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Assessment of adolescent weight status: Similarities and differences between CDC, IOTF, and WHO references

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Abstract

Objective—The research sought to determine the reliability of assessing adolescents' weight status based on three standard criteria, Centers for Disease Control and Prevention (CDC) growth charts, International Obesity Task Force (IOTF) standards, and the World Health Organization (WHO) growth references.

Methods—Data from the NEXT Generation Health Study US 10th grade cohort (n=2323, mean age=16.19 years) starting in 2009 were used. Kappa statistics assessed agreement of assignment to weight categories. Associations of weight status with perceived body image, weight control intention, and general health were examined using linear regressions accounting for complex survey design.

Results—Kappas across weight status criteria were .89 and agreement exceeded 90% in all analyses. For all three criteria, overweight and obese participants, compared to normal weight, were significantly more likely to indicate fatter body image, higher weight control intention, and poorer general health; small differences in the regression coefficients by classification method were observed.

Conclusion—The three criteria of weight status classifications substantially agreed. Associations of weight status with selected health correlates were similar regardless of the methods. Thus, the three classifications can be considered comparable for most research and practice purposes.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

Keywords

Adolescents; body weight; body mass index; growth charts

Introduction

Weight status has been widely used for purposes of health surveillance and assessment. Accurate classification of weight status is important for surveillance and intervention assessment purposes. Adult weight status is typically classified as normal weight, overweight or obese based on body mass index (BMI) cut points. Classification of adolescent weight status is complicated by rapid development during this period. Several references have been developed to assess weight status for adolescents. Must et al. developed a reference of BMI values to define overweight and obese youth based on 85th and 95th percentiles of BMI using the first National Health and Nutrition Examination Survey (Must et al., 1991) as the reference population. The US Centers for Disease Control and Prevention (CDC) used more recent US nationally representative data to develop a reference (CDC reference) for assessing weight status based on BMI by sex and age; for those 20 years or younger, the standards are based on percentile ranking of BMI for age (Kuczmarski et al., 2000). This reference is widely used in literature (Kuczmarski et al., 2000).

The International Obesity Task Force (IOTF) used six large nationally (five different countries) or regionally (Hong Kong) representative datasets to develop age/sex-specific cut points for BMI to evaluate weight status in children, linked to adult cut points (Cole et al., 2000). The IOTF approach (Cole et al., 2000) classifies weight status of youth younger than 20 years using age and sex specific BMI cut points, thereby providing a uniform method of assigning weight status as youth move into adulthood, which may be helpful in assessing longitudinal changes of weight status.

In 2007, the WHO issued another growth reference for school-aged children and adolescents that are in agreement with the WHO child Growth Standards for preschool children and BMI cut offs for adults (de Onis et al., 2007). The new reference was developed by first merging two samples: the data from 1977 National Center for Health Statistics/WHO growth reference (1–24 years) and the data from the under-five standards' cross-sectional (18–71 months). Then, the state-of-the-art Box-Cox power exponential method was used to construct growth curves for children and adolescents. The 2007 issued growth curves provide an appropriate reference for the 5-to-19 years age group (de Onis et al., 2007).

Previous studies have compared the prevalence of overweight and obesity in US children calculated with the different sets of reference BMI values. For example, Flegal et al. compared prevalence estimates obtained using different references points developed by Must et al., the IOTF, and CDC (Flegal et al., 2001). Wang and colleagues compared the references developed by Must et al. and the IOTF with a previous version of the WHO reference (Wang and Wang, 2002). However, no studies were found comparing the updated WHO method with either the IOTF or CDC method or the three references concurrently.

Weight status has been well documented to relate to perceived body image, intention to weight control, general health (Heshmat et al., 2015; Mintem et al., 2015; Sargent-Cox et al., 2014; Swallen et al., 2005; Vander Wal, 2012) which are correlates of health behaviors such as eating behavior, physical activity, weight control (Fredrickson et al., 2015; Wardle et al., 2006). However, limited research has examined whether these correlates differ according to weight status classification method.

Therefore, objectives of the study were to examine the agreement of assignment to weight status groups based on the CDC, IOTF, and WHO references, and compare the patterns of association between three health correlates (as examples) and weight status categorized based on the three references using nationally-representative data from US adolescents. Findings of the study will facilitate comparisons of weight status prevalence using different standards and further provide cross-country researchers with evidence to share and apply research findings based on different standards.

Methods

Study participants and setting

We used wave 1 reported data (N=2323; mean age=16.15 years, SE=0.03) of the NEXT Generation Health Study, a nationally-representative, longitudinal cohort starting with 10th grade students in the 2009-2010 school year. Sampling strategy was reported elsewhere (Li et al., 2014). The study protocol was approved by the Institutional Review Board of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development.

Measures

Height, weight, and BMI—Participants removed bulky outer layers of clothing and shoes prior to measurement of height and weight. Height was measured to the nearest 0.1 cm using a portable Seca® 217 Stadiometer. Weight was measured to the nearest 0.1 kg with a Healthometer® model 498 KL digital scale. BMI was calculated by weight (kilogram)/[height (meter)]².

Weight status classification for adolescents

IOTF reference based weight status (Cole et al., 2000): IOTF reference for defining child weight status was developed based on nationally representative datasets of youth from five countries (Brazil, Great Britain, the Netherlands, Singapore, and the United States) and one region (Hong Kong). In each dataset, seven centile curves (based on Z scores -2, -1.33, -0.67, 0, +0.67, +1.33, and +2) were constructed to indicate BMI values for ages 2 - 18 years by sex corresponding to adult BMI cutoffs for normal weight (BMI 18.5kg/m², <25 kg/m²), overweight (BMI 25 kg/m², <30 kg/m²) and obese (BMI 30 kg/m²) weight categories. Averages across the datasets of the resulting curves provide age- and sex-specific BMI cutoffs.

CDC reference based weight status (Kuczmarski et al., 2000): percentile ranking of BMI relative to CDC BMI-for-age growth charts (girls/boys from 2 through 19 years old) (normal

weight=5th to <85th percentile, overweight=85th to <95th percentile, obese= 95th percentile).

WHO growth reference based weight status (de Onis et al., 2007): The WHO weight classification is based on BMI-for-age z-scores for children and adolescents (5 through 19 years old): obesity if BMI>+2SD, overweight if BMI>+ 1 standard deviation (SD), normal weight between +1SD and -1SD, thinness if <-2SD, and severe thinness if BMI<-3SD.

Three health correlates were included in the study: 1) perceived body image was measured using the question, “do you think your body is ...?” (response options 1=much too thin to 5=much too fat); 2) a weight control intention question, “at present, are you on a diet or doing something else to lose weight?” (response options, 1=no, my weight is fine, 2=no, but I should lose some weight, 3=no, because I need to put on weight, and 4=yes), and 3) a general health question, “would you say your health is...?” (response options 1=excellent, 2=good, 3=fair and 4=poor).

Demographic variables—Demographic variables included sex, race/ethnicity (White, African Americans, Hispanics and others), family affluence, family structure, and parental education. Family socioeconomic status was estimated using the Family Affluence Scale (Currie et al., 2004) and participants were categorized as low, moderate or high affluence. Participants' family structure was collapsed into two categories: living with a single parent or other vs. two parents from seven options (mother, father, stepmother, stepfather, grandmother, grandfather, in a foster home or children's home, and someone or somewhere else) to the question “where do you live all or most of the time and mark all the people who live there.” Parental education, which reflected the highest of up to two parents' educations, was reported by the parent completing the consent form (< high school diploma, high school diploma/GED, some college/technical school/advanced degree, or a bachelors/graduate degree).

Analysis—Kappa statistics compared 2-group (normal weight vs overweight/obese) and 3-group (normal weight vs overweight vs obese) assignments in the overall sample, by sex, and by race/ethnicity. Linear regression was conducted to examine the associations between weight status as assigned by each method and health correlates using SAS SURVEYREG statement by taking into consideration the complex survey design (including weight, strata, and cluster) for the analyses. SAS program 9.4 was used for all analyses.

Results

Of the 2322 participants, 54.77% (weighted, the same hereinafter) were females, 19.46% Hispanic/Latino, 18.22% African Americans, 57.40% Whites, and 4.91% other minorities (See Appendix 1 in the online supplementary materials for more information).

Kappas were excellent (>.90, except in males Kappa=.89) and percent agreement exceeded 90% in all analyses (overall sample, by sex, and by race/ethnicity) (Table 1). Frequencies of weight status (both 2 group and 3 group categories) were computed based on the IOTF, CDC, and WHO criterion (data not shown). Overall, 66 study participants (2.8% of total N,

the same hereafter) classified as normal weight and 66 of study participants (2.8%) classified as obese by the CDC method were classified as overweight by the IOTF method. Further, 37 of study participants (1.6%) and 103 of study participants (4.4%) classified as normal weight by the IOTF and CDC methods, respectively, were classified as obese or overweight by the WHO method. For subjects classified differently by the IOTF and CDC methods, the BMI percentiles were within approximately 1 percentile of the CDC cut-offs. See the tables and Venn diagrams (Appendixes 2–6) in the online supplementary materials.

The results of multiple linear regressions indicate weight status in 2 and 3 groups was significantly associated with body image, weight control intention, and general health. The overweight and obese categories compared to normal weight reported fatter body image, higher weight control intention, and poorer general health. The magnitude of the differences in regression coefficients in the models using the IOTF, CDC, and WHO references was very small (Table 2).

Discussion

Overall, the results from agreement analysis in the study were consistent with previous findings (Flegal et al., 2001; Wang and Wang, 2002). There is a high agreement between the three classification methods in estimated proportions in each weight category, indicating that the prevalence of overweight and obesity can be compared across countries or regions. However, differences in classifications result from using different references (Flegal et al., 2001; Wang and Wang, 2002). IOTF reference classified more adolescents as overweight than the other methods, with those classified differently than the CDC reference drawing from the normal weight class and obese classes, and those classified differently from the WHO drawing from the obese class. Furthermore, the WHO reference classified more adolescents as overweight and fewer adolescents as obese compared to the CDC reference. When classed into two groups, normal weight versus overweight/obese, the WHO method classified more participants as overweight or obese than either IOTF or CDC reference.

Using the data from US National Health Examination Survey and the first, second, and third National Health and Nutrition Examination Surveys, Flegal (2001) found that the IOTF reference estimated higher prevalence of overweight and lower prevalence of obesity compared to the CDC reference for children 15–17 years old (Flegal et al., 2001). Our results with the participants within the similar age range (16 years) are consistent with the findings of Flegal and colleagues. Further, Wang and Wang (2002) found that IOTF and WHO references produced similar estimates of overweight/obesity prevalence but different estimate for obesity, which are consistent with our results as well. However, the comparison between our study and Wang & Wang's study (age 6–18) should be used with caution as the age range of the latter had large variation. Although the overall estimates are largely consistent, these systematic differences should be noted when prevalence estimates from different sources are considered especially when comparing the prevalence across ages. Accordingly, the CDC reference may be the most “conservative” criteria, followed by IOTF and WHO references, in identifying overweight/obese high-school students. It should be noted that there is an age component to all three criteria, and the CDC criteria is based on a

US population, thus possibly limiting the applicability of these results to other ages and populations.

The study extends the comparison between references to examine estimated associations of weight status using CDC, IOTF and WHO references with health correlates. We observed very similar associations in unadjusted and adjusted models for all three references, indicating that using different references to examine associations may be less problematic compared to monitoring weight status.

Conclusion

Overall, the three methods of weight status classifications showed substantial, but not perfect, agreement. Associations of weight status with selected health correlates were similar regardless of the reference used suggesting that results from studies using different weight status references are comparable.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Three weight status criteria (i.e., CDC, IOTF & WHO classifications) were examined.
- The three criteria of weight status classifications highly agreed in adolescents.
- Small differences in the regression results by classification method were observed.
- The three classifications can be comparable for most research & practice purposes.

Table 1

Kappa and agreement for CDC, IOTF, and WHO references by sex and race/ethnicity (N = 2323)

	Kappa	95% CI		Agreement (%)	Kappa	95% CI		Agreement (%)
	IOTF by CDC (3 groups)				IOTF by CDC (2 groups)			
Overall	0.92	0.90	0.94	93.89	0.94	0.91	0.96	97.03
Sex								
Female	0.94	0.93	0.97	95.99	0.94	0.92	0.97	97.32
Male	0.89	0.85	0.94	91.35	0.93	0.89	0.97	96.69
Race/Ethnicity								
Hispanic	0.92	0.90	0.94	92.91	0.93	0.90	0.96	96.46
Whites	0.93	0.91	0.95	94.95	0.95	0.93	0.97	97.52
Black	0.94	0.92	0.97	95.15	0.95	0.92	0.98	97.36
Other	0.91	0.84	0.97	94.35	0.94	0.88	1.00	97.58
	IOTF by WHO (3 groups)				IOTF by WHO (2 groups)			
Overall	0.95	0.93	0.96	95.73	0.97	0.95	0.98	98.45
Sex								
Female	0.97	0.95	0.98	97.34	0.98	0.97	0.99	98.98
Male	0.89	0.85	0.94	96.69	0.96	0.93	0.98	97.79
Race/Ethnicity								
Hispanic	0.95	0.93	0.97	95.62	0.98	0.96	0.99	98.77
Whites	0.94	0.92	0.96	95.43	0.95	0.93	0.97	97.71
Black	0.96	0.94	0.98	96.91	0.98	0.96	1.00	99.12
Other	0.95	0.90	1.00	96.77	1.00	1.00	1.00	100.00
	CDC by WHO (3 groups)				CDC by WHO (2 groups)			
Overall	0.94	0.91	0.96	94.70	0.91	0.88	0.93	95.48
Sex								
Female	0.95	0.93	0.97	95.98	0.92	0.89	0.95	96.30
Male	0.92	0.89	0.95	93.78	0.89	0.84	0.93	94.48
Race/Ethnicity								
Hispanic	0.94	0.92	0.96	94.53	0.90	0.87	0.94	95.21
Whites	0.93	0.91	0.95	94.54	0.90	0.87	0.93	95.23
Black	0.95	0.93	0.97	96.04	0.93	0.89	0.96	96.48
Other	0.94	0.88	0.99	95.97	0.94	0.88	1.00	97.58

Note. This was a nationally representative study in the US and the data was collected in 2009.

The weighted proportions of normal weight, overweight, and obesity were (57.7%, 24.5%, and 17.8%) by IOTF reference, (60.7%, 18.4%, and 20.9%) by CDC reference, and (56.1%, 23.4%, and 20.4%) by WHO reference.

The weighted proportions of normal weight, overweight/obesity were (57.7%, 42.30%) by IOTF reference, (60.7%, 39.33%) by CDC reference, and (56.1%, 43.89%) by WHO reference.

Table 2

Unadjusted and adjusted linear regressions of three health correlates (N = 2323)

Body image				Weight control								General health																
IOTF				CDC		WHO		IOTF		CDC		WHO		IOTF		CDC		WHO										
B	SE	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE									
3 groups ^a	NW	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref									
	OB	1.09	*	0.05	1.02	*	0.05	1.06	*	0.05	1.15	*	0.08	1.09	*	0.08	1.12	*	0.09	0.65	*	0.08	0.56	*	0.07	0.59	*	0.07
	OW	0.53	*	0.05	0.52	*	0.05	0.49	*	0.06	0.60	*	0.10	0.59	*	0.12	0.54	*	0.12	0.29	*	0.06	0.32	*	0.07	0.27	*	0.06
2 groups ^a	NW	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref									
	OW/OB	0.76	*	0.04	0.79	*	0.03	0.75	*	0.03	0.83	*	0.09	0.86	*	0.09	0.81	*	0.34	0.44	*	0.05	0.45	*	0.06	0.42	*	0.27
3 groups ^b	NW	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref									
	OB	1.11	*	0.05	1.05	*	0.05	1.08	*	0.04	1.17	*	0.08	1.14	*	0.09	1.16	*	0.09	0.62	*	0.09	0.54	*	0.08	0.56	*	0.08
	OW	0.53	*	0.05	0.52	*	0.05	0.50	*	0.05	0.64	*	0.10	0.60	*	0.11	0.56	*	0.11	0.29	*	0.07	0.31	*	0.07	0.28	*	0.06
2 groups ^b	NW	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref									
	OW/OB	0.77	*	0.03	0.80	*	0.02	0.77	*	0.03	0.86	*	0.08	0.88	*	0.09	0.83	*	0.09	0.42	*	0.06	0.43	*	0.06	0.41	*	0.06

Notes.

NW=normal weight, OB=obese, OW=overweight.

This was a nationally representative study in the US and the data was collected in 2009.

* $p < .001$.^aUnadjusted models.^bAdjusted models controlling for sex, race/ethnicity, family affluence, family structure, and parental education.