The choice of cutoffs for obesity and the effect of those values on risk factor estimation[1–3]

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ABSTRACT

Several studies have examined risk factors for overweight and obesity. However, inconsistent results have been observed for estimations of some risk factors, such as the infant feeding method, and for their link to childhood obesity. These studies originated from different countries and used different body mass index cutoffs to define overweight and obesity. Using a theoretical approach and data obtained in preschoolers, we show that the identification of genuine risk factors for overweight or obesity does not depend on the choice of the reference system. However, for meaningful international comparisons, in particular for those of prevalence, studies should also report estimates by using a widely accepted international reference system.   *Am J Clin Nutr* 2008;87:292–4.

KEY WORDS   Body composition, body weight and measures, BMI distribution, statistical models

INTRODUCTION

Several studies examined the effect of risk factors on childhood obesity. The search terms "obesity AND children AND risk factors" identified 2509 published reports in the MEDLINE database (Internet: http://www.ncbi.nlm.nih.gov) by 31 May 2007. Most of these studies originated in the United States, and the next largest numbers were from the United Kingdom and Germany.

Inconsistent results were observed for certain risk factors—eg, for breastfeeding and childhood obesity—across different publications. Among others, the studies may suggest varied cutoffs as a reason for different findings. In fact, studies were carried out in different countries, and the definitions of childhood overweight and obesity varied across these publications (1). These definitions are mostly based on arbitrary body mass index (BMI; in kg/m^2) cutoffs, because BMI cutoffs that are associated with later disease risks are not yet known. Whereas the sex- and age-specific 85th and 95th BMI percentiles are recommended by the Centers for Disease Control and Prevention (CDC) as the arbitrary cutoffs to define childhood overweight and obesity in the United States (2), the European Childhood Obesity Group favored the 90th and 97th percentiles (3), and the International Obesity Task Force (IOTF) proposed international cutoffs that correspond to the widely used World Health Organization BMI cutoffs of 25 and 30 in adulthood (4). These cutoffs differ in definition and underlying reference populations and therefore yield varied prevalence estimates for overweight, obesity, or both (5).

We aimed to show that different cutoffs can be used for the identification of genuine obesogenic risk factors. We assessed the effect of different cutoffs applied in a theoretical model and in one real data set on risk estimates for childhood obesity.

THEORETICAL BACKGROUND

BMI curves are usually positively skewed among all age groups with an increasing trend of skewness (6–8). Thus, we used log-normal distributions to depict risk factor estimations by applying different cutoffs (**Figure 1**). We assumed a mean BMI of 16.6 (log mean: 2.8) with an SD of 2.51 (log SD: 0.15) for the population that is not exposed to the risk factor. Such BMI data can be observed in childhood. According to a theoretical genuine risk factor, we assumed a right-shifted BMI distribution with a mean of 18.5 (log mean: 2.9) for the population with an underlying risk factor compared with the "non-exposed" population. We also assumed that the corresponding variance of this exposed population was larger, with an SD of 3.75 (log SD: 0.2) (Figure 1).

In this model, a total of 9.6% of the population without an underlying risk factor has BMI values above an a priori chosen arbitrary cutoff of 20, whereas 31.6% of the population with the underlying risk factor has such BMI values (Figure 1A). If we increase the arbitrary cutoff to 21, the respective fractions with BMIs above this cutoff are 5.2% of the population without and 23.5% of the population with the underlying risk factor (Figure 1B).

The odds ratio (OR) is an estimate with values >1 indicating a risk and values between 0 and 1 indicating a protective factor. ORs increase with increasing cutoffs because of our assumptions of a right-shifted mean value in the exposed population and of a variance that is equal to or above the variance in the nonexposed
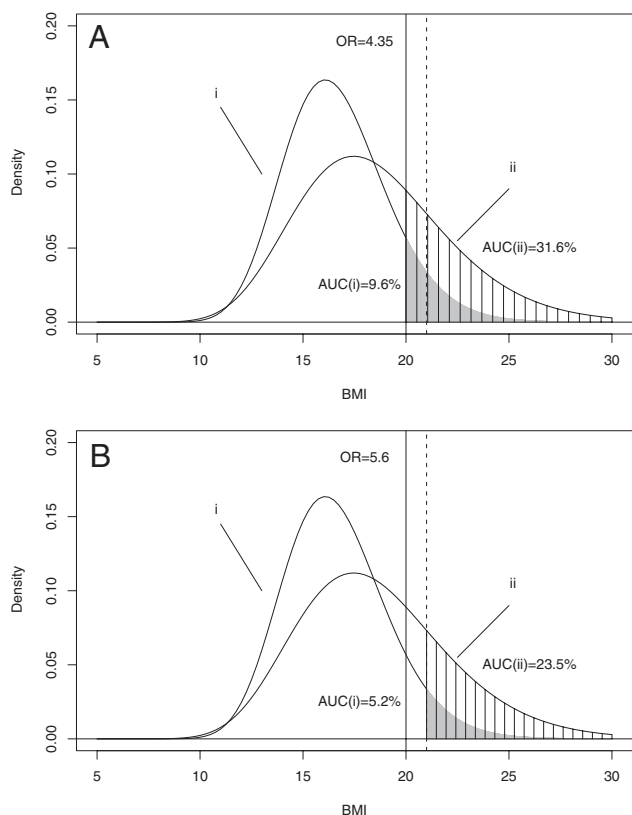
FIGURE 1. The area under the curve (AUC) and odds ratio (OR) for 2 BMI (in kg/m^2) cutoffs in populations not exposed (i) and exposed (ii) to the same obesogenic risk factor. A) —, BMI cutoff of 20; B) – – –, BMI cutoff of 21.

population. However, the corresponding ORs are 4.35 (BMI cutoff: 20) and 5.60 (BMI cutoff: 21), and they have the same direction. Furthermore, the direction of the OR (>1) is the same for any cutoff within one or both curves.

Whereas the direction of the OR estimation is unaffected, the sample power is associated with the proportion of persons who have values above the corresponding cutoffs. If a cutoff is located at or above the median of the overall BMI distribution, an increase in the cutoff will decrease the proportion of affected persons with BMI values equal to or higher than the cutoff. In addition, the sample power will decrease, as the corresponding CIs are getting wider. However, the quantitative detection of a difference between 2 groups is inversely related to the effect size and directly related to the level of variation. Therefore, a sample with a higher level of variation under a higher cutoff still may be

sufficient, because of the counterbalancing effect of a greater effect size, to allow detection of a difference between exposed and unexposed persons.

FINDINGS IN OBSERVATIONAL DATA

The theoretical considerations can be well observed among studies reporting risk estimates of obesogenic risk factors for both overweight and obesity. Because the obesity cutoffs are, by definition, higher than the overweight cutoffs, higher point estimates with wider CIs due to lower sample power are usually observed for obesogenic risk factors when obesity is compared with overweight. For example, the unadjusted effect of early intrauterine tobacco exposure on childhood body composition in an earlier study (9) showed an OR of 1.66 (95% CI: 1.27, 1.28) for overweight and a higher OR of 2.41 with a wider CI (95% CI: 1.49, 3.91). Among others, low physical activity was associated with an OR of 2.16 (1.78, 2.62) to overweight and a higher OR of 3.59 with a wider CI (2.58, 5.01) to obesity (9).

We reanalyzed the data from the school entry health examination 2001/2002 (9) and assessed the unadjusted effect of watching television for >1 h/d on childhood overweight and obesity among 5552 German children aged 5.00–6.99 y, by using different cutoffs (**Table 1**). Watching television is likely to be a surrogate marker for physical inactivity, and it was shown in a randomized controlled trial to increase BMI (10).

We used the 85th and 95th percentiles of the CDC growth charts from 2000 (2), the currently recommended German 90th and 97th percentiles (11), and the IOTF cutoffs (4) to define overweight and obesity in these preschoolers. The prevalence of overweight and obesity was highest with the use of the 85th and 95th percentiles, respectively, of the CDC growth charts from 2000 (Table 1) (2). The effect estimates and the width of the CIs were inversely related to the identified prevalence of overweight and obesity, respectively. For example, the IOTF obesity cutoff (4) yielded the highest OR of 3.13 but the lowest proportion of affected children. All effect estimates showed the same direction with ORs > 1.

CONCLUSION

Provided that an obesogenic risk factor is genuine, the use of different cutoffs derived from different cutoff definitions or the use of the same definitions for overweight and obesity among different reference populations yields meaningful risk factor estimations in the same direction (eg, ORs or relative risks > 1), with higher risk factor estimates for higher cutoffs and wider CIs.

TABLE 1
Prevalence and unadjusted odds ratios (ORs) (and 95% CIs) for television >1 h/d and overweight or obesity as defined by different reference systems[1]

Reference system	Overweight		Obesity	
	Prevalence	Watching television >1 h/d	Prevalence	Watching television >1 h/d
	%		%	
CDC, 85th and 95th percentiles (2)	15.4	1.99 (1.72, 2.30)[2]	6.7	2.43 (1.96, 3.01)
Current German cut offs, 90th and 97th percentiles (11)	8.9	2.17 (1.80, 2.62)	4.0	3.11 (2.35, 4.13)
IOTF cutoffs (4)	11.8	1.96 (1.66, 2.31)	3.6	3.13 (2.33, 4.22)

[1] CDC, Centers for Disease Control and Prevention; IOTF, International Obesity Task Force.

[2] OR; 95% CI in parentheses (all such values).

Opposite directions of risk estimates in different studies, however, are unlikely to be explained by the application of different cutoffs if genuine risk factors are defined by a greater mean BMI, a greater positive skewness, or both. In reality, however, results of observed data may differ because of methodologic limitations, such as measurement errors for the outcome or exposure.

Different sex- and age-specific BMI thresholds for the definitions of childhood overweight and obesity may affect the size of effect estimates, but the identification of genuine risk factors per se should be unaffected. However, for meaningful international comparisons of prevalences, studies also should report prevalence estimates by using an international reference system. The BMI cutoffs used to define childhood overweight and obesity, as proposed by the IOTF (4), are valuable for screening, population surveillance, and, in particular, international scientific comparisons across different countries.

REFERENCES

1. Flegal KM, Tabak CJ, Ogden CL. Overweight in children: definitions and interpretation. Health Educ Res 2006;21:755–60.
2. Centers for Disease Control and Prevention. About BMI for children and teens. Washington, DC: Department of Health and Human Services, 2000.
3. Poskitt EM. Defining childhood obesity: the relative body mass index (BMI). European Childhood Obesity Group. Acta Paediatr 1995;84: 961–3.
4. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240–3.
5. Flegal KM, Ogden CL, Wei R, Kuczmarski RL, Johnson CL. Prevalence of overweight in US children: comparison of US growth charts from the Centers for Disease Control and Prevention with other reference values for body mass index. Am J Clin Nutr 2001;73:1086–93.
6. Toschke AM, Martin RM, von KR, Wells J, Smith GD, Ness AR. Infant feeding method and obesity: body mass index and dual-energy X-ray absorptiometry measurements at 9–10 y of age from the Avon Longitudinal Study of Parents and Children (ALSPAC). Am J Clin Nutr 2007;85:1578–85.
7. Flegal KM, Troiano RP. Changes in the distribution of body mass index of adults and children in the US population. Int J Obes Relat Metab Disord 2000;24:807–18.
8. Toschke AM, Lüdde R, Eisele R, von Kries R. The obesity epidemic in young men is not confined to low social classes—a time series of 18-year-old German men at medical examination for military service with different educational attainment. Int J Obes (Lond) 2005;29:875–7.
9. Toschke AM, Montgomery SM, Pfeiffer U, von Kries R. Early intra-uterine exposure to tobacco-inhaled products and obesity. Am J Epidemiol 2003;158:1068–74.
10. Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. JAMA 1999;282:1561–7.
11. Kromeyer-Hauschild K, Wabitsch M, Kunze D, et al. Perzentile für den Body-mass-Index für das Kinder- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben. (Percentiles of body mass index in children and adolescents evaluated from different regional German studies.) Monatsschr Kinderheilkd 2001;149:807–18 (in German).