Published in final edited form as:

Am J Community Psychol. 2009 December ; 44(3-4): 338. doi:10.1007/s10464-009-9269-1.

Examining the Etiology of Childhood Obesity: The IDEA Study

Leslie A. Lytle

Division of Epidemiology and Community Health, University of Minnesota, 1300 South Second Street, Suite 300, Minneapolis, MN 55454-1054, USA

Leslie A. Lytle: lalytle@umn.edu

Abstract

The prevalence of childhood obesity is of great public health concern. A social ecological framework that is transdisciplinary and multilevel by nature is recognized as the most promising approach for studying this problem. The purpose of this paper is to describe longitudinal research using a social ecological framework to study the etiology of childhood obesity. Individual and contextual factors are assessed in a cohort of youth and their parents including psychosocial factors, and home, school and neighborhood environments. The conceptual model guiding the research and the study design and measures used to operationalize the factors in the model and the descriptive characteristics of the baseline sample of youth and parents enrolled in the research are presented. The use of a conceptual model to guide the research, a transdisciplinary approach, a longitudinal cohort design and state-of-the-art measures of the individual and the environment are strengths of this research.

Keywords

Social ecological model; Childhood obesity; Longitudinal cohort study

Introduction

Childhood obesity is well recognized as a major public health concern (Hedley et al. 2004; IOM 2005; US Department of Health and Human Services 2001). Based on National Health and Examination Survey (NHANES) data, approximately one-third of youth ages 6–18 are overweight, and half of these children are obese (Ogden et al. 2006). Obesity tracks from childhood into adulthood (Gordon-Larsen et al. 2004) resulting in personal, social and economic costs. A recent estimate projects that obesity will account for more than 16% of all health care expenditures by 2030 (Wang et al. 2008).

It is well recognized that the causes of childhood obesity are complex and multifaceted. Huang and Glass (2008) present a new research strategy for understanding and preventing obesity that is multilevel, addressing not only individual-level influences and choices that lead to energy imbalance, but also the complex systems occurring at the interpersonal, community, and governmental levels that provide the context for health-related behaviors. This comprehensive perspective is also reflected in the field's embracing of social ecological models and transdisciplinary research as the best ways to work collaboratively toward creative and far-reaching solutions.

Correspondence to: Leslie A. Lytle, lalytle@umn.edu.

Conflict of Interest Statement None declared.

Social ecological models for understanding obesity have been proposed over the last 10 years. Most of them have a genesis in the work of Bronfenbrenner (1977). In models proposed by Davison and Birch (2001) and Story et al. (2008) the individual is shown as contributing their cognitions, skills and behaviors, lifestyle, biology and demographics, while embedded in other circles representing the contexts that influence individual-level decision-making, including the social, physical and macro-level environments to which they are exposed including families, neighborhoods and the larger cultural environment. These social-ecological models are useful in showing the wide range of factors that contribute to a complex health issue like obesity but these models are theoretical in nature and do not readily suggest relationships between the factors or testable hypotheses. The International Task Force on Obesity offers another type of conceptual model that is more explicit about the relationship between factors, even suggesting a causal pathway, but the scope of the model is very large, including international global markets, urbanization and national agricultural policy (Stettler 2002). The expansiveness of current social ecological models have limited utility for suggesting testable hypotheses that may best inform health promotion activities at the community level.

Use of an ecological framework that embraces complex systems (including transportation, urban planning, agricultural policy, social networks, sociology, psychology and biology) naturally call for at least a multi-disciplinary approach, and, more appropriately, a transdisciplinary approach. Abrams (2006) defines multi-disciplinary as, "...a process in which researchers in different disciplines work relatively independently, each from his or her own disciplinary perspectives with limited direct interaction and cross fertilization." (Abrams 2006, p. 516). Transdisciplinary research extends the paradigm by involving a process whereby "...collaborators work jointly on a problem from the very onset, using a shared conceptual framework that draws together discipline-specific theories, models, methods, and measures into a new synthesis." (Abrams 2006, p. 516). Transdisciplinary research involves cross-fertilization between disciplines that includes finding a shared language, building tolerance for looking at an issue through a completely different lens, and using creativity to use new and old models, measures and analytic methods to solve complex problems.

The need for these more complex approaches is borne out in the current research, which examines the effectiveness of interventions to prevention childhood obesity. A series of review articles published in the last decade (Campbell et al. 2001; Doak et al. 2006; Hardeman et al. 2000; Katz et al. 2005; Stice et al. 2006; Summerbell et al. 2005) confirm that our interventions to date have had, at best, very modest results, and most show no statistically significant results. While we learn something from every intervention trial, we currently do not have empirically based scientific evidence to offer communities as proven ways to prevent childhood obesity.

The purpose of this paper is to describe longitudinal research using a social ecological framework to study the etiology of childhood obesity. The research strives to be transdisciplinary, involving researchers from different fields with an intention to achieve intellectual integration that extends the concepts, theories, and methods of the fields represented (Stokols 2006). This paper will discuss the conceptual model guiding the research, and the study design and measures used to operationalize the factors in the model. In addition, the descriptive characteristics of the baseline sample of youth and adults enrolled in the research study are presented.

The TREC IDEA Conceptual Model

Transdisciplinary Research in Energetics and Cancer (TREC) is an initiative from the National Cancer Institute (<https://www.compass.fhcrc.org/trec/>) with two main foci: (1) to increase our understanding of the mechanisms underlying the associations between energy balance and carcinogenesis across the cancer continuum, from causation and prevention through survival;

and (2) to develop effective innovative approaches with broad population impact at the social-environmental and policy levels for prevention of obesity, with particular emphasis on children and critical time periods during childhood where weight gain is likely. The Identifying Determinants of Eating and Activity (IDEA) project focuses on this second aim by examining predictors of youth obesity in a population-based sample.

The first research goal of the IDEA project was to develop a conceptual model to guide our research that would: (1) include multiple levels of influence; (2) focus on factors that showed evidence from previous research as being potential predictors of the development of obesity in youth; (3) focus on mutable factors that could be examined in future community-level health-promotion interventions; and (4) specify relationships between suggested predictive factors and the outcome of body mass index (BMI) and weight status in a causal pathway that could be tested in a single, comprehensive research trial.

The development of the TREC IDEA conceptual model began with a small team of investigators examining the peer-reviewed literature for factors suggested as related to the development of childhood obesity. A subset of levels of influence to be included in the conceptual model was identified, and, within each level of influence, a set of factors felt to be closest to energy balance and most likely mutable in intervention research. A theory-based framework was used to organize the levels of influence (Perry 1999). A larger team of scientists, from a wide set of disciplines (including urban planning, exercise physiology, nutrition, epidemiology, physiologists, and psychology) were asked to review the draft model and provide input on the factors selected and the relationships suggested in the causal pathway.

Figure 1 shows the conceptual model developed to guide empirical research on the etiology of childhood obesity. We did not attempt to identify every possible association in the model and, while causal pathways are inferred, we believe that many, if not most, of the relationships are reciprocal and bi-directional.

The model posits that obesity-related risk factors in youth, including BMI percentile and body composition, are most closely and most directly affected by diet, biological and activity-related factors. In turn, biological factors are directly affected by youth weight status. Physiologically, an individual's weight status is determined by metabolic interactions related to energy balance and the development of adiposity. In youth, pubertal status is well-recognized as influencing weight gain during critical developmental times and, conversely, weight status may affect pubertal development (Cook et al. 2003). Less is known about how weight status may affect blood chemistry in youth. There is some evidence to suggest that glucose and lipid metabolism and inflammation and oxidative stress may be biological markers that manifest as possible risk factors for cancer, cardiovascular and metabolic disease and that these markers may be related to obesity (Dandona et al. 2005; Lakka et al. 2002; O'Byrne and Dalglish 2001; Reaven 1988; Sinaiko et al. 2005; Young-Hyman et al. 2001). Examining the relationship of those biomarkers with weight status over time may provide important clues into how obesity affects risk factors for a number of chronic diseases.

Biological factors and energy balance are impacted by behavioral factors related to diet, activity and sedentary patterns, and other behaviors such as sleep, substance use and weight control behaviors. Dietary choices affect caloric intake and dietary patterns and specific eating behaviors, such as skipping breakfast, consumption of sugar-sweetened beverages. Eating a lot of fast food and not eating a lot of fruits, vegetables and whole grains have also been linked with obesity risk (Affenito et al. 2005; Ebbeling et al. 2004; Ludwig et al. 2001; Newby 2007). Behavioral choices related to the amount of physical activity and sedentary behaviors impact the energy expenditure side of the energy balance equation (Dietz and Gortmaker 1993; Gortmaker et al. 1996).

Other behaviors may impact both diet and activity levels. Recent research suggests a link between inadequate amount of sleep and obesity risk in adults (Gangwisch et al. 2005; Hasler et al. 2004; Singh et al. 2005). The unusual sleep patterns of many adolescents suggest that the relationship between sleep and obesity risk, as well as unhealthy sleep patterns and diet, activity and sedentary behaviors, is worth examining in youth. Substance use, including tobacco and alcohol use, may also affect obesity risk through diet and activity-related factors (Lytle et al. 1995; Pasch et al. 2007; Strauss and Mir 2001; Yeomans 2004). A literature is also beginning to develop that suggests that behaviors related to weight control, even in youth at healthy weights, may actually predict the development of obesity in youth (Klein et al. 2008; Neumark-Sztainer et al. 2006).

Contextual factors exist at multiple levels, including the individual/psychosocial level (e.g., one's beliefs, attitudes, values and expectations) and the socio-environmental level (e.g., interpersonal dynamics, role modeling, norms and support) that occur with families, among peers and within other community environments, specifically schools. The physical environment (e.g., the access to and support for healthy eating, recreational physical activity, and active transportation) is another important contextual factor that operates at the home, school, and neighborhood environments. The Geographical Information System (GIS) is an analysis tool for geographic data that is being used to assess the physical environment of neighborhoods (Melnick 2002). The GIS provides for systematic mapping of neighborhood resources for healthy energy balance, including the presence of parks, playgrounds, healthful transportation options and leisure time activities, healthful food options and other spatial assets and barriers in the environment. Documentation of the physical environment may add substantially to our understanding of the neighborhood contexts influencing a healthy weight balance.

Demographics, socioeconomic factors, family history, and structure are immutable factors for community-level health-promotion efforts that influence the context wherein young peoples' eating and activity behaviors occur, the behavioral opportunities presented to youth and many of their biological factors. Societal influences (such as media messages, portion sizes served in restaurants, cultural norms and expectations, and local, state and federal policy affecting economic conditions, food availability and the built environment) are even broader contextual factors potentially influencing obesity (IOM 2005), but are not delineated in the present model because these factors are not easily changed in most health-promotion intervention research. In addition, by the nature of our longitudinal research, we were limited in the number of factors that we could operationalize and evaluate.

The model is designed to guide a wide range of analyses. These analyses include examining proximal and distal correlates and predictors of weight status, the potential interactive effects of the factors assessed at each level of the conceptual model, mediating and moderating effects of the contextual, behavioral, and biological factors and a variety of outcomes including behavioral, biological and weight-related endpoints. The immutable factors, including family demographics, socioeconomic factors, and family structure and history will be examined as effect modifiers. In addition, other mutable factors, such as weight status at baseline, psychosocial or family status, and school or neighborhood situation may also emerge as potential effect modifiers. Most of the constructs are measured in a youth/adult dyad, adding another layer of interactions and predictors that may be examined.

The IDEA Study Design

IDEA is a longitudinal cohort study that follows youth (ages 10–16 at baseline) and one significant adult in their life (usually a parent) over 24 months, using three yearly data collection periods. From 2006 to 2007, 349 youth were recruited from within a 7-county metropolitan

area from Minneapolis/St. Paul, Minnesota. Youth were invited to participate regardless of weight status but were required to participate with one adult with whom they spent a significant amount of time (e.g., a parent/guardian, or other relative or adult that cares for them). Adult/youth pairs were excluded from participating if they planned to move from the area in the next 3 years, had a medical condition that affected their growth, were non-English speaking, and/or had any other physical or emotional condition that would affect their diet/activity levels, or make it difficult to complete measurements. Youth were recruited from: (1) an existing cohort of youth participating in the Minnesota Adolescent Community Cohort (MACC) Tobacco Study (Widome et al. 2007), (2) a Minnesota Department of Motor Vehicle (DMV) list restricted to the 7-county metro area, and (3) a convenience sample drawn from local communities. This recruitment method was retained as an identifier in the data to examine any potential differences in the sample, based on recruitment method. An attrition rate of 15% over the course of the study is expected, with a sample of 300 youth/adult dyads by the final measurement period.

Youth were invited to participate in an optional blood draw for the purpose of collecting fasting blood samples via vena puncture for biological markers of glucose and lipid metabolism, inflammation and oxidative stress as well as DNA samples. The optional blood draw was funded through a TREC ancillary study and the Biological Determinants of Obesity in Teens (BDOT) study (Donald R. Dengel, Ph.D.). Financial limitations precluded blood draws from the adult in the recruited pair.

Youth and adults receive financial incentives for completing the measurement protocol. In total, families participating in IDEA can receive up to \$150 for each measurement year. Youth participating in the blood draw can receive an additional \$100 in incentives. The human subjects review committee at the University of Minnesota approved all recruitment; consent and measurement protocols and all HIPAA clearances were obtained for clinic visits.

IDEA Measures

Using our ecological model as a guide, several measurement tools were identified or developed and tested to operationalize all factors in the model (Table 1). All protocols and measurement tools are available upon request from the author.

Each measure is collected at each of the three time points with the following exceptions: for the youth, blood draws, the 24 h recalls, and the accelerometer measures occur only at the first and last measurement periods. For the school-level measures, the observation of the a la carte, vending and school store offerings occur at the first and last measurement periods. The neighborhood measures assessed by Geographic Information Systems (GIS) occur only at the first measurement period, unless the youth moves during the study. Each method is described below.

Youth and Adult Measures

Direct Measures in the Clinic: Youth/Adult—Data collection for each youth and adult pair begins with their initial clinic visit. After written consent by the adult and assent by the youth is obtained, clinic staff measured each participant's height using a Shorr height board (Irwin Shorr, Olney, MD), and weight and body composition using a Tanita scale. The Tanita is a bioelectrical impedance device that assesses body weight, lean and fat mass (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL). Clinic staff assessed blood pressure of youth using Dinamap machines (Model 8100, Tampa, FL), taking three measures while the youth sits quietly. Because pubertal status is related to weight change, youth are asked to complete a 7-item self-report puberty scale (Petersen et al. 1988).

Blood Draw: Youth—A separate clinic visit is scheduled for the blood draw, since students have to fast for at least 12 h before coming in. Venous blood is drawn from an antecubital vein into chilled tubes containing EDTA. Plasma is separated by centrifugation at 4°C for measurement of glucose, insulin, triglycerides (TG), total cholesterol (total-C), low-density lipoprotein (LDL-C), and high-density lipoprotein (HDL-C) cholesterol by standard colorimetric reflectance spectrophotometry at the Fairview Diagnostics Laboratories, Fairview-University Medical Center (Minneapolis, Minnesota), a Center for Disease Control and Prevention certified laboratory. Serum samples for IL-6, TNF- α , IGF-1, IGF-BP1, F2-isoprostanes, leptin, adiponectin, and C-reactive protein measurements will be stored frozen at -70°C until assayed in the Cytokine Reference Laboratory at the University of Minnesota using ELISA assays. DNA samples will be processed and stored by the Molecular Genetic Core of the GCRC. Fasting glucose and insulin concentrations will be used to calculate the homeostasis model of assessment for insulin resistance (HOMA-IR), which will serve as an estimate of insulin sensitivity and glucose metabolism (Matthews et al. 1985).

Student and Adult Survey—During each clinic visit, youth and adults are asked to complete a survey. Behaviors are assessed that may be associated with energy balance such as usual breakfast, beverage intake, fast food consumption, sleep patterns, weight perceptions and behaviors related to maintaining or losing weight, activity and sedentary behaviors, including time spent watching a screen (TV, computer, video game, etc.) and time spent talking on the phone and text messaging. Theory of Planned Behavior (TPB), Social Cognitive Theory (SCT), and psychosocial factors related to energy balance from the empirical research informed the choice of attitudinal questions to be included (Ajzen 1991; Bandura 1986). A 30-item scale guided by TPB to assess psychosocial factors related to achieving or maintaining a healthy weight was developed for this research.

The student and adult surveys also include questions tapping perceptions of the family social and physical environments, including food and activity options in the home and messages delivered and received about maintaining a healthy weight. A knowledge quiz on energy balance was developed for this research and included in both the student and adult surveys. Newly created or significantly adapted questions used to assess the social and physical environment underwent psychometric evaluation during the pilot phase of the study, including test-retest reliabilities and assessment of internal consistency of scales.

A 7-item depression score (Kandel and Davies 1982) is included on the student survey, as are questions on smoking and alcohol use. To assess youth perception of the physical environment, youth are asked to report their perceptions of the availability of healthful options in their homes and schools, and their perceived safety of their neighborhoods (Saelens et al. 2003). Adults complete questions on family structure and family history of disease. Adults also respond to newly developed questions that tap the differences that they see in lifestyle patterns of their current family, as compared with the families in which they were raised. Financial constraints precluded our ability to conduct psychometric testing of the newly created family items. However, focus groups were conducted with adults during the development of the parent surveys to obtain input on the family and home factors they saw as salient issues related to helping children maintain a healthy weight.

Twenty-Four-Hour Recalls: Youth—Youth are asked to participate in three phone administered 24-h recalls. These recalls occur for 2 weekdays and 1 weekend day within a 2-week period. Trained and certified staff from the Nutrition Coordination Center at the University of Minnesota use the Nutrition Data System Research (NDS-R) to conduct the recalls using an interactive interview format, with direct data entry linked to a nutrient database (Schakel et al. 1988). The NDS-R data allow the examination of both nutrient intakes of the

youth, as well as eating behavior patterns (i.e., number of meals and snacks) and food group information (i.e., number of fruits and vegetables consumed.)

National Cancer Institute Diet History Questionnaire (NCI-DHQ): Adult—Diet information from adults is collected using the Diet History Questionnaire (DHQ 2007) food frequency instrument. This instrument is widely used to characterize usual food and nutrient intakes in adult populations. Adults receive the NCI-DHQ at the clinic visit and are asked to mail it in when completed.

Accelerometers: Youth—The ActiGraph physical activity monitor (Manufacturing Technologies Inc. Health Systems, Model 764, Shalimar, FL) is used as an objective measure of physical activity, and has been previously validated for use with children in laboratory and field setting (Eston et al. 1998; Trost et al. 1998). It collects and stores accelerations of movement on three planes in 30-s epochs. At the clinic visit, clinic staff give youth instructions on wearing the accelerometers for the following week which includes wearing it from the time they wake up until they go to bed and to remove the accelerometer when in the water. Youth are asked to return the accelerometers in the mail.

Three Day Physical Activity Record (3D-PAR): Youth—At the clinic visit, youth are asked to complete the 3-DPAR, which collects information on the type of active and sedentary activities youth participate in over the previous 3-day period. The 3D-PAR has been validated and used in other studies examining physical activity in youth (Pate et al. 2003; Swinburn et al. 1999).

International Physical Activity Questionnaire (IPAQ): Adult—The IPAQ is used to assess usual physical activity and sedentary behaviors in adults (Craig et al. 2003). This instrument has been used and validated in other adult populations. Adults complete this survey at the clinic visit.

Home Measures

The physical environment of the home is assessed through four new instruments that were developed specifically for this research: (1) a Home Food Inventory (HFI) to assess foods available in the home, including fruits, vegetables, prepared desserts and packaged foods, and the extent to which they are visible and easily accessed (Fulkerson et al. 2008); (2) a Brief Family Meal Screener (BFMS) to describe foods available during a family meal, where the food came from (e.g., homemade, frozen meal, take-out etc.) and, if prepared in the home, the preparation methods used; (3) a Physical Activity Inventory (PAI) to assess the availability of, and accessibility to, equipment that may impact physical activity by family members; and (4) a Media Inventory (MI) that assesses the availability of media-related equipment, such as televisions and video games (Sirard et al. 2007). Extensive psychometric testing of these home instruments occurred during the pilot phase. The HFI demonstrated excellent criterion validity (comparing independently and simultaneously completed inventories by research staff and family members) and good construct validity comparing foods in the home with reported dietary intakes of youth and adults (Fulkerson et al. 2008). The PAI and MI also demonstrated excellent criterion validity, comparing independently and simultaneously completed inventories by research staff and family members (Sirard et al. 2007). In the main research study, all of the family instruments are completed by family members in their homes and mailed to the study staff.

School Measures

As the youth cohort is recruited, they are asked to identify the school they attend. Research staff contacts the school and asks permission to collect a set of measures with school personnel

and through school observation. Appropriate consent is obtained from school administrators providing information and approval was obtained for sending staff into the schools to record observational-level data.

Principal Survey—The social environment of schools, as it relates to both eating and activity opportunities in the school, is assessed through surveys completed by principals. The surveys include questions tapping the policies and practices around eating and physical activity, as well as questions on the presence and activities of school wellness committees.

School Observation—Trained and certified study staff visit schools to record aspects of the school physical environment related to food choices. They record the number and content of each vending machine available for student use in each school. In middle schools, they also record all a la carte offerings on the school lunch line. Due to the large number of options of a la carte options available in high schools, a checklist is used to categorize the types of options offered there. The checklist identifies categories of common food products seen in schools, such as sweetened beverages, fresh fruit, regular cookies, low-fat and regular cookies and low-fat and regular salty snacks. Food products available in school stores are also recorded on a checklist for both middle and high schools. Reliability of the observation forms and protocol were evaluated by having data collection in 30 schools completed by two independent observers. Calculations of inter-rater reliability for the four observation forms (vending; a la carte middle schools; a la carte high schools; school stores) were all above 0.99.

Neighborhood Measures

The IDEA study expands earlier work that used GIS to understand how the neighborhood influences activity options by adding protocol to assess food-related options in the environment. When the baseline cohort was fully recruited, the addresses of each youth's home and school were given to our GIS study coordinator. The study of the neighborhood or nearby environment looks at straight line and network buffers around home and school at distances of 400 m and up to 3,000 m and a 100-m buffer on the most direct route from home to school. Street and straight-line distances to facilities such as restaurants, including major chains and fast food chains, all food stores, and other urban design and recreational facilities' potentially related to physical activity were also measured (Forsyth 2007).

Recruitment Results, Sample Characteristics, and Adherence to Study Protocol

Of the 349 youth/adult pairs successfully recruited, consented, and enrolled in the cohort, 26% were recruited from the MACC cohort, 49% were recruited from the DMV sample, and 25% were recruited from the convenience sample. The recruitment rate (proportion successfully recruited from those invited to recruit) was 18 and 6% for the MACC and DMV samples, respectively. A recruitment rate cannot be calculated for the convenience sample, since the denominator is unknown. More than half of youth participated in the optional blood draw.

Table 2 shows the demographic and body composition characteristics of the baseline cohort of youth, looking at the total sample and the samples recruited using each recruitment method. There were no significant demographic differences found between the youth from each recruitment source, or between youth choosing or not choosing to participate in the blood draw.

There are equal proportions of males and females in the youth sample, and the mean age is about 15 years. The youth sample is primarily white (93.4%); census data from the Minneapolis/St. Paul area (Twin Cities) indicates that 86.1% of youth under the age of 18 in the metro area is white; the difference in racial and distributions between our sample and the

census data is not statistically significant. While nearly 80% of our sample lives with both their mother and father, this proportion is much higher than the population in the Twin Cities, where about 41% of youth under 18 live with both parents. About 20% of our sample of youth is overweight.

Table 3 shows the demographic and body composition characteristics of the adult cohort, with information provided for the total sample and by each recruitment method. Females were more likely to enroll in the study with their child as compared to males. Overweight and obesity rates are as expected in the adult population. The completion rates for the first year of data collection were very high (ranging from 86.2 to 100%).

Discussion

This social–ecological model, using a transdisciplinary approach that effectively engaging researchers across disciplines at the University of Minnesota, and, as the TREC initiative continues to build momentum, across TREC sites, offers great potential for answering the large and complicated questions about how to prevent obesity and where the most potent intervention points might be. This approach is not without its challenges, however. The attempt to measure the obesogenicity of home and school environments involved several complex tasks that began with creating measures of the home and school environment and then testing their reliability and validity. Beyond criterion validity, we were interested in construct validity. While the literature speaks clearly about the idea that environments might be obesogenic, there is a dearth of research presenting environmental tools that show an association between the environment and a health outcome of interest, or that are able to rank environments with regard to their obesity risk potential. In addition, the literature currently offers no suggestion on how elements of an environment should be combined to represent obesogenicity. For example, in a summative score representing school level obesogenicity, does information from the principal about policies related to eating and activity opportunities at school count “equally” with observed information on what is available in vending, a la carte, and school stores, or should some weighting occur?

Analytic challenges are evident as well. Our cohort includes students that are nested within schools and neighborhoods, suggesting that we need to deal with intraclass correlations. At the same time, in nearly half of the schools represented, there is only one member of the cohort, making it difficult to make conclusions about how the school environment may influence risk at the population level. Planning analyses that cross several levels is often challenging and intimidating for researchers. Using multilevel data requires researchers to move out of their comfort level, which may be fixed in analyzing psychosocial surveys, or activity counts from accelerometers, or street connectivity. They are challenged to look beyond the variables and levels that they most commonly examine, and look instead at the contextual levels that may be influencing those psychosocial or activity outcomes, or the health outcomes affected by those contexts.

Analyses is also challenging because of the very large amount of data that are generated when assessing environments. For example, our GIS data provides over 100 variables, including everything from density of stores around a cohort’s home address to the level of connectivity in their neighborhood streets. What variables are most relevant to assess with regard to obesity risk or protective factors? Data reduction is of paramount importance, but currently the science does not offer a template for the best ways to approach the challenge of data reduction; in addition transparency is lacking in published environmental data.

While an important advancement in the field, the IDEA project is just one step toward understanding this complicated issue. Potentially important influences of obesity are not

assessed including the influence of media, agricultural policy, and other policy related to land use in communities. Other conceptual models, choosing other factors to examine, would be helpful in informing the field. In addition, we are examining just 3 years in a child's life, and may miss important trajectories of weight gain that occur earlier in childhood or later in adolescence. Our research has limited external validity; similar research is needed in other population groups, as factors implicated in predicting unhealthy weight gain is likely different by culture, socioeconomic status, and geographic location. We are currently using this conceptual model and adapting this study design in another cohort study, Etiology of Childhood Obesity (ECHO Grant HL R01 085978NIH/NHLBI). In the ECHO study, we are working with a health management organization (Health Partners), and their client database provides information that permitted us to recruit a cohort based on BMI of youth and parents, as well as race/ethnicity. Our ECHO cohort is more racially and ethnically diverse (76% white) and a larger proportion of the youth recruited are overweight or obese (31%). In addition, the ECHO cohort is younger (mean age = 14.0), allowing us an opportunity to examine earlier weight gain trajectories.

Research designed to examine the factors that seem to protect youth from or put them at risk for obesity using a longitudinal study design, a rigorous study protocol, an investigative team from diverse disciplines, and a set of state-of-the-science measures tapping multiple levels of potential influence is an important step in better understanding the most potent intervention approaches. The use of a conceptual model that is ecological in nature, while suggesting a causal pathway and a focus on a limited number of factors that may be mutable in community-based health promotion programs is an important advancement in the field.

Acknowledgments

A special thank you to Carrie Heitzler, Stacey Moe and Megan Treziok for their help with the preparation of this manuscript. Thanks to the investigators who contribute to this research: Donald Dengel, Ph.D.; Ann Forsyth, Ph.D.; Jayne Fulkerson, Ph.D.; Mary Hearst, Ph.D.; Marti Kubik, Ph.D.; Melissa Nelson, Ph.D.; Keryn Pasch, Ph.D.; Mark Pereira, Ph.D.; Cheryl Perry, Ph.D.; and John Sirard, Ph.D.

Funding This research was funded through a grant from the National Cancer Institutes as part of their Transdisciplinary Research in Energetics and Cancer Initiative. Grant# 1U54CA116849-01.

References

- Abrams DB. Applying transdisciplinary research strategies to understanding and eliminating health disparities. *Health Education and Behavior* 2006;33:515–531. [PubMed: 16769758]
- Affenito SG, Thompson DR, Barton BA, Franko DL, Daniels SR, Obarzanek E, et al. Breakfast consumption by African-American and white adolescent girls correlates positively with calcium and fiber intake and negatively with body mass index. *Journal of the American Dietetic Association* 2005;105(6):938–945. [PubMed: 15942545]
- Ajzen I. The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 1991;50:179–211.
- Bandura, A. *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice-Hall; 1986.
- Bronfenbrenner U. Toward an experimental ecology of human development. *American Psychologist* 1977;32:513–559.
- Campbell K, Waters E, O'Meara S, Summerbell C. Interventions for preventing obesity in childhood. A systematic review. *Obesity Reviews* 2001;2(3):149–157. [PubMed: 12120100]
- Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents: Findings from the third national health and nutrition examination survey, 1988–1994. *Archives of Pediatric and Adolescent Medicine* 2003;157(8):821–827.
- Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-Country reliability and validity. *Medicine and Science in Sports and Exercise* 2003;35(8):1381–1395. [PubMed: 12900694]

- Dandona P, Aljada A, Chaudhuri A, Mohanty P, Garg R. Metabolic syndrome: A comprehensive perspective based on interactions between obesity, diabetes, and inflammation. *Circulation* 2005;111(11):1448–1454. [PubMed: 15781756]
- Davison KK, Birch LL. Childhood overweight: A contextual model and recommendations for future research. *Obesity Review* 2001;2(3):159–171.
- Diet History Questionnaire. Version 1.0, National Institutes of Health, Applied Research Program. National Cancer Institute; 2007.
- Dietz WH, Gortmaker SL. TV or not TV: Fat is the question. *Pediatrics* 1993;91(2):499–501. [PubMed: 8424034]
- Doak CM, Visscher TL, Renders CM, Seidell JC. The prevention of overweight and obesity in children and adolescents: A review of interventions and programmes. *Obesity Review* 2006;7(1):111–136.
- Ebbeling CB, Sinclair KB, Pereira MA, Garcia-Lago E, Feldman HA, Ludwig DS. Compensation for energy intake from fast food among overweight and lean adolescents. *Journal of the American Medical Association* 2004;291(23):2828–2833. [PubMed: 15199032]
- Eston RG, Rowlands AV, Ingledew DK. Validity of heart rate, pedometry, and accelerometry for predicting the energy cost of children's activities. *Journal of Applied Physiology* 1998;84(1):362–371. [PubMed: 9451658]
- Forsyth, A. Environment, food, and youth: GIS protocols. 2007. 1.2. Retrieved September 2007, from http://www.designforhealth.net/pdfs/TREC_Protocol_V1_2_July07FINAL.pdf
- Fulkerson JA, Lytle LA, Nelson MC, Moe S, Heitzler C, Pasch KE. The validity of the home food inventory. *International Journal of Behavior Nutrition and Physical Activity* 2008;5:55.
- Gangwisch JE, Malaspina D, Boden-Albala B, Heymsfield SB. Inadequate sleep as a risk factor for obesity: Analyses of the NHANES I. *Sleep* 2005;28(10):1289–1296. [PubMed: 16295214]
- Gordon-Larsen P, Adair LS, Nelson MC, Popkin BM. Five-year obesity incidence in the transition period between adolescence and adulthood: The national longitudinal study of adolescent health. *American Journal of Clinical Nutrition* 2004;80(3):569–575. [PubMed: 15321794]
- Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986–1990. *Archives of Pediatric and Adolescent Medicine* 1996;150(4):356–362.
- Hardeman W, Griffin S, Johnston M, Kinmonth AL, Wareham NJ. Interventions to prevent weight gain: A systematic review of psychological models and behaviour change methods. *International Journal of Obesity and Related Metabolic Disorders* 2000;24(2):131–143. [PubMed: 10702762]
- Hasler G, Buysse DJ, Klaghofer R, Gamma A, Ajdacic V, Eich D, et al. The association between short sleep duration and obesity in young adults: A 13-year prospective study. *Sleep* 2004;27(4):661–666. [PubMed: 15283000]
- Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. *Journal of the American Medical Association* 2004;291(23):2847–2850. [PubMed: 15199035]
- Huang TTK, Glass TA. Transforming research strategies for understanding and preventing obesity. *Journal of the American Medical Association* 2008;300(15):1811–1813. [PubMed: 18854544]
- IOM. Preventing childhood obesity: Health in the balance. Washington, DC: Institute of Medicine; 2005.
- Kandel DB, Davies M. Epidemiology of depressive mood in adolescents. *Archives of General Psychiatry* 1982;39(10):1205–1212. [PubMed: 7125850]
- Katz DL, O'Connell M, Yeh MC, Nawaz H, Njike V, Anderson LM, et al. Public health strategies for preventing and controlling overweight and obesity in school and worksite settings: A report on recommendations of the task force on community preventive services. *MMWR Recommendations and Reports* 2005;54(10):1–12.
- Klein E, Lytle LA, Chen V. Social ecological predictors of unhealthy weight gain in youth: Results from the TEENS study. *Journal of the American Dietetic Association* 2008;108:1163–1169. [PubMed: 18589024]
- Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *Journal of the American Medical Association* 2002;288(21):2709–2716. [PubMed: 12460094]

- Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: A prospective, observational analysis. *The Lancet* 2001;357(9255):505–508.
- Lytle LA, Kelder SH, Perry CL, Klepp KI. Covariance of adolescent health behaviors: The class of 1989 study. *Health Education Research* 1995;10(2):133–146.
- Matthews D, Hosker J, Rudenski A, Naylor B, Treacher D, Turner R. Homeostasis model assessment: Insulin resistance and *b*-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985;28:412–419. [PubMed: 3899825]
- Melnick, A. Introduction to geographical information systems in public health. Gaithersburg, MD: Aspen Publications; 2002.
- Neumark-Sztainer D, Wall M, Guo J, Story M, Haines J, Eisenberg M. Obesity, disordered eating, and eating disorders in a longitudinal study of adolescents: How do dieters fare 5 years later? *Journal of the American Dietetic Association* 2006;106(4):559–568. [PubMed: 16567152]
- Newby P. Are dietary intakes and eating behaviors related to childhood obesity? A comprehensive review of the evidence. *Journal of Law, Medicine and Ethics* 2007;35:35–60.
- O’Byrne KJ, Dalglish AG. Chronic immune activation and inflammation as the cause of malignancy. *British Journal of Cancer* 2001;85(4):473–483. [PubMed: 11506482]
- Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *Journal of the American Medical Association* 2006;295(13):1549–1555. [PubMed: 16595758]
- Pasch, KE.; Lytle, L.; Nelson, MC.; Moe, S.; Perry, C. Cross-sectional and longitudinal associations between weight status and factors of risk and resiliency in adolescents. 6th Annual Conference of the International Society for Behavioral Nutrition and Physical Activity; Oslo, Norway. 2007.
- Pate RR, Ross R, Dowda M, Trost SG, Sirard JR. Validation of a 3-day physical activity recall instrument in female youth. *Pediatric Exercise Science* 2003;15(3):257–265.
- Perry, C. Creating health behavior change: How to develop community-wide programs for youth. Thousand Oaks, CA: Sage Publications; 1999.
- Petersen AC, Crockett LJ, Richards M, Boxer A. A self-report measure of pubertal status: Reliability, validity and initial norms. *Journal of Youth and Adolescence* 1988;17(2):117.
- Reaven GM. Banting lecture 1988. Role of insulin resistance in human disease. *Diabetes* 1988;37(12):1595–1607. [PubMed: 3056758]
- Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: An environment scale evaluation. *American Journal of Public Health* 2003;93(9):1552–1558. [PubMed: 12948979]
- Schakel SF, Sievert YA, Buzzard IM. Sources of data for developing and maintaining a nutrient database. *Journal of the American Dietetic Association* 1988;88(10):1268–1271. [PubMed: 3171020]
- Sinaiko AR, Steinberger J, Moran A, Prineas RJ, Vessby B, Basu S, et al. Relation of body mass index and insulin resistance to cardiovascular risk factors, inflammatory factors, and oxidative stress during adolescence. *Circulation* 2005;111(15):1985–1991. [PubMed: 15837953]
- Singh M, Drake CL, Roehrs T, Hudgel DW, Roth T. The association between obesity and short sleep duration: A population-based study. *Journal of Clinical Sleep and Medicine* 2005;1(4):357–363.
- Sirard J, Nelson MC, Pereira MA, Lytle LA. Reliability and validity of a physical activity and media equipment inventory. *International Journal of Behavioral Nutrition and Physical Activity* 2007;5:24. [PubMed: 18445280]
- Stettler N. Environmental factors in the etiology of obesity in adolescents. *Ethnicity and Disease* 2002;12(1):S1, 41–45. [PubMed: 11913619]
- Stice E, Shaw H, Marti CN. A meta-analytic review of obesity prevention programs for children and adolescents: The skinny on interventions that work. *Psychological Bulletin* 2006;132(5):667–691. [PubMed: 16910747]
- Stokols D. Toward a science of transdisciplinary action research. *American Journal of Community Psychology* 2006;38(1–2):63–77. [PubMed: 16791514]
- Story M, Kaphingst KM, Robinson-O’Brien R, Glanz K. Creating healthy food and eating environments: Policy and environmental approaches. *Annual Review of Public Health* 2008;29:253–272.

- Strauss RS, Mir HM. Smoking and weight loss attempts in overweight and normal-weight adolescents. *International Journal of Obesity and Related Metabolic Disorders* 2001;25(9):1381–1385. [PubMed: 11571603]
- Summerbell CD, Waters E, Edmunds LD, Kelly S, Brown T, Campbell KJ. Interventions for preventing obesity in children. *Cochrane Database of Systematic Reviews* 2005;(3):CD001871.
- Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: The development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine* 1999;29(6 Pt 1):563–570. [PubMed: 10600438]
- Trost SG, Ward DS, Moorehead SM, Watson PD, Riner W, Burke JR. Validity of the computer science and applications (csa) activity monitor in children. *Medicine and Science in Sports and Exercise* 1998;30(4):629–633. [PubMed: 9565947]
- US Department of Health and Human Services. The surgeon general's call to action to prevent and decrease overweight and obesity. Rockville, MD: United States Department of Health and Human Services, Public Health Service, Office of the Surgeon General; 2001.
- Wang Y, Beydoun MA, Liang L, Caballero B, Kumanyika SK. Will all Americans become overweight or obese? Estimating the progression and cost of the US obesity epidemic. *Obesity* 2008;16(10):2323–2330. [PubMed: 18719634]
- Widome R, Forster JL, Hannan P, Perry C. Longitudinal patterns of youth access to cigarettes and smoking progression: Minnesota adolescent community cohort (macc) study (2000–2003). *Preventive Medicine* 2007;45(6):442–446. [PubMed: 17719080]
- Yeomans MR. Effects of alcohol on food and energy intake in human subjects: Evidence for passive and active overconsumption of energy. *British Journal of Nutrition* 2004;92(Suppl 1):S31–S34. [PubMed: 15384320]
- Young-Hyman D, Schlundt DG, Herman L, De Luca F, Counts D. Evaluation of the insulin resistance syndrome in 5- to 10-year-old overweight/obese African-American children. *Diabetes Care* 2001;24(8):1359–1364. [PubMed: 11473070]

Fig. 1.
Conceptual model: etiology of childhood obesity

Table 1**Measures used in the IDEA study**

Factors included in the conceptual model	Source
<i>Individual</i>	
Youth: BMI/body composition	
Shorr height board	Direct measure, clinic visit
Tanita scale	Direct measure, clinic visit
Youth: biological	
Blood: glucose and lipid metabolism, biomarkers of inflammation, oxidative stress, DNA (optional)	Direct measure, clinic visit
Pubertal status	Self-report, survey
Blood pressure	Direct measure, clinic visit
Youth: behavioral	
Diet: 3 24-h recalls	Phone interviews
Diet: eating behaviors	Self-report, survey
Other behaviors: sleep patterns	Self-report, survey
Other behaviors: tobacco, alcohol and other drugs	Self-report, survey
Other behaviors: weight control	Self-report, survey
Activity: accelerometers	Direct
Activity: 3 day physical activity record	Self-report, survey
Sedentary behaviors	Self-report, survey
Youth: psychosocial ^a	Self-report, survey
Adult: BMI/body composition	
Shorr height board	Direct measure, clinic visit
Tanita scale	Direct measure, clinic visit
Adult: behavioral	
Diet: diet history questionnaire (NCI)	Self-report, survey
Diet: eating behaviors	Self-report, survey
Other behaviors: sleep patterns	Self-report, survey
Other behaviors: weight control	Self-report, survey
Activity: international PA questionnaire	Self-report, survey
Sedentary behaviors	Self-report, survey
Adult: psychosocial ^a	Self-report, survey
<i>Home environment</i>	
Home: social environment	
Social support for diet and activity	Self-report, student survey
Family meal time	Self-report, student and parent survey
Parent-child interactions around food and activity	Self-report, student and parent survey
Home: physical environment	
Diet: home food inventory	Self-report, inventory
Diet: brief family meal screener	Self-report, screener
Activity: physical activity inventory	Self-report, inventory
Activity: media inventory	Self-report, inventory

Factors included in the conceptual model	Source
<i>School environment</i>	
School: social environment	
Diet: food policies and practices	Self-report, principal survey
Diet: advertising	Self-report, principal survey
Diet: perceptions of the school environment	Self-report, student and parent survey
Physical activity: policies and practices	Self-report, principal survey
Diet and activity: wellness councils	Self-report, principal survey
School: physical environment	
Diet: a la carte, vending and school store options	Observation by study staff
Diet: foods available, a la carte/vending	Self-report, principal survey
Activity: facilities available	Self-report, principal survey
<i>Neighborhood environment</i>	
GIS measures related to diet and activity	Observation, existing data
Perceptions of neighborhood activity opportunity	Self-report, student survey
Perceptions of neighborhood safety	Self-report, student survey
Perceptions of neighborhood cohesion	Self-report, parent survey

^a Psychosocial measures for student and parents include a large number of constructs from Social Cognitive Theory and Theory of Planned Behavior, and a knowledge quiz on energy balance. For the students, there is also a measure of depression. For parents, there is a set of newly developed questions of perceptions of changes in family life

Table 2

Baseline characteristics of the youth sample

Variable	Total sample (<i>n</i> = 349)		MACC cohort (<i>n</i> = 91)		DMV cohort (<i>n</i> = 170)		Convenience cohort (<i>n</i> = 88)		Blood draw sample (<i>n</i> = 189)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Gender										
Male	49.0	(2.7)	53.8	(5.2)	48.2	(3.8)	45.4	(5.3)	48.7	(3.6)
Age, years	Mean = 15.4	SD = 0.1	Mean = 15.5	SD = 0.1	Mean = 16.0	SD = 0.1	Mean = 14.1	SD = 0.2	Mean = 15.4	SD = 0.1
Grade level										
6th Grade	7.7	(1.4)	1.1	(1.1)	2.3	(1.2)	25.0	(4.6)	7.9	(2.0)
7th Grade	8.9	(1.5)	8.8	(3.0)	4.1	(1.5)	18.2	(4.1)	8.5	(2.0)
8th Grade	13.5	(1.8)	11.0	(3.3)	10.6	(2.4)	21.6	(4.4)	14.8	(2.6)
9th Grade	16.0	(2.0)	17.6	(4.0)	13.5	(2.6)	10.2	(3.2)	11.1	(2.3)
10th Grade	39.5	(2.6)	34.1	(5.0)	7.6	(2.0)	13.6	(3.7)	16.9	(2.7)
11th Grade	15.4	(0.1)	26.4	(4.6)	61.2	(3.7)	11.4	(3.4)	39.7	(3.6)
School type										
Public	82.5	(2.0)	80.2	(4.2)	82.9	(2.9)	84.1	(3.9)	81.5	(2.8)
Private	14.0	(1.9)	19.8	(4.2)	11.2	(2.4)	13.6	(3.7)	15.9	(2.7)
Home-schooled	3.2	(0.9)	0		5.3	(1.7)	2.2	(1.6)	2.1	(1.0)
Race/ethnicity										
Hispanic origin	2.9	(0.9)	5.5	(2.4)	1.2	(0.8)	3.4	(1.9)	3.2	(1.3)
White	93.4	(1.3)	92.3	(2.8)	92.9	(2.0)	95.4	(2.2)	92.6	(1.9)
African American	1.4	(0.6)	2.2	(1.5)	1.2	(0.8)	1.1	(1.1)	1.6	(0.9)
Asian	0.3	(0.3)	0		0.6	(0.6)	0		0.5	(0.5)
Mixed ^a	4.6	(1.1)	4.4	(2.2)	5.3	(1.7)	3.4	(1.9)	4.8	(1.6)
Family structure										
Mother and father together	79.9	(2.1)	75.8	(4.5)	79.4	(3.1)	85.2	(3.8)	79.4	(3.0)
Mother and father equally, but separate	3.1	(0.9)	5.5	(2.4)	1.8	(1.0)	3.4	(1.9)	2.1	(1.0)
Parent and step-parent	3.7	(1.0)	1.1	(1.1)	5.3	(1.7)	3.4	(1.9)	4.2	(1.5)
Mother mostly	12.0	(1.7)	16.5	(3.9)	12.4	(2.5)	6.8	(2.7)	12.7	(2.4)
Body composition										

Variable	Total sample (n = 349)		MACC cohort (n = 91)		DMV cohort (n = 170)		Convenience cohort (n = 88)		Blood draw sample (n = 189)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)
BMI ^b	Mean = 21.9	SD = 0.2 (0.6)	Mean = 21.6	SD = 0.4 (1.1)	Mean = 22.6	SD = 0.4 (0.9)	Mean = 20.7	SD = 0.4 (1.1)	Mean = 21.6	SD = 0.3 (0.9)
Underweight ^c	1.1		1.1		1.2		1.1		1.6	
Healthy weight ^c	79.1	(2.2)	80.2	(4.2)	77.1	(3.2)	81.8	(4.1)	81.5	(2.8)
At risk of overweight ^c	12.0	(1.7)	13.2	(3.6)	11.8	(2.5)	11.4	(3.4)	11.1	(2.3)
Overweight ^c	7.7	(1.4)	5.5	(2.4)	10.0	(2.3)	5.7	(2.5)	5.8	(1.7)
Percent body fat	Mean = 20.3	SD = 0.5	Mean = 20.0	SD = 1.0	Mean = 21.0	SD = 0.8	Mean = 19.5	SD = 0.5	Mean = 20.2	SD = 0.7

^aMore than one race/ethnicity indicated

^bBMI = weight (kg)/[height (m)]

^cBMI-for-age weight status categories based on CDC BMI-for-age growth charts: underweight = <5th percentile; healthy weight = 5th–<85th percentile; at-risk-for overweight = 85th–<95th percentile; overweight = >95th percentile

Table 3

Baseline characteristics of the adult sample

	Total sample (n = 349)		MACC cohort (n = 91)		DMV cohort (n = 170)		Convenience sample cohort (n = 88)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Gender								
Female	75.6	(2.3)	74.7	(4.6)	74.1	(3.4)	79.5	(4.3)
Age, years	Mean = 46.7	SD = 0.3	Mean = 48.7	SD = 0.5	Mean = 46.6	SD = 0.4	Mean = 44.6	SD = 0.6
Race/ethnicity								
Hispanic origin	1.7	(0.7)	3.3	(1.9)	1.2	(0.8)	1.1	(1.1)
White	98.8	(0.6)	100.0		97.6	(1.2)	100.00	
African American	0.3	(.03)	0		0.3	(0.6)	0	
Mixed ^a	0.9	(0.5)	0		1.8	(1.0)	0	
Education								
Less than HS	0.6	(0.4)	0		1.2	(0.8)	0	
HS or GED	8.6	(1.5)	7.7	(2.8)	8.8	(2.2)	9.1	(3.1)
Some college	26.1	(2.4)	29.7	(4.8)	24.7	(3.3)	25.0	(4.6)
College degree	35.2	(2.6)	29.7	(4.8)	35.9	(3.7)	39.8	(5.2)
Training beyond college	27.8	(2.4)	30.8	(4.9)	28.8	(3.5)	22.7	(4.5)
Body composition								
BMI ^b	Mean = 26.6	SD = 0.3	Mean = 26.7	SD = 0.6	Mean = 26.9	SD = 0.4	Mean = 25.9	SD = 0.5
Underweight ^c	1.4	(0.6)	2.2	(1.5)	1.2	(0.8)	1.1	(1.1)
Healthy weight ^c	44.4	(2.7)	42.9	(5.2)	41.8	(3.8)	51.1	(5.4)
Overweight ^c	30.1	(2.5)	34.1	(5.0)	31.2	(3.6)	23.9	(4.6)
Obese ^c	24.1	(2.3)	20.9	(4.3)	25.9	(3.4)	23.7	(4.6)
Body fat	31.5	(0.5)	31.3	(1.0)	32.0	(0.7)	30.8	(0.9)

^aMore than one race/ethnicity indicated^bBMI = body mass index calculated as weight (kg)/[height (m)]²^cUnderweight = BMI < 18.5; healthy weight = BMI 18.5–24.9; overweight = BMI 25.0–29.9; obese = BMI ≥ 30