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***Retrospective Study***

**Obesity and cardiometabolic disease risk factors among US adolescents with disabilities**

Messiah SE *et al.* Cardiometabolic disease in adolescents with disabilities

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**Abstract**

**AIM:** To generate prevalence estimates of weight status and cardiometabolic disease risk factors among adolescents with and without disabilities.

**METHODS:** Analysis of the 1999-2010 National Health and Nutrition Examination Survey data was conducted among 12-18 years old with (*n* = 256) and without disabilities (*n* = 5020). Mean values of waist circumference, fasting glucose, high-density-lipoprotein cholesterol, triglycerides, systolic and diastolic blood pressure and metabolic syndrome (MetS, ≥ 3 risk factors present) were examined by the following standardized body mass index (BMI) categoriesfor those with and without disabilities; overweight (BMI ≥ 85th - < 95th percentile for age and sex), obesity (BMI ≥ 95th percentile) and severe obesity (BMI ≥ 99th percentile). Linear regression models were fit with each cardiometabolic disease risk factor independently as continuous outcomes to show relationships with disability status.

**RESULTS:** Adolescents with disabilities were significantly more likely to be overweight (49.3%), obese (27.6%) and severely obese (12%) *vs* their peers without disabilities (33.1%, 17.5% and 3.6%, respectively, *P* ≤ 0.01 for all). A higher proportion of overweight, obese and severely obese children with disabilities had abnormal SBP, fasting lipids and glucose as well as MetS (18.9% of overweight, 32.3% of obese, 55% of severely obese) *vs* their peers without disabilities (9.7%, 16.8%, 36.3%, respectively). US adolescents with disabilities are over three times as likely to have MetS (OR 3.45, 95%CI: 1.08-10.99, *P* = 0.03) *vs* their peers with no disabilities.

**CONCLUSION:** Results show that adolescents with disabilities are disproportionately affected by obesity and poor cardiometabolic health *vs* their peers with no disabilities. Health care professionals should monitor the cardiometabolic health of adolescents with disabilities.

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**Key words**: Adolescents; Children; Disability; Obesity; Cardiometabolic; Disease risk

**Core tip:** Our results here show that US adolescents with disabilities are disproportionately affected by obesity and are over three times as likely to have the metabolic syndrome *vs* their peers with no disabilities. Half of all adolescents with disabilities are overweight, obese or severely obese. In addition to the metabolic syndrome, obese adolescents with disabilities are significantly more likely than their normal weight counterparts to have increased or abnormal systolic blood pressure, lipid and fasting glucose levels, placing them at risk for cardiovascular disease and/or type 2 diabete. Health care professionals should monitor the cardiometabolic health of adolescents with disabilities.

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**INTRODUCTION**

In 2011 an estimated 5.1% (2.3 million) of 5-15 years old and 5.6% (1.2 million) of 16-20 years old in the United States reported a disability (physical, [sensory](http://en.wikipedia.org/wiki/Sensory_processing_disorder), and [cognitive](http://en.wikipedia.org/wiki/Cognitive_impairment) or [developmental disabilities](http://en.wikipedia.org/wiki/Developmental_disability))[1].Even more troubling, obesity is 38% higher in children with disabilities and mobility limitations compared to their peers without disabilities[2].Similarly, 57% of adults who are disabled are obese compared to 35.7% of peers without disabilities[3]. Healthy people 2020 reports that not only are individuals with disabilities more likely to be overweight or obese, they are also less likely to engage in outdoor physical activities[4,5], less likely to have social support to do so, and have worse overall health status *vs* their non-disabled counterparts[6].

These above stated prevalence statistics are important because obesity is strongly linked to hypertension, hyperlipidemia, type 2 diabetes mellitus, respiratory and musculoskeletal problems, liver disease, psycho-social problems, low self-esteem, which all lead to increased healthcare costs[7,8].As such, it has been estimated that life expectancy will decrease due to obesity-related health issues alone[9].Many studies have shown that the current childhood obesity epidemic has resulted in poor cardiometabolic health consequences including the components of metabolic syndrome (MetS)-elevated blood pressure and glucose concentrations, hypertriglyceridemia, low high density lipoprotein (HDL) cholesterol concentrations, and central adiposity (elevated waist circumference) - and the syndrome itself (three or more of these components in the same individual)[10-13].Cardiometabolic disease risk factors present during the pediatric years predicts chronic diseases such as cancer, stroke, type 2 diabetes and cardiovascular disease in adults[14,15].While previous studies have documented that youth with the MetS are at high risk for cardiometabolic disease and atherosclerosis as adults, there are few population-based studies examining the prevalence of cardiometabolic risk among adolescents with disabilities despite their increased prevalence of obesity *vs* their peers without disabilities.Therefore, the purpose of the current analysis is to estimate the prevalence of cardiometabolic disease risk, including the MetS, among the United States adolescent population with and without developmental physical and/or learning disabilities by weight status (normal weight, overweight, obese, severely obese). It was hypothesized that obese adolescents with disabilities would be significantly more likely to have the metabolic syndrome *vs* obese adolescents without disabilities.

**MATERIALS AND METHODS**

***Study population***

Participant data from the National Health and Nutrition Examination Survey (NHANES) were analyzed. Six cycles of NHANES data (1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, and 2009-2010) were combined to ensure adequate sample size and statistical reliability[16]. The NHANES sampling design to obtain a nationally representative sample of the United States population is described in detail elsewhere[16].

***Eligibility criteria***

We selected all adolescents ages 12-18 years old from the combined 1999-2010 NHANES data who had the following variables available for analysis: waist circumference, body mass index (BMI), high density lipoprotein (HDL) cholesterol, systolic and diastolic blood pressure, and fasting glucose and triglycerides. Because we chose to only analyze those who had data available on the cardiometabolic disease risk factors collected for their age group, the sample size was reduced from a total sample size of 10173 to 5276. There were no baseline significant differences between adolescents included in the sample (*n* = 5276) and those excluded (*n* = 4897) in terms of gender, ethnicity, education, income, or disability status. The mean age in the group included was 15.1 years compared to 14.9 years for those not included (*P* = 0.01).

Children were excluded from the analysis if they were known to have diabetes (*n* = 51), used medication that altered blood pressure, lipid metabolism, or blood glucose such as insulin, androgens, anabolic steroids, or adrenal corticosteroids (*n* = 42), or self-reported and/or tested positive *via* urine test as pregnant (*n* = 117).

***Disability status***

Individual physical functioning data were compiled from the NHANES Physical Function questionnaires[17] to determine disability status. A participant was categorized as having a disability (yes/no) if they answered yes to any of the following questions: (1) “Do you/does child have an impairment or health problem that limits (your/his/her) ability to crawl, walk, run, or play?”; (2) “Is this an impairment or health problem that has lasted, or is expected to last 12 months or longer?”; and (3) “Is (child) limited in the kind or amount of play activities he/she can do because of a physical, mental, or emotional problem?” Participants who did not report a disability were placed in the no disability category, which constituted the reference group for the analyses. Information on specific category of disability (autism, Down’s syndrome) is not available for NHANES participants under the age of 19.

***Individual cardiometabolic disease risk factors***

The criteria used to estimate the prevalence of abnormal or elevated (or low in the case of HDL cholesterol) individual cardiometabolic disease risk factors were modified to pediatric-specific criteria based on the National Cholesterol Education Program’s Adult Treatment Panel (ATP III) MetS definition for adults[18].The threshold values used in this study to define each pediatric-specific abnormal risk factor are described below.

**Waist circumference:** Abnormal waist circumference was defined as above the 90th percentile of the NHANES III (1988-1994) prevalence estimates adjusted for age, sex and ethnicity[19].

**Systolic and diastolic blood pressure:** Blood pressure was considered to be abnormal if systolic and/or diastolic values were greater than standardized 90th percentile values adjusted for age and sex[20].

**HDL cholesterol:** NHANES III values[21] for cholesterol less than the 10th percentile were used to define abnormal or low HDL-cholesterol for the current study.

**Triglyceride**:NHANES III[21] findings for triglyceride greater than the 90th percentile values adjusted for sex and ethnicity were used to define elevated levels in the current study.

**Fasting glucose:** A fasting glucose level of 100 mg/dL or higher was classified as abnormal[22].The fasting glucose-specific, 4-year weights were applied for analysis.

***Metabolic syndrome***

An adolescent met criteria for the MetS if they had ≥ 3 of the following risk factors: elevated waist circumference, triglycerides, fasting glucose, systolic and/or diastolic blood pressure, and low HDL cholesterol[11-13].

***BMI percentile categories***

Comparison of abnormal cardiometabolic disease risk factors were examined by the following standardized BMI categoriesfor those with and without disabilities; (1) normal weight = BMI < 85th percentile for age and sex; (2) overweight = BMI ≥ 85th - < 95th percentile for age and sex; (3) obese = BMI ≥ 95th percentile for age and sex[23]; and (4) severely obese = absolute BMI ≥ 35 kg/m[24].

***Measures and data collection***People who were selected and consented to participate in the NHANES completed an in-home survey collected *via* Computer Assisted Personal Interviewing (CAPI) procedures. Demographic, socioeconomic, dietary, and health-related information was collected during this process. After the in-home interview, participants were asked to undergo a physical exam at a Medical Examination Center (MEC).

All laboratory methods used at the MEC are reported in detail in the NHANES Laboratory/Medical Technologists Procedures Manual[25,26]. Heights and circumferences were recorded to the nearest 0.1 cm.

## *Covariates*

Demographic data including age in years, gender, ethnicity (Non-Hispanic White, Non-Hispanic Black, Mexican American, Other Hispanic and Other) and education level were used in analysis as covariates. Mexican American and Other Hispanic categories were combined to create a “Hispanic” classification.

***Statistical methods***

All data were analyzed using SAS survey procedures (SAS version 9.3, SAS Institute, Cary, NC). Sample weights (created to generate estimates for an entire sampling frame) were readjusted to account for the combined survey cycles. Weighting takes into account the specific probabilities of selection for the individual domains that were over-sampled (for example, in the 1999-2000 and 2001-2002 surveys both Mexican Americans and blacks were over-sampled), as well as non-response and differences between the sample and the total population. The correct sampling weights must be used to produce unbiased estimates when multiple surveys/years are combined.

Survey frequencies were used to summarize demographic descriptive characteristics of the sample, and the SAS survey means procedure was used to obtain descriptive characteristics of anthropometric measurements. A binary variable for disability status was created for comparison and analysis purposes. The prevalence of each cardiometabolic disease risk factor was estimated for all 4 BMI categories for those with and without disabilities.

Linear regression models were fit with each cardiometabolic disease risk factor independently as continuous outcomes to show relationships with disability status. Logistic regression models were fit with a cluster of ≥ 3 abnormal cardiometabolic disease risk factor (MetS) as a binary outcome [Y = ≥ 3 abnormal factors; N = ≤ 3 abnormal factors) Adjustments were made in a step-wise procedure for Model (1) age, gender, ethnicity; Model (2) age, gender, ethnicity, education level; and Model (3) [Full Model]] age, gender, ethnicity, education level, and annual household income. Adjusted odds ratios were reported with corresponding 95% confidence intervals.

***Statistical analysis***

The statistical review of the study was performed by senior author Dr. Kristopher Arheart, a biomedical statistician and a leading expert on NHANES data and analysis. His approval of the methods are documented *via* his senior authorship inclusion on the manuscript.

**RESULTS**

Demographic characteristics of the sample (*n* = 5276, weighted *n* = 15942916) are presented in Table 1. Five percent (5.1%) of the sample (*n* = 256, weighted *n* = 812061) was classified as having a disability. There were no statistically significant differences in gender, ethnicity, education level, or annual household income between disabled and no-disability groups. Adolescents with disabilities were significantly less likely to be normal weight *vs* their peers with no disabilities (50.7% *vs* 66.9%, *P* < 0.001), and were significantly more likely to be overweight (49.3% *vs* 33.1%, *P* < 0.001) and obese (27.6% *vs* 17.5%, *P* = 0.01). Adolescents with disabilities had a significantly higher mean BMI percentile (71.3%ile), and *Z*-score (0.83) *vs* children without disabilities (64.4%ile; 0.53, respectively).

No significant differences between adolescents with and without disabilities were found for all cardiometabolic disease risk factors mean values among overweight, obese and severely obese sub-groups with the exception of fasting glucose; among those who were overweight, mean values were significantly higher in those with disabilities (96.7 mg/dL) *vs* those without disabilities (94.0 mg/dL, *P* = 0.03). Normal weight adolescents with disabilities were significantly more likely to have an elevated waist circumference *vs* those children without disabilities (74.7 cm *vs* 73.1 cm, *P* = 0.01) (Table 2).

With the exception of diastolic blood pressure and triglycerides, overweight, obese and severely obese adolescents with and without disabilities were significantly more likely to have abnormal or elevated levels of waist circumference, systolic blood pressure, HDL cholesterol, triglycerides, fasting glucose, and MetS *vs* their normal weight counterparts. A higher proportion of overweight, obese and severely obese children with disabilities had abnormal SBP, fasting lipids and glucose as well as MetS (15.7% of overweight, 28.1% of obese, 61.3% of severely obese) *vs* their peers without disabilities (9.1%, 15.4%, 31.2%, respectively) (Table 3).

Adjusted logistic regression analysis showed that disabled adolescents are more than 3 times as likely as their nondisabled peers to have the MetS (AOR: 3.45, 95%CI: 1.08-11.0, *P* = 0.04). Females were significantly less likely to have MetS *vs* males (OR: 0.33, 95%CI: 0.21-0.53, *P* < 0001) (Table 4).

**DISCUSSION**

Our results here show that US adolescents with disabilities are disproportionately affected by obesity and are over three times as likely to have the MetS *vs* their peers with no disabilities. Half of all adolescents with disabilities are overweight, obese or severely obese. In addition to the MetS, obese adolescents with disabilities are significantly more likely than their normal weight counterparts to have increased or abnormal systolic blood pressure, lipid and fasting glucose levels, placing them at risk for cardiovascular disease and/or type 2 diabetes.

The findings in this study are consistent with previous literature describing higher rates of obesity and obesity related conditions in adults with disabilities[3]. Specifically, Froehlich-Grobe *et al*[3] reported that the prevalence those with disabilities have a significantly higher prevalence of obesity and extreme obesity (41.6% and 9.3%, respectively) compared to individuals without disabilities  (29.2% and 3.9%, respectively). Additionally, those with disabilities at all weight categories were significantly more likely to have cardiometabolic risk factors and overt disease risk present. Furthermore, when comparing level of physical activity among disabled and nondisabled adolescents the literature consistently shows that adolescents with disabilities are less likely to participate in sports or regular physical activity and are thus exposed to more inactivity *via* screen time such as TV, computer and video games[27].

Qualitative research has identified various barriers to facilitate participation in fitness and recreation programs and facilities among those with disabilities. These barriers include but are not limited to the built and natural environment, equipment, interpretation of guidelines, regulations, and laws, professional knowledge, education, and training issues; and facility- and community-level policies and procedures[28]. Research conducted in urban areas suggests that three out of five individuals with disabilities do not have sidewalks between their residences and the nearest bus stop, and over 70% lack curb cuts and bus shelters[29].

Thus, a Healthy People 2020 recommendation is to include those with disabilities in health promotion programs that include both healthy eating and active living components to help decrease their health risks[1]. Inclusion of persons with disabilities in urban planning and transportation planning processes, and promoting the principles of Universal Design[30] are also recognized as an important strategies. Similarly, the National Prevention Strategy, whose aim is to improve the health of each American at every stage of life and eliminate all health disparities, has formulated a plan that includes improving social inclusion of those with disabilities with mental and emotional well-being, healthy eating and active living with all citizens[31].The combination of healthy eating and active living programs have a positive health effect on people with disabilities, including a decrease in weight and BMI, becoming more fit[32], higher fruit and vegetable intake and self-reported activity levels, and decreased health risks.

We report that half of all United States adolescents with disabilities are either overweight, obese or severely obese, which has strong implications for adult health. Previous studies have documented the importance of childhood obesity as one of the strongest risk factors for adult obesity and cardiometabolic disease[14,15].We also found that adolescents with disabilities are at over triple the risk for the MetS *vs* their peers with no disabilities, which also has direct implications for their adult health. Previous studies have shown that if MetS is present in the childhood years, that individual has an almost 10 fold risk for cardiovascular disease, and 4 fold risk for type 2 diabetes as an adult[7,14,15]. Our findings here suggest that adolescents with disabilities who are concomitantly challenged with unhealthy weight should be closely monitored for associated cardiometabolic risk to prevent chronic disease onset.

***Limitations***

A few study limitations should be noted. First, because NHANES is a cross-sectional design, causality cannot be inferred (*e.g.,* whether disability causes obesity or vice versa). Second, the prevalence of obesity in this subpopulation of NHANES data may be underestimated because those with the most severe disabilities may not be able to participate. Additionally, height and weight was not recorded in those participants who could not stand independently. However, our analysis only included those participants who had all cardiometabolic disease risk factors available, including BMI and waist circumference. Finally, information on specific category of disability (autism, Down’s syndrome) was not available for NHANES participants under the age of 19.

***Conclusion***

Recently, the American Medical Association (AMA) officially labeled obesity as a disease “requiring a range of medical interventions to advance obesity treatment and prevention”[33]. This statement has direct implications for our finding here that half of all US adolescents with disabilities are either overweight, obese or severely obese. As adolescents, those with disabilities are already more than three times as likely as their peers without disabilities to have the MetS. Future research efforts should focus on the etiology of the disproportionate prevalence of both obesity and cardiometabolic disease risk in those with developmental disabilities. Our findings suggest that overweight and obese adolescents with disabilities should be clinically monitored for elevated weight and concomitant cardiometabolic disease risk factors throughout their teenage years.

**COMMENTS**  
***Background***

The prevalence of obesity is 38% higher in children with disabilities and mobility limitations compared to their peers without disabilities.Similarly, 57% of adults who are disabled are obese compared to 35.7% of peers without disabilities. Healthy People 2020 reports that not only are individuals with disabilities more likely to be overweight or obese, they are also less likely to engage in outdoor physical activities, less likely to have social support to do so, and have worse overall health status *vs* their non-disabled counterparts.There are few population-based studies examining the prevalence of cardiometabolic risk among adolescents with disabilities despite their increased prevalence of obesity *vs* their peers without disabilities.Therefore, the purpose of the current analysis is to estimate the prevalence of cardiometabolic disease risk, including the metabolic syndrome, among the United States adolescent population with and without developmental physical and/or learning disabilities by weight status (normal weight, overweight, obese, severely obese).

***Research frontiers***

The purpose of the current analysis is to estimate the prevalence of cardiometabolic disease risk, including the metabolic syndrome, among the United States adolescent population with and without developmental physical and/or learning disabilities by weight status (normal weight, overweight, obese, severely obese).

***Innovations and breakthroughs***

Our results here show that United States adolescents with disabilities are disproportionately affected by obesity and are over three times as likely to have the metabolic syndrome *vs* their peers with no disabilities. Half of all adolescents with disabilities are overweight, obese or severely obese. In addition to the metabolic syndrome, obese adolescents with disabilities are significantly more likely than their normal weight counterparts to have increased or abnormal systolic blood pressure, lipid and fasting glucose levels, placing them at risk for cardiovascular disease and/or type 2 diabetes.

***Applications***  
Our findings suggest that overweight and obese adolescents with disabilities should be clinically monitored for elevated weight and concomitant cardiometabolic disease risk factors throughout their teenage years.

***Terminology***  
The metabolic syndrome is defined as having ≥ 3 of the following cardiometabolic disease risk factors present simultaneously - elevated blood pressure, elevated glucose concentrations, hypertriglyceridemia, low high density lipoprotein cholesterol concentrations, and central adiposity (elevated waist circumference.

***Peer review***

This is a very interesting and well written manuscript.

**REFERENCES**

1 **Cornell University Employment and Disability Institute.** U.S. Census Bureau's 2011 American Community Survey (ACS) Public Use Microdata Sample (PUMS) data. [Accessed March 10, 2014]. Available from: URL:http: //www.disabilitystatistics.org/reports/acs.cfm?statistic=1

2 **Rimmer JH**, Yamaki K, Davis BM, Wang E, Vogel LC. Obesity and overweight prevalence among adolescents with disabilities. *Prev Chronic Dis* 2011; **8**: A41 [PMID: 21324255]

3 **Froehlich-Grobe K**, Lee J, Washburn RA. Disparities in obesity and related conditions among Americans with disabilities. *Am J Prev Med* 2013; **45**: 83-90 [PMID: 23790992 DOI: 10.1016/j.amepre.2013.02.021]

4 **Coombes E**, Jones AP, Hillsdon M. The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Soc Sci Med* 2010; **70**: 816-822 [PMID: 20060635 DOI: 10.1016/j.socscimed.2009.11.020]

5 **Hillsdon M**, Panter J, Foster C, Jones A. The relationship between access and quality of urban green space with population physical activity. *Public Health* 2006; **120**: 1127-1132 [PMID: 17067646 DOI: 10.1016/j.puhe.2006.10.007]

6 **U.S. Department of Health and Human Services**. Healthy People 2020. 2013. Available from: URL: http: //www.healthypeople.gov/2020/topicsobjectives2020/overview.aspx?topicid=9

7 **Lipshultz SE,** Messiah SE, Miller TL, editors. Pediatric Metabolic Syndrome: Comprehensive Clinical Review and Related Health Issues. London: Springer, 2012. Available from: URL: http: //books.google.com/books?hl=en&lr=&id=hI1qVQEqik0C&oi=fnd&pg=PR4&dq=Pediatric Metabolic Syndrome: Comprehensive Clinical Review and Related Health Issues. London: Springer; 2012.&ots=od0V0eC0mM&sig=OrqXUtIvnWuS-O9STep0yK\_gVWo#v=onepage&q=Pediatric Metabolic Syndrome: Comprehensive Clinical Review and Related Health Issues. London: Springer; 2012.&f=false

8 **Finkelstein EA**, Trogdon JG, Cohen JW, Dietz W. Annual medical spending attributable to obesity: payer-and service-specific estimates. *Health Aff (Millwood)* 2009; **28**: w822-w831 [PMID: 19635784 DOI: 10.1377/hlthaff.28.5.w822]

9 **Olshansky SJ**, Passaro DJ, Hershow RC, Layden J, Carnes BA, Brody J, Hayflick L, Butler RN, Allison DB, Ludwig DS. A potential decline in life expectancy in the United States in the 21st century. *N Engl J Med* 2005; **352**: 1138-1145 [PMID: 15784668 DOI: 10.1056/NEJMsr043743]

10 **Doak CM**, [Visscher TL](http://www.ncbi.nlm.nih.gov/pubmed?term=Visscher%20TL%5BAuthor%5D&cauthor=true&cauthor_uid=16436107), [Renders CM](http://www.ncbi.nlm.nih.gov/pubmed?term=Renders%20CM%5BAuthor%5D&cauthor=true&cauthor_uid=16436107), [Seidell JC](http://www.ncbi.nlm.nih.gov/pubmed?term=Seidell%20JC%5BAuthor%5D&cauthor=true&cauthor_uid=16436107). The prevention of overweight and obesity in children and adolescents: a review of interventions and programmes. *Obes Rev* 2006; **7**: 111–13 [PMID: 16436107 DOI: 10.1111/j.1467-789X.2006.00234.x]

11 **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. *Arch Pediatr Adolesc Med* 2003; **157**: 821-827 [PMID: 12912790 DOI: 10.1001/archpedi.157.8.821]

12 **Messiah SE**, Arheart KL, Luke B, Lipshultz SE, Miller TL. Relationship between body mass index and metabolic syndrome risk factors among US 8- to 14-year-olds, 1999 to 2002. *J Pediatr* 2008; **153**: 215-221 [PMID: 18534237 DOI: 10.1016/j.jpeds.2008.03.002]

13 **de Ferranti SD**, Gauvreau K, Ludwig DS, Neufeld EJ, Newburger JW, Rifai N. Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. *Circulation* 2004; **110**: 2494-2497 [PMID: 15477412 DOI: 10.1161/01.CIR.0000145117.40114.C7]

14 **Morrison JA**, Friedman LA, Gray-McGuire C. Metabolic syndrome in childhood predicts adult cardiovascular disease 25 years later: the Princeton Lipid Research Clinics Follow-up Study. *Pediatrics* 2007; **120**: 340-345 [PMID: 17671060 DOI: 10.1542/peds.2006-1699]

15 **Sun SS**, Liang R, Huang TT, Daniels SR, Arslanian S, Liu K, Grave GD, Siervogel RM. Childhood obesity predicts adult metabolic syndrome: the Fels Longitudinal Study. *J Pediatr* 2008; **152**: 191-200 [PMID: 18206688 DOI: 10.1016/j.jpeds.2007.07.055]

16 **Centers for Disease Control and Prevention**. National Center for Health Statistics. National Health and Nutrition Examination Survey Data. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2010. Available from: URL: http: //www.cdc.gov/nchs/about/major/nhanes/nhanes2009-2010/questexam03\_04.htm

17 **Centers for Disease Control and Prevention.** National Center for Health Statistics. National Health and Nutrition Examination Survey. 2009 - 2010 Data Documentation, Codebook, and Frequencies. Physical Functioning (PFQ\_F). Available from: URL: http: //www.cdc.gov/nchs/nhanes/nhanes2009-2010/PFQ\_F.htm

18 **National Institutes of Health.** The Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Bethesda, MD: National Institutes of Health; NIH Publication 01-3670, 2001

19 **Fernández JR**, Redden DT, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. *J Pediatr* 2004; **145**: 439-444 [PMID: 15480363 DOI: 10.1016/j.jpeds.2004.06.044]

20 **National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.** The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004; **114**: 555-576 [PMID: 15286277]

21 **Hickman TB**, Briefel RR, Carroll MD, Rifkind BM, Cleeman JI, Maurer KR, Johnson CL. Distributions and trends of serum lipid levels among United States children and adolescents ages 4-19 years: data from the Third National Health and Nutrition Examination Survey. *Prev Med* 1998; **27**: 879-890 [PMID: 9922071 DOI: 10.1006/pmed.1998.0376]

22 **American Diabetes Association.** American Diabetes Association: clinical practice recommendations 2002. *Diabetes Care* 2002; **25** Suppl 1: S1-147 [PMID: 11788484 DOI: 10.2337/diacare.25.2007.S1]

23 **Kuczmarski RJ**, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Mei Z, Curtin LR, Roche AF, Johnson CL. CDC growth charts: United States. *Adv Data* 2000; **(314)**: 1-27 [PMID: 11183293]

24 **Kelly AS**, Barlow SE, Rao G, Inge TH, Hayman LL, Steinberger J, Urbina EM, Ewing LJ, Daniels SR. Severe obesity in children and adolescents: identification, associated health risks, and treatment approaches: a scientific statement from the American Heart Association. *Circulation* 2013; **128**: 1689-1712 [PMID: 24016455 DOI: 10.1161/CIR.0b013e3182a5cfb3]

25 **The Centers for Disease Control and Prevention.** National Health and Nutrition Examination Survey: Laboratory Procedures Manual. 2004. Available from: URL: www.cdc.gov/nchs/data/nhanes/lab1-6.pdf

26 **Chumlea NC**, Kuczmarski RJ. Using a bony landmark to measure waist circumference. *J Am Diet Assoc* 1995; **95**: 12 [PMID: 7798573]

27 **Rimmer JH**, Riley B, Wang E, Rauworth A, Jurkowski J. Physical activity participation among persons with disabilities: barriers and facilitators. *Am J Prev Med* 2004; **26**: 419-425 [PMID: 15165658 DOI: 10.1016/j.amepre.2004.02.002]

28 **Centers for Disease Control and Prevention.** Disability and Health. [Accessed 2013 Novermber 7]. Available from: URL: http: //www.naccho.org/topics/environmental/landuseplanning/upload/DisabilityFocusGroupReport\_000.pdf

29 **Clarke P**, Ailshire JA, Bader M, Morenoff JD, House JS. Mobility disability and the urban built environment. *Am J Epidemiol* 2008; **168**: 506-513 [PMID: 18667526 DOI: 10.1093/aje/kwn185]

30 **Mobility International USA.** Universal Design/Accessibility Standards Resources. [Accessed 2013 Novermber 7]. Available from: URL: http: //www.miusa.org/ncde/tools/universaldesign.

31 **United States Department of Health and Human Services.** National Prevention Strategy. Washington, DC. [Accessed 2013 September 13]. Available from: URL: http: //www.surgeongeneral.gov/initiatives/prevention/strategy/

32 **Naaldenberg J**, Kuijken N, van Dooren K, van Schrojenstein Lantman de Valk H. Topics, methods and challenges in health promotion for people with intellectual disabilities: a structured review of literature. *Res Dev Disabil* 2013; **34**: 4534-4545 [PMID: 24161461 DOI: 10.1016/j.ridd.2013.09.029]

33 **American Medical Association.** Report of the Council on Science and Public Health. CSAPH Report 3-A-13. Is obesity a disease? Chicago: American Medical Association, 2013. Available from: URL: http: //www.ama-assn.org/assets/meeting/2013a/a13-addendum-refcomm-d.pdf

**P-Reviewer:** Das UN,Masaki T, Zdravkovic M **S-Editor:** Ji FF **L-Editor: E-Editor:**

**Table 1 Demographic and anthropometric characteristics of United States 12-18 years old with and without disabilities, 1999-2010 National Health and Nutrition Examination Surveys**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Overall**  ***n* = 5276** | **Disability**  ***n* 256** | **No Disability**  ***n* = 5020** | ***P*-valuea** |
|  | ***n* (%)** | ***n* (%)** | ***n* ( %)** |  |
| **Gender** |  |  |  | 0.31 |
| Boys | 2674 (50.8) | 126 (2.5) | 2548 (48.3) |  |
| Girls | 2602 (49.2) | 130 (2.6) | 2472 (46.6) |  |
|  |  |  |  |  |
| **Race/Ethnicity** |  |  |  | 0.78 |
| Non-Hispanic white | 1477 (61.1) | 80 (64.3) | 1397 (60.9) |  |
| Non-Hispanic black | 1414 (13.5) | 64 (12.1) | 1350 (13.6) |  |
| Hispanic | 2146 (18.7) | 97 (17.9) | 2049 (18.7) |  |
| Other | 239 (6.7) | 15 (5.7) | 224 (6.8) |  |
|  |  |  |  |  |
| **Education Level** |  |  |  | 0.22 |
| Grade School | 295 (5.2) | 19 (6.1) | 276 (5.1) |  |
| Middle School | 2247 (41.5) | 101 (34.7) | 2146 (41.9) |  |
| High School | 2264 (44.5) | 117 (52.6) | 2147 (44.1) |  |
| High School graduate/GED | 292 (6.4) | 9 (3.5) | 283 (6.6) |  |
| More than High School | 111 (2.3) | 6 (2.9) | 105 (2.3) |  |
|  |  |  |  |  |
| **Household Income** |  |  |  | 0.17 |
| < $10000 | 236 (5.3) | 22 (9.9) | 214 (5.1) |  |
| $10000-$19999 | 595 (13.0) | 32 (17.1) | 563 (12.7) |  |
| $20000-$34999 | 692 (15.8) | 32 (21.4) | 660 (15.5) |  |
| $35000-$54999 | 644 (20.2) | 24 (14.0) | 620 (20.5) |  |
| $55,000-$74,999 | 375 (14.0) | 16 (11.1) | 359 (14.1) |  |
| > $75000 | 679 (31.7) | 26 (26.4) | 653 (32.0) |  |
|  |  |  |  |  |
| **Body Mass Index Percentile Groupb** |  |  |  |  |
| Normal weight | 3281 (66.1) | 135 (50.7) | 3146 (66.9) | < 0.001 |
| Overweight | 1995 (33.9) | 121 (49.3) | 1874 (33.1) | <0.001 |
| Obese | 1099 (18.0) | 67 (27.6) | 1032 (17.5) | 0.01 |
| Severely obese | 261 (4.2) | 16 (5.8) | 245 (4.1) | 0.26 |
|  |  |  |  |  |
| **Body Mass Index** | **Mean (SE)** | **Mean (SE)** | **Mean (SE)** |  |
| Percentile | 64.4 (0.6) | 71.3 (2.4) | 63.9 (0.6) | < 0.01 |
| z score | 0.53 (0.02) | 0.83 (0.1) | 0.52 (0.0) | 0.01 |
|  |  |  |  |  |
| **Age** | 15.1 (0.04) | 15.1 (0.2) | 15.1 (0.04) | 0.68 |

aRepresents mean difference between those with and without disabilities; bNormal weight = body mass index < 85th percentile for age and sex, overweight = body mass index ≥ 85th - < 95th percentile for age and sex, obese = body mass index ≥ 95th percentile for age and sex (Kuczmarski*et al*[23], 2000) severely obese = absolute body mass index ≥ 35 kg/m2 (Kelly *et al*[24], 2000);

**Table 2 Mean values of cardiometabolic disease risk factors among United States 12-18 years old with and without disabilities by body mass index weight categorya, 1999-2010 National Health and Nutrition Examination Surveys**

|  |  |  |  |
| --- | --- | --- | --- |
| **Cardiometabolic Disease Risk Factors** | **Disability**  **mean (SE)** | **No disability**  **mean (SE)** | ***P*-value** |
| **Waist circumference, cm** |  |  |  |
| Normal weight | 74.7 (0.61) | 73.1 (0.18) | **0.01** |
| Overweight | 96.5 (1.63) | 94.7 (0.38) | 0.31 |
| Obese | 105.1 (1.59) | 102.2 (0.50) | 0.10 |
| Severely Obese | 122.2 (3.30) | 116.6 (0.71) | 0.09 |
|  |  |  |  |
| **Systolic blood pressure, mmHg** |  |  |  |
| Normal weight | 106.7 (1.22) | 107.3 (0.26) | 0.61 |
| Overweight | 114.2 (1.46) | 112.2 (0.36) | 0.19 |
| Obese | 115.7 (1.85) | 113.7 (0.38) | 0.31 |
| Severely Obese | 120.9 (3.49) | 116.2 (0.65) | 0.18 |
|  |  |  |  |
| **Diastolic blood pressure, mmHg** |  |  |  |
| Normal weight | 60.8 (0.45) | 61.2 (1.72) | 0.82 |
| Overweight | 59.8 (0.59) | 61.7 (1.45) | 0.19 |
| Obese | 59.7 (0.67) | 60.8 (2.17) | 0.59 |
| Severely obese | 61.1 (1.46) | 60.8 (3.75) | 0.94 |
|  |  |  |  |
| **High density lipoprotein, mg/dL** |  |  |  |
| Normal weight | 50.3 (1.23) | 52.9 (0.29) | 0.05 |
| Overweight | 44.9 (1.66) | 45.9 (0.37) | 0.53 |
| Obese | 41.0 (2.10) | 43.9 (0.45) | 0.19 |
| Severely Obese | 37.2 (3.07) | 41.1 (0.92) | 0.24 |
|  |  |  |  |
| **Triglycerides, mg/dL** |  |  |  |
| Normal weight | 92.3 (10.77) | 78.4 (1.14) | 0.21 |
| Overweight | 105.4 (11.05) | 100.3 (3.27) | 0.63 |
| Obese | 115.9 (15.40) | 113.2 (4.53) | 0.85 |
| Severely Obese | 173.0 (23.62) | 131.0 (12.76) | 0.12 |
|  |  |  |  |
| **Glucose, mg/dL** |  |  |  |
| Normal weight | 92.8 (1.32) | 92.4 (0.37) | 0.80 |
| Overweight | 96.7 (1.16) | 94.0 (0.35) | **0.03** |
| Obese | 96.8 (1.59) | 95.2 (0.47) | 0.32 |
| Severely Obese | 94.5 (1.10) | 95.9 (1.00) | 0.39 |

aNormal weight = body mass index < 85th percentile for age and sex, overweight = body mass index ≥ 85th - < 95th percentile for age and sex, obese = body mass index ≥ 95th percentile for age and sex (Kuczmarski*et al*[23], 2000) severely obese = absolute body mass index ≥ 35 kg/m2 (Kelly *et al*[24],2000);

**Table 3 Prevalence of abnormal cardiometabolic disease risk factors among overweight, obese and severely obese United States 12-18 years old with and without disabilities compared to those of normal weighta, 1999-2010 National Health and Nutrition Examination Surveys**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Cardiometabolic disease risk factors** | **Normal weighta**  ***n* (%)** | **Overweight**  ***n* (%)** | ***P*-value** | **Obese**  ***n* (%)** | ***P*-value** | **Severely obese**  ***n* (%)** | ***P*-value** |
| **Waist circumference, cmb** |  |  |  |  |  |  |  |
| Disability | 0 (0) | 33 (29.7) | < 0.0001 | 33 (53.0) | < 0.0001 | 15 (90.7) | < 0.0001 |
| No disability | 0 (0) | 441 (23.8) | < 0.0001 | 432 (43.6) | < 0.0001 | 225 (94.6) | < 0.0001 |
| **Systolic blood pressure, mm Hgc** |  |  |  |  |  |  |  |
| Disability | 5 (4.2) | 20 (17.6) | 0.02 | 16 (24.2) | 0.01 | 7 (37.4) | 0.004 |
| No Disability | 145 (3.7) | 251 (12.8) | < 0.0001 | 169 (14.5) | < 0.0001 | 57 (21.5) | < 0.0001 |
| **Diastolic blood pressure, mm Hgc** |  |  |  |  |  |  |  |
| Disability | 15 (11.6) | 17 (16.5) | 0.49 | 8 (16.0) | 0.69 | 2 (16.2) | 0.86 |
| No disability | 367 (11.2) | 194 (11.4) | 0.83 | 121 (12.5) | 0.35 | 45 (19.6) | 0.0002 |
| **High density lipoprotein, mg/dLd** |  |  |  |  |  |  |  |
| Disability | 23 (15.7) | 42 (37.8) | < 0.001 | 30 (47.0) | 0.001 | 11 (62.0) | 0.006 |
| No Disability | 370 (13.2) | 583 (33.7) | < 0.0001 | 390 (41.0) | < 0.0001 | 113 (56.0) | < 0.0001 |
| **Triglycerides, mg/dLd** |  |  |  |  |  |  |  |
| Disability | 13 (23.3) | 21 (34.2) | 0.82 | 16 (45.8) | 0.06 | 7 (67.1) | 0.007 |
| No disability | 224 (16.6) | 271 (31.4) | < 0.0001 | 182 (40.8) | < 0.0001 | 46 (50.1) | < 0.0001 |
| **Glucose, mg/dLe** |  |  |  |  |  |  |  |
| Disability | 9 (6.1) | 13 (15.5) | 0.03 | 8 (13.9) | 0.50 | 0 (0) | - |
| No Disability | 232 (7.4) | 171 (8.5) | 0.35 | 107 (10.7) | 0.02 | 26 (12.1) | 0.05 |
|  |  |  |  |  |  |  |  |
| **Metabolic Syndrome** (≥ *3 risk factors)* |  |  |  |  |  |  |  |
| Disability | 0 (0) | 17 (15.7) | < 0.0001 | 17 (28.1) | < 0.0001 | 11 (61.3) | < 0.0001 |
| No disability | 8 (0.20) | 153 (9.1) | < 0.0001 | 144 (15.4) | < 0.0001 | 71 (31.2) | < 0.0001 |

a Normal weight = body mass index < 85th percentile for age and sex, overweight = body mass index ≥ 85th - < 95th percentile for age and sex, obese = body mass index ≥ 95th percentile for age and sex (Kuczmarski*et al*[23], 2000) severely obese = absolute body mass index ≥ 35 kg/m2 (Kelly *et al*[24], 2000); b> 90th percentile for age and sex(Fernandez *et al*[18], 2004); c> 90th percentile for age and sex(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004); d> 90th percentile for age and sex for triglycerides, < 10th percentile for age and sex for HDL cholesterol (Hickman *et al*[20], 1998); e> 100 mg/dL(American Diabetes Association, 2006).

**Table 4 Odds Ratios to predict the metabolic syndrome by selected covariates among United States 12-18 years old with and without disabilities, 1999-2010 National Health and Nutrition Examination Survey**

|  |  |  |
| --- | --- | --- |
|  | **OR (95%CI)** | ***P*-value** |
| **Disability status** |  |  |
| No disability (ref) | 1 | - |
| Disability | 3.45 (1.08-10.99) | 0.03 |
| **Age** |  |  |
| 12 years old (ref) | 1 | - |
| > 12 years old | 1.22 (1.03-1.44) | 0.02 |
| **Sex** |  |  |
| Male (ref) | 1 | - |
| Female | 0.33 (0.21-0.53) | <0.0001 |
| **Ethnicity** |  |  |
| Non-Hispanic white (ref) | 1 | - |
| Race/Ethnicity | 0.77 (0.59-1.00) | 0.05 |
| **Education** |  |  |
| < High School (ref) |  |  |
| Education Level | 1.01 (0.97-1.05) | 0.70 |
| **Household Income** |  |  |
| > $75000 |  |  |
| Household Income | 1.02 (1.00-1.03) | 0.05 |
|  |  |  |