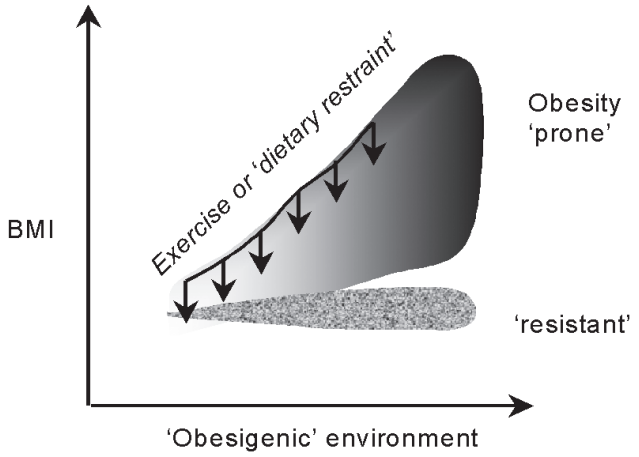

Figure 3. Genetic 'Susceptibility' to a Western 'obesogenic' lifestyle. As noted in the epidemiological data presented in Figure 2, some individuals resist the environmental 'pressures' to become obese. These environmental pressures come in the form of readily accessible and inexpensive foods, high fructose, an American 'fast food culture', decreased physical activity levels. The gene pool has not changed, but studies in rodents and humans suggest a differing ability to resist these environmental changes. This does not mean that we are 'destined to become fat' based on our genes. Conscious decisions to increase physical activity and avoidance of specific foods and food patterns are clearly able to modify the impact of the obesogenic environment on body fatness as indicated by the arrows.

In summary, the thrifty phenotype may account for a large portion of the obesity epidemic (Figure 3). It is likely that a individual from a population living in a "restrictive" environment characterized by a traditional lifestyle moves towards an "obesogenic" environment, such as that found in industrialized countries, most individuals from this population are likely to gain weight. However, those with the highest genetic predisposition for obesity will gain the most weight whereas those resistant to obesity will gain little weight. Other factors, such as imprinting, assortative mating and changes in infant feeding/development may also play a role.

PHYSIOLOGICAL CONTROL SYSTEMS REGULATING BODY WEIGHT: WHAT DO WE KNOW?

Whether the culprit is increased food intake or decreased energy expenditure is generally unknown and probably varies from case to case (Table). Indeed, when we examine the literature on gene mutations in rodents leading to obesity some have clear increases in food intake, but many do not. It is likely that obesity results from both impaired energy expenditure and an inability to control food intake in an environment not conducive to physical activity and in which highly palatable food is widely and easily available.

Table. 'Control systems' for regulating body weight?

I. Food Intake:
- Hypothalamic neuropeptides and neurotransmitters
- Hypothalamus receives signals from the brainstem/ periphery and cortex
  - Satiety signals from periphery:
    - Gut peptides
      - Ghrelin, CCK, GLP-1,
    - Hormones
      - Adipocyte: (?)
      - Other: insulin, glucocorticoids
    - Vagal nerve afferents
  - Hunger signals from periphery:
    - Hormones
      - Adipocyte: ↓ Leptin

II. Energy expenditure / metabolism
- Efferent signals to the periphery
  - Sympathetic outflow to adipose tissue and muscle
  - 'Fidgeting' signal(s)
  - Regulation of pituitary hormone secretion (e.g. growth hormone)
  - ? unknown hormones ?

It is useful to consider the weight control systems as an integrated feedback model.[38, 39] In this model, afferent signals indicate to the central controllers in the brain the state of the external and internal environments as they relate to food, metabolic rates and activity/behavior, to name but a few. In turn, these central controllers transduce these messages into efferent signals, governing the behavioral search for acquisition of food, as well as modulating its subsequent deposition into such energy storage compartments as adipose tissue, liver, and muscle and by modulating metabolic pathways.

The central control systems for the regulation of food intake and energy expenditure are coordinated and controlled by neuronal systems converging on the ventral hypothalamus. It has been known for years that lesions in this region produce an increase or a decrease in the regulated weight, depending of the specific site of the lesion.[38] It is also known that monoamines, including norepinephrine, serotonin, dopamine and histamine modulate feeding.[10, 40]

THE HYPOTHALAMUS AS A CENTRAL 'PROCESSOR' OF ENVIRONMENTAL (EXTERNAL) AND PHYSIOLOGICAL (INTERNAL) SIGNALS

The hypothalamus has long been recognized as the key brain center in the regulation of energy intake. Various biochemical and neural signals from the gut and major energy stores arrive at the hypothalamus, which controls energy intake by negative feedback systems.[41] These hormonal and neural signals include insulin, leptin, glucocorticoids, neuropeptide Y, serotonin. GlP-1, ghrelin, sympathetic, and parasympathetic afferent signals.

Environmental cues such as stress/psychological factors, diet composition, and other medical conditions also play a role. Medication usage, e.g., glucocorticoids, alters the activity of the brain feeding centers by suppressing corticotrophin releasing hormone – a powerful anorectic - neuropeptide.

In addition to these environmental cues, the peripheral tissues send signals to the brain. These peripheral sensors (and their respective signals) come from adipose tissue (leptin and adiponectin), the proximal and distal gut (GLP-1, PYY) and from the liver (glucose and glycogen content vis-à-vis vagal afferent nerve fibers).[3, 36] Again, these signals converge on the brainstem and hypothalamus to regulate food intake, energy metabolism, and fat partitioning. If this model is correct, one of the most important remaining questions in the field is: "why do the increasing fat stores not provide a signal to the brain to reduce food intake in some people, but do so in others?"

Total energy expenditure (TEE) is comprised of three principle components; resting metabolic rate (RMR), meal-induced thermogenesis and physical activity. The largest component of TEE is basal metabolic rate (BMR), which accounts for 65-75% of TEE. It is defined as the cost of maintaining the biochemical systems of the body at rest and is the minimum level of energy expended to sustain life.[42] In most situations it is difficult to measure BMR except during sleep. RMR is a form of BMR and refers to the metabolic rate early in the morning after awakening and before movement or food consumption.[43] According to a meta--analysis of published studies, formerly obese subjects have a 3-5% lower mean relative RMR than control subjects, which likely contributes to the high rate of weight regain in formerly obese persons.[44] Elegant studies by Rudy Liebel and colleagues at the Rockefeller showed that energy expenditure goes up when people are over-fed; evidence for a physiological mechanism to dissipate excess body fat.[45] These systems are relatively weak in comparison to our ability to overconsume calories. In other studies from the same group, weight reduction reduced metabolism below levels predicted by changes in body mass. This energy conserving system is turned on when blood levels of the fat derived hormone leptin are reduced and these effects can mostly be reversed by treating people with the hormone leptin.[46,47] Why are some people not able to increase their metabolic rates or discretionary physical activity to match their inappropriately high levels of caloric intake? We don't know, but clearly a physiological system exists in an attempt to regulate body weight.

Another important component of TEE is physical activity (or the thermic effects of exercise).[30] Physical activity energy expenditure is the energy consumed in muscular work and can be divided into two variables; the energy cost of unrestricted activity and spontaneous physical activity (SPA; also called Non-Exercise Activity Thermogenesis or NEAT).[42] Physical activity energy expenditure is the most variable component of TEE and

can vary greatly within and between individuals, ranging from 15% in sedentary individuals to 50% in extremely active people. A recent study found that resistance to the development of obesity might be due to a decreased ability to increase spontaneous physical activity in response to overfeeding.[29]

One ramification of the decreased physical activity is an increased risk of obesity, with greater prevalence reported in individuals participating in no or low levels of leisure activity.[48] Consistent with the cross-sectional observation of a decrease in spontaneous physical activity in obese subjects, longitudinal studies showed that even in the confined environment of a respiratory chamber, spontaneous physical activity is a familial trait and that a low level of spontaneous physical activity is associated with subsequent weight gain in males, but not in females.[49]

Given that some or all of these physiological systems might be dysregulated in an obese individual, it is amazing that some individuals overcome their propensity to develop obesity or actually reverse obesity. These 'post-obese' individuals maintain weight loss, but at the cost of constant dietary restrictions and regular physical activity regimens totaling almost 1 hour per day on average.[50]

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Environmental and Lifestyle Influences on Obesity

Phillip J. Brantley, PhD; Valerie H. Myers, PhD; and Heli J. Roy, PhD, RD

Obesity is an end result of the intricate interactions of biology, behavior, and environment. Recent hypotheses in the scientific community suggest the current obesity epidemic is being driven largely by environmental factors (e.g., high energy/high fat foods, fast food consumption, television watching, "super-sized" portions, etc.) rather than biological ones. Individuals are bombarded with images and offers of high fat, high calorie, highly palatable, convenient, and inexpensive foods. These foods are packaged in portion sizes that far exceed federal recommendations. Furthermore, the physical demands of our society have changed resulting in an imbalance in energy intake and expenditure. Today's stressful lifestyles compound the effects of environmental factors by impairing weight loss efforts and by promoting fat storage. Combating the obesity epidemic demands environmental and social policy changes, particularly in the areas of portion size, availability of healthful foods, and promotion of physical activity.

Obesity is a condition of excessive body fat that results from an imbalance in energy intake and energy expenditure.[1] It is a chronic health problem, and like many other chronic health problems the etiology of the disease is multifactorial. Obesity is an end result of the intricate interactions of biology, behavior, and environment (Figure 1). Biological influences (e.g., genetics, metabolism, adiposity) are factors known to impact obesity. For example, genetic factors have been hypothesized to explain 25-40% of the variance in body weight.[2] Behavioral influences are complex psychological factors (e.g., beliefs, behaviors, cognitions) that are developed through individual learning histories. Environmental influences include accessible foods, activity demands, and life stressors. Obesity research has traditionally focused on the influence of biology and behavior, and paid less attention to the impact that environmental influences have on obesity. The following paper will review the contribution that various environmental and lifestyle variables have on the development and maintenance of obesity in our culture.

OBESOGENIC ENVIRONMENT

Egger and Swinburn insist that environmental influences are the public health aspect of the obesity epidemic, and can be subcategorized into *macro* and *micro* factors. *Macro* influences include those of the larger population (e.g., health care system, food and agricultural market, etc.), whereas *micro* influences are those that are more intimate or closer in proximity to the individual (e.g., family, neighborhood, school/work, etc.)[3, 4] The macro-environment dictates the prevalence of obesity in the general population. Whereas, the micro-environment in conjunction with biological and behavioral factors determines obesity in the individual.[3] These three influences have driven the concept of an *obesogenic environment*. The obesogenic environment is defined as a set of conditions external to the individual, that in combination with genetic predisposition toward obesity, increase the likelihood of the disease.[1] It is hypothesized that obesity occurs more often in this type of environment, because the body has strong physiological defenses against undernutrition, and rather weak defenses against energy surfeits.[1] Genetic composition has not changed dramatically in the last few decades to explain the accelerating trend in obesity. Therefore, a nascent hypothesis in the scientific community is that the obesity epidemic is being driven by environmental factors (e.g., high energy/high fat foods, fast food consumption, television watching, "super-sized" portions, etc.) rather than biological ones.[5, 6] Subsequently, many researchers suggest that combating the obesity epidemic demands environmental changes, particularly in the areas of portion size, availability of healthful foods, and promotion of physical activity.[7]

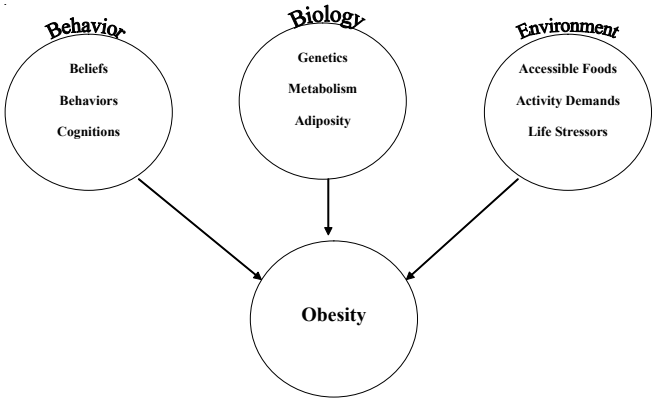

Figure: Factors in obesity

Two theoretical frameworks have been developed to study the obesogenic environment.[4, 8] A systems-oriented casual web was developed by the International Obesity Task Force depicting the impact of health, food marketing, media, public policy, urban design, education, and transportation at the national, community, and family level on the individual.[8, 9] Also, Swinburn and colleagues developed a conceptual model for understanding the influence of environment on obesity named the ANGELO framework (analysis grid for environments linked to obesity). ANGELO takes into account the impact of availability, cost, public policy, and cultural attitudes and beliefs at the intimate level (e.g., individual, neighborhood, school, religious setting, etc.) and at the global level (e.g., transportation system, health system, etc.).[4] These theoretical models have been helpful in the identification of potential areas of research and intervention, and have further supported the claims by obesity researchers that the environment is a critical component in the war against obesity. Several environmental influences have been identified, and their impact on obesity have been studied to varying degrees. The areas that have received the most attention, albeit it minimal compared to the scientific literature on biological and behavioral factors, are sedentary lifestyle practices and increased energy consumption.

INCREASED ENERGY CONSUMPTION

The incidence of obesity has increased dramatically over the past few decades despite improvements in diet quality.[10] One postulation for this dichotomized trend is the contribution that inexpensive, high fat, convenient foods have played. Horgen and Brownell have proposed that most people are exposed to a "toxic environment" of fast food restaurants, and other high calorie, high fat foods. [6] In turn, Egger and Swinburn hypothesize that obesity is a result of an abnormal environment.[3] This abnormal environment consists of poor quality food and increased portion sizes. In a comprehensive review of environmental impacts on obesity, French and colleagues [11] identified several contributors to the obesity epidemic. These include changes in food supply trends, eating meals away from home, and television advertisements.

The food supply is more abundant now than it has been in generations past. For example, per capita energy availability in the United States increased 15% from 1970 to 1994.[12] Interestingly, there has been a decrease in the percentage of energy intake from fat by 4% during this same time period, however the absolute grams of fat per capita have increased by 3%.[12] There has been a dramatic increase in the consumption of added fats (e.g., those added on food products used directly by consumers such as butter on bread, and oils in commercially prepared pastries) in the last century.[11, 13] Notably, between 1970 and 1996 there has been a 22% increase in added fats and oils to the American food supply.[11, 14]

The per capita consumption of milk declined by 7 gallons between the years 1970 and 1997.[15] However, the consumption of cheese has risen exponentially.[11] Between the years of 1970 and 1997, the consumption of cheese increased by 146% (i.e., from 11 lbs to 28 lbs per person).[15] Of notable concern is that two-thirds of cheese eaten is from commercially prepared, calorie dense foods such as pizza and nachos.[15] Some authors noted that the increased consumption of cheese is best reflected through the increased consumption of pizza.[15] Specifically, in a twenty year period, eating pizza increased by 150% with an increase in sales of 25% (e.g., over $20 billion) just between the years 1991 and 1995.[11, 15]

Since fewer people are drinking milk, it has been postulated that the concurrent increase in soft drink consumption is not by mere chance.[11] Between 1977 and 1996, consumption of soft drinks increased by 131%, the greatest increase in consumption among any food group.[16] By 1997, 44.4 gallons of soda were consumed annually per capita in the United States.[15] Dietary intake research suggests that this has contributed to 16% of total energy intake due to added sugars present in most sodas.[17] Adolescents appear to be the most vulnerable to this trend.[11] Among adolescents, 20% of total energy intake is from soft drinks, and soda consumption has nearly tripled among adolescent males.[11, 17] Data suggest that approximately one-third of added sugars in adolescents' diets are a result of regular soft drinks.[16]

The increased prevalence and availability of soda vending machines is hypothesized to be a major contributor to increased consumption of soft drinks.[11] A study by Sanford revealed that in 1999 alone, 25.9 billion soft drinks were dispensed by 2.8 million vending machines.[18] The availability of soft drink machines in the school environment fueled concern over what types of food and beverages should be made available to children and adolescents while away from home.[11] A concerning trend is the increasing number of contracts between cola manufacturers and schools for vending machines and volume of sales.[11] These contracts often encourage schools to promote the consumption of soft drinks products in return for a percentage of the profits. Monies obtained from vending contracts are viewed by many as an important source of funding needed for school supplies, equipment, and maintenance.

An additional concern in the school environment is the increase in snack and candy vending machines, as well as the introduction of fast food chains and a la carte services in the school cafeteria. A recent national survey of schools found that 95% of high schools had soft drink, candy and snack machines; and over three-fourths offered pizza and burgers in their a la carte areas.[19] A smaller study replicated this national data by additionally reporting that high fat foods such as chips and ice cream were highly prevalent in a la carte areas (21.5%) whereas fruits and vegetables accounted for a significantly smaller amount (4.5%).[20] Additionally, in this

study over two-thirds of the schools had legal contracts with soda manufacturers.[20] This trend of easily accessible high fat a la carte options and fast food restaurants compounded with the fact that 88% of children rate pizza and chicken nuggets as their favorite lunch entrée encourages the likelihood of children eating these products at school especially if food chains such as McDonald's and Pizza Hut are available.[6] Children who eat fast food for lunch are more likely to also eat fast food for dinner.[6] Approximately, 85% of all meals consumed by children are consumed outside of the home, and 35% to 40% of a child's daily energy is consumed at school.[20-22] In a recent position paper, the Society for Nutrition Education cited that schools are providing inadequate healthy eating environments. The Society states that only 2% of school aged children meet the suggested dietary recommendations for all food groups, and that 84% of these children are consuming too much fat.[23] Half of the children eat only one serving of fruit daily, and 1 out of 5 adolescents do not eat breakfast.[23]

On a more positive note, per capita fruit and vegetable availability has increased between 1970 and 1995 by 19%.[11, 24] This trend has resulted in more product item availability in supermarkets and an increase in farmer's markets.[11] Additionally, consumption of fruits and vegetables by Americans increased by 24% since 1970.[15] Despite this positive increase in the consumption of fruits and vegetables by the American people, fruit and vegetable intake is still well below the recommended daily allowance.[11] In 1996, the average vegetable intake was 3.8 servings, just shy of the recommended 4 daily servings. However, frozen potatoes in the form of french fries and potato chips account for over 15% of all vegetable servings.[11] Fruit intake was also well below the recommended 3 servings at an average daily consumption of 1.3 servings.[14] Notably, in a study of low-income Louisiana primary care patients, 61% of participants consumed greater than 30% of their calories from fat, and averaged less than 1 serving of fruits and only 1 serving of vegetables per day.[25] According to Louisiana Health Report 2001, 83% of adults in Louisiana reported not eating at least 5 servings of fruit and vegetables per day.[26]

Eating Out. The American public loves to eat outside of the home. Estimates suggest that 46% of adults eat in a restaurant on any given day, and 21% of American households use the convenience of restaurants or food delivery daily.[27] In line with the demand of changing eating behaviors, the number of commercial eating places has increased by nearly 90% since the 1970s.[28] By 1995, meals and snacks eaten at fast food restaurants alone increased by 200%.[27] For example, Burger King Corporation reports that in 2003, 2.2 billion hamburgers and 523 million pounds of fries were sold annually in the United States.[29] By the year 2010, this trend in away-from-home food consumption is expected to raise the estimated percentage of food dollars spent outside of the home to 53%.[27] The convenience of easily accessible food has increased the popularity of fast food and restaurant use. Estimates from 1999 indicate that 60% of women were in the workforce, and fewer than 10 hours a week were dedicated to food preparation.[30] The increased stress and demands of daily living have been reflected in the nation's food consumption. Food preparation and eating trends suggest that the convenience of eating out, as well as using quick-food preparation devices (e.g., microwave, frozen dinners, etc.) may be driven by the decreased time available for food preparation due to other life responsibilities.[30]

There are two significant caveats to the convenience of fast foods and away-from-home foods: nutritional content and portion size. Specifically, foods prepared away from home are traditionally higher in energy and fat, and lower in fiber than foods prepared at home.[11, 31, 32] Furthermore, continued fast food consumption has been shown to predict increased BMI in both children and adults.[10, 32, 33] Specifically, the number of fast food meals eaten in a week is positively correlated with total energy intake and percentage of energy from fat.[10] Some of the most popular items at fast food restaurants are also the highest in fat and calories; a typical meal of a cheeseburger and fries can equal more than half of the daily recommendation for calories and percentage from fat.[11] Although many restaurants and fast food chains have opted for promotion of lower fat, lower calorie alternatives these products have often been discontinued due to slow sales.[11] This finding may be best explained through the concept of habits. Specifically, most habits (e.g., eating higher fat foods, eating away from home) occur without volitional effort.[34] Habits are learned via complex interactions of behavior, physiology, environmental, and personal factors. Regularly presented environmental cues (e.g., passing by a fast food restaurant while driving the same way to work each day) encourages associative learning which then can result in automatic behaviors (e.g., stopping at the restaurant for coffee and a doughnut).

Portion sizes in restaurants, fast food chains, and pre-packaged store bought products have been steadily increasing.[11] For example, a "king-size" McDonald's soft drink in the 1950s is equivalent to the "child-size" today.[11] Another notable example of the increase in portion sizes is with the manufacturing of the soft drink Coca Cola.[11] Originally, Coca Cola was sold in 6.5 oz bottles. Now this product is bottled in 20 and 32 oz portions, and the 20 oz product is steadily replacing the once standard 12 oz size available in vending machines.[11] Pre-packaged foods are not exempt from this increase in portion size. Candy bars and potato chips sizes have increased dramatically from their "traditional" sizes.[11] A recent study by Young and Nestle weighed ready-to-consume foods from marketplaces, fast food chains, and family restaurants, and compared them to the USDA and FDA recommendations for portion size.[35] The authors found that portions have increased in size and exceed federal recommendations. Specifically, items in the cookie

category were 700% larger than the USDA standards followed by pasta (480%), muffins (333%), steaks (224%), and bagels (195%).[35] The authors further note that hamburger, french fries, and soda portions are 2 to 5 times larger than their original portion sizes.

Larger portion sizes encourage increased intake of already high energy, high fat foods at fast food restaurants. The concept of "super-sizing" your order is one that is fundamentally based on wanting to get more value for your dollar. The greater the affordability of food and the greater the amount available to consume per dollar spent, is a driving factor in the super-sizing phenomenon. Studies have demonstrated that increased portion sizes encourage increased consumption.[36] Specifically, if given more to eat, the general public will eat it. The theory behind this phenomenon is that consumers perceive the unit cost as lower, and they therefore get more than what they paid for (i.e., value for their dollar). Companies now use this phenomenon as a selling point. Companies promote their wares with signs and advertisements of larger sizes, restaurants use larger dinner plates, newer cookbooks specify smaller number of servings resulting in larger portion compared to similar recipes of a generation ago, and car manufacturers are even accommodating the trend by producing larger cup holders in their cars.[35] Unfortunately, the result of this phenomenon is that consumers dramatically underestimate their portion sizes.[11] Therefore, the more consumers eat away from home, the more they will be inclined to choose oversized portions. The consumers' poor perception of accurate portion size results in overconsumption of these already energy dense foods with the end result being an increase in excess weight. These environmental factors can be compounded by individual behavioral factors, too. Specifically, research has demonstrated that individuals who choose high fat foods (i.e., have poorer eating habits) on average have higher energy intake and gain more weight than individuals who choose lower fat options.[37] This suggests that dietary restraint (a measure of conscious control over food intake) can moderate the impact of a high fat, calorie dense diet.[37]

SEDENTARY LIFESTYLE

An increase in the consumption of high fat, high calorie foods is not the only plausible explanation for the recent obesity epidemic. The environment in the United States does not favor a balance between physical activity and food intake.[38] Decreased levels of physical activity are associated with increased obesity, and our current environment discourages physical activity.[7] More than 60% of adult and adolescent Americans are physically under-active, and 25% of the US population report no leisure time physical activity.[39] Among Louisiana adults, 83.9% reported being physically inactive in the preceding month. Men and women reported similar levels of inactivity (82.2%) and (85.4%).[26] Another study of low income Louisiana residents revealed significantly higher rates of sedentary behaviors (52%) which was substantially higher than previously reported national (28%) and Louisiana (32.6%) averages.[40]

A study of British citizens between 1970 and 1990 illustrated a decline of 750 kcal of energy intake per day, but a 2.5 kg mean weight increase.[41] Interestingly, in this same study a decline in daily energy expenditure of approximately 800 kcal was noted due to mechanization, transportation, computers, television use, and concerns of safety which limited play and walking.[41] Therefore, despite the fact that these individuals were eating less, they were also less physically active which resulted in a positive energy balance of 50 kcal per day. This study suggests much of the same phenomenon in the United States. Overall, there are several domains which have contributed to the increase in sedentary lifestyle including increase in television viewing, modern advancements which have reduced the need for physical labor, and society's "built" environment just to name a few.

Television. Ninety-eight percent of all US households own a television.[42] Estimates suggest that adults spend an average of two hours a day watching television, and children and adolescents watch an average of 25 hours a week.[42, 43] One out of every five children and adolescents watch 35 hours a week of television.[43] Children spend more time watching television than any other activity with the exception of sleeping, and by the age 18 the average teenager has spent more time watching television than learning in the classroom.[44] Over 50% of teenagers have televisions in their bedrooms, and the incidence of obesity is highest among children who watch four or more hours of television a day.[43,45]

The impact of television on the obesity epidemic has been delineated into two different categories: the influence of television advertising on food choice, and the decrease in physical activity that is associated with television viewing. Television is the most widely used advertising medium.[11] There are 6 minutes of commercial advertising per hour on television which translates into 90 minutes of advertising viewed by the average viewing adult per week.[11] Since a considerable number of people eat their meals away from home, fast food restaurants and food and beverage manufacturers spend an enormous amount of time and money investing in television as their primary advertisement medium. An estimated $11 billion was spent in 1997 on mass media advertising by the food and beverage retailers and manufacturers.[46] In 1997, the Coca Cola company spent $277 million, or $1 per person on television advertising, and McDonald's and Burger King spent over $571 million and $407 million respectively in their advertising efforts.[11,47, 48] The total food industry in the U. S. spends about $45 per person in advertising.[49] Foods that are heavily marketed on television enjoy high rates of consumption (e.g., sugary breakfast cereals, fast foods, soft drinks, and alcohol). This is very concerning when you compare the

amount of money spent by food retailers and manufacturers on food advertisements to that of governmental agencies spending on advertisements. For example, in 1996, only $29.8 million was spent on the "Got milk?" campaign, and $1 million on the 1999 "5-a-day For Better Health" message by the National Cancer Institute.[46]

Notable attention has been given to the amount of advertising targeted at children, because children and adolescents may see up to 3 hours a week of television advertising or 20,000 commercials a year.[44, 50] Furthermore, foods that are most frequently requested by children are those that they see most often on television.[51] Taras and colleagues found that weekly hours of television viewing correlated with number of requests by children and subsequent parental purchase of these foods, and children's energy intake.[51] Fast food chains often market directly to children through a fun, recognizable character (e.g., Ronald McDonald is known to 96% of children in the United States).[6, 21] Unfortunately, children are not capable of distinguishing between commercials and television programming.[52] Kotz and Story examined food advertisements during children's television programs and assessed them for compliance with dietary recommendations.[44] Over 50 hours of children's Saturday morning television were viewed and there were 997 commercials selling products, and 68 public service announcements. Over 56% of the advertisements were for food, and 43.6% of these were in the fats, oils, and sugary food group. High sugar cereals were the most frequently promoted product. A British study replicated the Kotz and Story findings, as well as other data from the US.[50,53] In this study, over half of 828 advertisements during children's television programming were for food products, and 60% were for high sugar breakfast cereals and confectionaries. Notably, the authors found that food advertisements used significantly more animation, stories, fun/happiness themes, and humor to promote their product.

Not only has the quality of television (i.e., advertising, marketing strategies) been identified as a contributor to the increase in obesity, but the consequence of television watching (i.e., sedentary behavior) has also been targeted. Television viewing, electronic video games, computers, internet use, and VCR/DVD players have all been identified as contributing factors to the increase in sedentary lifestyle.[11] Interestingly, community-based data suggests that availability of free time has increased dramatically since 1965, and television is the most commonly reported free-time activity.[54] The Behavioral Risk Factor Surveillance System (BRFSS), a comprehensive state-based surveillance system that tracks health risks via telephone survey, found that 30% of respondents are physically inactive despite this increase in available leisure time.[55] The BRFSS suggests that rates of physical inactivity were highest among those over the age of 65 years, women, racial/ethnic minorities, persons with lower educational attainment, and lower socioeconomic status. Most individuals report that television is not a necessary part of their life, but they nonetheless devote a tremendous amount of time to it.[11, 54]

Several studies have examined the association between television viewing and obesity. In a study of adults, individuals who reported watching 1 to 2.5 hours of television a day were 93% more likely to be overweight than those adults watching less than 1 hour a day.[56] Adults watching 2.5 to 4 hours or more than 4 hours a day of television were 1.83 to 4 times more likely to be overweight.[56] Television viewing hours have been positively associated with energy intake and BMI in women, and television viewing has been shown to predict weight gain in high income women.[10]

Additional studies have been conducted with children. A portion of the National Health and Nutrition Examination Survey (NHANES-III) examined the relationship between television viewing, physical activity, energy intake, and obesity status among American youth aged 8 to 16 years.[45] Anthropometric and interview data were collected on over 4000 children. Results showed that the lowest incidence of obesity was with children who watched 1 hour or less of television a day and the highest incidence of obesity was in children who viewed over 4 hours of television a day. The authors found that even when controlling for age, race/ethnicity, family income, and energy intake, television was still positively associated with obesity. The data also suggested that total energy intake was higher among boys, girls were less physically active than boys, and only 56.7% of the children engaged in 5 or more days of physical activity a week. Increased television viewing was associated with a higher prevalence of obesity among girls, but not boys. These results have encouraged researchers to pursue methods to decrease television watching by children. Robinson conducted a randomized clinical trial aimed at reducing television, videotape, and video game use among third and fourth graders.[57] Children in the intervention condition received an 18 lesson, 6 month school-based curriculum on how to encourage reduced television and videogame usage. Children in the intervention condition had statistically significant decreases in BMI, triceps skinfold thickness, waist circumference, and waist-to-hip ratio compared to children in the control condition. Furthermore, children in the intervention condition had statistically significant decreases in television viewing and meals eaten in front of the television. Faith and colleagues examined the impact of contingent television viewing on physical activity and television viewing in obese children.[58] Children were given a stationary cycle ergometer with an attached television. For the intervention group, activating the television was contingent upon pedaling. Specifically, one minute of pedaling earned two minutes of television time. Children in the control condition did not have any contingencies for television viewing. The results indicated that the intervention significantly reduced television viewing and in-

creased pedaling. The intervention group pedaled 64.4 minutes a week compared to 8.3 minutes by controls, and the intervention group watched 1.6 hours a week of television compared to 21 hours a week in the control condition. Other studies have also shown the benefits of reinforcing physical activity with television privileges.[59, 60]

Decreased Physical Labor. Less physical labor is required in the American workplace, because of 1) improvements in technological devices, and 2) shifts in occupational duties. Most occupations have shifted from heavy manual labor (e.g., farming) to occupations requiring little physical effort (e.g., desk jobs). Computers have also changed the American workplace, as their numbers have increased exponentially in the last two decades. It has been suggested that in the workplace, the impact that sending an email rather than walking to the office next door to communicate information would decrease energy expenditure by half.[11] Children are not immune to this trend of decreased activity. Current practices in the school environment shows a steady decline in time devoted to recess and physical education. Physical education practices do not meet the national health objectives standard despite the positive effects that exercise has on academic achievement.[23]

"BUILT ENVIRONMENT"

The "built environment" provides opportunities to participate in physical activities, and in turn can also provide barriers.[61] One of the most important determinants of physical activity is a person's immediate environment (e.g., neighborhood, number of sidewalks, scenery, street lights, etc.). Research has shown that lack of facilities (e.g., sidewalks and parks), and safety concerns are two critical barriers to physical activity.[61] For example, CDC survey data suggest that low levels of physical activity were higher among individuals who reported that their neighborhoods were not safe.[55]

Automobile use has been identified as a main contributor to the increase in sedentary lifestyle. There has been a steady increase over the last three decades in the number of commuters who drive to work (e.g., 87% in 1990) compared to a mere 4% who walk.[62] Census data suggest that automobile use for commuting to work, as well as short trips has increased, and people are less likely to use more physically demanding modes of transportation (i.e., walking, bicycling).[11, 62] The automobile is a convenient mode of transportation. Automotive sales are steadily increasing, and in 1997, 15.4 billion new cars were purchased.[11] Census data suggest that over 50 million households have at least two automobiles.[11]

Land use policies facilitate a dependence on automobiles, and make alternative modes of transportation (e.g., walking, bicycling) difficult and even dangerous.[38] The United States compared to other countries has the least walkable cities, and the lowest rate of walking as a means of transportation.[38] The Surgeon General' Report on Physical Activity found that people walk and ride bicycles more in neighborhoods with "traditional" designs than in sparsely designed neighborhoods.[63] Traditional designs are those neighborhoods that are densely populated, compact, have high street connectivity, and adequate sidewalks.[64] These neighborhoods encourage walking to local markets, movie theaters, etc., because of its relative ease. Neighborhoods that are sparsely designed, vast, sprawling, and remote, encourage transportation via automobile.[64] These designs are developed with great distances between homes, schools, and areas of shopping.[61] Suburban America is sparsely connected and taking over much of the national landscape. Individuals in densely designed neighborhoods tend to be more physically active than individuals living in the suburbs.[61] Saelens and colleagues reviewed research in the areas of transportation, urban design, and planning to assess the relationship between physical environment and walking or cycling for transport. [65] Their findings suggested that residents from areas with higher density, more land use mix, and greater connectivity had higher rates of walking and cycling for utilitarian purposes compared to residents in communities that were low density, poorly connected, and had single land use purposes. Another study by Saelens and colleagues replicated this finding, and further revealed that for their sample, residents of high-walkability neighborhoods reported 70 minutes more of physical activity and lower obesity prevalence than the low-walkability neighborhood. [66] Other researchers have suggested that specific built environment factors exert weaker influences on walking and bicycling behavior than believed, nonetheless these influences are not inconsequential.[67] However, they contend that greater public health benefit might result by designing walkable neighborhoods based on demographic characteristics of specific neighborhoods rather than using a microdesigned format.

Research on the concept of built environment and the impact that urban design and automobile use has on physical activity is still scarce. Nonetheless, certain areas of the country are beginning to encourage social policy change through local programs that are conducive to more physical activity (e.g., America on the Move and Active Living by Design).[68, 69, 70] Furthermore, in July 2003, the Pedestrian and Cyclists Equity Act was introduced to the U. S. Congress. The passing of this legislation would channel $350 million annually for six years to fund active living strategies.[68]

LIFESTYLE AND STRESS

The concept of stress is an important contributor when examining the influence that environmental factors have on obesity. The impact of stress on the occurrence of obesity is twofold: the effect that stress has on eating habits, and the physiological responses to stress that result in

adiposity. Our society is demanding. Modern conveniences intended to make our lives easier (e.g., email) have instead resulted in higher demands on individuals. In turn, evidence suggests that daily life stress and coping ability can negatively affect health related behaviors (i.e., making healthy food choices, following an exercise plan), and that the impact of frequent minor stressors (e.g., driving in heavy traffic) on psychological and physical health may be greater than the influence of major stressors (e.g., divorce). [71, 72] This suggests that the chronic, daily demands of a more modern society, mediated through poor eating habits, may be influencing the increase in obesity.

Data suggest that psychological stress is associated with weight gain.[73, 74] Stress results in an overproduction of cortisol and other stress hormones which can produce metabolic abnormalities (e.g., insulin insensitivity) that can lead to increased fat storage.[75] Bjorntorp hypothesizes that repeated activation of the hypothalamic-pituitary-adrenal axis (HPA) and sympathetic nervous system as a reaction to stress may be involved in the pathogenesis of abdominal obesity.[76] Specifically, Bjorntorp proposes that chronically elevated activation of the HPA axis secondary to psychological stress results in the development of visceral obesity.[77] Bjorntorp postulates that the pressures of society's competitive lifestyles results in chronic stress that produces daily elevations in cortisol which over time compromises the feedback control of the regulatory mechanisms. Studies have documented that this stress cycle results in increased deposition of intra-abdominal fat tissue.[78] In sum, these findings suggest that the impact that lifestyle via environmental controls has on obesity has both behavioral (i.e., food choices made) and physiological (neuroendocrine stress response abnormalities) components.

FUTURE DIRECTIONS AND CONCLUSION

The obesity epidemic over the last three decades is being driven by environmental influences interacting with permissive genetics. There is an imbalance between energy intake and energy expenditure in our society. Individuals are bombarded with images and offers of high fat, high calorie, highly palatable, convenient, and inexpensive foods. Furthermore, these foods are attractively packaged in portion sizes that far exceed the recommendation of the FDA and USDA. The physical demands of our society have changed. Advances in technology have reduced the need for physically demanding jobs, and increased the number of sedentary office jobs. Unfortunately, these technologies have come at a high psychological price. Technological advances have created a demand for higher productivity resulting in a faster paced and more stressful life which have impacted the time for food preparation and quality of leisure activity.[5, 40] Modern conveniences such as microwaves, television, and automobiles have contributed to a steady reduction in energy output. Our neighborhoods and cities discourage walking and cycling for transportation rendering us dependent on automobiles for transportation. The type and quality of our leisure time activity has changed. Television viewing, video games, movies, and internet use are common leisure time activities replacing others such as playing outside and walking around the neighborhood.

Several researchers and proponents have called for social change that will provide social and economic encouragement for healthy lifestyle choices.[9] Suggestions have included reducing portion sizes, reducing fat content while maintaining flavor, interdisciplinary collaboration with professionals in urban planning, continued research of environmental characteristics of communities, and comprehensive nutritional programs.[5, 7, 65, 64, 23] Horgen and Brownell offered eight recommendations to combat the "toxic environment" including regulating food advertising and prohibiting soft drink and fast food sales in schools.[6] Policy change can be a dauntingly slow task. Therefore, in the short-term, individual based education and support to assist people with making better lifestyle choices for themselves is needed.[55, 79]

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Politics of the Obesity Epidemic: Results of the 2003 Louisiana Physicians Survey

Donna H. Ryan, M.D. and Catherine M. Champagne, Ph.D

The obesity epidemic is producing growing interest in public policy measures targeting prevention. We developed a printed survey suitable for mailing to primary care physicians in Louisiana. Questions were asked concerning health policies relating to motorcycle helmet use, smoking, and obesity. We also obtained personal data, including type of practice, gender, age, ethnicity, personal income, height, and weight. Of 993 surveys mailed, there were 218 responses: 74% were male, 55% were from East Baton Rouge parish, an urban location, and 84% had an income of >$100,000. Of respondents, 74% strongly agreed with helmet laws, 73% strongly agreed with limitations on smoking spaces and 62% strongly agreed with cigarette taxation. Concerning health policies related to obesity prevention, strongest support was for school concession policies, with 73% reporting strong agreement or agreement. There was support for regulating food advertisements, where 60% agree or strongly agree. However, only 29% agree or strongly agree with the taxing of unhealthy foods, compared to 78% of respondents favoring cigarette taxation, a statistically significant difference (<0.0001). Support was particularly weak for governmental involvement in obesity discrimination, with only 16% of respondents agreeing or strongly agreeing. Political response to the obesity epidemic is only now emerging. However, our survey indicates that support among Louisiana physicians for obesity-related policy is not equal to support for policies directed against helmet and smoking laws.

Along with the rest of the United States and much of the world, Louisiana is suffering from the unprecedented health threat brought on by the epidemic of obesity. With United States obesity rates currently exceeding 60%, and with nearly 5% having a BMI $\geq$ 40 Kg/m^2, public health officials have targeted obesity for action.[1]

Tommy G. Thompson, the Secretary of the Department of Health and Human Services, has become one of the chief spokespersons regarding obesity. At the September 15, 2003 Secretary's Challenge Kickoff Event he remarked, "Today, 51% of children and teenagers don't eat fruit every day and 29% don't eat even one vegetable each day, unless it is fried.[2] That tells us something. We are not eating healthy and we're not exercising. We have become an obese and overweight society. And today, overweight or obesity is the second leading cause of preventable death in the United States. 300,000 of our fellow citizens die each year, and cost the American taxpayers $117 billion dollars." He expanded on the economic impact of obesity at the December 10, 2003 Innovation in Prevention Awards Gala. He noted, "The cost to US businesses of obesity-related health problems in 1994 added up to almost $13 billion, with $8 billion of this going toward health insurance expenditures, $2.4 billion for sick leave, $1.8 billion for life insurance and close to $1 billion for disability insurance."[3]

The obesity epidemic is producing growing interest in public policy measures targeting prevention. The political response to the epidemic is inevitable. The model to address the obesity epidemic is the anti-smoking model government campaigns to educate people, tax tobacco products, and place restrictions on tobacco companies, which has resulted in reduced smoking rates. In Louisiana, the Obesity Task Force is the result of legislation targeting study of the problem with an ultimate aim of undertaking policy initiatives.[4] In some states, taxes on vending machine snacks, or even banning of foods with little nutritional value (soft drinks and hard candy) in schools have been suggested.[5] Some food companies are vulnerable to lawsuits; but a case brought against McDonald's by two fat teenagers was dismissed for the second time in September, 2003.[6]

In order to assess the opinion of Louisiana physicians regarding policy options for controlling the obesity epidemic, we conducted a survey of primary care physicians in East Baton Rouge and 14 rural parishes. We utilized the questionnaire developed by Oliver and Lee and utilized by them in a telephone survey conducted in April and May of 2001 in 909 adult respondents.[7] They developed nine statements designed to assess public attitudes to policy measures addressing smoking, motorcycle helmets and obesity risk factors. Their sample was selected to generalize the US adult population in telephone households and also to provide additional completed interviews with African-American respondents over and above what would be obtained in a straight random sample of the general population (Figure1).

METHODS

We developed a printed survey suitable for mailing, and

A. Strongly Agree; **B**. Agree; **C**. Neither Agree nor Disagree; **D**. Disagree; **E**. Strongly Disagree

1. We should outlaw smoking in all public places like restaurants, airports, and stadiums.
2. There's too much advertising for junk food and fast food on television that is aimed at children and the federal government should regulate these ads the way they do for cigarettes and alcohol.
3. The government should impose a snack tax on unhealthy food and use the proceeds to support the production and distribution of nutritious foods.
4. The government should require all people on a motorcycle to wear helmets.
5. We should eliminate fast food and soft drink concessions from our public schools.
6. We should tax cigarettes to pay for all the public medical costs caused by smoking.
7. Our government's policies take too much care of people and deprives them of too much individual responsibility.
8. The government should play a more active role in protecting overweight people from discrimination.
9. Overweight people should be subject to the same legal protections and benefits offered to people with other physical disabilities.

Figure 1. Policy Issues. Please indicate your agreement with the following statements:

Table 1. Rate of Response to Mailing by Geographic Location

	Number Mailed	Number Returned	% Responders
All Parishes	993	218	22
Urban parish			
East Baton Rouge	596	126	21
Rural parishes	397	92	23
Ascension	34	11	32
Assumption	6	4	67
East Feliciana	19	2	11
Iberville	19	1	5
Lafourche	76	14	18
Livingston	12	2	17
St. Charles	17	2	12
St. Helena	2	1	50
St. James	12	6	50
St. John the Baptist	25	7	28
St. Landry	80	16	20
St. Martin	9	3	33
Terrebonne	82	21	26
West Baton Rouge	4	2	50

included nine questions based on the published questionnaire.[7] It was sent to primary care physicians in one urban and 14 rural parishes in Louisiana (Table 1). The survey questions that assessed political opinions are depicted in Figure 1. In addition, we obtained personal data, including type of practice (family medicine/general practice, internal medicine, obstetrics and gynecology, pediatrics and other), gender, age, ethnicity, personal income (<$100,000 and >$100,000 annually), height (inches), and weight (pounds). From height and weight, BMI was calculated. The survey included an incentive for participation. The survey stated "The first 400 respondents will receive a copy of Dr. George Bray's "Contemporary Diagnosis and Management of Obesity and the Metabolic Syndrome," Third Edition.[8] A postage-paid, self-addressed envelope was included in the mail out so that the respondent could return the scannable answer sheet and indicate interest in receiving the book. The participants were assured of anonymity, but the response materials were bar-coded to determine the respondent's address.

A mailing list was developed from the Louisiana Board of Medical Examiners mailing list for the following parishes: Ascension, Assumption, East Baton Rouge, East Feliciana, Iberville, Lafourche, Livingston, St. Charles, St. Helena, St. James, St. John the Baptist, St. Landry, St. Martin, Terrebonne, and West Baton Rouge. We included all those who were categorized by the Louisiana State Board of Medical Examiners as primary care physicians (family medicine/general practice, internal medicine, obstetrics and gynecology, pediatrics) and excluded all others. Table 1 describes the response to the mail out, which included 993 letters.

Table 2. Characteristics of Survey Respondents

	Number	Percent
Profession		
General Practice	69	31.7%
Internal Medicine	49	22.5%
Obstetrics and Gynecology	28	12.8%
Pediatrics	40	18.3%
Other/Unanswered	32	14.7%
Gender		
Male	162	74.3%
Female	55	25.2%
Unanswered	1	0.5%
Ethnicity		
Caucasian	184	84.4%
African American	12	5.5%
Other	20	9.2%
Unanswered	2	0.9%
Income Range		
≤$100,000	26	11.9%
>$100,000	183	83.9%
Unanswered	9	4.1%
Age		
≤50	106	48.6%
>50	99	45.4%
Unanswered	13	6.0%
Location		
Urban	120	55.0%
Rural	98	45.0%
BMI		
Males	160	Mean 26.0 (Range 16.6-42.1)
Females	54	Mean 24.5 (Range 17.0-42.2)
Unanswered (BMI or gender)	4	

For the analysis we categorized the sample according to the following characteristics: urban (East Baton Rouge) or rural (all other parishes); gender (male or female); and income (less than $100,000 or $100,000 and greater). We calculated body mass index (BMI) as weight in Kg divided by the square of the height in meters. We categorized BMI as normal (<25 kg/m^2), overweight (25-29.9 kg/m^2) and obese (30 kg/m^2 or greater).

RESULTS

Table 2 describes the characteristics of those who responded to the survey. Of the respondents, 74% were male, 55% were from East Baton Rouge parish, an urban location, and 84% had an annual income of >$100,000.

We have arrayed the survey results by demographic variables in Table 3. Three of the survey statements address respondents' attitudes to health policy not related to obesity (statements 1, 4 and 6), five address obesity-related policy issues (statements 2, 3, 5, 8 and 9) and one statement addresses attitude to government intrusiveness (statement 7).

The three statements that address respondents' attitudes to public policy with regard to health issues not affecting obesity show strong agreement with a policy and regulatory approach. Of respondents, 74% strongly agreed with helmet laws, 73% strongly agreed with limitations on smoking spaces and 62% strongly agreed with cigarette taxation. For statements 1 and 6 that address smoking policy, there was consistent strong agreement across demographic variables, except among those with income <$100,000. In those, a smaller proportion (50%) strongly agreed with regulation to outlaw smoking, compared to 77% of the higher income group (p = 0.01) and 39% strongly agreed to cigarette taxation compared to 65% in the income group >$100,000 (p = 0.02). For opinions regarding helmet laws, the gender difference in strong agreement response was significant (p = 0.01) with 86% of females, but only 70% of men expressing strong agreement.

One statement addresses attitudes to government intrusiveness. Of all respondents, 50% either agreed or strongly agreed with the statement, "Our government's policies take too much care of people and deprive them of too much individual responsibility." Among rural respondents, this proportion was 60%, compared to 41% among urban respondents, a significant difference in attitudes (p = 0.006). Men were

Table 3. Percentage of Respondent Physicians Providing Opinion on Health Issue Statements

Statement	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1. Outlaw Smoking					
All	73	11	5	5	5
By Gender					
Male	72	12	6	6	5
Female	79	9	4	4	4
By Location					
Rural	76	11	3	5	4
Urban	72	11	7	5	5
By Income					
<100,000	50	19	12	8	8
≥100,000	77	10	3	5	4
By BMI status					
Normal weight	70	11	6	5	5
Overweight	72	14	4	6	4
Obese	85	4	4	4	4
2. Regulate Food Ads					
All	44	16	17	7	16
By Gender					
Male	41	15	17	7	18
Female	52	18	14	5	9
By Location					
Rural	48	17	14	6	12
Urban	40	14	18	8	18
By Income					
<100,000	35	23	15	12	12
≥100,000	44	15	17	7	16
By BMI status					
Normal weight	40	16	13	10	18
Overweight	46	17	15	6	15
Obese	48	15	33	0	4
3. Snack Tax					
All	18	11	14	13	42
By Gender					
Male	17	12	12	10	46
Female	20	5	20	23	30
By Location					
Rural	17	12	12	12	4
Urban	18	9	16	14	41
By Income					
<100,000	12	4	39	15	27
≥100,000	19	12	12	13	44
By BMI status					
Normal weight	19	11	13	14	40
Overweight	13	8	21	13	44
Obese	30	15	4	15	37
4. Helmet Laws					
All	74	6	4	2	12
By Gender					
Male	70	8	5	3	14
Female	86	2	0	2	9
By Location					
Rural	75	5	4	3	11
Urban	73	8	3	2	13
By Income					
<100,000	69	4	8	4	12
≥100,000	74	7	3	2	12
By BMI status					
Normal weight	73	5	3	3	15
Overweight	71	10	6	3	10
Obese	82	4	4	0	11
5. School Snack Policy					
All	49	24	14	4	7
By Gender					
Male	46	25	14	4	8
Female	57	20	14	4	4

Table 3 continued on next page.

Table 3. Continued from previous page . . .

By Location					
Rural	49	24	14	2	8
Urban	49	24	14	6	6
By Income					
<100,000	35	15	42	0	4
≥100,000	50	25	10	5	8
By BMI status					
Normal weight	52	23	13	4	6
Overweight	43	25	17	4	10
Obese	44	30	15	7	4
6. Cigarette Tax					
All	62	16	8	2	11
By Gender					
Male	62	15	7	2	14
Female	61	20	13	2	4
By Location					
Rural	65	17	5	2	9
Urban	59	15	11	2	13
By Income					
<100,000	39	31	15	4	8
≥100,000	65	14	8	1	12
By BMI status					
Normal weight	60	17	9	1	12
Overweight	64	14	8	3	11
Obese	59	22	7	4	7
7. Government too Intrusive					
All	23	27	34	11	5
By Gender					
Male	24	28	32	11	4
Female	18	21	39	11	9
By Location					
Rural	30	30	29	6	4
Urban	17	24	38	14	6
By Income					
<100,000	23	27	39	8	0
≥100,000	21	26	34	11	6
By BMI status					
Normal weight	23	26	39	12	7
Overweight	25	29	35	7	1
Obese	19	26	33	15	7
8. Government Involvement Obesity Discrimination					
All	6	10	28	28	26
By Gender					
Male	6	11	26	29	27
Female	9	9	34	23	23
By Location					
Rural	6	8	32	26	26
Urban	7	12	25	29	26
By Income					
<100,000	12	4	42	23	15
≥100,000	6	12	25	28	27
By BMI status					
Normal weight	5	6	28	31	28
Overweight	4	11	36	22	22
Obese	11	26	11	30	22
9. Disability Extended to Obese					
All	13	13	19	27	26
By Gender					
Male	15	12	15	30	25
Female	7	14	29	18	29
By Location					
Rural	16	11	17	26	27
Urban	10	14	20	28	25
By Income					
<100,000	15	12	27	23	19
≥100,000	13	13	18	28	26
By BMI status					
Normal weight	13	11	18	28	28
Overweight	10	11	19	31	25
Obese	19	30	19	19	15

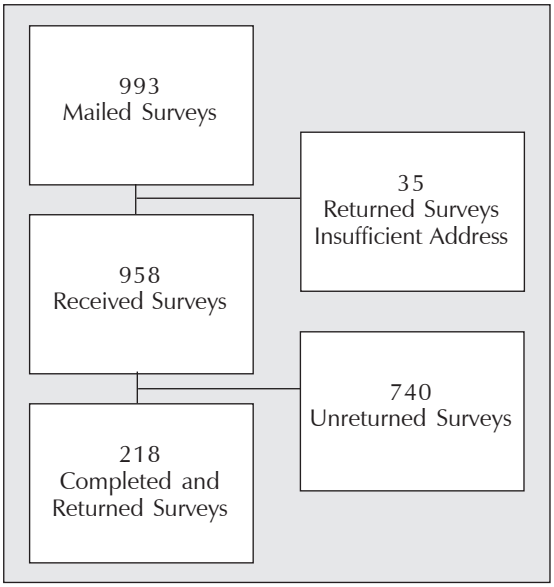

Figure 2. Response to Survey Mailing

more likely to agree or strongly agree with this statement (52%), compared to women (39%), a difference that was not statistically significant (p = 0.11).

The statements that address obesity-related policy issues focus on regulating food advertising (statement 2), taxing unhealthy foods to fund production and distribution of healthier foods (statement 3), eliminating public school concessions (statement 5), governmental role in anti-discrimination for obesity (statement 8) and providing disability protection and benefits for obesity (statement 9). The strongest support lies with school concession policies, with 73% reporting strong agreement or agreement and for regulating food ads, where 60% agree or strongly agree. However, only 29% agree or strongly agree with the taxing of unhealthy foods, compared to 78% for cigarette taxation, a statistically significant difference between response to issue (p = <0.0001). Support was particularly weak for governmental involvement in obesity discrimination, with only 16% of respondents agreeing or strongly agreeing. For the statement, "Overweight people should be subject to the same legal protections and benefits offered to people with other physical disabilities," only 26% expressed agreement or strong agreement.

The response to the obesity-related statements did appear to differ by weight status. In Table 4, the response to statements is displayed by BMI status. Obese and normal weight subjects are compared. Of particular interest is the significant difference in response to statement 8, which addresses anti-discrimination, and statement 9, which addresses disability status for obesity, where obese respondents were more likely to be in agreement. Still, for these two statements, those obese physicians who agreed (37% and 49%) were in the minority.

Table 4. Response to Obesity-Related Statements by BMI Status of Respondent

Statement	Percentage who Agree or Strongly Agree	P value
Statement 2. Regulate food ads		
Normal weight[1]	56%	NS
Obese[1]	63%	
Statement 3. Snack tax		
Normal weight	30%	NS
Obese	45%	
Statement 5. School snack policy		
Normal weight	75%	NS
Obese	74%	
Statement 8. Government involvement in obesity discrimination		
Normal weight	11%	P = 0.002
Obese	37%	
Statement 9. Disability extended to obese		
Normal weight	24%	P = 0.01
Obese	49%	

[1]Of respondents, there were 114 with BMI $\leq$ 25 Kg/m^2, 27 with BMI $\geq$ 30 Kg/m^2. There were 73 categorized as overweight (BMI 25-29.9 Kg/m^2), but they are not included in this table.

Table 5. Comparison of Response from Louisiana Physicians with the US Population

Statement	Strongly Agree	Agree	Strongly Agree and Agree
Statement 1. Ban public smoking			
US population	34%	34%	68%
LA physicians	73%	11%	84%
Statement 2. Regulate food ads			
US population	20%	37%	57%
LA physicians	44%	16%	60%
Statement 3. Snack tax			
US population	6%	11%	17%
LA physicians	18%	11%	29%
Statement 4. Helmet Laws			
US population	39%	42%	81%
LA physicians	74%	6%	80%
Statement 5. No school junk food			
US population	15%	32%	47%
LA physicians	49%	24%	73%
Statement 6. Cigarette taxes			
US population	23%	42%	65%
LA physicians	62%	16%	78%
Statement 8. Government more active in protecting obese			
US population	7%	39%	46%
LA physicians	23%	27%	50%
Statement 9.Disability extended to obese			
US population	7%	41%	48%
LA physicians	13%	13%	26%

DISCUSSION

The most striking finding from our analysis of physicians' attitude to public health policy and obesity is the disparity in attitudes toward obesity versus smoking and helmet law policy (Table 3). Whereas 62-74% of Louisiana physicians in our survey supported helmet laws and measures to regulate smoking space and cigarette taxes, only 44% strongly supported regulating food advertisements, 49% strongly supported regulating school snacks, and merely 16% supported taxing unhealthy foods. Even more striking is the lack of support for government involvement in obesity discrimination (6% strongly agreed) and in extending disability to the obese (13% strongly agreed). There was greater support for obesity-related policy among the obese respondents, but the level of enthusiasm for obesity-related policies was less than for smoking and helmet policies, even among the obese.

Our interpretation of these survey results is limited by several factors. First, our survey is limited to an analysis of 218 respondents (22% of those mailed). Thus, the results may be biased because more interested and committed physicians may have returned the survey. Second, the respondents were primarily male and Caucasian. We do not have an adequate sample to characterize response by both age and race. Third, while we characterized respondents according to parish, the parish we classified as urban (East Baton Rouge) is characterized by a mid-size city and a suburban lifestyle that may not differ significantly from some of the parishes we classified as rural.

In the survey conducted in 2001 by Oliver and Lee, a representative sample of the US population responded to the statements that we posed to Louisiana physicians.[7] Table 5 displays the response to eight of the statements from the 2001 survey by Oliver and Lee, compared to the Louisiana physicians' responses. Louisiana physicians voiced strong agreement more often to all the statements. Combining responses, strongly agree and agree, showed that except for the statement, "Overweight people should be subject to the same legal protections and benefits offered to people with other physical disabilities," Louisiana physicians were more likely than the population in general to support the statements. Compared to the US population, Louisiana physicians are stronger in their

support for helmet laws and cigarette measures, with more than twice the proportion voicing strong agreement for these measures. Louisiana physician support for the snack taxes, food ad regulation and school snack regulations, all targeting obesity, was evidenced by higher rates of strong agreement than the US population. However, those who indicated strong agreement or agreement to these measures among Louisiana physicians did not differ greatly. In terms of issues regarding obesity discrimination, there may not be a great difference in physician and general attitudes. Surprisingly, Louisiana physicians were less likely than the general population to support equal protection for the obese under discrimination statutes.

CONCLUSIONS

Obesity is a major health problem for Louisiana. According to the last survey of self-reported weight, Louisiana ranked seventh among the 50 states in prevalence of obesity.[9] Despite the prevalence of the disease, political response to the epidemic is only now emerging. If there is to be an effective public health campaign directed toward obesity, it will require the elite opinion signals of the medical profession to initiate and sustain policy action. Our survey indicates that support among Louisiana physicians for obesity-related policy is not equal to that for policies similar to those directed against smoking and helmet laws. However, we do demonstrate that Louisiana physician attitudes are more positive than the general population. Louisiana physicians can send the elite opinion signals to direct the policy action necessitated by the obesity epidemic, provided that the trend of supportive attitudes among physicians for these measures is amplified by key opinion leaders in the physician community.

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Can Obesity Prevention Work for Our Children?

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The prevalence of obesity in children and adolescents is higher than 20 years ago in all racial-ethnic, age, and gender groups. Research has lead to the discovery of many risk factors for obesity, which may help practitioners target at-risk individuals. Insight concerning obesity prevention can come from examining other public health programs, which center on prevention; such as smoking, seat belt use, and sexually transmitted disease. Another guide when establishing obesity prevention is evaluation of currently successful programs. Prevention and treatment interventions for childhood obesity should promote the replacement of unhealthy eating and exercise practices with healthier behaviors. The goal of prevention should always be maintenance of normal growth patterns, rather than weight loss. In predisposed children, sedentary, non-nutritious environments challenge metabolic capacity and promote overweight conditions, further inactivity and increased sedentary behaviors. This results in clinically significant obesity, reduced insulin sensitivity and ultimately type 2 diabetes later in life. Prevention of future chronic disease in children and adults may depend on our ability to prevent the onset of obesity in young children. This should be a primary goal of pediatricians, family health care professionals, and public health professionals.

The prevalence of obesity in children and adolescents is higher than 20 years ago in all racial-ethnic, age, and gender groups. In some population subgroups, more than 30% of children are overweight or at risk for being overweight.[1] Studies done by the Pennington Biomedical Research Center in Baton Rouge identified over 50%of the 12- to 14-year-olds were above the 85th percentile for weight. Unpublished studies conducted in New Orleans found that among 6- to 14-year-olds in four elementary schools, the percentage of children with body mass index (BMI) above the 95th percentile averaged 31%, and was as high as 43% among six year olds. (See Table 1). Unless intervention is successful these children will contribute to the already over 35% of adult Americans who are obese.[2] The related disease risks include diabetes mellitus, hypertension, heart disease, stroke, gout, arthritis and cancer.[1,3] The related health care costs of adult obesity are estimated to be 45.8 billion dollars.[1,4] Wang and Dietz found that the amount of pediatric hospital discharges for obesity-related conditions has risen dramatically from 1979-1999.[5] They estimate that the annual pediatric obesity-associated hospital costs have increased from $35 million during 1979-1981 to $127 million during 1997-1999. Given the statistics above, no one would argue that something needs to be done, but there seems to be a growing pessimism that anything can be done.[6] Certainly, obesity needs to be seen as the epidemic it is, and systemic changes need to be instituted to address this problem, rather than continuing to focus on individual change.[6] Prevention needs to be and has been attempted with varying degrees of success. Unfortunately, few programs have been reported, and those reports are variable in quality as well as approach. Although data are limited, information on causes and risk factors of pediatric obesity, prevention programs and pediatric weight treatment programs is available. The knowledge gained from these sources should help to guide existing and future programs to thrive and be effective. There is also considerable advocacy for primary care practitioners to be more aggressive with their patient counseling, which has been successful in changing other health behaviors. Examining all of these facets of what we do know is crucial, as the question is not can prevention work, but how to make it work and reverse the epidemic.

Table 1: Body Mass Index Data on Children from Four Elementary Schools in New Orleans.*

Mean Age (yrs)	N = all subjects	BMI > 95th (mean ± SD)	N > 95th BMI	% > 95th BMI
6	123	20.5±3.6	53	43%
7	125	22.4±3.5	44	35%
8	98	24.8±3.8	28	29%
9	111	24.6±2.7	31	28%
10	116	26.6±3.2	35	30%
11	89	28.5±3.7	27	30%
12	79	31.4±3.8	15	19%
13	67	30.9±3.1	17	25%
14	11	29.6±2.7	2	18%

* Printed with permission. Fagout G. unpublished thesis.

CAUSES OF CHILDHOOD OBESITY

Familial factors strongly impact the development of childhood obesity. Children with two obese parents have an 80% chance of developing obesity during their lifetime.[7,8] If only one parent is obese, this risk factor declines to 40%. Remarkably, only 7% of children born to lean par-

ents will develop childhood obesity.[7,8] However, it is unclear if these outcomes are based on environmental issues or genetic predisposition.[9] Bouchard suggests that in most individuals, the human variation in body composition is not associated with genetic predisposition.[10] These individuals may be positively impacted by appropriate clinical and educational interventions. Dietary intake and physical activity are behavioral and, thus, modifiable aspects of the prevention and treatment of childhood and adolescent obesity.[1] It is clear, that human obesity and metabolic disease are determined by a complex matrix of familial factors including genetics, culture, diet and activity patterns. Research during the last decade has focused on determining environmental conditions that promote obesity and metabolic disease in genetically vulnerable individuals. Current studies seek to identify genetic markers for fatness and altered metabolism. There are strong arguments for the impact of the genetic profile, as well as the early nutritional environment on the tracking of obesity from birth to adulthood.[11-13]

The concept of a thrifty genotype was first proposed by Neel almost 40 years ago.[13] Human populations exposed to nutritional stresses are proposed to have genetically selected *thrifty* metabolic profiles.[13,14] Genotypes with efficient methods of assimilating a limited food supply, if provided with unlimited access to high calorie foods, develop obesity.[15] This concept is supported by the observation that western dietary habits have led to an increase of metabolic disorders due to the thrifty genetic profile, especially in developing countries.[14] In other studies, patterns of intrauterine growth may be associated with obesity and chronic disease later in life.[11] Small size at birth caused by constraints in growth is associated with long-term metabolic and physiologic dysfunction.[12] Studies of Pima Indians and Pacific Island populations provide support for the genetic origin of the relationship of low birth weight to obesity and metabolic disease later in life.[16,17] However, Jackson et al and Lucas suggest that there exists a programming response established by the interaction of the infant and the environment during critical periods.[11, 18] The response establishes an upper limit of metabolic competence or the ability of an individual to cope with metabolic stress. Impaired metabolic competence, when combined with an environment that challenges an individual's ability to cope with metabolic stress, increases the risk of metabolic and physiologic dysfunction and ultimately chronic disease.[11] Ravelli and colleagues examined the impact of food deprivation in pregnancy using a large Dutch population during the winter of 1944-1945.[19] Adult obesity was highly correlated to famine during early pregnancy as opposed to late pregnancy. In contrast, Allison et al in a study of 13,000 twin pairs, reported that the intrauterine environment significantly impacted adult height independent of weight but not weight independent of height.[20] Other studies indicate that central adiposity may be more highly associated with retarded fetal growth than body weight.[21-23] Law et al studied 845 men and determined that increased waist for height ratio was associated with decreased growth during infancy.[23] Insulin resistance syndrome, which is closely related to central adiposity, has also been associated with low birth weights in both Caucasians and Hispanics.[24] The interaction of genetics and early human environment and its relationship to obesity and metabolic disease continues to be a fascinating area of investigation.[25]

Environmental factors may contribute as much as 80% to the causes of childhood obesity. These factors include increased calorie and fat intake, e.g., energy-dense foods and beverages, irregular meal patterns, snacking and dining out, and sedentary behaviors, such as television viewing and absence of regular physical activity.[26-28] Research suggests that obese children demonstrate decreased levels of physical activity and increased psychosocial problems.

RISK FACTORS FOR CHILDHOOD OBESITY

Research has lead to the discovery of many risk factors for obesity, which may help practitioners and programs to target at-risk individuals. Obesity results when susceptible individuals are placed in "adverse" environments.[1] In young children under 6 years of age, the most important of these environmental factors is parental obesity.[1] It is well accepted that the environment of the family plays a key role in young children at risk for adult obesity and related diseases such as diabetes.[29-32] Research shows that parent inactivity strongly predicts child inactivity.[31] Moreover, the exercise patterns of parents have a strong influence on the frequency of exercise in their children.[33] Research also shows that parental influences are early determinants of food attitudes and practices in young children.[34] Furthermore, food preferences greatly influence the consumption patterns of young children.[35] Efforts to halt and reverse obesity and related metabolic disease, therefore, should begin in childhood. More importantly, educational interventions that target the parents of children at risk for obesity should be an integral part of standard pediatric and family medical care.

Whitaker and colleagues identified parental obesity as an important predictor of adult obesity in both non-obese and obese children under 10 years of age.[8] Children one to two years of age with one obese parent expressed a 28% increased risk of obesity. In addition, the obesity status of children over six years of age was shown to be a strong predictor of adult obesity. However, before 3 years of age the obesity status of the child was not a predictor of adult obesity. But in non-obese children less than six years of age, obesity in both parents significantly increased the risk of adult obesity.[8] In a retrospective study of 3,277 obese adults, there was a stronger association of adult body adiposity with a mothers body com-

position than with a fathers.[36] A similar trend was found in obese grandmothers compared to the obese grandfathers of subjects studied.[36]

The prevalence of significant obesity early in life is steadily increasing.[37] Grundy cites the spread of Western lifestyle habits and industrialization as major risk factors for weight gain and its related metabolic abnormalities.[38] Recent studies show a consistent rise in the prevalence of obesity among preschool children from low-income families.[39] These children often have low levels of cognitive stimulation, which is associated with a significant increase in the risk for early onset obesity.[29] Similar findings have been noted among people of low educational achievement.[40] Similarly, the role of food insecurity in the inverse relationship of obesity and low socioeconomic status is evident but not well understood.[41] Though these studies suggest that people from low socioeconomic status should be targeted, one study showed that physicians were more likely to speak about physical activity with their patients who were from higher income brackets and who had higher educational achievement.[42]

The critical periods for the development of obesity in children include gestation, 5-6 years of age, and adolescence.[4,43] Research indicates that weight and adiposity are significantly influenced by early life experiences.[4,43] Both Dietz and Law et al propose that weight and adiposity are entwined during early life.[4,23] Jackson and colleagues provide a strong argument for nutrition-induced changes in the hypothalamic-pituitary-adrenal axis in the mother and the fetus.[11] The availability of nutrients during pregnancy, especially protein, has strong implications for future metabolic health. This relationship may reflect adjustments that occur to protect the brain preferentially over visceral and somatic growth resulting in an altered metabolic profile.[11] Stern and others suggest that the impact of a thrifty genotype on the birth weight may actually worsen an already altered metabolic profile later in life.[44] Thus, nutrition during pregnancy has strong implications for future obesity and related chronic disease. Moreover, low birth weight and breast feeding history are both factors in obesity development in young children. Current research suggests that breast-fed children have a lower risk of obesity than formula-fed children.[45-48] Infants fed longer at the breast have a lower risk of childhood obesity.[49] Hypotheses about this protective effect includes maternal dependence on satiety cues, differences in endocrine responses to formula and breast milk in terms of body fat deposition and increased acceptance of flavors by breastfed children because they have experienced more variety in breast milk flavors.[45-49] Five to six years of age has also been identified as a potential period of adiposity rebound in children.[10,50] An excessive protein intake earlier in life was shown to promote increased fatness at 8 years of age, suggesting that a high protein diet early in life could promote an increased risk of obesity later in childhood.[50,51]

There are several environmental factors that contribute to adult obesity. Low physical activity, calorie rich, high fat foods, and lowered exercise tolerance are some of the many factors contributing to development of obesity.[52,53] National survey data indicates that children are less active than in previous surveys due to an increase in sedentary activity time (TV and video games), less walking, fewer household chores, and less physical activity at school.[54] Most studies of the connection between television viewing and obesity show a direct correlation between the two. One study even showed that having a television in the bedroom was positively associated with children becoming obese.[55] These studies show an importance in developing programs to combat these environmental factors.

SUCCESSFUL PREVENTION PROGRAMS

Insight concerning obesity prevention can come from examining other public health programs, such as smoking, seat belt use, and sexually transmitted disease.[6] These programs are very similar to obesity prevention programs because they require behavior modification. They also address the environmental elements that work against healthy behavior, the idea of self- induced illness and the effect on personal freedom.[6] These health initiatives have all been at least moderately successful and should serve as good models.[6] They employ strategies that promote active decisions not to participate in unhealthy behavior, passive decisions to make participation in unhealthy behaviors difficult, encourage the gathering of knowledge, and make use of social marketing.[6] The programs are supported by a large number of stakeholders, and are well coordinated and evaluated.[6] Smoking prevention programs for adolescents are a good example of how research can help to refine programs. The Surgeon General's Report of 2000 details how these programs went from being based on an information deficit model, which supposed that adolescents would stop smoking if they knew it was bad for their bodies, to models addressing developing intrapersonal resources, and models focusing on social skills to resist peer pressure.[56] The treatment models changed as research showed that previous programs were ineffective, although basic information about the ill effects of smoking was retained. Programs today which have been shown to be effective are mostly school-based. Research has shown that increasing educational sessions with students result in more successful programs, suggesting a dose-response effect.[56] Shorter programs were found to have a short term effect and longer, more intense programs a more sustained effect. There is also some evidence that smoking prevention worked within larger programs addressing other substance use as well, increasing confidence that broader programs can work. In fact, programs using the broadest curriculum addressing changing health behavior seem to be effective with a range of populations. Research with the social influences model was also carried out across

several different geographical areas and populations and using different personnel, in order to show the generalizability of these programs. Publications regarding multifaceted anti-smoking programs in our pro-smoking environment may be helpful in establishing obesity prevention programs in schools in the current obesogenic environment.[56]

PEDIATRIC WEIGHT MANAGEMENT PROGRAMS

Another guide when establishing obesity prevention is evaluation of currently successful programs in the management of childhood obesity.[57, 58] Although long-term maintenance of weight loss in obese adults is rare, research indicates that weight loss during childhood can be maintained into adulthood.[1,58] The goal of an obesity prevention and treatment program for children must allow for adequate nutrition for growth and development. Prevention and treatment interventions for childhood obesity should promote the replacement of unhealthy eating and exercise behaviors with healthier behaviors.[1, 59-60] Reducing television viewing time, increasing sports and leisure physical activity time, avoiding snacking, replacing high sugar beverages with water, and regulating meal times are examples of simple measures to reduce the risk of obesity in children.[61-63] By the time children enter kindergarten, their food preferences and the social context with which they associate foods are already established.[64] Infants whose parents were instructed in health education emphasizing fat-prudent diets were less likely to be obese at 3 years than age-matched controls.[43] Therefore, educating the families of young children about nutrition may have a powerful, positive impact on the obesity risk of those children, especially those with obese parents. Successful prevention should therefore include family interventions with nutrition and physical activity education, and behavior modification. A team of health care experts in a nurturing, non-intimidating environment should deliver these interventions. This type of approach has been used in a school setting with some success.[65]

OBESITY PREVENTION PROGRAMS

Studies of obesity prevention programs are somewhat limited, both in quantity and quality, making the development of conclusions difficult. Hardeman et al conducted a systematic review of programs for all ages and found varying degrees of effectiveness among nine identified programs.[66] The programs varied in approach, behavior model, length of follow up, and what was measured. Only five of eleven approaches described a randomized controlled trial. The programs were generally not well described, therefore making it difficult to replicate. The authors felt that effectiveness might have been better demonstrated if the programs had more objective measures and if there had been longer periods of follow up. Campbell et al performed a similar review specifically for pediatric obesity prevention programs, which included seven studies.[67] Three were long-term (over 1 year) and four were short-term, making it inappropriate to combine study outcomes statistically. Most of the programs were school-based and focused on healthy eating habits and/or physical activity. Two of the long term and two of the short term interventions showed a positive effect on the prevalence of obesity in the intervention versus control group, giving some hope for prevention programs.

Stolley et al performed a randomized controlled study using a community based tutoring intervention program for mothers and daughters.[68] The eleven-week program focused on eating a low fat, low calorie diet as well as increasing physical activity. The subjects were all African-American and of low socioeconomic status, but the program was tailored to be culturally sensitive. Outcome measures included weight, height, daily caloric intake, fat gram intake, percent of calories from fat, saturated fat, and dietary cholesterol. A measure of parental support and role modeling was used which had not been validated for children. Body mass index showed no significant change, though weight data specifically was not reported for baseline or follow up. However, there was a significant decrease in the amount of saturated fat consumed by mothers and a decrease in calories from fat consumed by mothers and daughters. These results suggest some success in changing behavior, which perhaps would have yielded some weight change if monitored for a longer period of time.[68]

Flores conducted a twelve-week, randomized controlled trial on the effects of using a physical education class for preadolescents.[69] The class consisted of fifty minutes of aerobic dance, given three times a week along with a health education class. Though the baseline population contained a mixture of boys and girls, the follow up group was composed of all girls, with no mention of male dropout. All participants were either African-American or Hispanic. Outcome measures were weight, height, a timed mile run, resting heart rate, and an attitude survey regarding physical activity.

In Italy, Simonetti et al compared two types of dietary education over a one-year period.[70] Schools were divided into three groups: those receiving a multimedia program, those receiving a written program, and those receiving no program. The multimedia program consisted of written pamphlets, audiovisual aids and a group of professionals to present the material, while the written program only consisted of the pamphlets. Though baseline differences between the groups were not discussed, the multimedia group had a larger BMI than either of the other groups, and the written group had a larger BMI than the control group. BMI was the only outcome measure. A twelve percent decrease in the prevalence of obesity and a twelve percent decrease in the

prevalence of overweight was noted over the study period in the multimedia group, whereas the written and control groups showed no changes.[70]

Robinson developed a short-term program simply focused on reducing television and video game time at home.[71] Eighteen lessons, 30-50 minutes in length, were given to an intervention group as part of the standard school curriculum for 3rd and 4th graders. The children were asked to turn off the TV for a set period of time and were asked to budget a maximum of seven hours of TV/video per week. Parents and children were asked about the children's TV time, time spent doing other sedentary activities, meals eaten in front of the TV, and a 24-hour activity checklist. All of these measures were validated prior to starting the study. Weight, height, triceps skinfolds and waist and hip circumferences were taken at baseline and follow up. Over a six-month period, the intervention group had decreases in BMI, triceps skinfold thickness, waist circumference, television viewing time, and meals eaten in front of the television, while there were no differences in the control group. This is a promising, population-based approach to the problem.[71]

Gortmaker et al developed "Planet Health".[72] This is a school-based obesity program that focuses on decreasing television time, decreasing high fat foods, increasing fruit and vegetable consumption and increasing moderate and vigorous physical activity. Lessons regarding these four goals were incorporated into language arts, math, science and social studies classes, as well as a physical education class. The investigators conducted a randomized controlled trial with intervention and control groups with an eighteen-month follow up period. Outcome measures included weight, height, and triceps skinfolds. Self-report measures were also used, specifically a food and activity survey, a TV/video measure, a youth activity questionnaire, and a food frequency questionnaire, all of which were validated. BMI decreased among girls in the intervention group and increased in girls in the control group. There was no change in BMI for the boys in either group. There was a significant decrease in time spent watching television among both girls and boys, and each hour of decrease resulted in a decrease in obesity prevalence. The girls in the intervention group also showed an increase in their fruit and vegetable consumption and a decrease in their total energy intake. It was also noted that extreme dieting behavior was low and the same between the intervention and control groups with no change during the study period.[72]

Interestingly, Wang et al conducted an economic analysis of the Planet Health program to assess the cost-effectiveness and cost-benefit.[73] Estimating intervention costs at $14 per student, the program would prevent almost 2% of the female students (5.8 of 310) from becoming overweight adults. An estimated 4 quality-adjusted life years would be saved, and society would save about $16,000 in medical care costs and about $25,000 in lost productivity. These results show a cost of $4300 per quality adjusted life year saved and a total saving to society of $7300. When the cost per quality adjusted life year is less than $30,000, the prevention program is considered cost-effective. This is based on studies of other kinds of prevention programs than obesity, since there have not been enough research done on obesity programs. A univariate sensitivity analysis showed that the program should be cost-effective and cost-saving in other locations as well, as long as the effectiveness of the program stays at the base case level. This analysis should be performed on all up and coming obesity prevention projects so as to give federal- and state-level decision makers the knowledge they need to know how to spend health care dollars. [74]

When attempting to prevent obesity among children, most researchers have developed school-based programs, such as Planet Health, due to the population and the availability of resources. There have been some community-based programs for adults, though this data is limited.[40] The Stanford Five-City Project was an extensive multi-media education program of cardiovascular disease risk factors, targeting everyone ages 12-74 in two cities. There were two control cities with no intervention. The Minnesota Heart Health Program instituted a social and behavioral management program that alerted people to primary prevention and advocated behavioral change in three communities with three control communities for comparison. Both programs saw a rise in body mass index in both the intervention and control group, which does not speak well for the community approach. However, studying these programs to determine how to make refinements may lead to effective changes.[40]

THE ROLE OF THE PRIMARY CARE PRACTITIONERS

The potential role of prevention through primary care is currently underrated by the medical community.[28] This is a grave mistake made by practitioners, especially considering there is evidence to show an effect on patients with regard to physical activity, breast feeding, and smoking.[75-77] Although studies of the effects of physician counseling on pediatric obesity have not been done, studies in adults have shown that patients are more likely to engage in weight loss activities when counseled.[30] In one study, it was concluded that frequent medical clinic visits of preschool aged children might reduce the degree of obesity.[3] The Committee on Nutrition of the American Academy of Pediatrics recommends early recognition of both risk factors for obesity as well as irregular increases in growth.[79] The Committee also recommends that research be done on primary prevention in the primary care setting, so as to develop effective strategies. Effective strategies will involve a multidisciplinary approach, combining the efforts of physicians, nurses, dieticians, behavioral psychologist, physical therapists a and exercise physiologists.[79] In an unpublished study

Table 2. Patients Diagnosed and Referred for Treatment from Physicians in Lafayette, Louisiana.*			
	Dr. A	**Dr. B**	**Dr. C**
Total number of patients	552	205	294
Total number obese	69	30	30
Percent Obese	12.5%	14.83%	10.20%
Total number diagnosed with obesity	19	12	0
Percent diagnosed	27.54%	40.00%	0%
Total number referred for obesity treatment	6	2	0
Percent referred for treatment	8.70%	16.67%	0.00%
* Printed with permission. Fagout G. unpublished thesis.			

performed in three pediatric offices in Lafayette, practitioners attached diagnoses of obesity to very few of their obese patients, and referred fewer for treatment, proving that identification is still difficult. (See Table 2.) When growth abnormalities are noted, they should be discussed with parents, who may be over or under concerned, or who may not know the associated risks.[80] Sarah Barlow and William Dietz published an article outlining the guidelines for practitioners to identify, evaluate, and treat their overweight pediatric patients.[81] The article reviews how to calculate BMI, as well as how to identify cutoff values, stressing the importance of noting increases that may still be within the normal range but may signal an abnormal accumulation of weight. They also stress beginning dialogue early and making education and treatment a family affair. Targeting families of susceptible children with nutrition and lifestyle behavior education may create an added benefit for other family members.[28]

The goal of prevention should always be maintenance of normal growth patterns, rather than weight loss.[82] The types of advice that practitioners should give will vary with age.[83] Perinatal advice will include the discussion of appropriate maternal weight gain, good prenatal nutrition and activity patterns, and the importance of breastfeeding. During infancy, the practitioner should continue to support breastfeeding to one year of age if possible and encourage parents to help their child develop healthy food preferences and maintain healthy eating habits for both themselves and their children. Practitioners should continue this advice into the preschool years, monitoring children for any abnormal increases in weight. For school-age children, parents should be aware of what kind of school lunch their child is receiving, and how often the children are allowed to be active. Both parents and practitioners can be advocates for healthy changes in the school environment.[79, 83] Adolescents require one on one intervention with their practitioner, who should provide nutrition and activity information and reinforce healthy behaviors. There are many opportunities for practitioners to make a difference during well-child visits, and opportunities should not be missed.

CONCLUSION

It is well known that, if untreated, 80% of obese 10-13 year old children will become obese adults.[31, 32] A large percentage of obese adults will develop Type 2 diabetes.[84] especially those with obese parents and a family history of the disease.[1] Subjects with low levels of leisure time physical activity also have a greater diabetes risk.[85] Jackson suggests that genetic make-up determines the limits of metabolic function; but, the environmental experience contributes to obesity and metabolic disease.[86] The current environmental experience of young children includes few opportunities for physical activity and an overabundance of high calorie foods.[59] Sedentary lifestyles and poor nutrition challenge children who are genetically predisposed to diabetes. Obesity is a logical response to this challenge. Therefore, in predisposed children (e.g., those with obese parents and/or a family history of diabetes), sedentary, non-nutritious environments challenge metabolic capacity and promote overweight conditions, reduced fitness, further inactivity and, increased sedentary behaviors (TV watching and snacking). This results in clinically significant obesity, reduced insulin sensitivity and ultimately type 2 diabetes in adulthood. Research suggests that increasing physical activity and improving nutrition may significantly affect this series of events.[72,87-88]

By utilizing selective prevention measures it is hoped that successful prevention of obesity in young children is feasible.[28] To date, there are few controlled trials that have successfully illustrated prevention of obesity in non-obese children.[28] More prospective research is needed in order to identify effective strategies for preventing obesity. Controlled trials are required to examine the impact of family-based educational interventions on young children at risk for obesity.[1-3, 43] This is especially true in minority and low-income populations.[1-2, 89] The programs would be well served to build themselves upon a behavior model, and should use objective measures to show effectiveness.[66] Longer periods of follow up would also help to show effectiveness.[66, 67] Describing the programs in detail in the literature would help others replicate successful programs.[66] There needs to be publication of programs that do not work to learn from them as well.[66] All programs should be subjected to economic analysis to determine which are the most cost-saving and cost-effective to make funds invested in prevention stretch as far as possible.[74] Prevention of future chronic disease in children and adults may depend on our ability to prevent the onset of obesity in young children. Prevention of obesity in young children should be a primary goal of pediatricians, family health care professionals, and public health professionals.

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Obesity Related Morbidity and Mortality

Tracie Manuel Bellanger, MD, MPH and George A. Bray, MD

The epidemic of obesity has highlighted the extent of the risks associated with this disease. The risks arise from the increased mass of fat tissue, as well as the products produced by the increased number and size of fat cells in obese individuals. Psychosocial dysfunction, obstructive sleep apnea, and osteoarthritis can be a direct result of increased fat mass. Other diseases associated with obesity result from the metabolic consequences of enlarged fat cells. Diabetes, gallbladder stones, high blood pressure, liver disease, coronary artery disease, cerebrovascular disease, certain types of cancers, and infertility can all be traced in part to the increased secretion of inflammatory and coagulation molecules from fat cells. Finally, obesity also increases overall mortality. It is clear from this review that the morbidity and increased mortality of overweight and obesity is substantial and should prompt further attention towards the need for appropriate weight management in health care.

During the past few decades, the prevalence of obesity in the United States has increased to dramatic, near epidemic, proportions. Based upon National Health and Nutrition Examination Survey (NHANES) data, which utilizes directly measured BMI data, the prevalence of obesity (body mass index $\geq$ 30 kg/m^2) in both men and women age 20 to 74 has increased from 13.4% during 1960-1962 to 30.9% during 1999-2000[1] (Figure 1). It is currently estimated that at least 64% of adults in the US, or 110 million people, are either overweight or obese.[2] The state of Louisiana has experienced increased rates of obesity to an even greater extent. Based upon self-reported height and weight data (subject to under-reporting error), the prevalence of obesity among adults in Louisiana in 2001 was 23.3%, compared to 20.9% in the country as a whole.[3]

Health care costs related to obesity have substantially increased over the past few decades, as well. It has been estimated that obesity accounts for 5.5-7.0% of national health care expenditures in the US.[4] and that direct (medical expenses) and indirect (value of lost productivity) costs of obesity exceed $100 billion each year.[5]

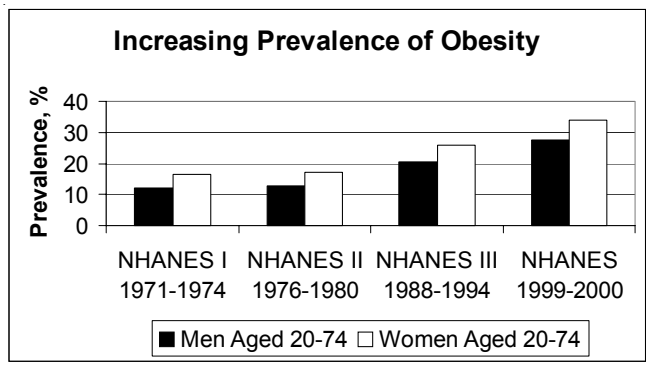

Figure 1. Increasing Prevalence of Obesity. The above figure demonstrates the dramatic increase in the prevalence of obesity (BMI $\geq$ 30 kg/m^2) from 1971 through 2000, as documented by NHANES data.[1]

CME Information

Target Audience

"Obesity Related Morbidity and Mortality" is intended for primary care physicians and nurses, endocrinologists, gastroenterologists, diabetologists, cardiologists, and surgeons interested in obesity.

Educational Objectives

After reading the article, the healthcare provider should know that overweight is a BMI of 25-29.9 and obesity is a BMI $\geq$ 30 kg/m2 and that this disease costs about 5.5-7% of healthcare expenditure. The healthcare provider should also know the medical complications of obesity and that they can result from increased fat mass as well as the increased secretion of many products by fat cells.

Credit

The LSMS Educational and Research Foundation designates this educational activity for a maximum of 1 category 1 credits toward the AMA Physician's Recognition Award. Each physician should claim only those hours of credit that he/she actually spent in the educational activity.

Disclosure

Dr. Bellanger has nothing to disclose.
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Table 1. Cost of Obesity in the United States, 1995[5]	
Disease	**Direct Cost in Billions**
Diabetes mellitus	$32.4
Coronary heart disease	$ 7.0
Osteoarthritis	$ 4.3
Hypertension	$ 3.2
Gallbladder disease	$ 2.6
Colon cancer	$ 1.0
Breast cancer	$ 0.84
Endometrial cancer	$ 0.29

Table 1 provides an estimate of the direct cost of obesity that is attributable to various medical conditions in the United States, for the year 1995.

Several studies have also demonstrated increasing health care costs at the individual level that directly correspond to increasing body mass index (BMI). One such study demonstrated that in a large health-maintenance organization, mean annual costs were 25% higher in participants with a BMI between 30 and 35 kg/m^2, and were 44% higher in those with a BMI above 35 kg/m^2, when compared with "normal weight" individuals with a BMI of 20-25 kg/m^2.[6]

Unfortunately, economic costs are not the only costs associated with the rising prevalence of obesity. The health risks of obesity are profound, and encompass a wide range of disease processes leading to significant morbidity and mortality.[7] In this review, we will discuss the morbidity and mortality associated with obesity, in the context of the pathologic lesion of obesity—the hyperplasia and hypertrophy of fat cells.

PATHOGENESIS

Obesity develops when a person ingests more energy than is expended over a long period of time. While genetic background can explain about 40% of the variance in body mass in humans, changes to the genome alone have not resulted in the marked increase in prevalence of obesity over the past few decades (genetic mutation and selection are too slow). It is rather, changes in our environment that have led to both increased energy intake and a decline in physical activity,[8-11] which are most likely responsible for the increased obesity prevalence.

Excess energy that is ingested is stored in fat cells that enlarge and/or increase in number. It is this hyperplasia and hypertrophy of fat cells that is the pathologic lesion of obesity.[12,13] The clinical manifestations of obesity develop from two types of functional impairments caused by the increased size and mass of fat cells.

The first type of functional impairment in obesity involves the increased mass and physical weight of the fat cells themselves. This causes the physical appearance of obesity, leading to the psychosocial responses to the overweight individual. The increased mass also brings increased amounts of physical stress on bones and joints, contributing significantly to conditions such as osteoarthritis. In addition, the location of the increased mass of fat itself can cause other obstructive types of health problems, like sleep apnea.

Table 2. Relative Risk (RR) of Health Problems Associated with Obesity in Developed Countries[66]
Greatly Increased (RR >3)
Diabetes
Gallbladder disease
Hypertension
Dyslipidemia
Insulin resistance
Breathlessness
Sleep apnea
Moderately Increased (RR 2-3)
Coronary heart disease
Osteoarthritis of the knees
Hyperuricemia and gout
Slightly Increased (RR 1-2)
Cancer (breast cancer in postmenopausal women, endometrial cancer, colon cancer)
Reproductive hormone abnormalities
Polycystic ovary syndrome
Impaired fertility
Low back pain
Increased anesthetic risk
Fetal defects from maternal obesity

The second type of functional impairment in obesity involves the metabolic consequences resulting from the excessive secretion of products by the enlarged fat cell.[13] As the fat cells increase in size, they produce increased amounts of a variety of peptides, including leptin, cytokines, angiotensinogen, adipsin, etc., and metabolites such as free fatty acids and lactate.[12,13] The products of the fat cell in turn modify metabolic processes in the host. For the susceptible host, these metabolic changes lead in turn to a variety of metabolically related health conditions, including hyperinsulinemia, hypertension, gallbladder disease, etc. Table 2 shows the relative risks for many health conditions among obese individuals.

DISEASES ASSOCIATED WITH INCREASED FAT MASS

Psychosocial Function

Obesity is associated with impaired quality of life. One study that utilized the Medical Outcomes Study Short-form Health Survey (SF-36) demonstrated that obese people presenting for treatment at a weight management center had profound abnormalities in health related quality of life.[14] Higher BMI values were associated with greater adverse effects. Obese women appear to be at greater risk of psychological dysfunction, when compared to obese men; this is potentially due to increased societal pressures on women to be thin.[15]

Intentional weight loss has been consistently associated with improved quality of life.[16] Severely obese patients who lost an average of 43kg through gastric bypass demonstrated improvements on all domains of the SF-36 to such an extent that their post-weight loss scores were equal to or better than population norms.[17]

Obstructive Sleep Apnea

Obstructive sleep apnea, characterized by multiple apneic episodes despite persistent respiratory efforts, is often due to either partial or complete upper airway obstruction by increased amounts of periluminal fatty tissue and/or increased pressure on the wall of the pharynx.[18] Risk of sleep apnea is significantly correlated with obesity, with those having a BMI of at least 30 at greatest risk.[18, 19] Symptoms of sleep apnea have also been shown to improve with weight loss.[18]

Obesity can also lead to respiratory compromise through increased weight on the thoracic cage and abdomen. This causes decreased respiratory compliance, increased work of breathing, and restricted ventilation as measured by decreased total lung capacity, forced vital capacity, and maximal ventilatory ventilation.[18]

Osteoarthritis

The risk of osteoarthritis in weight bearing joints, especially the knees, increases significantly with overweight and obesity.[20, 21] When compared to those with a BMI of 25-29.9 kg/m^2, people with a BMI of 30 or greater are at markedly increased risk for osteoarthritis of the knee.[22] The effect of obesity on osteoarthritis is most likely due to increased stress on weight bearing joints.[23] However, dietary and metabolic factors have also been implicated.[24]

DISEASES ASSOCIATED WITH INCREASED METABOLIC ACTIVITY OF FAT CELLS

Type 2 Diabetes Mellitus

Type 2 Diabetes Mellitus (DM) is strongly associated with overweight and obesity in both genders and in all ethnic groups.[25, 26] The risk of Type 2 DM increases with the degree and duration of overweight, as well as a more central distribution of body fat. The Nurses Health Study demonstrated a curvilinear relationship between increasing BMI and the risk of diabetes in women.[27] Those individuals with a BMI below 22 kg/m^2 had the lowest risk of diabetes. As BMI increased, the relative risk increased, such that at a BMI of 35 kg/m^2, the relative risk of diabetes increased 40-fold or 4,000%. A similar strong curvilinear relationship was observed in men in the Health Professionals Follow-up Study.[26] The lowest risk of diabetes was associated with a BMI below 24 kg/m^2 (slightly higher than for the women in the Nurses Health Study). At a BMI above 35 kg/m^2, the age-adjusted relative risk for diabetes increased to 60.9, or more than 6,000%!

In the Swedish Obese Subjects Study, Sjostrom et al observed that diabetes was present in 13-16% of obese subjects at baseline.[28] Of those who underwent gastric bypass and subsequently lost weight, 69% who initially had diabetes went into remission, and only 0.5% of those who did not have diabetes at baseline developed it during the two years of follow-up. In contrast, the obese control group that lost no weight had only 16% of those with diabetes experience remission, while the incidence of new diabetic cases was 7.8%.

Weight loss or moderating weight gain over years reduces the risk of developing diabetes. This is most clearly shown in the Health Professionals Follow-up Study, in which relative risk declined by nearly 50% with a weight loss of 5-11 kg.[26] Type 2 DM was almost nonexistent with a weight loss of more than 20 kg or a BMI below 20 kg/m^2.

Hypertension

Blood pressure often is increased in overweight individuals.[29] In the Swedish Obesity Study, hypertension was present at baseline in 44-51% of subjects. One estimate suggests that control of overweight would eliminate 48% of the hypertension in Caucasians and 28% in African Americans.

Overweight and hypertension interact with cardiac function. Hypertension in normal weight people produces concentric hypertrophy of the heart with thickening of the ventricular walls. In overweight individuals, eccentric dilation occurs. The combination of overweight and hypertension leads to thickening of the ventricular wall and larger heart volume, and thus to a greater likelihood of cardiac failure.

Gallbladder Disease

Cholelithiasis is the primary hepatobiliary pathology associated with overweight. The Nurses' Health Study demonstrated the increasing incidence of clinically symptomatic gallstones with increasing BMI.[30] When compared with those having a BMI or 24 kg/m^2 or less, those women with a BMI greater than 30 kg/m^2 had a 2-fold increased risk of symptomatic gallstones, while those with a BMI greater than 45 kg/m^2 had a 7-fold increased risk of symptomatic gallstones.

For reasons that are unclear, the relative increased risk of symptomatic gallstones with increasing BMI is less for men than women. When both genders were matched on BMI, two large prospective studies of men have demonstrated the prevalence of gallstones was lower in men than in women.[31, 32]

Ironically, weight loss also leads to increased risk of gallstones due to increased bile cholesterol supersaturation, enhanced cholesterol crystal nucleation, and decreased gallbladder contractility.[33] In obese patients who experience rapid weight loss after gastric surgery, the incidence of new gallstones is approximately 35%.[34] Diets with moderate levels of fat that trigger gallbladder

contraction and subsequent emptying of the cholesterol content may reduce the risk of gallstone formation. Similarly, the use of bile acids, such as ursodeoxycholic acid, can be effective at decreasing gallstone formation and should be considered if the risk of gallstone formation is increased.[35]

Liver Disease

Nonalcoholic fatty liver disease (NAFLD) is the term given to describe a constellation of liver abnormalities associated with obesity, including hepatomegaly, elevated liver enzymes, and abnormal liver histology such as steatosis, steatohepatitis, fibrosis, and cirrhosis.[36] A retrospective analysis of liver biopsy specimens obtained from overweight and obese patients with abnormal liver biochemistries but without evidence of acquired, autoimmune, or genetic liver disease, demonstrated a 30% prevalence of septal fibrosis and a 10% prevalence of cirrhosis.[37] Another study utilizing a cross-sectional analysis of liver biopsies, suggests that in obese patients, the prevalence of steatosis, steatohepatitis, and cirrhosis are approximately 75%, 20%, and 2% respectively.[38]

Cancer

Overweight and obesity are associated with an increased risk of esophageal,[39] gallbladder, pancreatic,[40] cervical, breast, uterine, renal,[41] and prostate cancer.[42, 43] It is, however, difficult to separate the effect of a high-fat, high-calorie diet from obesity itself, in regards to increased cancer risk.

Coronary Artery Disease

Obesity is associated with an increased risk for coronary artery disease (CAD).[44] This is especially true for those with increased abdominal fat distribution. Data from the Nurses Health Study demonstrated that women in the lowest BMI but highest waist-to-hip circumference ratio had a greater risk of myocardial infarctions than those in the highest BMI but lowest waist-to-hip circumference ratio.[45]

The increased risk of CAD is felt to be mostly secondary to the increased rate of obesity related CAD risk factors, such as hypertension, dyslipidemia, and diabetes. However, several long-term epidemiological studies, after correcting for other risk factors, have still provided evidence that overweight and obesity acted as independent risk factors for CAD.[46, 47] As a result, the American Heart Association added obesity to its list of major risk factors for CAD.[48]

Cerebrovascular Disease

The risk of ischemic strokes in men[49] and women[50] is increased in both overweight and obesity. With increasing BMI, the risk of ischemic stroke increases progressively and is doubled in those with a BMI greater than 30 kg/m^2 when compared to those with a BMI less than 25 kg/m^2. Overweight and obesity do not increase the risk of hemorrhagic strokes.

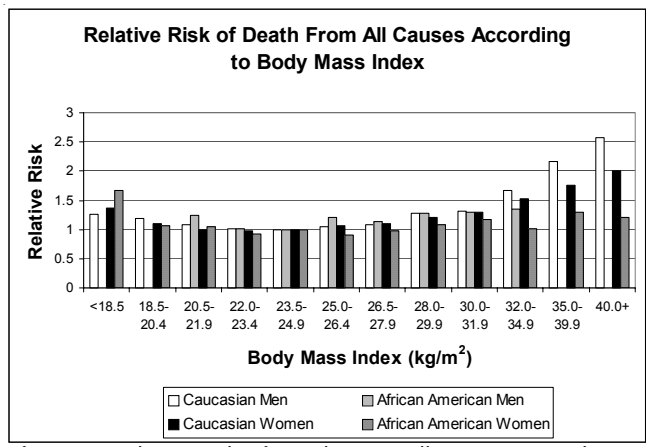

Figure 2. Relative Risk of Death From All Causes According to Body Mass Index The above figure illustrates the relative risk of death from all causes among subjects who had never smoked and had no history of disease, according to body mass index and race.[6] Subjects with a BMI of 23.5-24.9 was utilized as the reference category.

Infertility

Irregular menses, amenorrhea, and infertility are associated with obesity.[51] Women with a BMI greater than 30 kg/m^2 have abnormalities in secretion of hypothalamic gonadotropin releasing hormone (GnRH), pituitary luteinizing hormone (LH), and follicle stimulating hormone (FSH), which results in anovulation.[52]

MORTALITY

Years of Life Lost

Using data from the Framingham Study, Peeters et al estimated that non-smoking women who were overweight (BMI 25-30 kg/m^2) at age 40 lost 3.3 years and male non-smoking men lost 3.1 years compared to normal weight men and women.[53] Non-smoking women with a BMI > 30 kg/m^2 lost 7.1 years of life, while male non-smokers lost 5.8 years. Data from the Third Health and Nutrition Examination Survey found that the optimal BMI for longevity in Caucasians was between 23-25 and in African Americans was between 23-30 kg/m^2.[54] The years of life lost with a BMI > 45 kg/m^2 was 13 years for Caucasian men and 8 years for Caucasian women. The effect on years of life lost in African American women was considerably less, suggesting important ethnic differences in the health manifestations of obesity.

Excess Body Weight

The mortality associated with excess weight increases as the degree of obesity and overweight increases. One study estimated that between 280,000 and 325,000 deaths

could be attributed to obesity annually in the United States.[55] More than 80% of these deaths occur among people with a BMI >30 kg/m^2. The increase in death from obesity has been documented in a number of studies around the world.

Nurses' Health Study — In the Nurses' Health Study, the risk of death rose progressively in women with a BMI above 29 kg/m^2.[47] Mortality was lowest among women who weighed at least 15% less than the United States average for women of similar age and among those whose weight had been stable since early adulthood.

American Cancer Society's Cancer Prevention Study I — Among 62,116 white men and 262,019 white women (both groups were healthy non-smokers) who were followed for 14 years, a greater BMI was associated with increased rate of death from all-causes and from cardiovascular disease in both groups up to age 75 years.[56] The impact of the excess body weight was higher among younger subjects than older ones.

American Cancer Society's Cancer Prevention Study II— In an even larger study (457,785 men and 588,369 women) with a 14-year follow-up, the association of BMI and mortality was affected by smoking status and history of other disease.[6] Among the non-smokers, the lowest mortality for men was in the BMI group 23.5-24.9 kg/m^2 and for women it was in the BMI group 22.0-23.4 kg/m^2. Among Caucasian subjects with a BMI $\geq$ 40 kg/m^2 the relative risk of death was 2.6 times higher for men and 2.0 times higher for women compared with those having a BMI between 23.5-24.9 kg/m^2. African American men and women had lower risks than corresponding categories of Caucasians (Figure 2). Among African American women with a BMI $\geq$ 40 kg/m^2, the relative risk of death was 1.2 compared to 2.0 for Caucasians; among African American men with a BMI of $\geq$ 32.0, the relative risk of death was 1.35 compared to 1.66 for Caucasians (the limited number of male African American deaths prevented analysis at BMI $\geq$ 40). There was no effect of age, and the risk of death or cardiovascular disease did not significantly increase over the BMI range 22.0-26.4 kg/m^2 for men and 20.5-24.9 kg/m^2 for women.

Aerobics Center Longitudinal Study — In this study 25,714 men were followed from 1 to 10 years. The all-cause mortality and cardiovascular mortality was higher in men with a BMI > 30 kg/m^2, and lowest in those with a BMI between 18.5-24.9 kg/m^2.[57] Deaths from cardiovascular disease increased from just over 5 deaths/10,000 man years to nearly 8 deaths/10,000 man-years to nearly 12 deaths/10,000 man-years for men with a body fat percentage of < 16.7, 16.7 to < 25.0, and > 25.0, respectively.

Finnish Heart Study — The association between obesity and the risk of death from CAD was confirmed by a study of 8373 Finnish women (aged 30 to 59 years) followed for 15 years.[58] This study found that, for each increase in body weight of approximately 1 kg, the risk of coronary mortality increased by 1-1.5%. A substantial part of this risk was mediated through the link between body weight and blood pressure.

Regional Fat Distribution

Regional fat distribution is also important in the risk of death.[59, 60] The life insurance industry first noted this at the beginning of the 20th century. The Framingham Study has examined the relationship between fat distribution and metabolic risk factors.[61] Three clusters could be detected with some overlap. The metabolic complex of insulin, glucose, triglycerides, and BMI was one constellation. A second cluster included cholesterol, low-density lipoprotein cholesterol, and high-density cholesterol. The final cluster was BMI, systolic blood pressure, and diastolic blood pressure.

Weight Gain

In addition to overweight and central fatness, the amount of weight gain after age 18 to 20 also predicts mortality. This is clearly illustrated for cardiovascular disease in the Nurses' Health Study, in which a graded increase in mortality from heart disease is associated with increasing degrees of weight gain.[62] A gain of more than 10 kg indicates a higher level of increased risk. Weight gain in men after age 20 in the Health Professionals Study showed a similar relationship.

Sedentary Lifestyle

A sedentary lifestyle is the final important component in the relationship of excess mortality to obesity. A sedentary lifestyle increases the risk of death at all levels of BMI.[63] Unfit men in the BMI range below 25 kg/m^2 had a significantly higher risk than the men with a high level of cardiorespiratory fitness. Obese men with a high level of fitness had risks of death that were not different from the fit men of normal body fat. A similar relationship was found with waist girth. Men who were physically unfit had significantly higher risk of death at any level of waist circumference than men who were physically fit.

Intentional Weight Loss

If overweight increases risk of mortality, then we would anticipate that intentional weight loss would reduce it. A definitive demonstration of this prediction is not available, but several studies suggest that intentional weight loss does reduce risk. Weight loss maintained for 2 years reduces blood pressure, improves abnormal lipid levels, and reduces risk of diabetes.[28] A follow-up of women aged 40 to 64 in the American Cancer Society study who intentionally lost weight found a significant reduction in all-cause mortality of 20% to 25%.[64] Using the National Health Interview Survey with a nine-year follow-up, intentional weight loss lowers mortality rate (Hazard Rate Ratio) by 24%.[65] In contrast, those with unintentional weight loss had a 31% higher mortality rate.

Weight loss affects a number of risk factors. The data on participants in the Swedish Obesity Study demon-

strates how the degree of weight loss affects individual risk factors.[28] Changes in blood pressure and triglycerides are very responsive to weight loss, decreasing after a 5% to 10% loss of original body weight. HDL cholesterol increases with a similar weight-related change. Total cholesterol, on the other hand, does not show a sustained effect until weight loss exceeds 20%. For most comorbidities, however, a 10% weight loss is sufficient to see significant improvement in risk factors.[66] Unfortunately, blood pressure returns to baseline by 4 to 6 years even when weight loss is maintained.

Recent studies support the idea that losing about 5% of body weight can significantly reduce the risk of developing Type 2 diabetes in high-risk individuals. In studies from Finland[67] and the United States[68] conversion rates from impaired glucose tolerance to diabetes were reduced by 58%.

CONCLUSION

The epidemic of obesity has highlighted the extent of the health risks associated with this disease. These risks arise from the increased mass of fat tissue, as well as the products produced by the increased number and size of fat cells in obese individuals.

Psychosocial dysfunction, obstructive sleep apnea, and osteoarthritis can be a direct result of increased fat mass. Other diseases associated with obesity result from the metabolic consequences of enlarged fat cells. Diabetes, gallbladder stones, high blood pressure, liver disease, coronary artery disease, cerebrovascular disease, certain types of cancers, and infertility can all be traced in part to the increased secretion of inflammatory and coagulation molecules from fat cells. Finally, obesity also increases overall mortality. It is clear from this review that the morbidity and increased mortality of overweight and obesity is substantial and should prompt further attention towards the need for appropriate weight management in health care.

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CME QUESTIONS

To earn CME credit, read the preceding CME article and complete the registration, evaluation, and answer form on page S76. Mail or fax the registration, evaluation, and answer form to the Educational and Research Foundation. Answers must be postmarked or faxed prior to December 31, 2005. Participants must attain a minimum score of 75% to receive credit.

For each question, choose the one answer that is most correct.

1. True or False. Obesity accounts for approximately 5.5-7% of national health care expenditures in the United States.

2. Body mass index is a measurement used to evaluate body adiposity and is defined as which of the following:
   a) body in kg/height in cm
   b) body weight in lbs/height in inches
   c) body weight in kg/height in meter^2
   d) body weight in kg/height in meters
   e) body weight in lbs/height in feet

3. Which of the following is greatly increased (relative risk > 3) in obese patients in developed countries?
   a) Impaired fertility
   b) Low back pain
   c) Polycystic ovary syndrome
   d) Cancer
   e) Insulin resistance

4. True or False. In obese individuals, changes in blood pressure and triglycerides are very responsive to even a 5-10% reduction in weight.

Behavior and Lifestyle: Approaches to Treatment of Obesity

Donald A. Williamson, PhD and Tiffany M. Stewart, PhD

The increasing prevalence of overweight and obesity in adults and children demonstrates a steadily growing epidemic. This rising rate of obesity is associated with obesity related comorbidities including cardiovascular disease, hypertension, some cancers, joint disease, and particularly, type 2 diabetes. Modest weight loss (5% to 10% of total body weight) through lifestyle intervention approaches has been found to have a beneficial effect on comorbid conditions, particularly hypertension and type 2 diabetes. Effective behavioral treatment of obesity involves modification of eating and physical activity patterns to yield negative energy balance. Research studies have found that interventions that combine a low-calorie diet, increased physical activity, and behavior therapy are most effective for weight loss and maintenance. Furthermore, extended length of treatment contact, weight loss satisfaction, and social support may promote positive long-term outcomes in obese adults and children.

Obesity occurs when the energy consumed exceeds the amount of energy expended, and the long-term result is excess body weight caused by storage of "extra" energy in body fat stores.[1] The focus of a behavioral intervention incorporates modification of eating behaviors and physical activity to yield negative energy balance that results in weight/fat loss. Obesity is strongly associated with type 2 diabetes, hyperlipidemia, and hypertension. Research studies have reported that moderate weight loss (5-10% of initial body weight) has a beneficial effect on comorbid cardiovascular conditions associated with obesity.[2] Recent lifestyle intervention research also suggests that moderate weight loss may delay or prevent the onset of type 2 diabetes.[3] In 2003, the Diabetes Prevention Program reported that lifestyle intervention for obesity reduced the risk of diabetes by 58%.[3] This study found that lifestyle intervention was more effective than metaformin, and was effective in individuals of every gender, age and BMI group. These results suggest that there is great promise for the application of lifestyle behavioral interventions for the reduction of obesity and the risk for comorbid health conditions.

A positive relationship between moderate weight loss and health benefits has been reported. Given the success of lifestyle intervention for the induction of moderate weight loss, behavioral treatment for obesity is a logical initial treatment option for people who are overweight, moderately obese, or prefer to adopt a healthier lifestyle.

The origins of behavioral treatment for obesity date to the late 1960s. Since the 1970s, behavioral treatment programs for obesity have been intensified in terms of length and aggressiveness, yielding average weight losses of ranging from 7-10% of initial body weight. On average, most people reach their maximum point of weight loss about 6 months after the initiation of treatment. However, it is important to note that these weight losses usually occur in the short-term and are not maintained in the long-term, after treatment ends. Thus, maintenance of weight loss is a focus of treatment outcome research.

PHILOSOPHY OF TREATMENT

The general principle underlying behavior therapy of obesity (Social Learning Theory) is that obese patients have learned eating and exercise patterns that are contributing to weight gain and/or maintenance of obesity. However, these behaviors can be modified in order to produce weight loss. Learning principles from both classical and operant conditioning are applied in training new behaviors. Behavioral treatment of obesity, including lifestyle change, seeks to alter the environment, since some environmental reinforcement contingencies shape eating behavior and physical activity. This paper describes the behavioral approach to lifestyle change for obesity, research outcomes, components of lifestyle behavior modification, and special considerations for treatment of adults and children.

BEHAVIORAL TREATMENT FOR ADULTS

Approach and Outcomes

Behavioral treatment is best orchestrated by the collaboration of a multidisciplinary team of professionals, including medical doctors, psychologists, dietitians, and exercise physiologists. There are two phases of the behavioral treatment approach: weight loss induction and weight maintenance. To induce weight loss, specific calorie goals for food intake and specific goals for physical activity are prescribed for each individual. These goals

are designed to yield a one to two pound weight loss per week. Physical activity and exercise goals are gradually increased until individuals expend an additional 1,000 kcal/week via physical activity. Treatment typically involves attendance to weekly outpatient treatment groups during the six months of the weight loss induction phase and is reduced to biweekly or monthly meetings thereafter.

Behavioral studies of weight management have focused on changing physical activity, eating behavior, and motivational strategies to improve weight loss. Generally, longer duration of treatment (at least six months) and the combination of diet and exercise has been shown to yield greater success in weight loss and weight maintenance over time.[4] In an effort to make weight loss therapies more effective, treatment length has been increased over time from an average of 8 weeks in 1974 to an average of 21 weeks by the 1990s. Comparable increases in weight loss have occurred with increases in treatment duration. In 1974, the average weight loss associated with the 8-week treatment protocol was 3.8 kg, and in 1990, the average weight loss associated with a 21-week treatment protocol was 8.5 kg. In 2000, Jeffery et al estimated that average weight losses in behavioral treatment studies have increased by approximately 75% between 1974 and 1994, and that this approximate doubling of average weight loss has occurred in conjunction with the approximate doubling of treatment duration in the last 20 years.[5] In 1989, M. Perri and collaborators reported that treating participants for 40 weeks as opposed to 20 weeks was associated with more weight loss.[6] In a review of this research in 1998, Perri concluded that extended contact with participants yielded better weight loss.[7] Therefore, longer duration of treatment has been consistently associated with greater weight loss.

Targets and Tools

The targets for the behavioral treatment of obesity include the individuals' eating and physical activity as well as ways in which they interact with the environment (e.g., coping with stress and training effective problem-solving skills). The primary goal of treatment is to create negative energy balance whereby caloric expenditure exceeds caloric intake. Accomplishment of this goal requires many behavior and lifestyle alterations. In recent years, there has been a growing trend toward individually tailoring treatment. To accomplish individualized treatment plans, the weight management therapist needs a "tool-box" with many therapeutic "tools." The primary tools for change are described in the table. These tools include self-monitoring, stimulus control, goal setting, behavioral contracting and reinforcement, nutrition education, meal planning, modification in physical activity, social support, cognitive restructuring, and problem-solving. Research outcome related to the use of some of these tools is described below.

Meal Planning

Prescribed meal plans are typically based on dietary exchange programs, utilization of meal replacements, and/or structured meal planning. Use of structured meal plans with food provision (actually providing the persons with the appropriate food) can increase initial weight loss, but is no more effective in the long-term than provision of a calorie goal such as 1000-1500 kcal / day. The most important component of structured meal plans is the provision of structure for foods that are to be consumed and the provision of grocery shopping lists. Therefore, it is not the provision of food, per se that is important. Structured meal plans appear to be useful because they provide assistance for selecting healthy foods, and by creating a regular meal pattern (i.e., breakfast, lunch, dinner).

Utilization of meal replacement plans (e.g. Slim Fast) has also been studied. These studies prescribed meal plans for consuming 1,200-1,500 kcal per day by eating two or three meal replacements and one healthy meal, usually at dinner in the evening. This approach has yielded average weight losses of 7 kg over the first three months of treatment, and 10.2 kg at 24 -month follow-up for those that continued on meal replacements.[8] These studies suggest that the main benefit to such dietary plans is satisfactory adherence due to the simplicity and structure of the plans.

Modification of Physical Activity and Exercise

Physical activity level has been shown to be a significant determinant of long-term maintenance of weight loss. Recent research has focused on the type of exercise that produces the greatest weight loss. Recent studies have supported the benefit of the combination of diet and exercise approaches (versus diet alone or physical activity alone). Tests of the exercise prescription include: 1) lifestyle activity versus structured exercise, 2) long bout versus short bout of exercise, and 3) home- based versus group- based exercise. In long-term weight loss (one year or longer follow-up), Wing concluded that there was greater long- term weight loss for groups receiving diet plus exercise treatment, though the effects of the combined treatment were often only marginally better than those achieved by diet alone.[9] It has been suggested that the limited long-term impact of exercise programs may be due to the inability of most people to maintain physical activity regimens over a long duration of time. With regard to improvement of exercise adherence, studies of supervised group exercise versus home-based approaches to physical activity have reported that home-based programs may have a long term advantage, because they promote greater adherence. Additionally, short- bout exercise prescription was shown to yield higher maintenance of physical activity in the long term (12-18 months) as well as overall better weight loss than long-bout exercise programs.[4, 9]

Amount of exercise has been shown to be an impor-

Table. Summary of "tools" used in behavioral treatment for obesity.

Self-monitoring	Recording food intake and intentional efforts to increase physical activity. It is designed to help the individual become more aware of their eating and exercise patterns and allows for feedback from the counselor on dietary and physical activity patterns over time.
Stimulus Control	Stimulus control procedures are designed to alter the environmental antecedent stimuli that control eating and exercise patterns of behavior and change the environment from one that supports weight gain behaviors to one that does not and by replacing cues that stimulate weight gain behaviors to ones that stimulate weight loss behaviors.
Goal Setting/Shaping	Behavioral weight control programs are goal oriented. Shaping refers to setting small, but reasonable goals at first, and then gradually making them more challenging over the course of treatment.
Behavioral Contracting/ Reinforcement	Behavioral contracting involves defining a goal, breaking the overall goal into multiple, minor steps, and rewarding the participant for attaining the minor goals.
Nutrition Education	Patients are educated on the nutritional aspects of weight loss and weight maintenance.
Meal Planning	Meals are planned to facilitate individuals eating regularly scheduled meals. Content, amount, frequency and time of meals are planned.
Modification of Physical Activity	Programs to increase physical activity generally include increasing exercise and decreasing sedentary behavior.
Social Support	Social support may be derived from a spouse, family members, or friends. Enhancement of social support is best accomplished by inviting family members and friends to attend some of the therapy sessions.
Cognitive Restructuring	Cognitive restructuring involves educating participants about the effect of negative and dysfunctional thoughts (often associated with low self-worth, depression, and/or body dissatisfaction) because they can serve as cues for overeating and sedentary behavior.
Problem-Solving	Problem-solving training teaches patients to systematically overcome problematic situations.

tant variable in the success in weight loss and weight maintenance over time. Typical exercise prescriptions recommended in behavioral weight loss programs consist of 1,000 kcal per week. Reports from the National Weight Control Registry (adults who have lost significant weight and maintained it for at least one year) have indicated that successful weight loss maintenance was achieved by an average of 2,800 kcal per week of physical activity.[10] Thus, higher levels of exercise than are typically prescribed in behavioral programs may be necessary for long-term weight maintenance.

Social Support

Enhancement of social support has been studied as a means for improving long-term weight loss.[11] The most common way to enhance social support has been to include spouses, family members, or friends in the treatment process. These studies have reported that there are both short-term and long-term weight loss benefits for inclusion of strong family support.[11]

Satisfaction with Weight Loss

Obese adults often have difficulty establishing reasonable weight loss goals. Setting unreasonable weight loss goals in the behavioral treatment of obesity often leads to disappointing outcomes and little motivation to continue adherence to treatment programs. A recent study investigated whether informing obese persons of the expectation of a weight loss of 5-15% would influence them to adopt more realistic expectation for weight loss.[12] This study found that simply providing information promoting an expectation of moderate weight loss (5-15%) had no significant impact on weight loss expectations. Therefore, if weight loss expectations are to be modified, it appears that a more intensive effort will be required.

Weight Maintenance Strategies

The primary strategy used to facilitate weight maintenance is to extend the length of treatment and maintain longer therapeutic support and/or booster treatment as needed. The increased length of contact should result in continuous use of weight loss strategies, and thus, weight maintenance. Perri concluded that the addition of therapist contact via the telephone and mail, significantly enhanced maintenance of weight loss for a group that received behavior therapy plus relapse prevention training.[7] Similar results have been obtained with the use of booster sessions to enhance maintenance of weight loss.[13] Also, in recent years, the Internet has been employed as a means of increasing therapist contact to improve long-term weight maintenance, and preliminary results of this approach are encouraging.[14] An additional tool that has been utilized is television broadcasting, which warrants further investigation of effectiveness.

There is general consensus that development of skills to respond immediately to overeating, periods of inactivity, or to small weight gains, is useful for long-term management of obesity.[13] Relapse prevention is based on the idea that individuals will encounter "high risk" situations that threaten accomplished behavior changes. Relapse prevention programs generally assist in the identification of situations that place the person at risk for returning to previous, unhealthy patterns of behaviors and to develop specific plans to manage these high-risk situations. Specific relapse prevention techniques include identifying high-risk situations, building confidence, and reframing pessimistic thoughts about relapse versus continued success.

SPECIAL CONSIDERATIONS

Cultural issues may influence one's motivation and ability to succeed in weight loss. For example, the stigma of obesity varies across cultures, genders, and races. Women, more than men, are likely to attempt weight loss for appearance reasons. Men are more likely to enter into obesity treatment programs when they believe that their overweight status has negative health consequences. Generally, African Americans are less likely to experience social pressures to lose weight and may therefore be less motivated to seek treatment. For some individuals, it may be useful to emphasize health-related benefits of weight loss rather than appearance-based reasons for weight loss.

In addition, an individual's physical health must be considered when prescribing caloric restriction and/or a physical activity regimen. A physician should evaluate the safety of caloric restriction and increased exercise. A dietitian or nutritionist should be consulted to formulate dietary recommendations. Individuals with type 2 diabetes or cardiovascular disease may require special diets and medical monitoring throughout the course of any weight loss program. Further, overweight individuals may experience knee or other joint problems; in such cases physical activity may be limited.

It is also important to consider the psychological sequelae of obesity. In American culture, there is a stigma associated with obesity. The "obesity stereotype" is that people who are overweight tend to be less socially competent, lazier, and less intelligent than normal weight individuals. In addition, most obese people have experienced various forms of discrimination and teasing about their weight. As a result, obese people often suffer from low self-esteem and may be very concerned about their body shape. In addition, many individuals may have attempted unsuccessfully to lose weight in the past, or they may have lost weight only to regain it later. A pattern of unsuccessful weight loss attempts frequently leads to frustration and lowered self-esteem. It is important that clinicians remain sensitive to these issues when treating obesity.

Finally, it is important to identify individuals with eating disorders. The most common type of eating disorder associated with obesity is Binge Eating Disorder. Binge Eating Disorder is characterized by recurrent episodes of binge eating in which the individual consumes large amounts of food and perceives a loss of control over eating. Unlike the pattern of behavior observed in Bulimia Nervosa, binge eating episodes in Binge Eating Disorder do not occur with compensatory behaviors to prevent weight gain (e.g., fasting, purging, exercise). Binge Eating Disorder occurs in less than 2% of obese people, though binge-eating as a behavioral symptom is much more common. When such problems are identified, the treatment strategy should incorporate a component to reduce the frequency of binge episodes.

BEHAVIORAL TREATMENT FOR CHILDREN AND ADOLESCENTS

Approaches and Outcomes

The main goal for treating pediatric obesity is regulation of normal body weight, with consideration for growth and development.[15] Effective behavior change in children consists of three components: 1) behavior therapy to foster healthier behavior change, 2) modification of diet, and 3) modification of physical activity habits. Tools for behavior change in children, just as in adults, often include reinforcement, stimulus control, behavioral contracting, self-monitoring, meal planning, modification of physical activity, problem solving, and social support. Intensive behavioral treatment programs generally yield weight losses of 6 to 10 kg during the initial weight loss induction phase that is completed in about six months.[15] Treatment that spans one year or more generally results in greater weight loss.

Reinforcement, Adherence, and Behavior Change

Frequent or daily reinforcement is necessary to foster motivation and adherence and this reinforcement most commonly comes from parents. From a behavioral viewpoint, positive reinforcement for healthy behavior is necessary to establish sustained behavior change. Over time, parents are likely to revert to punishment to influence children's behavior, which promotes negative parent-child interactions. Adherence to recommendations such as self-monitoring of diet and physical activity habits is extremely difficult for both the child and parent, and these records are frequently inaccurate. Therefore, the child and parent should work with the therapist to establish small attainable goals. They should establish clearly specified guidelines for treatment (called behavioral contracts) and, upon successful attainment of the goals, rewards should be provided. Children and adolescents can learn to monitor eating and exercise, but parents must assist by reminding and reinforcing completion of self-

monitoring. Parents are also trained to use behavioral contracting which generally includes some type of reinforcement contingency for successful attainment of the goal (e.g. child receives a music compact disk for meeting weekly a physical activity goal).

Social Support and Parent Training

Parent involvement in treatment is recommended to promote the enhancement of social support, which can be accomplished by inviting parents to treatment sessions.[11] In these sessions, parents learn to be supportive of the child's progress (and reinforce healthy behavior change) and to avoid actions that sabotage progress. One reason for the significant impact of parental involvement on weight change is control over the home environment, including types and amounts of foods available, food preparation methods, and physical activity opportunities.

Research has provided support for not only parental involvement, but for specific types of parent training related to healthy eating and exercise. These findings support the inclusion of parents in childhood obesity treatment, even if the child is relatively disengaged in treatment.

Problem-Solving

In therapy sessions, parents and children are trained in problem-solving techniques to aid in identifying and solving potential situations that threaten success, particularly adherence in behavioral weight loss treatment. They learn to use these skills to promote adherence and to remove obstacles for successful weight management.

Meal Planning

Several different dietary approaches have been reviewed with children including individualized dietary interventions, the diabetic exchange program, the "traffic-light" diet, and the protein-sparing modified fast (PSMF). Meal planning for children and adolescents relies on moderate calorie restriction (800 to 1,000 kcal per day). More restrictive diets produce more weight loss in the short-term. However, they produce similar long term results as the less restrictive diets. It is important to note that the addition of nutrition education to the behavioral techniques of self-monitoring, behavioral contracting, positive reinforcement, and stimulus control procedures significantly improves reduction in percentage overweight, versus nutrition education alone.[15]

Physical Activity

Exercise combined with dietary change improves childhood obesity greater than alteration of diet alone. Reduction of sedentary lifestyle behavior (versus programmed aerobic exercise), such as watching television, has been found to be a useful form of exercise prescription. When children are reinforced for less sedentary behavior they lose more weight and maintain better progress over time. However, it is important to note that reducing the duration of sedentary behavior may not necessarily promote children to allocate more time to physical activity.

Physical activity, combined with dietary changes facilitates weight loss and long-term weight maintenance in children. Research on this topic has found that: 1) Diet plus lifestyle changes maintained weight losses over time, whereas diet plus aerobic activity, diet plus callisthenic activity, and controls exhibited increases in weight over time; 2) Children reinforced for decreasing sedentary behavior and children reinforced for increasing physical activity showed comparable results in reduction of overweight. Thus, there may be a limit for the amount of physical activity that can be used to replace sedentary behavior.

Special Considerations

Once a child has been identified for weight control treatment, a medical evaluation is necessary to determine if a medical condition is contributing to body weight or weight gain (e.g., hypothyroidism). Additionally, a child should receive medical clearance before increasing physical activity, a primary component of behavioral weight control interventions.

Special issues related to the treatment of pediatric weight problems include cultural factors, eating disorders, and motivation for lifestyle change. Ethnic and cultural factors should be considered when making recommendations. For example, dietary plans should take into consideration religious events or special dietary needs. Additionally, the presence of child or parental psychopathology negatively affects weight loss and maintenance. Should psychopathology or family conflict be present, referrals for mental health treatment or family counseling to address these problems prior to initiating weight loss treatment may be appropriate. Finally, family support may not be universal and not all family members will support the behavioral changes necessary to promote weight loss for the child or adolescent who is the focus of therapy. For example, family members may offer poor food choices to the person in therapy, tease them, or reinforce their behavior with the provision of food.

Another concern about dieting by children and adolescents is the development of eating disorder symptoms or the effect of dieting on the growth and development of children and adolescents. Research findings suggest that moderate calorie restriction might temporary reduce growth rate, but there is no effect on long-term growth.

Motivation for behavior change and adherence to recommendations are particularly problematic for children and adolescents, especially in an environment conducive to sedentary behavior and ingestion of large portions of energy dense/high calorie foods. In addition, motivation for lifestyle behavior change can be strongly impacted by culture. For example, some overweight African-American girls are relatively unconcerned about their

weight status and may have fatalistic attitudes about the health risks associated with obesity.

In summary, research on weight control in children suggests that frequent or daily reinforcement facilitates behavior change and weight loss. In addition, weight loss is promoted by gradual or extended therapeutic contact. It is wise to present didactic information to the child at a pace that is flexible and promotes mastery of concepts. Providing children with perceived choices in therapy also promotes weight loss and longer therapy is generally associated with greater weight loss. Self-control training and cognitive therapy in the absence of parental support have not been found to promote long-term weight loss in children or adolescents. Therefore, the most effective treatment involves parents so that the child's environment is modified to promote healthy nutrition and physical activity.

GENERAL SUMMARY AND CONCLUSIONS

Behavioral weight control therapies involve weight loss and weight maintenance. Treatment should be individualized and cultural, physical, and motivational issues should be taken into account when developing a treatment plan. During the period of weight loss, energy intake via eating is reduced and energy expenditure from physical activity is increased. A variety of therapeutic techniques can be used to modify these habits. During the period of weight maintenance therapy, the person learns to match energy intake (eating habits) with energy expenditure (exercise). Individuals also work to maintain lifestyle change behavior patterns and prevent and/or work through lapse or relapse.

Generally, the most effective weight loss programs have offered a combination of exercise, diet, and behavior modification. Treatment components that may enhance long-term success in lifestyle behavior change targeting obesity in adults and children include, but are not limited to: 1) The use of portion control and structured meal plans; 2) The use of home-based and short-bout exercise prescription coupled with behavior therapy contact; 3) Utilization of social support throughout treatment; and 4) Extended therapeutic contact or booster treatment to promote long-term weight maintenance benefits.

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Pharmacologic Therapy for Obesity

John N. Udall, Jr., MD, PhD; Dolleen M. Licciardi, MD; and Frank Svec, MD, PhD

Obesity is a chronic condition, and long-term treatment will most likely be needed. Approved prescription medications for weight loss appear to have similar efficacy in controlled studies. No predictors of responsiveness in an individual patient or class of patients have been established. The choice of a medication is based on the underlying medical indication or contraindication of a particular drug, concurrent medication, age of the patient, need for monitoring, anticipation of the length of therapy, and the preference of a patient. Behavioral and dieting interventions, and increased physical activity are considered the primary means to promote and maintain weight loss. Weight-loss medications should be considered only as an adjunct for patients who are at substantial risk because of their obesity and in whom non-pharmacologic treatments have not resulted in sufficient weight loss to improve health or to prevent weight regain.

A number of unfortunate outcomes has tarnished the use of pharmacologic therapy in the treatment of obesity.[1] From the introduction of thyroid hormone as a therapeutic modality in 1893 to the recent ban of ephedra by the Food and Drug Administration (FDA), almost every drug that has been tried in obese patients has led to undesirable outcomes resulting in termination of the drug. This review will focus on drugs that are currently approved and available to the clinician as he/she decides on appropriate treatment for the obese patient. Some investigational drugs and unapproved medications will be mentioned. More extensive reviews of pharmacologic agents for the treatment of obesity are available.[1-5]

Obesity is a chronic condition, and long-term treatment will most likely be needed. The pharmacologic treatment of obesity may be compared to the treatment of hypertension. Numerous studies indicate that just as blood pressure may increase when antihypertensive drugs are

Table 1. Drugs listed in the *Physicians' Desk Reference* for obesity management [7,8]

Trade Name	Generic Name	Company
Short-Term Therapy		
Adipex-P	phentermine hydrochloride	Gate
Ionamin	phentermine cationic exchange resin	Celltech
Bontril Slow-Release	phendimetrazine tartrate	Amarin
Desoxyn	methamphetamine hydrochloride	Abbott
Long-Term Therapy		
Meridia	sibutramine hydrochloride	Abbott
Xenical	orlistat	Roche

Table 2. Selected over-the-counter medications available for the treatment of obesity.

Trade Name	Major Ingredient	Company
7-Keto	3-acetyl-7-oxo-dehydroepiandrosterone	Eckerd Drug Co. Clearwater, FL
Chitosol	Chitosol	Windmill Health Products West Calchnell, NJ
Dexatrim Natural	Synephrine, caffeine	Chattem Inc. Chattanooga, TN
Dieter's Advantage	Garcinia gambogia extract	Atkins Nutritionals, Inc. Ronkonkoma, NY
Metabolite	Garcinia gambogia extract	Metabolite International San Diego, CA
PatentLean	3-acetyl-7-oxo-dehydroepiandrosterone	Patent Health Canton, OH
PharmaPure	Chromium, multiple extracts	PureTek Corp. Fernando, CA
Puralin	Calcera carbonic, chitosan	Apothecus Pharmaceutical Corp. Oyster Bay, NY
Slimfx	Chromium, gymnema sylvestre	Worldwide Health Resomar Boca Raton, FL

discontinued, regaining lost weight when weight loss medications are discontinued is extremely likely.[5]

Approved prescription medications for weight loss appear to have similar efficacy in controlled studies. No predictors of responsiveness in an individual patient or class of patients have been established. The choice of a medication is based on the underlying medical indication or contraindication of a particular drug, concurrent medication, age of the patient, need for monitoring, anticipation of the length of therapy, and the preference of a patient. A practical guide for treating the obese patient has been adopted from the NIH guidelines.[6] This evidence-based guideline suggests initially changes in lifestyle, then pharmacotherapy under certain conditions and occasionally, weight-loss surgery (Figure 1).

This review of medications which can be used in the treatment of obesity will be divided into a discussion of approved, investigational, and disapproved medications. Much of the prescribing information is taken from the Physician Desk Reference (PDR) since the information contained in this reference text is readily available and is widely used by physicians to guide them in the pharmacologic therapy of obesity. Other prescription drugs are available, but recent PDRs identify only six drugs which can be used to treat obesity.[7,8] These are listed in Table 1. Additional over-the-counter preparations are available at local drug and health food stores. There is less governmental control over these preparations and most have never been studied in controlled, double-blind studies. The variety and number of available products is considerable and a thorough discussion is beyond the scope of this review. However, a selected few are noted in Table 2.

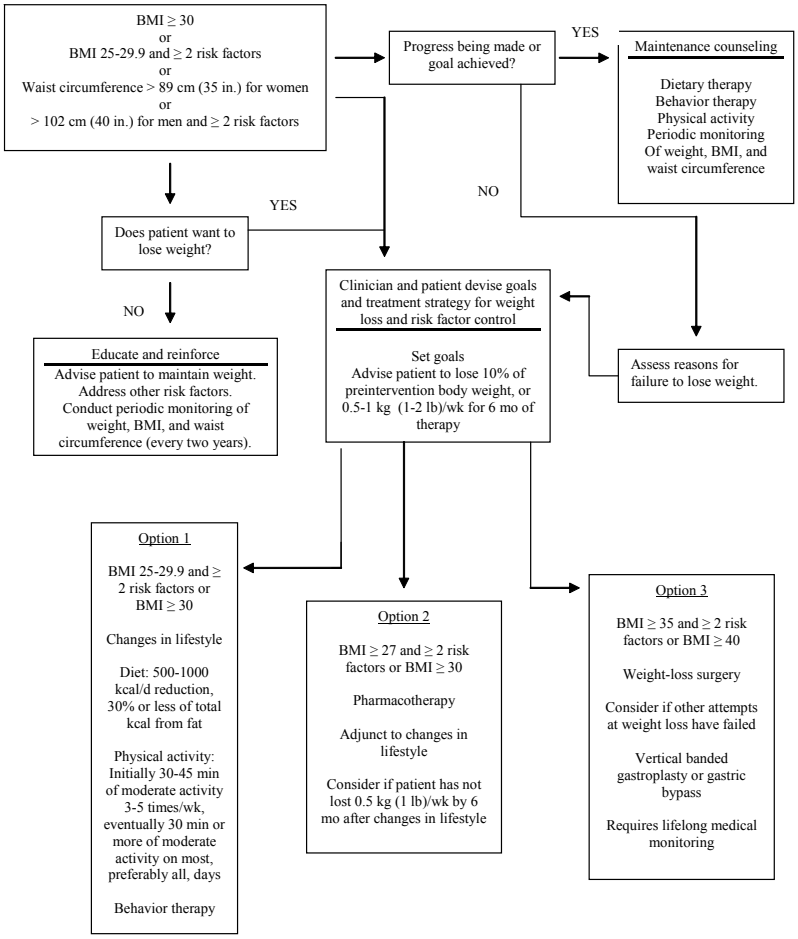

Figure 1. Evidence-based algorithm for the treatment of obesity. BM denotes Body Mass Index (kg/m^2). (Adapted with permission, reference 5)

APPROVED MEDICATIONS

Currently, medications noted in the PDR for the treatment of obesity are divided into those for short-tern use and preparations available for long-term use.[7,8]

Table 3. Drugs listed in the *Physicians' Desk Reference* for the short-term treatment of obesity: dose size and suggested administration.[7,8]

Drug	Dose Size	Administration
Phentermine HCL	37.5 mg tablet & capsule	Usual dose is 18.75 - 37.5 mg taken before breakfast or 1-2 hours afterwards. Evening doses should be avoided because of the possibility insomnia.
Phentermine Resin	15 and 30 mg capsules	Usual dose is 15-30 mg daily before breakfast or 10-14 hours before retiring. Not recommended for use in patients < 16 years of age.
Phendimetrazine Tartrate	105 mg slow-release	Usual dose is 105 mg capsule taken in the morning, 30-60 minutes before the morning meal. Not recommended in children < 12 years of age.
Methamphetamine HCl	5 mg tablet	One 5 mg tablet taken 1/2 hour before each meal.

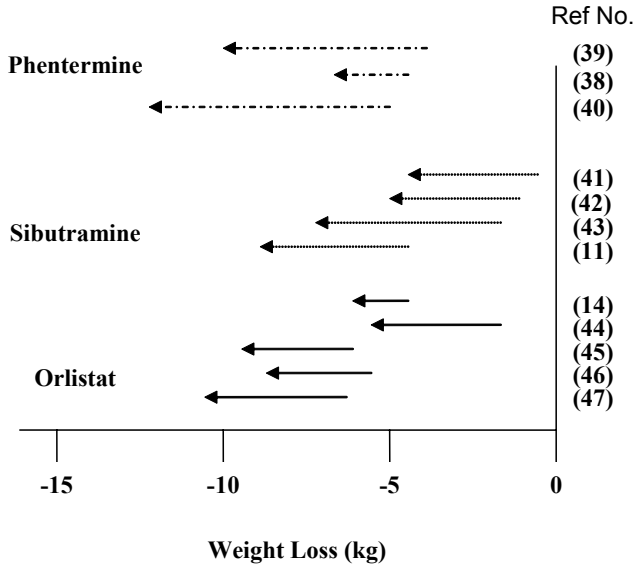

Figure 2. Effect sizes for three weight loss drugs. Each line is a separate study with either phentermine, sibutramine, or orlistat. Reference to each study is in parentheses. The right hand end of the arrow represents the weight loss of the placebo-treated group and the tip of the arrow indicates the weight loss of the drug-treated group (Adapted with permission, reference 1).

Short-Term Use

The four currently FDA-approved medications for the short-term treatment of obesity are noradrenergic drugs with pharmacologic activity similar to the prototype drug of the class, amphetamine. These four, phentermine hydrochloride, phentermine cationic exchange resin, phendimetrazine tartrate, and methamphetamine hydrochloride are all central nervous system stimulants (Table 3). These drugs are indicated as a short-term ($\leq$ 12 weeks) adjunct in a regimen of a weight reduction program based on exercise, behavioral modification and caloric restriction. Few studies of their safety and efficacy have extended more than a few months. Obese individuals who may be considered for pharmacologic therapy are those with a body mass index (BMI) of $\geq$ 30 kg/m^2 or a BMI of $\geq$ 27 kg/m^2 in the presence of other risk factors (e.g., hypertension, diabetes, hyperlipidemia.)

The four drugs all tend to suppress appetite and are therefore known as "anorectics" or "anorexigenics." It is not clear if this is the only mechanism by which these drugs influence weight loss. The rate of weight loss is greatest in the first weeks of therapy and the amount of weight loss varies from trial to trial and may be related to other factors such as the population studied, diet, and activity prescribed. The drugs have peripheral actions including central nervous system stimulation, tachycardia, elevation of systolic and diastolic blood pressure and weak bronchodilator and respiratory stimulant action. One group of drugs, the amphetamines and related compounds have been extensively abused, and the possibility of abuse of these drugs should be kept in mind when evaluating the desirability of including one of these as part of a weight-reduction program.

The short-term use medications are contraindicated in advanced arteriosclerosis, cardiovascular disease, moderate and severe hypertension, glaucoma, hyperthyroidism, agitated states, and within 14 days following the administration of monoamine oxidase inhibitors.[7,8] While these appetite suppressants are approved for obesity treatment in the United States, some experts suggest that older-generation medications (methamphetamines and phendimetrazine) have no current appropriate role in obesity treatment.[4] However, phentermine resin has been shown to have demonstrated efficacy in long-term, double-blind, placebo-controlled studies (Figure 2).

Long-term Use

Two medications have been approved by the FDA for long-term use ($\geq$ 12 weeks) in the treatment of obesity. One is sibutramine hydrochloride. Metabolites of sibutramine hydrochloride inhibit the reuptake of serotonin and norepinephrine and weakly inhibit dopamine uptake. The indications for its use are the same as the indication for short-term use medications: BMI $\geq$ 30 kg/m^2 or a BMI $\geq$ 27 kg/m^2 with a comorbidity. Unlike fenfluramine and dexfenfluramine, this medication does not induce serotonin release, and has not been implicated in the development of valvular heart disease. [5] Over a 6-month period, subjects who follow a reduced-calorie diet and receive sibutramine typically lose 5-8% of their pre-intervention body weight as compared to a 1-4% weight loss among subjects who receive placebo (Figure 2).

A recent study of behavior therapy and sibutramine was conducted using obese adolescents.[9] Investigators enrolled 82 adolescents (13-17 years of age) in a double-blind study for 6 months. Participants BMI's ranged from 32-34 kg/m^2. Behavior therapy was initiated in both the control group and the sibutramine-treated group. At the end of six months, weight loss in the control group was 3.2 $\pm$ 6.1 kg ($x \pm$S.E.M.) and 7.8 $\pm$ 6.0 kg in the sibutramine-treated group. The BMI decreased 4.0 $\pm$ 5.4% and 8.5 $\pm$ 6.9% respectively. An open trial extended another 6 months and those subjects maintained on sibutramine tended to maintain their weight loss compared to the control group. Although this study involved adolescents, sibutramine is not approved for patients less than 16 years of age.[9]

A number of other long-term randomized, placebo-controlled, double-blind clinical trials of sibutramine have been conducted in adults of all ethnic groups ranging in age from 18 to 65 years with BMIs between 27-40 kg/m^2.[1] In one 6 month, variable-dose (1, 5, 10, 15, 20, and 30 mg/d) study of 1,047 participants, investigators evaluated the response to the drug at the completion of the 6 month study.[10] Of the subjects completing the study, 67% achieved a 5% weight loss, and 35% lost 10% of

Table 4. Drugs currently approved by the FDA for the long-term treatment of obesity: dose size and suggested administration.[7,8]		
Drug	**Dose Size**	**Administration**
Sibutramine	10 mg capsule	Starting dose is 10 mg once daily. May be increased after 4 weeks to a total of 15 mg once daily (5 mg a day if 10 mg not tolerated). Blood pressure and heart rate change should be monitored.
Orlistat	120 mg capsule	One capsule three times a day with each meal containing fat. A multivitamin containing fat-soluble vitamins is advised.

their initial weight or more. Percent weight loss from baseline was as follows: placebo, 1.2%; 1.0 mg, 2.7%; 5 mg, 3.9% 10 mg, 6.1%; 15 mg, 7.4%; 20 mg, 8.8%; and 30 mg, 9.4%. Clearly, there was increased weight loss with increased dose strength. The authors concluded that sibutramine administered once daily for 6 months to individuals with uncomplicated obesity produced a dose-related weight loss. Improvement in serum lipid profile was noted and adverse events tended to be related to mean increases in blood pressure and heart rate.[10] In another study, adult subjects (BMI > 30 kg/ M^2) were tracked following 4 weeks of treatment with a very-low-calorie diet that resulted in a loss of at least 6.0 kg of body weight.[11] At 4 weeks, subjects were then randomly assigned to one year of treatment with sibutramine (10 mg/d) or an identical placebo. Absolute weight change at one year was -5.2 ± 7.5 kg ($x \pm S.D.$) in the 81 patients in the sibutramine group and +0.5 ± 5.7 kg in the 78 patients in the placebo group ($p = 0.004$). Additional analysis at one year showed that 75% of subjects in the sibutramine group maintained 100% of the weight loss achieved on the very-low-calorie diet, compared with 42% in the placebo group ($p < 0.01$) The authors concluded that following 4 weeks of very-low-calorie diet, sibutramine is effective in maintaining and improving weight loss for up to one year.[11]

Finally, in a study in which eight European centers participated, 605 obese patients were initially enrolled in open fashion and were treated with 10 mg sibutramine each day for six months.[12] Patients who lost more than 5% of their initial body weight were randomized in double-blind fashion to either placebo or sibutramine. The subjects were followed for 18 months. Again, those in the placebo group tended to regain weight and those in the sibutramine group tended to keep the weight off and had a healthier profile in regards to blood triglycerides, HDL- and LDL-cholesterol.[12]

Despite these positive findings, it should be noted that sibutramine is contraindicated in patients receiving monoamine oxidase inhibitors and in patients taking other centrally acting appetite suppressant drugs. The most common adverse side effects noted in studies are increases in blood pressure and heart rate, dry mouth, anorexia, insomnia, constipation, and headache.[7,8]

The second drug approved for the long-term treatment of obesity is orlistat. This drug inhibits gastric and pancreatic lipase, and therefore interferes with the complete digestion and absorption of ingested dietary fat. Patients who take 120 mg of orlistat with meals excrete in their stool, approximately one-third of the dietary fat they ingest, thereby reducing calorie and fat intake (Figure 2).

Orlistat-treated subjects completing a one-year trial lost approximately 8.4% of their pre-intervention body weight as compared with a 5.7% weight loss of those who took placebos.[13] Orlistat has also been found to slow the rate of weight regain during a second year of use. This finding was noted in a large study of orlistat used to treat obese adults over a 3-year interval.[14] Participants (body mass index 30-43 kg/M^2) in this study were evaluated at 18 research centers in the United States. Subjects received a placebo plus a controlled-energy diet during a 4-week lead-in phase. Thereafter on study day 1, the diet was continued and subjects were randomized to receive a placebo drug three times a day or orlistat, 120 mg three times a day for 52 weeks. After 52 weeks, subjects began a weight-maintenance diet and the placebo group (n = 133) continued to receive placebo and orlistat-treated subjects were randomized to receive placebo three times a day (n = 138), orlistat 60 mg (n = 152) or 120 mg (n = 153) three times a day for an additional 52 weeks. A total of 1,187 subjects entered the protocol and 892 were randomly assigned on day 1 to double-blind treatment. For intent-to-treat analysis, 223 placebo-treated subjects and 657 orlistat treated subjects were evaluated. During the first year, orlistat-treated subjects lost more weight than did placebo-treated subjects. Subjects treated with 120 mg of orlistat three times day during year 1 and year 2 regained less weight during year 2 than those that received 60 mg of orlistat or placebo in year 2.[14] Another study tested the hypothesis that orlistat combined with dietary intervention improves glucose tolerance status and prevents worsening of diabetes status more effectively than placebo.[15] Data was pooled from 675 obese (BMI 30-43 kg/m^2) adults at 39 US and European research centers in three randomized, double-blind, placebo-controlled clinical trials. Subjects received a placebo plus a low-energy diet during a 4-week lead-in period. On study day 1, the diet was continued and subjects were randomized to receive placebo three times a day (n = 316) or treatment with 120 mg of orlistat three times a day (n = 359) for 104 weeks. A standard 3-hour oral glucose tolerance test was performed on day 1 and at the end of treatment. The mean length of follow-up

was 582 days. Subjects treated with orlistat lost more weight than subjects in the placebo group. In addition, the addition of orlistat to a conventional weight loss regimen significantly improved oral glucose tolerance and diminished the rate of progression to the development of impaired glucose tolerance and type 2 diabetes.[15]

The most common side effects noted in these and other studies of orlistat are related to the gastrointestinal tract. These side effects include flatulence, fecal urgency, fecal incontinence, steatorrhea, oily spotting of under clothes, and increased frequency of defecation. It has been suggested by some that a fat-soluble vitamin preparation be used with orlistat. This drug has recently been approved for use in adolescents as young as 12 years of age.[16]

In another study, long-term pharmacotherapy for overweight and obesity was evaluated using a systematic review and meta-analysis of randomized controlled trials.[17] Only double blind, randomized controlled studies of sibutramine and orlistat with follow-up periods of one-year or greater were eligible for inclusion. Three sibutramine studies (929 subjects) and eleven orlistat studies (6,021 subjects) met inclusion criteria. Attrition rates averaged 48% and 33% respectively. Compared to placebo, sibutramine-treated patients displayed a 4.3 kg or 4.6% greater weight loss than controls after one year of follow-up. Orlistat-treated subjects lost 2.7 kg and had a 2.9% greater weight loss than controls. The number of patients achieving 10% or greater weight loss compared to control subjects was 15% for sibutramine and 12% for orlistat. The authors concluded that sibutramine and orlistat appear modestly effective in promoting weight loss.[17]

Finally, it is well known that obesity is an important factor in the development of type 2 diabetes mellitus. Several placebo-controlled studies have recently demonstrated that both sibutramine and orlistat are able to promote weight loss in obese type 2 diabetic patients treated with diets alone, sulphonylureas, metformin, or insulin.[18] The greater the weight reduction as compared to placebo was associated with a significant reduction in glycated hemoglobin levels and/or a reduction in the doses of antihyperglycemic agents especially in good responders who lost at least 10% of their body weight. However, even modest weight reduction can improve blood glucose control in overweight subjects.[18]

INVESTIGATIONAL MEDICATIONS

Leptin

The observation that the protein leptin is a critical signal molecule in the regulation of body fat and body weight was made in the 1990s. Leptin is produced by fat cells, circulates in the blood, and enters the brain where it functions to reduce food intake, reduce serum glucose and insulin levels, and increase metabolic rate ultimately leading to a reduction in fat mass and body weight. Mice deficient in leptin are obese and administration of exogenous leptin to these mice causes dramatic reductions in the food intake and body weight.[19]

After the discovery of leptin, two cousins with severe, early-onset obesity and undetectable serum leptin concentrations were found to be homozygous for a frameshift mutation in the leptin gene.[20] Later, one of these children was treated with recombinant human leptin.[21] This nine-year old girl with congenital leptin deficiency had marked hyperphagia, excessive weight gain early in life, and severe obesity. Treatment with recombinant human leptin over 12 months led to a sustained reduction in weight, predominantly as the result of fat loss. Her energy expenditure increased and energy intake decreased markedly. The therapeutic response to leptin in this leptin-deficient child confirmed the importance of leptin in the regulation of body weight in humans and established the important role of this hormone in the regulation of appetite.[21]

Studies of leptin administration were then undertaken in obese subjects not deficient in the protein. In one study, a long-acting recombinant human methionyl leptin (met-leptin) was administered to lean and obese human volunteers.[22] The medication was well tolerated in both groups for up to 24 weeks. Met-leptin treatments resulted in significant dose-dependent weight loss ranging from -1.3 kg in the placebo group and -1.4 kg in the group given 0.03 mg/kg to -7.1 kg in the 0.30 mg/kg group over the 24-week period. Importantly, the loss of fat mass accounted for more than 95% of the weight loss achieved in the two highest dose cohorts, whereas changes in the fat-free body mass were not significant. These findings suggest that relative leptin resistance, which occurs in obesity, can be overcome, in some cases, by high leptin concentrations.[22] However, resistance to the proposed antiobesity action of leptin has been observed in both animals and humans and this has been noted in a number of studies of obese humans. Hukshorn et al assessed the biological activity and tolerability of pegylated recombinant native human leptin (PEG-OB) in 30 obese men.[23] Men were randomized to a double blind treatment with weekly subcutaneous injections of 20 mg PEG-OB or placebo for 12 weeks in addition to a

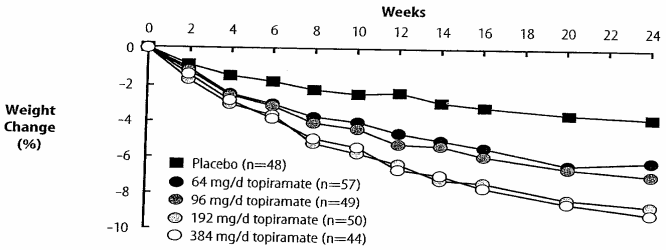

Figure 3. Topiramate in obesity: percent body-weight change from baseline to week 24 in subjects completing the study. (Adapted with permission, reference 28)

hypocaloric diet. Weekly injections of PEG-OB led to sustained serum concentrations of leptin throughout treatment. However, there was no significant difference in percent weight loss or percent body fat between the PEG-OB and placebo groups.[23] In a more recent study, PEG-OB administered at a dose of 80 mg subcutaneously weekly to obese men led to a significant ($p < 0.03$) additional weight loss and reduction in appetite ($p < 0.05$) after 46 days.[24] Although controversy may exist concerning the use of leptin in the treatment of obesity, interventional studies using leptin are absolutely necessary. These studies are expected to contribute greatly to our knowledge of energy homeostasis and, on this basis, may lead to the development of novel therapeutic approaches to the treatment of obesity.[25]

Ciliary Neurotrophic Factor

Ciliary neurotrophic factor (CNTF) is a protein of a molecular weight of 22 kD.[26] It is an endogenous neuroprotective factor that is present in Schwann cells and astrocytes, but is not found in the peripheral circulation. When used in a study of individuals with amyotrophic lateral sclerosis to determine if it had neuroprotective properties, CNTF did not alter disease progression but was found to cause marked weight loss in patients who were not obese. The result was not fully understood until it was discovered that CNTF and the weight regulating hormone leptin have a related intracellular signaling mechanism. Recombinant human variant CNTF is a genetically engineered variant of CNTF with increased potency and improved pharmacological properties. It binds to the CNTF receptor in the hypothalamic nuclei and activates intracellular signaling pathways, which in turn regulate food intake and body weight. Both leptin and recombinant CNTF are capable of causing pronounced weight loss in leptin-deficient obese mice. Again, as noted above, published research strongly suggests that obese humans are leptin-resistant. In contrast, recombinant CNTF causes weight loss in diet induced obese mice, suggesting that the agent may bypass the known leptin-resistance present in this animal model. Ettinger et al designed a 12-week, double-blinded, dose ranging, and multi-center clinical trial of 173 obese adults.[2] Subjects had a BMI of 41.1 ± 4.1 ($x \pm$S.E.M.). Patients were randomly assigned to receive a subcutaneous injection each day for 2 weeks of a placebo ($n = 32$) or 0.3 μg/kg ($n = 32$), 1.0 μg/kg ($n = 32$), or 2.0 μg/kg ($n = 33$) of recombinant CNTF. Another group received 1.0 μg/kg for 8 weeks and placebo for 4 weeks ($n = 38$). Of 173 randomized patients, 123 (71%) completed the double-blind dosing period. Mean (S.E.M.) changes in kilogram from baseline body weights were 0.1 kg (0.6) for placebo, -1.5 kg (0.6) for the 0.3 μg/kg dose group, -4.1 kg (0.6) for the 1.0 μg/kg dose group, and -3.4 kg (0.7) for the 2.0 μg/kg group. The recombinant CNTF was generally well-tolerated with mild injection site reactions being the most frequently reported adverse event. The authors concluded that in this initial dose ranging, 12-week study, treatment with recombinant CNTF resulted in more weight loss than placebo. However, they suggest that their preliminary findings require confirmation in larger prospective clinical trials.[26]

Peptide YY

The gut hormone fragment peptide YY_{3-36} (PYY) reduces appetite and food intake when infused into subjects of normal weight. Like leptin, PYY reduces food intake by modulating appetite circuits in the hypothalamus. In obesity, as noted previously, there appears to be a marked resistance to the action of leptin. Batterham et al investigated whether obese subjects were also resistant to the anorectic effects of PYY.[27] They compared the effects of PYY infusion on the appetites and food intake of 12 obese and 12 lean subjects in a double blind, placebo-controlled, crossover study. They found that obese subjects were not resistant to the anorectic effects of infused PYY and that levels of PYY were low in the obese subjects. They speculated that PYY deficiency may contribute to the pathogenesis of obesity in humans.[27]

Topiramate

Binge eating disorder occurs in up to 2% of the population and is characterized by recurrent episodes of binge eating without the compensatory weight-loss behavior of bulimia nervosa and anorexia nervosa.[28] People seeking treatment for binge eating disorder are often overweight or obese. Conversely, binge eating is common among obese individuals, occurring in 8-19% of these patients. Recently, McElroy and colleagues studied the effect of topiramate, an anti-epileptic agent noted to be associated with weight loss.[28] Obese binge eaters were enrolled in a 14 week, double-blind study. Participants all had a BMI ≥ 30 kg/m^2 and were assigned to receive topiramate ($n = 30$) or placebo ($n = 31$). The investigators measured binge frequency and weight loss. (Figure 3) Topiramate was associated with significantly greater reductions in binge frequency (topiramate 94%, placebo 46%). The mean weight loss for topiramate-treated subjects was 5.9 kg during the 14-week study while those receiving placebo lost a mean of 1.2 kg. The authors concluded that topiramate was superior to placebo on many outcome measures of binge eating behavior and weight and was relatively well tolerated. They suggest that topiramate may represent a promising new treatment for binge eating disorder associated with obesity.[28]

Zonisamide

Another antiepileptic drug, zonisamide, was found in short-term clinical trials of epileptic patients to be associated with weight loss. With this information, and the knowledge that zonisamide exerts dose-dependent dopaminergic and serotonergic activity, Gadde and colleagues studied the effect of zonisamide in the treatment of obese adults.[29] Sixty obese adults, age 21 to 50 with a

BMI of 36.3 ± 0.5 (x±S.E.M.) were randomized in double-blind, parallel-group fashion to a zonisamide or placebo group. Groups received either zonisamide capsules or identically designed placebo capsules. The dose of zonisamide was gradually increased over 16 weeks. At the end of the 16-week phase, participants wishing to continue received the same treatment in a single-blinded fashion for an additional 16-week extension phase. Patients in both groups were instructed to follow a diet that was calculated to reduce their daily energy intake by 500 kcal/d from the amount needed to maintain their usual weight. The prescribed diet emphasized decreasing portion size, eating more fruits and vegetables and drinking eight 8-ounce glasses of water each day along with increased activity. At the end of 16 weeks, the mean weight of the zonisamide group went from 98.2 kg to 92.3 kg (5.9 kg difference). The mean weight of the placebo group went from 97.8 kg to 96.9 kg during the 16-week interval (0.9 kg difference). The difference in weight loss between the zonisamide-treated group and the control group was highly significant ($p < 0.001$). Other parameters measured, such as waist circumference and body fat mass decreased significantly in the zonisamide group at 16 and 32 weeks compared to the control group.[29]

Rimonabant

Investigators at the March 2004 American College of Cardiology meeting in New Orleans presented details of their studies of rimonabant, the first of a new class of drugs (selective CB1 blockers) aimed at helping with weight loss and smoking cessation. CB1 blockers act on the endocannabinoid (EC) system, a natural system that modulates the body's energy balance and nicotine dependence. An over-stimulated EC system is thought to play a role in obesity and in tobacco dependence, and CB1 blockers reduce this overstimulation.[30, 31]

Data from two studies were reported. In the first, called the STRATUS-US (Studies with Rimonabant And Tobacco Use) study, the drug's effect on smoking cessation was evaluated. In this study, 787 smokers (average of 23 cigarettes per day) were randomized to receive either placebo, or rimonabant in doses of either 5 mg or 20 mg per day. Subjects received the study drugs for 10 weeks. They were permitted to continue smoking for the first 2 weeks, but were instructed to attempt to quit smoking on Day 15. The number of patients who had not smoked during the last 4 weeks of the 10 week period were tabulated. Of patients who took 20 mg of rimonabant, 36% had quit smoking. Of patients who took either placebo or 5 mg rimonabant, only 20% had successfully quit. Furthermore, of those patients who quit smoking, the ones taking either placebo or 5 mg rimonabant gained 84% more weight than those taking 20 mg rimonabant. Thus, rimonabant at 20 mg per day significantly increased the rate of successfully quitting smoking, and also greatly reduced post-smoking-cessation weight gain.

In the second study, the RIO-Lipids study (Rimonabant-In-Obesity), 1036 patients who were either overweight or obese and also had serum hyperlipidemia were randomized to one of three groups (20 mg/day rimonabant, 5 mg/day rimonabant, or placebo). After one year of treatment, patients receiving 20 mg/day rimonabant lost an average of 20 pounds of weight, compared to 5 pounds for patients taking the placebo. Seventy-five percent of subjects taking the 20 mg/day dose, 42% of subjects on the 5 mg/day dose, and 28% on the placebo achieved the goal of 5% or more weight loss during the year of treatment. Furthermore, patients receiving 20 mg/day rimonabant had significant improvements (compared to placebo) in waist circumference, serum HDL, triglyceride, c-reactive protein, and insulin sensitivity. For patients with metabolic syndrome at baseline, which included about 50% of the study population, half of those taking 20 mg/day rimonabant no longer had metabolic syndrome at the end of the study. The drug was found to be well tolerated. The only relatively common side effects were nausea and dizziness, and these side effects were transient.

There is still much to learn concerning rimonabant, and further studies will be required before the drug is approved for general use.[30, 31]

UNAPPROVED MEDICATIONS

Recently, a review of published literature evaluated herbal and dietary supplements, which have been promoted as effective treatments for the obese. These agents included chitosan, capsaicin, conjugated linoleic acid, ephedra alkaloids, and garcinia cambogia.[32, 33] Although some of these preparations may have actions that could plausibly lead to weight-loss, the National Institutes of Health guidelines state that herbal preparations are not recommended as part of a weight loss program because of unpredictable amounts of active ingredients.[6]

Two medications, one a prescription drug, fenfluramine-phentermine (fen-phen), and the other an over- the-counter preparation (ephedra) have received adverse FDA review. The fenfluramin-phentermine combination (fen-phen) was found to be an extremely effective agent, but was removed from the market in 1997 because of its association with serious heart disease.[34] Specifically endocardial fibroplasias seen in heart valves removed from patients treated with the medication were described as indistinguishable from the pathologic changes unique to carcinoid syndrome (serotonin excess) and ergotamine toxic reactions (serotonin-agonist effect).

However, recent studies which were more scientifically rigorous than the early reports have questioned the role of fen-phen in valvular heart disease.[35] In fact, Burger and colleagues criticized the small number of patients studied, limited data on dose and duration of fen-phen therapy and no correlation with matched controls.[36] These investigators studied 226 obese adults exposed to

the drug using transthoracic echocardiographs. Framingham Heart Study subjects were used as controls. The investigators concluded that fen-phen therapy is associated with a low prevalence of significant valvular disease. They suggest that the valvular disease in their subjects may reflect age-related, degenerative changes and not fen-phen toxicity.[36]

Unlike drugs, dietary supplements—naturally occurring substances derived from botanicals—are not subject to FDA review before they come to market. Ephedra, an adrenaline-like stimulant known also by its Chinese name, Ma Huang, has for years been suspected of causing heart attacks, strokes, and sudden death in otherwise healthy people. An FDA consumer alert was issued December 30, 2003, noting that dietary supplements containing ephedra present an unreasonable risk of illness or injury and should not be consumed. The Agency has notified firms manufacturing and marketing these products that it intends to issue a final rule prohibiting their sale, which will take effect 60 days after the publication.[37] The statement notes a vast amount of data shows little evidence of ephedra's effectiveness except for short-term weight loss, while confirming that the substance raises blood pressure and stresses the circulatory system. These reactions have been conclusively linked to serious adverse health outcomes. "Consumers are urged to stop buying and using these products immediately," continues the regulation.[37]

SUMMARY

Behavioral and dieting interventions, and increased physical activity are considered the primary means to promote and maintain weight loss. Weight-loss medications should be considered only as an adjunct for patients who are at substantial risk because of their obesity and in whom non-pharmacologic treatments have not resulted in sufficient weight loss to improve health or to prevent weight regain.[14] Of the three most commonly used, FDA-approved drugs: phenteramine, sibutramine, and orlistat, only orlistat should be used for obese adolescents under 16 years of age.

In many ways, the current state of treatment for obesity is similar to the state of the treatment of hypertension several decades ago. Few medications were available; their efficacy was limited and predictors of response were lacking. Just as research into the underlying causes and consequences of hypertension led to dramatic improvement in its treatment, advances in our understanding of energy balance will most likely lead to more effective treatments of obesity in the future.[5]

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Bariatric Surgery

William J. Raum, MD, PhD and Louis F. Martin, MD, FACS

The surgical treatment of obesity is indicated in patients who have failed sincere attempts at medical therapies to lose weight. The BMI must exceed 40 or exceed 35 and be associated with at least two comorbid conditions. Comorbid conditions include diabetes mellitus, hypertension, obstructive sleep apnea, hyperlipidemia, and other weight related conditions that may benefit from weight loss. Patients need to be educated concerning the specific operation to be performed. They must be taught what they need to do to optimize the likelihood of success of the surgery, and they must have an understanding concerning the potential adverse side effects. When this format is followed, bariatric surgery is a legitimate treatment for morbid obesity, and the only treatment that is generally successful.

The National Institute of Health Consensus Panel on the Treatment of Severe Obesity concluded that surgical treatment of obesity is indicated in patients who had failed sincere attempts at medical weight loss, and exceeded a BMI of 40 or a BMI of 35 with at least two comorbid conditions. Comorbid conditions include diabetes mellitus, hypertension, obstructive sleep apnea, hyperlipidemia, and other weight related conditions that should benefit from weight loss.[1]

Patients need to meet or exceed the requirements above to be considered for surgery but they must also not have an excessive degree of physical, medical or psychological disease that would increase the risk of surgery beyond its potential benefits. Patients need to be evaluated for psychological disorders or learning disabilities that will prevent them from following directions concerning the restrictions in feeding imposed by the surgical procedure. Unstable cardiac disease, severe and irreversible pulmonary disease, inflammatory or neurogenic gastrointestinal disease, or cancer not cured or not in long-term remission are problems that should preclude someone from being considered for bariatric surgery.

There are only a few absolute contraindications to the surgical approach to morbid obesity (Table). A patient may have only one irreversible condition that is a contraindication to surgery, but they are more likely to be rejected based on a combination of factors.

In order to reach a consensus regarding a patient's medical, physical, psychological, and socioeconomic condition, a treatment team approach is highly desirable. Many times these conditions can be modified, improved or eliminated with treatment, counseling, or using community services and resources. They may all impact on the success or failure of surgical treatment.

EVALUATION AND PREPARATION FOR BARIATRIC SURGERY

Patients with morbid obesity may have a number of conditions that may impact their ability to respond to both the behavior modification induced by the surgery and the medical and physical demands of the surgery. A multiplicity of undiagnosed and untreated medical, physical and psychological maladies may be present. We perform a comprehensive evaluation of these possible problems using a multidisciplinary team approach. When conditions are diagnosed, they can and should be treated to decrease perioperative risk and improve overall outcome. Most morbidly obese patients will have significant dyspnea on exertion, heartburn, dependent edema, symptoms of obstructive sleep apnea, pain or disability of weight bearing joints and back, and hypertension. They may also have undiagnosed diabetes mellitus, hyperlipidemia, clinical depression, cholelithiasis, steatosis of the liver, hyperuricemia, Pickwickian syndrome, significant reductions in ventilatory capacity, obstructive sleep apnea, and proteinuria. Most of these conditions can be treated preoperatively and their treatment will greatly reduce the risk of surgery.

Table. Contraindications to Bariatric Surgery

Most cancers in remission for less than 5 years
Chronic Active Hepatitis
Cirrhosis and Portal Hypertension
Ulcerative Colitis
Crohn's Disease
Severe Personality Disorders
Suicidal Ideation
Psychosis
Current substance abuse (alcohol and other addictive drugs)
Bulimia, Binge-eating disorder
Severe Pulmonary Dysfunction
Unstable Coronary Artery Disease
Hyperthyroidism
Hyperparathyroidism

Pulmonary Disease

Pulmonary disease imposes one of the greatest risks to potential bariatric surgery patients.[2] If they smoke, they are told to quit smoking and are strongly advised concerning the risk of mucus plug formation and acute res-

piratory decompensation. We provide advice on behavior modification programs and medications to quit smoking as needed. The diagnosis and treatment of obstructive sleep apnea eliminates the nightly hypoxia that leads to pulmonary hypertension, right heart failure, atelectasis, shunting, excessive fatigue and reduction in daily activity. Continuous positive airway pressure (CPAP) will markedly improve pulmonary and cardiac function if used for at least a month before surgery.[3] Auto-titrating or flexible CPAP is a new method of providing positive airway pressure that provides variable pressure as needed and may be better tolerated than conventional CPAP in some individuals.[4] Patients are more active during the day and have an improved mood when they sleep well at night. Small airway disease responds to beta agonist and glucocorticoid metered dose inhalers given twice per day for a month before surgery combined with incentive spirometer therapy. A flutter valve may be added to help with the clearing of secretions for those with chronic obstructive pulmonary disease. Weight loss and decreased abdominal mass can lead to a markedly decreased restrictive component and improved pulmonary function. Patients are advised on the use of a low calorie high protein liquid diet and a gradual increase in activity. Many are given specific weight loss goals of up to 10% to 20% of their current body weight.

Hypertension

Hypertension may be secondary to obesity and respond well to even modest weight loss induced by a preoperative low calorie liquid diet. A reduction in calories and salt may cause a complete remission of hypertension postoperatively even before any major weight loss occurs. In this situation, antihypertensive therapy may not be necessary. Primary causes of hypertension are also much easier to control with weight reduction. Antihypertensive therapy in the perioperative period should be designed to avoid certain side effects. Low calorie liquid diets generally produce an excellent diuresis; therefore diuretics are usually discontinued when patients start liquid diets. The combination of the diet and diuretics increase the risk of hypokalemia, hyperuricemia and low volume induced hypotension which may occur at the induction of anesthesia. Diuretics are rarely indicated after surgery because patients tend to be volume depleted due to their restricted volume intake. Angiotensin converting enzyme inhibitors may be used but renal function needs to be monitored. Calcium channel blockers and transdermal clonidine patches are preferred. Beta-blockers have the advantage of some cardioprotective effect against supraventricular tachycardias, which are relatively common postoperatively and occur about 5% of the time. Caution must be observed in patients with diabetes in order to avoid hypoglycemia, and in those with bradycardia. Indapamide, a non-loop and non-thiazide diuretic, may be considered for use if peripheral edema is a significant concern.

Cardiovascular Disease

Cardiovascular function is initially assessed by history, physical, and electrocardiograms. Patients may have coronary artery disease, arrhythmias (usually atrial fibrillation), atrial and ventricular hypertrophy, diastolic dysfunction and/or cardiomyopathy. Further cardiac clearance is required with various combinations of cardiac risk factors beyond morbid obesity including diabetes mellitus, hyperlipidemias, family history of cardiac disease, and poor cardiovascular fitness. Many times the diagnostic test desired cannot be performed because of the patient's size, weight and disabilities. Stress echocardiograms may not visualize valves and wall motion effectively. Radionuclide stress tests and treadmill stress electrocardiograms may not be able to be performed because of weight limits of the equipment. The patient may not be able to meet exercise requirements for most of the stress tests because of physical limitations as well. Patients who cannot be fully evaluated must be made aware of these limitations in determining their risk assessment. It is imperative to optimize their medical treatment if bariatric surgery is going to remain an option.[5, 6]

Pain Control

Pain control may be a problem post-operatively. We generally do not make any changes in medications preoperatively, but do advise patients that control of chronic pain may be more difficult after surgery. The surgery may not improve symptoms from spinal disk disease, fibromyalgia, severe osteoarthritis or rheumatoid arthritis. Systemic glucocorticoids and local injections should be avoided when possible to reduce their adverse effects on wound healing and immune function. If possible, nonsteroidal anti-inflammatory drugs are eliminated or reduced in dosage because of the risk for developing gastritis or post-anastomotic ulcer after bariatric procedures.[7]

Diabetes

Diabetes mellitus usually improves, as patients are more motivated with the prospects of an effective treatment for their obesity. When they are instructed concerning low calorie high protein liquid diets and increased activity goals, blood sugar control usually improves. For those patients taking insulin or oral hypoglycemic agents, doses are reduced on an individually crafted sliding scale. The following rationale is used with the goal to keep blood sugars greater than 110 and less than 180. If blood sugar tested twice daily is less than 150 then the dose of their hypoglycemic drugs should be reduced. The level of reduction needs to be estimated based on the number and types of drugs being taken and how blood sugars respond. Aggressive reduction in drug therapy is instituted when blood sugars are less than 110. Start by decreasing long acting then intermediate acting insulin, then sulfonylureas, short acting insulins and glitazones. Glucophage usually may be continued without risk of

hypoglycemia. It will aid in reduction of insulin resistance and enhance weight loss. Good glucose control is essential in reducing postoperative infection risk and improving protein synthesis for wound healing.[8, 9]

Deep Venous Thrombosis

Deep venous thrombosis (DVT) and potential pulmonary embolus are high risks for the morbidly obese undergoing abdominal surgery.[10] Although our overall death rate is low, pulmonary embolism has been the primary cause of postoperative death in our bariatric patients over the last 20 years despite an aggressive prophylactic protocol. To reduce the risk of DVT, women on estrogen, progesterone, or combination hormone therapy, birth control or menstrual regulators are advised to stop these drugs at least one month before surgery. The drugs can be restarted two months after surgery.[11] For those with severe venous stasis, or a history of prior deep venous thrombosis or pulmonary embolus, the placement of a Greenfield® vena cava filter is necessary preoperatively. For further risk assessment, a venous Doppler ultrasound of the lower extremities may be performed in some patients. All patients receive enoxaparin prophylactically 6 to 12 hours before surgery and then every 12 hours after surgery. The dose given is equal to their BMI. Thus, if the BMI is 50, they receive enoxaparin 50 mg subcutaneously every 12 hours.

Psychological and Psychosocial Evaluation

Bariatric surgery may be considered behavior modification surgery. Patients are being forced into a new lifestyle. Most follow the signals provided by the surgery to eat slowly in small portions, chew thoroughly, drink slowly, eat frequently, gradually increase the complexity and thickness of food over time, avoid sweets and fat, and consume their protein at the beginning of meals.[12] They are also instructed to avoid alcohol and addictive drugs and perform gradually increasing daily activity, and keep follow up appointments with physicians and support staff. In some there are barriers to following this regimen regardless of their very sincere desire to eliminate their morbid obesity. These include behavior disorders that prevent changing eating habits or result in the adoption of even more destructive behavior involving alcohol or drugs.[13] There may be additional barriers to a good outcome including poor social support, family conflicts, transportation problems, poor understanding of the procedure, bulimia, psychoses, anxiety disorders, and clinical depression. Some of these conditions may be reversible or controlled, others may not. It is the task of the team, including the psychologist and social worker to find community resources, therapists, family counselors, and continued patient education to overcome these problems. The goal is to avoid putting the patient in a position following bariatric surgery where they are having problems adapting and no preparation was made to help them. Preoperatively, patients submit to extensive psychological and psychosocial evaluations to identify problems that can and should be treated as well as those that are intractable and will eliminate them from consideration for bariatric surgery.[14, 15]

Nutrition

Generally patients are not malnourished in macronutrients before surgery. Suspected micronutrient and mineral deficiencies should be corrected. Iron is commonly low in menstruating females. Diuretics used to treat hypertension or edema may reduce potassium or magnesium. Replacement and then modification of diuretic treatment can correct these deficiencies. Body stores of calcium and bone density are rarely reduced. In our experience bone density scanning preoperatively is not cost effective. The excessive weight of morbid obesity imposes stress and keeps bone density high. Only in those treated with long-term glucocorticoids for joint or pulmonary disease, or those who are postmenopausal without estrogen replacement have a need for preoperative calcium and vitamin D supplementation. Protein stores expressed as pounds and not as percent of body weight are increased since muscle mass is needed to support the excessive body weight.

We prescribe a low calorie high protein liquid diet (LCLD) for at least two to four weeks before surgery. The calorie content is generally set at about two calories per pound body weight with steps at 600, 800, 1000 or 1200 kcal/day. Protein intake is set in grams at 30% of their body weight in pounds. For example a patient weighing 300 pounds would get a diet consisting of 600 kcal/day with 90 grams of protein. The weight loss induced is helpful to all patients, but some benefit more than others. They become accustomed to the liquid protein supplements and may experiment with taste, texture, cost and availability of the many supplements. It is easier for them to obtain an adequate supply of the supplement before surgery when they are more mobile than after. They will also have a better appreciation of the restrictions of the liquid diet having tried it before surgery. The physiological advantages of pre-surgery weight loss are a decrease in liver size and steatosis, improvement of liver function and increased accessibility to the operative site. Decreased intra-abdominal fat also improves lung expansion by allowing an increase in diaphragmatic excursion. The LCLD is very low in sodium and induces a significant diuresis, decreasing edema, total body water and sodium, decreasing blood pressure and decreasing the need for diuretics and perhaps other antihypertensives. Lastly, the patient's adherence to the diet helps to demonstrate their compliance. Those who have difficulty will require additional counseling and more support group sessions pre- and postoperatively.

Education

In addition to the medical and ancillary assessments, patients receive extensive education during their preop-

erative evaluation. They are given a series of educational manuals and brochures for reference, but the contents are explained and patients are given many opportunities to ask questions. Patients initially take a two page quiz to determine their basic knowledge about the procedures, results, side effects, diet, activity and follow up responsibilities.[16, 17] The test is given a second time to ensure that they understand the information. When questions remain, additional counseling is given.

PRE-ADMISSION PREPARATION AND ADMISSION

Once consents and insurance approvals are obtained, the patients are given instructions and prescriptions. For three days prior to admission, they take two showers per day and alternate between three soaps: Hibiclens, Phisoderm, and Dial antibacterial. They take oral antibiotics, ciproflaxin 500mg b.i.d., metronidazole 500 mg q.i.d. and fluconazole 200 mg daily. Patients are admitted at midnight on the day of surgery for any final adjustment in medications, laboratory studies, including pregnancy tests when indicated and they start their deep venous thrombosis prophylaxis with enoxaparin. One dose is given approximately 6 hours before surgery at a dose equal to their BMI and this is continued postoperatively every twelve hours. The dose is rounded down at 5 unit intervals so that a patient with a BMI of 43 gets 40 mg of enoxaparin and one with a BMI of 58 gets 55 mg. A peripheral intravenous line is established and they are given levofloxacin 400 mg, metronidazole 500 mg and fluconazole 200 mg IV on call to the operating room.

BARIATRIC PROCEDURES

The history of bariatric procedures since the 1950s and detailed information on the risks and expected outcomes of the most common procedures is beyond the scope of this review. We have recently written a textbook on bariatric surgery published by McGraw-Hill available through their web site or from Amazon.com.[18] The text provides a comprehensive review of bariatric surgery.

Small Bowel Bypass

Surgeons in the mid-west began seeing morbidly obese patients after World War II, when food became relatively inexpensive, more available, and there were improvements in food processing (freezing and refrigerated transportation, etc.) Physicians and surgeons began thinking that surgical procedures might help severely obese individuals who presented with severe disabilities and numerous comorbid conditions. Dr. Richard L. Varco, a surgeon at the University of Minnesota, is credited with performing the first bariatric operation. He performed a jejunoileostomy to shorten the length of small bowel by over 70%, leaving the bypassed small bowel anastomosed

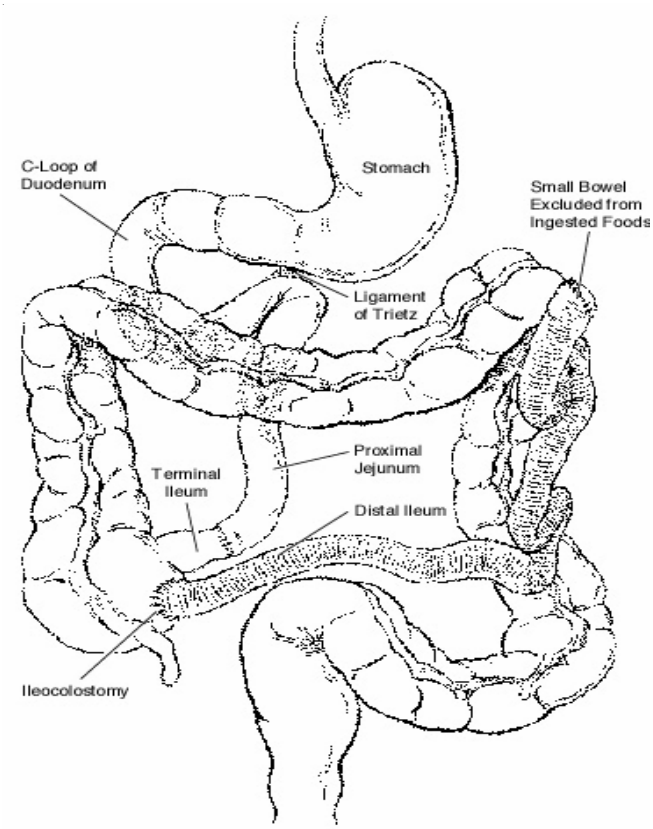

Figure 1. The first malabsorption procedure performed by Dr. Richard Varco in 1953 at the University of Minnesota to treat morbid obesity.

to the cecum so that intestinal mucous could be drained (Figure 1). He envisioned the bypassed small bowel would be put back into continuity during a second operation once the patient had reached the initial goal weight.[19]

The operation was termed "small bowel bypass" and it was performed well into the 1980s even though it became obvious in the 1970s that the procedure produced severe complications that made the risk-benefit ratio of these operations unacceptably high. Before the procedure was abandoned, it cast a negative pall over the field of bariatric surgery, which has not entirely lifted. The operation caused malabsorption, so the more the patient ate, the more diarrhea they had. To lead a social life, intake had to be decreased and weight was lost due to the combined effects of less bowel surface to absorb nutrients and a decreased intake. However, many patients developed electrolyte and vitamin deficiencies, kidney stones, immune type arthralgias, acute liver failure (leading to over a 5% one-year mortality), and cirrhosis (80% of patients developed some cirrhosis within 20-years of their procedure). Obviously, the creators of this procedure anticipated none of these side effects, but the results from this ongoing experiment clarified many is-

sues in gastrointestinal physiology.

Gastric Bypass

As it became clear that small bowel bypasses caused a number of significant complications, surgeons began creating other bariatric procedures. Dr. Edward Mason, at the University of Iowa, was the first surgeon to devise a popular alternative, the gastric bypass, initially reported in the 1960s.[20] The procedure decreased food intake by a combination of restricting the size of the stomach by more than 95% and by having the exit from this restricted pouch redirected to enter the proximal jejunum. Gastric acid, gastric enzymes that help dissolve complex proteins, bile, and pancreatic juices, all necessary for the absorption of nutrients, are not mixed with food entering the proximal gastric pouch until three feet of bowel have been bypassed. The original procedure has undergone various modifications. Surgical staplers were introduced in the late 1970s (Figure 2) and the procedure was further adapted so that it could be performed laparoscopically in the early 1990s using minimally invasive techniques.[21]

The Roux-en-Y gastric bypass is now the most common bariatric procedure performed in the United States. Approximately 100,000 such procedures were performed in 2003. At least one-half of these procedures are now performed laparoscopically. Laparoscopic techniques decrease postoperative wound complications and pain, and usually result in a 50% decrease in the time to return to full work and social activities when compared to the open surgical approach.[22] As mentioned elsewhere in this review, this procedure usually results in patients losing 75% of their excess weight, but some micronutrient deficiencies may occur, especially vitamin B12 deficiency and anemia.

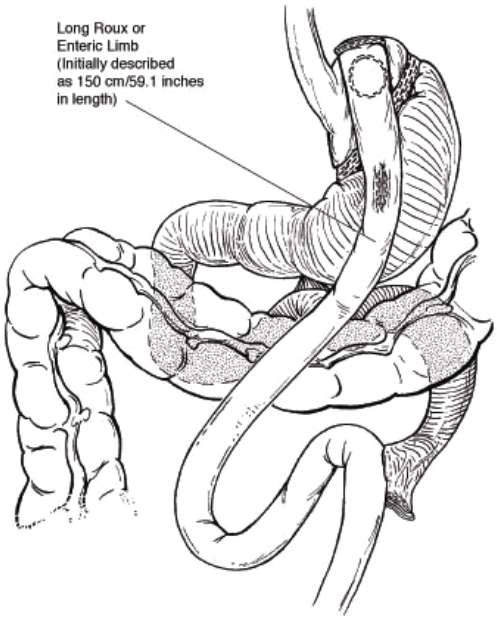

Figure 2. Roux-en-Y gastric bypass demonstrating the use of the various "stapled" anastomosis.

Gastric Banding

Even though the side effects of gastric bypass are minimal enough to produce a very favorable risk-benefit ratio, there are still many morbidly obese patients and some bariatric surgeons who want a treatment that is viewed as "safer" and several operations have been proposed to fill this ideal. However, it was not until the mid-1980s that two medical device-manufacturing companies began producing silastic bands designed to fit around the upper portion of the stomach to constrict off a small gastric pouch (15-20/mL) similar to the pouch used in the gastric bypass.[22] The innovation was the development of an adjustable band, which was attached to a length of tubing and a subcutaneous access port (similar to those used to inject chemotherapy medications into the central veins of patients with cancer). The band was placed around the upper portion of the stomach so the opening was large enough that the swelling associated with the surgical procedure did not delay a hospital discharge because of an inability to swallow liquids. Once swelling from the surgical procedure decreased, saline would be injected percutaneously into the reservoir or access port, sewn onto the anterior rectus muscle fascia. The added fluid caused the balloon to enlarge and the restriction around the upper stomach to increase. (See Figure 3.) Periodic adjustment could then "fine tune" the degree of obstruction a patient needed to lose weight yet still eat small quantities of nutritious foods. These adjustable bands could also be placed by laparoscopic techniques making this potentially an outpatient procedure with significantly lower costs and fewer initial complications rates than gastric bypass. These features and the fact that it is an "easy" procedure to learn, have led this operation to become the most common bariatric operation outside of the United States.

Bariatric surgeons' in this country use this procedure in only 10% to 15% of the patients who qualify for bariatric surgery. In many instances, insurance companies have blocked patients from receiving the adjustable gastric band procedure. They have declared the procedure "experimental", even though over 100,000 adjustable gastric bands have been placed worldwide with fol-

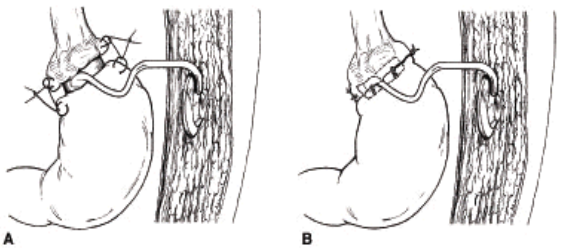

Figure 3. A) Band with its self locking mechanism B) Stomach sewn over the band to imbricate it in place in its own tunnel.

low-up approaching 10 years in studies conducted in Australia and Europe. In addition, American surgeons have been more skeptical of the bands than their European counterparts because it is well known that most medical devices do not function for more than 10-15 years and they worry that the balloon may be functional for even shorter periods of time. Although the initial band placement is associated with lower morbidity and mortality rates than gastric bypass because it is a clean procedure without the need to open the gastrointestinal track or reroute the bowel. However, long-term complication rates are still unknown. In addition, the devices can become displaced causing obstruction, and can erode into the stomach. The devices are also susceptible to external trauma. (The access port can be broken or become infected.) Fluoroscopic gastrointestinal contrast studies can be used to adjust the band's volume. This is expensive; up to $900 per adjustment. These features increase complication rates and costs so that studies extending more than 10 years are needed to determine which procedure will be most cost-effective. Patients receiving a gastric band in order to achieve weight loss similar to that of a gastric bypass, need a more intense program of behavior modification for the first several years because gastric banding is only a restrictive operation. Whereas Roux-en-Y gastric bypass is a restrictive procedure, but also has a malabsorption component since some small bowel is bypassed.

Biliopancreatic Bypass

Dr. Nicola Scopinaro developed the biliopancreatic bypass (BPB) in the mid-1970s in Genoa, Italy. This is a second generation malabsorptive procedure modeled after the small bowel bypass with significant modifications to reduce the side effects. It is designed to increase malabsorption of food since ingested food is prevented from mixing with gastric juices, bile, and pancreatic enzymes until further down the course of the gastrointestinal track. It does not combine the food limb (enteric or Roux limb) with the biliopancreatic or malabsorptive limb until a point 50-cm from the ileocecal valve (three to four feet further downstream than does a gastric bypass). Therefore, diarrhea occurs when too much food is consumed (Figure 4). The stomach is also decreased in size, but not nearly to the degree that it is with a gastric bypass. Patients who choose this procedure are attracted to it because it allows them to eat greater quantities of food than a gastric bypass or adjustable gastric band and have weight loss results that are superior to gastric bands and often even greater than weight loss associated with gastric bypass. The unattractive feature of this operation is that patients must consume a diet much higher in protein (usually greater than 100 gms per day) in addition to nutritional supplements because of greater malabsorption. If patients are not compliant, they develop low body protein stores, edema, malnutrition and nutritional deficiencies. Individuals undergoing this procedure must be

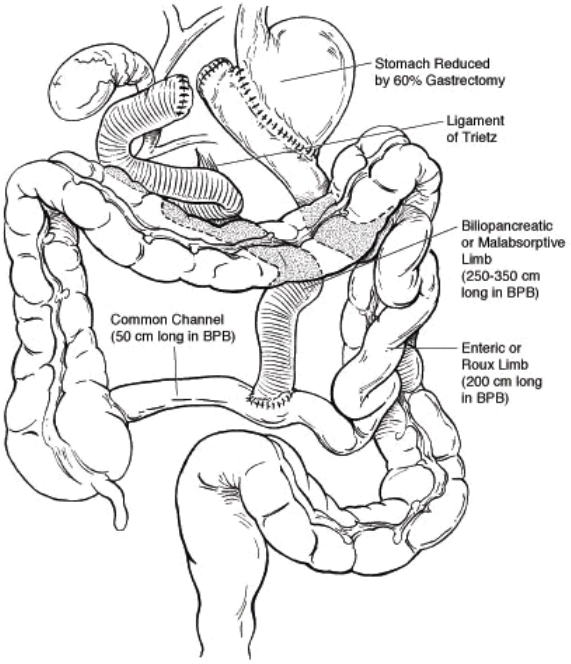

Figure 4. The biliopancreatic bypass (BPB) developed by Dr. Nicola Scopinaro in Genova in the 1970s.

able to afford the extra supplements and food costs. Medical insurance companies also try to label this procedure experimental even though good, long-term studies from Canada and Italy support its use.[23]

Other Procedures

There are other bariatric operations that are used when a primary operation fails. Individuals who do not lose the expected weight, or become malnourished may need further surgical intervention. Embarking on a revision procedure should be undertaken only after extensive re-evaluation of the cause of the failure and a well-considered plan for correction. These patients are at much higher risk for complications and are less likely to mount a favorable weight loss than with a primary procedure. Those that need revisions of bariatric procedures should all be referred to experienced bariatric surgeons. The issues that must be considered when evaluating these patients have been recently reviewed.[24]

The Best Procedure

Conflicting data makes choosing the best bariatric procedure for an individual an inexact science. Bariatric surgeons tend have their own preferences. Their practices are often structured to support one of these procedures more than another due to their level of experience and also due to the attitudes and beliefs of staff members. Patients who feel the adjustable gastric band is the preferable procedure because it is "less invasive and/or less mutilating" often cannot be persuaded to have a gastric bypass, which may be a better procedure for their

condition. We, personally, cannot recommend using an adjustable gastric band in an adolescent because the device would have to be replaced at least twice as the individual matures increasing risks of complications with each change. It is wise to know the level of experience and the attitudes and beliefs of the surgeons to whom you refer patients if your patients are to have the best procedure for their situation.

POST SURGICAL CARE

Initial follow up is at one week following hospital discharge. This visit is primarily for wound care. Two weeks later the emphasis is on nutritional and medical follow up. A dietitian, exercise physiologist, endocrinologist and nurse practitioner follow patients for nutritional, exercise and medical follow up while the surgeon concentrates on problems related to the procedure. Additional clinical visits depend on medical, surgical, psychological, or nutritional concerns. However, patients should be seen at least every 3 months until body weight stabilizes and then every 6 to 12 months.

Weight Loss Goals

For most procedures, we expect patients to lose from 5% to 15% of their current body weight per month. Weight loss rates vary by procedure and are influenced to a great degree by the patient's understanding, participation, and response to the behavior modification each procedure attempts to enforce. Studies have not stratified subjects according to risks, lifestyle, severity of obesity, or compliance with postoperative care guidelines. When patients are combined, there is a cohort of patients who can markedly distort the overall success of any procedure.[25] By taking the patients who are most compliant with postoperative follow up the following results can be obtained with gastroplasty and adjustable gastric banding which are restrictive and not malabsorptive procedures. Fifty percent of patients lose 60% of their excess body weight with these restrictive procedures. Only small food portions can be ingested. Patients need to keep portions small to avoid vomiting and must avoid liquid forms of high fat and high sugar foods or they will not lose weight. Gastric bypass results in more than 80% of patients losing 75% or more of excess body weight by enforcing a significant dietary restriction. Weight loss also occurs because excess dietary fat and carbohydrate results in malabsorption and diarrhea. Even small amounts of concentrated sugar or fat may cause dumping syndrome.[26] Early dumping, usually from sugar, results in beta-adrenergic stimulation with tachycardia, sweating, tremor, lightheadedness, and anxiety. Late dumping is usually due to fat and results in diarrhea, gas, lower abdominal cramps, and nausea. Filling the gastric pouch too rapidly may also cause severe epigastric pain that may radiate to the back or other areas and may only be relieved by vomiting. Dumping and vomiting may initially lead to higher weight loss rates at the expense of significant malnutrition of protein, fat-soluble vitamins, and irregular absorption of medications. Prolonged inappropriate eating behavior may eventually render the procedures ineffective due to anatomical adaptations to the excessive ingestion of fat and sugar.[27] Biliopancreatic diversion is less restrictive, but more malabsorptive in its mechanism of weight loss. With this procedure, an excessive intake of foods high in fat causes diarrhea to a greater degree. The increase in malabsorption results in more malnutrition than occurs with gastric bypass. Weight loss is generally equal to or greater than occurs with gastric bypass surgery.

Resting Energy Expenditure and Body Composition

Our goal is for patients to reach a BMI of 25. It is important that the majority of weight loss be fat and not lean body mass. We aim postoperatively for a fat to lean body mass loss of 2:1 (wt: wt). This initial goal depends on lean body mass before surgery. Women should have a lean body mass of 75% and men 85% and fat mass of 25% and 15% respectively. It is more important that they reach these body composition goals than actual weights. For example is it not desirable for a woman to have a BMI of 22 and fat mass of 40%. Proper management of nutrition and activity should allow the vast majority of all patients who undergo bariatric surgery to attain these goals.

We measure resting energy expenditure (REE) or resting metabolic rate to ensure that a reasonable level of calories are being burned each day.[28] Even with normal thyroid metabolism some patients reduce their metabolic rates through hormonal mechanisms to prevent weight loss, specifically fat loss.[29] One may predict excessive lean body mass loss and low REE level if patients express symptoms of feeling cold, excessive fatigue, and/or lack of energy. These symptoms may also be caused by the loss of subcutaneous fat, or clinical depression. The best way to eliminate misdiagnosis is to measure REE and body composition.

The treatment for loss of excessive lean body mass is to increase a patient's activity slowly but progressively. The safest activity is walking. It is important to use a pedometer to monitor and measure progress. Patients are encouraged to increase steps by 50 to 100 per day to a total of 10,000 steps per day, a goal everyone should try to achieve. Upper body exercises with the same slow, progressive increase in intensity is also recommended. Because of physical limitations and disability of many of our patients, some exercises are prescribed through a physical therapist.

Intake of high quality protein is essential in maintaining lean body mass. We measure serum prealbumin levels to help monitor what the patient is taking and also to determine if our estimate of the requirement is correct.[30] Finding the correct high quality protein drink or

formula that the patient can afford and tolerate for the stage of their postoperative course is the responsibility of and many times a challenge for our talented dietary staff.

If patients continue to lose lean body mass, cannot maintain adequate prealbumin levels, or cannot raise their REE, then we prescribe ephedrine for short periods.[31] Ephedrine increases metabolic rate and increases loss of fat mass while reducing the loss of lean body mass.[32] Ephedrine is given at a 25 mg dose and is titrated from one to three times per day. Lower doses are used for those who experience excessive adrenergic side effects. However, in the 20 years that we have used this medication, only a few have been unable to tolerate a therapeutic dose when the dose is increased slowly. We have had no serious side effects like those reported with the unsupervised use of over-the-counter ephedra products. Several months after surgery protein intake should increase, along with activity. Then ephedrine can be tapered and discontinued with great benefit. Patients rarely achieve fat loss percentages that exceed 60-70% of total weight loss on their own. However, it is routine to have fat losses of 90-100% or even gain lean body mass while taking ephedrine.

POSTOPERATIVE NUTRITION

Regardless of the treatment used, medical or surgical, patients on restricted diets require nutritional supplements. The patients are in negative nitrogen balance and lose lean body mass, but because of variations in absorption, storage, and utilization, no single nutritional protocol will suit every individual. It is not possible to supplement and prevent all possible deficiencies. Some individuals cannot tolerate the volume or taste of all macronutrient and micronutrient preparations. However, we have arrived at a rationale for supplementation. Major nutritional deficiencies are replaced to overcome an estimated deficiency, and then nutritional markers are measured at predetermined intervals to ensure that supplements are adequate.

Multivitamins and Iron

Supplementation for pure restrictive procedures (gastroplasty or adjustable gastric banding) is no different than any low calorie diet. These surgical procedures result in portion control and there are no specific deficiencies associated with them. A multivitamin is needed to overcome potential deficiencies of the restricted balanced diet. Restricted diets tend to be low in iron. However, iron replacement drugs tend to cause constipation. Serum iron levels and iron stores should be measured before surgery, then usually at 3 to 6 month intervals during weight loss. Stool softeners and mild laxatives should be given to avoid constipation if the patient is at risk. Gastric bypass patients tend to have more difficulties with iron absorption because of the loss of acid and ionization capabilities important in the absorption of iron.[33, 34] Menstruating women are at greater risk for iron deficiency than men. When able, lean red meat is the best source of absorbable and non-constipating iron, and an excellent source of high quality protein. Biliopancreatic bypass surgery usually induces less iron loss than gastric bypass because a larger portion of the stomach is left intact with increased acid production resulting in greater iron absorption.

Protein Supplementation

There is an obligatory loss of body protein during weight loss regardless of whether weight loss is the result of surgical or medical therapies.[35] The amount of protein lost also varies with the procedure and individual. Laboratory measurements of protein stores are essential in obtaining the best outcome for the patient. For gastric bypass patients, we start with an estimate of 30% of total body weight in pounds to determine the number of grams of protein to be ingested daily (example: 300 pounds times 30% equals 90 grams). We obtain food journals from patients and measure prealbumin (30). Lean and fat body mass are assessed by body impedance or dual energy x-ray absorptiometry (DEXA) until weight loss stabilizes.[30] Protein supplements must be of high quality, contain all essential amino acids and be palatable, affordable, and appropriate for the procedure type and current clinical status. For example, lean beefsteak is an excellent source of high quality protein, but its consistency would likely cause gastric outlet obstruction following most procedures in the early postoperative period. Liquid protein supplements are essential in the early postoperative period but regular protein sources such as meat, fish, dairy products and vegetable protein need to be gradually introduced if the goal of eating three regular healthy meals and one snack per day is to be achieved. Patient understanding of the importance of protein to other food groups, and a dietitian with experience in dealing with patients who have undergone specific bariatric procedures is essential for the best outcome. It is far easier to maintain the lean body mass of patients than it is to replace a deficit in lean body mass acquired during weight loss.

As mentioned elsewhere in this review, protein supplement is needed at a higher level in BPD than in all other procedures because of decreased absorption in the shortened enteric limb.[36] Following a BPD, protein replacement is calculated at 40% of total body weight in pounds as the grams of protein required per day. Prealbumin and body mass measurements are also determined, as described above, for each patient and are updated on a regular basis.

Calcium and Vitamin D

Calcium loss from bone occurs normally starting at 40-50 years of age. The loss is greater in women than men. It is accentuated during menopause (natural or surgical),

low calcium and vitamin D intake, sedentary lifestyle, use of glucocorticoids, and weight loss. Bone density or calcium content of bone is nearly always high in the morbidly obese. The high calorie intake of most obese individuals is associated with more than adequate dietary calcium. Furthermore, the stress on bone of carrying a heavy body load leads to increased deposition of calcium in bones. During surgically induced weight loss, protein supplementation is usually provided in the form of milk-based formulas and foods high in calcium and vitamin D. Additional supplementation is rarely required following gastric bypass. Insufficient dietary protein is potentially more detrimental to bone than insufficient dietary of calcium.

The malabsorption that occurs with BPB may result in higher losses of calcium and vitamin D than with other procedures.[37] Excessive loss of calcium generally does not cause hypocalcemia, but may be associated with elevated serum parathyroid hormone and increased measures of bone turnover including serum alkaline phosphatase and N-telopeptide. Early supplementation with calcium and vitamin D will reduce the likelihood of osteoporosis.

High-risk patients are those with milk intolerance, those who are postmenopausal, or those who have a history of regular glucocorticoid therapy, or a family history of osteoporosis. Patients who undergo a BPB procedure should receive calcium and vitamin D supplementation during the first postoperative month. Calcium citrate rather than calcium phosphate or gluconate is best absorbed. Being soluble in water, it is most compatible with the liquid consistency of the early postoperative diets. Vitamin D (25-OH vitamin D), N-telopeptide levels, and bone density measurements should be used to monitor response and adjust treatment.

Procedure Specific Nutritional Supplements

Because of the loss of gastric juices and absorption capacity, vitamin B12 and iron are common deficiencies in gastric bypass patients.[38] Mucosal absorption of sublingual, chewable or intranasal vitamin B12 overcomes this deficiency in essentially all patients as it circumvents the need for intrinsic factor produced in the stomach. As long as serum B12 levels are maintained above 400 mcg/dL, the route of administration of the vitamin B12 should be designed to best meet the lifestyle of the patient. The level of 400 mcg/dL is selected over the lower limit of normal (usually 200 mcg/dL) because higher levels have been shown to decrease homocysteine levels and reduce coronary artery disease risk.[39] Iron needs vary with a patient's situation. Constipation is common in the early postoperative course due to low fiber intake. Fluid intake needs to be balanced with the constipating effect of iron supplementation. If severe constipation develops, this may lead to nausea, vomiting, and volume depletion and hospitalization to relieve fecal impaction. If anemia is mild and iron levels are gradually improving, iron balance will return as the diet becomes more liberal and contains more iron (red meat and dark green vegetables). Men rarely require supplementation compared to menstruating females who continue to lose iron with menses and have lower iron stores before surgery. If iron supplementation is needed, a stool softener and/or mild laxative are appropriate to prevent severe constipation.

Fat-soluble vitamins (A, D, E, K) are commonly lost following BPB surgery. However, only vitamin A and D require supplementation. The more diarrhea a patient experiences, the more supplementation is required. Because deep venous thrombosis and subsequent pulmonary embolus is a serious consequence, we rarely replace vitamin K unless there is evidence of significant blood loss. Measurement of prothrombin time can help to guide the need for additional vitamin K. Blood chemistry measurement of 25-OH vitamin D and vitamin A will provide evidence of deficiency and help determine appropriate replacement therapy. It is common to supplement both vitamin A and vitamin D3 to maintain normal levels in patients following BPB. Some gastric bypass patients who experience periods of late dumping or are severely malnourished from frequent vomiting also may become deficient in fat-soluble vitamins and should have serum levels monitored. Generally, deficiencies from gastric bypass are less severe, less frequent, and less prolonged than with BPB. We have seen clinical signs of deficiency of vitamin A with decreased night vision in patients undergoing BPB, but not with the other procedures.

Deficiencies may occur with any restricted diet or with frequent vomiting. However, deficiencies of minerals (calcium and iron), vitamins, and protein do not usually occur with gastric banding because there is no gastric or intestinal malabsorption. Therefore if deficiency does occur, correction of the deficiency is easier. The usual recommendations are to eat a balanced diet and take a multivitamin daily.

Other Supplements

There are now many products on the market to help bariatric surgery patients contend with protein, mineral and vitamin deficiencies including protein bars, liquid supplements, and specialized vitamin and mineral capsules and liquids. However, selection of these products should be managed by a dietitian with knowledge of the patient's financial resources and skilled in the balance of a patient's actual requirements and their individual needs.

Addressing the potential need for zinc, magnesium, assorted vitamins (folate, thiamin), and trace elements exceeds the space allotted for this review. One must temporize the number of supplements that can be given according to their actual benefit and avoid potential nutrient interactions that may be detrimental. Multiple supplements will not replace a balanced diet, plenty of exercise, and regular medical follow-up which is most important

for the overall well-being and good outcome following these procedures.

SUMMARY

Bariatric surgery is a legitimate treatment for morbid obesity and the only treatment that is generally successful. Selection of a skilled experienced surgeon backed by a multidisciplinary team, in a properly equipped hospital and office is the essential first step toward a successful outcome. Comprehensive screening for potential complicating medical and psychological problems to prepare and identify good surgical candidates reduces perioperative and postoperative complications. Patients need to be well educated in the consequences and requirements of the operation performed. Timely follow up with physicians and staff is essential. Surgery can result in the resolution of most if not all comorbidities and a normal or near normal body composition. The ultimate outcome can improve both the quality and length of life.

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