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ORIGINAL ARTICLE

Retrospective Study

Obesity and cardiometabolic disease risk factors among US 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, $\geqslant$ 3 risk factors present) were examined by the following standardized body mass index (BMI) categories for those with and without disabilities; overweight (BMI $\geqslant$ 85th - < 95th percentile for age and sex), obesity (BMI $\geqslant$ 95th percentile) and severe obesity (BMI $\geqslant$35 kg/m^2). 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, $P \leq 0.01$ 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.

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, and cognitive or developmental disabilities)[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 mo 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 categories for 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^2[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/

Table 1 Demographic and anthropometric characteristics of of those 12-18 years old with and without disabilities in the United States, 1999-2010 National Health and Nutrition Examination Surveys *n* (%)

	Overall *n* = 5276	Disability *n* = 256	No disability *n* = 5020	*P*-value[a]
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)	
$55000-$74999	375 (14.0)	16 (11.1)	359 (14.1)	
> $75000	679 (31.7)	26 (26.4)	653 (32.0)	
Body mass index percentile group[b]				
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

[a]Represents mean difference between those with and without disabilities; [b]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/m^2 (Kelly *et al*[24], 2000).

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 Mode)] age, gender, ethnicity, education level, and annual household income. Adjusted odds ratios were reported with corresponding 95%CIs.

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

Table 2 Mean values of cardiometabolic disease risk factors among those 12-18 years old with and without disabilities in the United States by body mass index weight category[a], 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

[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/m^2 (Kelly *et al*[24], 2000).

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

Table 3 Prevalence of abnormal cardiometabolic disease risk factors among those who are overweight, obese and severely obese and 12-18 years old with and without disabilities in the United States compared to those of normal weight[a], 1999-2010 National Health and Nutrition Examination Surveys *n* (%)

Cardiometabolic disease risk factors	Normal weight[a]	Overweight	*P*-value	Obese	*P*-value	Severely obese	*P*-value
Waist circumference, cm[b]							
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, mmHg[c]							
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, mmHg[c]							
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/dL[d]							
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/dL[d]							
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/dL[e]							
Disability	9 (6.1)	13 (15.5)	0.03	8 (13.9)	0.5	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/m^2 (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).

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

Table 4 Odds Ratios to predict the metabolic syndrome by selected covariates among those 12-18 years old with and without disabilities in the United States, 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

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

The 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

The 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 $\geqslant$ 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.

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