Body mass index is increasing faster among taller persons

Deborah A Cohen and Roland Sturm

ABSTRACT

Background: During the past 40 y, there has been a trend toward more eating away from home, increased food availability, the opportunity to order extra-large portion sizes, and general weight gain. 

Objective: Because shorter people need fewer calories than taller people to maintain their weight, our goal was to determine whether the body mass index (BMI)–height relation has changed over time. 

Design: Data are from 3581 nonpregnant women and 3091 men examined in the 1959–1962 National Health Examination Survey and 4651 nonpregnant women and 4691 men examined in the 2001–2004 National Health and Nutrition Examination Survey. We tested whether the relation between BMI and height has changed for men and women, after adjustment for other demographic changes.

Results: In the past, on average, shorter American men and women had significantly higher BMIs than taller people. However, taller people have been increasing their BMI during the past 40 y at a faster rate than shorter people.

Conclusions: This study documents that the obesity epidemic has changed the height-BMI relation. The data cannot identify causal pathways, and there are numerous explanations. A plausible hypothesis is that changes in the food environment may have eliminated constraints on weight gain for taller people that existed in a more calorie-constrained environment. Am J Clin Nutr 2008;87:445–8.

KEY WORDS NHANES, National Health and Nutrition Examination Survey, obesity, BMI, height, food environment

INTRODUCTION

Most Americans are either overweight [a body mass index (BMI; in kg/m²) > 25] or obese (BMI ≥ 30), and a larger proportion of persons are overweight or obese among lower-educated groups, blacks, and Mexican Americans (1–3). The sociodemographic differences in the prevalence of unhealthy weight contribute to health disparities, although it appears that most subpopulations have increased their BMI at fairly similar rates during the past 2 decades. Two noticeable exceptions are that women are increasing BMI faster than men and African Americans are gaining faster than both men and African Americans are gaining faster than other racial or ethnic groups (4). One relation that has not been studied is whether the obesity epidemic has affected taller and shorter persons differentially.

There are several reasons that the relation between height and BMI may have changed. One hypothesis focuses on dietary patterns and the shift to prepared meals away from home. The share of food away expenditures as a proportion of total food expenditures has tripled during the past 70 y (5). Serving sizes influence the quantity consumed (6–10), which makes it plausible that persons with lower energy needs obtain relatively more excess calories than do persons with higher energy needs when given the same portions. This hypothesis has some circumstantial support because BMI among women has increased more than among men in the past 20 y (4).

However, when the environment has constraints on food availability, it may be more difficult for taller people to obtain enough calories. Because this constraint has disappeared, taller people may have gained relatively more body mass. In the past couple of decades, food outlets have not only supersized portions, but they have also customized food portions, removing small and medium choices and replacing them with large, extra-large, and colossal sizes. For example, Big Gulp fountain drinks from 7-Eleven are available in 32-, 44-, and 52-oz servings (11).

BMI measures both lean body mass and body fat. The correlation between body fatness and BMI ranges from 0.6 to 0.8, depending on methods for determining body fat and populations. The relation between BMI and percentage of body fat also differs across racial groups (12–14). Thus, we cannot simply test whether height and BMI are correlated; we need to estimate how the height-BMI relation has changed over time.

Historically, an argument for using BMI as a universal measure to assess excess weight is that BMI is strongly correlated with weight but independent of height and that it captures the relation between weight and height (which means that weight changes with the square of height). This idea goes back to Quetelet (15) (and BMI is sometimes called Quetelet’s index), who first suggested that weight varies with the square of height among adults. If the ratio of weight in kilograms to height in meters is constant in a population (2), then regressing log weight on log height should give a coefficient of 2. However, the relation is only approximate: height and BMI are negatively correlated in most populations, and the slope of log weight regressed on log height often differs from 2, i.e., weight does not change with the square of height in most populations (16, 17). In fact, in 72 subpopulation comparisons, height and BMI were significantly correlated in 51 of 40 subgroups of men and in 32 of 32 groups of women (18).

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TABLE 1
Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
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<tbody>
<tr>
<td></td>
<td>(n = 3581)</td>
<td>(n = 4651)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.2 ± 5.3</td>
<td>28.2 ± 7.0</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.4 ± 13.5</td>
<td>74.5 ± 19.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>160 ± 6.5</td>
<td>163 ± 6.7</td>
</tr>
</tbody>
</table>

*All values are 𝑥 ± SD. Statistics weighted for sampling probability. The interaction between sex and year of survey was not significant for any variable.*

TABLE 2
Regression of BMI (in kg/m²) on height (in m)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>P</th>
<th>Test for change over time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1959–1962 (n = 3581)</td>
<td>–10.44</td>
<td>1.44</td>
<td>–7.23</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>2001–2004 (n = 4651)</td>
<td>–4.20</td>
<td>1.92</td>
<td>2.19</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1959–1962 (n = 3091)</td>
<td>–5.80</td>
<td>1.15</td>
<td>–5.03</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>2001–2004 (n = 4591)</td>
<td>1.20</td>
<td>1.43</td>
<td>0.83</td>
<td>0.40</td>
<td></td>
</tr>
</tbody>
</table>

*Results adjusted for age in 10-y groups and race or ethnicity.*

RESULTS

The sample sizes, means, and SDs of weight, height, and BMI for men and women are shown in Table 1. Women were 3 cm taller on average in 2001–2004 than in 1959–1962 but 10.1 kg heavier; men were 4 cm taller and 11.3 kg heavier.

The linear regression of BMI on height (in m) is shown in Table 2. A strong negative correlation was observed between BMI and height for women in both time periods and for men in 1959–1962, but it is positive (and not significantly different from zero) for men in 2001–2004. Height is measured in meters, so a coefficient of –10.4 indicates that women in 1959–1962 who were 10 cm taller (0.1 m) had a BMI that was on average 1.04 (95% CI: 0.76, 1.33) lower than that of shorter women. For men, being 10 cm taller in 1959–1962 was associated with a mean BMI that was 0.58 (95% CI: 0.35, 0.81) lower. The relation has changed noticeably by 2001–2004. For women, being 10 cm taller is now associated with a BMI that is 0.42 (95% CI: 0.04, 0.80) lower and for men with a BMI that is 0.12 (95% CI: –0.16, 0.40) higher. The change between the 2 time periods is significant for both men (P < 0.01, t = 3.81) and women (P = 0.01, t = 2.60). The final model only controls for age and race as a main effect. In addition, we tested whether the slope of BMI on height has changed differentially by race over time, but the interaction was not statistically significant for either women or men.

The regression results of ln weight (in kg) on ln height (in m) is shown in Table 3. Except for men in 2001–2004, the coefficient is <2, indicating that the ratio of weight divided by height squared is not constant at any point in time. For women, the coefficient is significantly different from 2 in 1959–1962 (P < 0.001) and in 2001–2004 (P < 0.01); for men, it is significantly different from 2 in 1959–1962 (P < 0.001) but not in 2001–2004 (P = 0.30). Once again, the change between the 2 time periods is highly significant for men (P < 0.01, t = 3.57) and for women (P = 0.003, t = 2.97). Now, tall men are just as likely to be overweight or obese as are shorter men, but tall women are still less likely to be overweight or obese than are shorter women, although they appear to be catching up.

DISCUSSION

This study documents an interesting new fact about obesity, namely that taller people have been gaining BMI at a faster rate than shorter people during the past 40 y. The causal factors are unknown, and, in fact, the results ran counter to our initial hypothesis: we expected that people with lower energy needs, including shorter people, obtain excess calories if they are eating prepackaged and restaurant meals that come in uniform sizes, meant to serve short and tall people equally.
Nonetheless, the new food environment may still be the cause of the change in the association between BMI and height. Even as recently as 1960, taller people may have been more energy constrained. Policies enacted during the 1960s reflect those concerns, such as the Food Stamp Pilot Program from 1961 to 1964, the Food Stamp Act of 1964, the 1962 amendments to the National School Lunch Act, and the 1966 Child Nutrition Act.

Of course, there are other potential explanations beyond diet. If taller people are not consuming relatively more calories than are shorter people, then shorter people are burning relatively more calories. Differential occupational demands, such as in construction or agriculture, may exist by height, or differential participation in leisure-time activities. A decline in parity, the leveling off of the secular trend in increasing height, and socio-demographic mortality differentials are alternative hypotheses.

We have no evidence for causal pathways, although we believe that changes in the food supply are probably involved. One potential pathway is through the calories that are readily available in larger portions of ready-to-eat foods and beverages. Taller people might preferentially choose larger portions, because they do in fact need more calories than do shorter people to maintain their weight. Tall men might choose larger portions more often than taller women, because it is more culturally acceptable for men to have “robust” appetites.

Although this is speculative, even a small psychological bias could have a substantial effect. The calorie differences between medium and larger sizes of fast foods and beverages are generally far greater than differences in energy needs because of height disparities. The difference in calories that should be consumed by a 5-foot 8-inch man (2 inches below average) compared with a 6-foot 0-inch man (2 inches above average) (20), if both are moderately active and have a BMI of 23, is 340 calories, or an absolute difference of <15% (21). In contrast to these relatively small differences in energy needs between a taller and a shorter person, a “large” restaurant portion can easily have 50–100% more calories than a “small” or “medium” portion. For example, a small serving of McDonald’s French fries has 250 kcal, a medium serving has 380 kcal, and a large serving has 570 kcal (22). If the taller man orders a large drink, a large fries, and a double Quarter Pounder with cheese at McDonald’s, he consumes 1610 calories for lunch. In contrast, if the shorter man orders the regular cheeseburger, the medium fries, and the medium drink, he consumes 900 calories. It is arguably too much for either one, but the taller man consumes relatively more than would be needed to account for his height.

Studies indicate that persons cannot precisely self-regulate their energy balance; they do not naturally compensate for eating too much at one meal by eating less at another (23). The lack of ability to accurately judge portion sizes and experience satiation commensurate with calories consumed is yet another factor leading to energy imbalances (6, 24, 25). The report of the Keystone Forum on Away-from-Home Foods recently reviewed a variety of factors that may be implicated in excessive calorie consumption and recommended that food outlets reduce portion sizes, eliminate the largest portions, label the calorie content, and provide sufficient information to allow persons to overcome psychologic and perceptual limitations that prevent them from naturally being able to balance their energy consumption with energy expenditure (26). Although the pathway for the increase in BMI among tall people compared with shorter people is speculation, the adoption of Keystone recommendations could provide a natural experiment to test our hypothesis and allow persons to play a more active role in regulating caloric intake and to reduce the trend in weight gain that has become epidemic.

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The author’s responsibilities were as follows—RS: conducted the statistical analysis; DAC: conceived the hypothesis; DAC and RS: contributed data and to the writing of the paper. Neither author had a personal or financial conflict of interest.

REFERENCES


### TABLE 3

| Regression of ln weight (in kg) on ln height (in m) |
|-----------------|-----------------|-----------------|
| **Women**       | **Coefficients** | **SE**          | **P**          |
| 1959–1962 (n = 3581) | 1.34            | 0.09            | < 0.001        |
| 2001–2004 (n = 4651) | 1.74            | 0.14            | 0.004          |
| **Men**         | **Coefficients** | **SE**          | **P**          |
| 1959–1962 (n = 3091) | 1.63            | 0.08            | < 0.001        |
| 2001–2004 (n = 4591) | 2.06            | 0.08            | 0.43           |

1. Results adjusted for age in 10-y groups and race or ethnicity.
2. H0: coefficient = 2.
22. McDonald’s USA nutrition facts for popular menu items. Oak Brook, IL: McDonald’s Corporation, 2006.
23. Levitsky DA, Youn T. The more food young adults are served, the more they overeat. J Nutr 2004;134:2546–9.