Center for Demography and Ecology

University of Wisconsin-Madison

Looks that Kill: Predicting Adult Health and Mortality from Adolescent Facial Characteristics in Yearbook Photographs

Eric N. Reither
Robert M. Hauser
Karen C. Swallen

CDE Working Paper No. 2006-11

Looks that kill: predicting adult health and mortality from adolescent facial characteristics in yearbook photographs

Eric N. Reither[†] [*], Robert M. Hauser,[‡] Karen C. Swallen[‡]

Utah State University,[†] University of Wisconsin-Madison[‡]

[*]Corresponding author:

Utah State University

Department of SSW&A

0730 Old Main Hill

Logan, UT 84322-0730

Phone: 435-797-1217

FAX: 435-797-1240

e-mail: ereither@hass.usu.edu

ABSTRACT

Some of the richest longitudinal studies in the social sciences did not, at their outset, gather biomarkers that are routinely recorded today—including the height and weight of participants. The Wisconsin Longitudinal Study (WLS) is a large cohort study of over 10,000 individuals that fits this description. To account for this shortcoming, an eleven point scale was developed to code the senior yearbook photographs of WLS participants for relative body mass (RBM). It is a reliable (α=0.91) and valid way to assess body mass. Despite the passage of 36 years between measures, the standardized relative body mass index (SRBMI) was moderately correlated ($r = 0.31$) with body mass at index (BMI) at ages 53-54 and uncorrelated with height. Overweight adolescents (defined as at or above the 90th percentile of SRBMI) were about three times more likely than normal weight adolescents (5th to 85th percentile) to be obese in adulthood and, as a likely consequence, significantly more likely to report health problems such as chest pain and diabetes. Sadly, overweight adolescents also suffered twofold risk of premature death from all non-accidental causes and fourfold risk of heart disease mortality. The RBM scale has removed a serious obstacle to obesity research in the WLS, highlighting the promise of innovative new solutions for other longitudinal studies that currently lack measures of body mass.

Longitudinal research in social sciences has enriched our understanding of many important issues, including social development, economic fortunes, family structures and the antecedents and consequences of poor health (Young, Savola, and Phelps 1991; Phelps, Furstenberg, and Colby 2002). However, at the time when many longitudinal studies were conceived, several indicators of health were omitted that are routinely recorded today. Importantly, height and weight—the constituent components of body mass—were omitted in a number of longitudinal studies that would otherwise provide excellent data resources for obesity research.

For instance, the National Longitudinal Study of the Class of 1972 (NLS-72) surveyed 22,652 high school seniors about their educational attainment and career aspirations. Subsequent waves in 1973, 1974, 1976, 1979, and 1986 created an exceptionally rich archive for scholars who investigate influences such as family background, high school curriculum and racial/ethnic identification on educational and occupational outcomes (U.S. Dept. of Education 1999). Unfortunately, the NLS-72 never measured either height or weight, making it impossible to determine the impact of obesity on the career trajectories of participants in the study. The capacity of longitudinal studies like the NLS-72 to contribute to obesity research would expand tremendously if there were some way to add new measures of body mass, particularly at baseline. But is there any recourse for such investigations other than unreliable retrospective questioning that excludes subjects that, for one reason or another, no longer participate?

Recent research from the Wisconsin Longitudinal Study (WLS) provides a promising answer to this question. The WLS is a large cohort study of over 10,000 individuals who graduated from a Wisconsin high school in 1957. It followed this cohort from 1957 into the new millennium (Sewell, Hauser, Springer, & Hauser, 2004) and boasts a wide variety of socioeconomic, demographic, psychological and health indicators. While the WLS collected data on height and weight in both the 1992-93 and 2003-05 waves, it did not collect data on either height or weight in the initial 1957 wave or in a subsequent wave in 1975.

In a recent study of physical attractiveness approximately 3,000 photographs were extracted from the senior high school yearbooks of WLS participants (Meland, 2002). Might these photographs, which provide visual information on the physical characteristics of the faces and necks of WLS participants, have some utility in establishing the relative weight or "body mass" of WLS participants at baseline? A review of the scientific literature on the associations between adiposity, BMI and physical characteristics of the face and neck suggests that the answer to this question is "Yes."

Adiposity, Body Mass and Facial Characteristics

A number of clinical studies have investigated the relationship between facial characteristics, adiposity and body mass and in samples of human subjects. These studies have demonstrated that deposits of adipose tissue in the cheeks and neck, neck circumference, and craniofacial morphology are all related to body mass and central adiposity. For instance, Levine, Ray and Jensen (1998) used computer tomography to measure cheek, visceral abdominal and abdominal subcutaneous fat in 25 patients who were being treated at the Mayo clinic for various conditions. Despite the small sample of subjects, Levine et al. demonstrated that the quantity of cheek fat was strongly related to deposits of visceral abdominal fat ($r = 0.54$, $p < 0.01$).

In another study, Laakso, Matilainen and Keinänen-Kiukaanniemi (2002) evaluated associations between neck circumference and obesity. Results of this study of 541 Finns clearly demonstrated that neck circumference was strongly correlated with various measures of obesity. Among men, neck circumference was significantly associated with waist-to-hip ratio ($r = 0.41$, $p < 0.01$), waist circumference ($r = 0.65$, $p < 0.01$) and BMI ($r = 0.69$, $p < 0.01$). These correlations were nearly identical among women ($p < 0.01$ in each case).

Like neck circumference, deposits of subcutaneous adipose tissue (SAT) in the neck are strongly related to central and upper body adiposity. To study the relationships between SAT deposits in 15 different body locations, Möller, Tafeit, Pieber, Sudi and Reibnegger (2000) utilized the LIPOMETER to assess SAT-topography in 590 healthy adult subjects. Factor analyses of these data indicated that SAT deposits in the neck, upper back, front chest, lateral chest, upper abdomen, lower abdomen and hip were highly interrelated.

This evidence suggests that neck circumference and fatty deposits in the neck and cheek may provide useful indicators of general adiposity. In addition, studies of craniofacial morphology have demonstrated that bone structures in the face are also associated with body mass in human subjects (Yu, Fujimoto, Urushibata, Matsuzawa, & Kubo, 2003). Sadeghianrizi (2003) and Örhn, Al-Kahlili, Huggare, Forsberg, Marcus, and Dahllöf (2002) compared cephalometric measurements of obese adolescents (similar in age to WLS participants in 1957) to age and sex matched control subjects who were not obese. These studies revealed that the facial skeletal structures of obese adolescents are typically somewhat larger than their normal weight peers. Most notably, each study found that the mandibles of obese adolescents tend to be relatively long. Studies of adolescents have proven consistent with studies of adults, which have reported similar associations between facial bone structures and body mass (e.g., Liao, Chuang, Huang, & Tsai, 2004; Paoli, Lauwers, Lacassagne, Tiberge, Dodart, & Boutault, 2001). The etiology of craniofacial differences between heavy and normal weight individuals may stem from hormonal factors, nutritional factors, or both (Örhn et al., 2002; Sadeghianrizi, 2003).

Health Outcomes Associated with Adiposity of the Face and Neck

Research has demonstrated that the distribution of adipose tissue affects the probability of disease incidence. For instance, central adiposity is an important determinant of hypertension, diabetes and heart disease in women (Rexrode, Carey, Hennekens, Walters, Colditz, Stampfer et al., 1998). Although not widely recognized, research has also shown that characteristics of the face and neck are associated with health complications such as type-II diabetes (Sierra-Johnson & Johnson 2004), sleep apnea (Mortimore, Marshall, Wraith, Sellar, & Douglas, 1998) and weight cycling (Wallner, Luschnigg, Schnedl, Lahousen, Sudi, Crailsheim et al. 2004). To illustrate, Laakso et al. (2002) found that neck circumference was an independent predictor of hypertension among northern Finns. Regardless of gender, Finns in the highest quintile of neck circumference were approximately three times more likely to have hypertension than Finns in the lowest quintile, even after controlling for BMI. This finding was corroborated Tafeit, Möller, Sudi and Reibnegger (2000), who found that neck adiposity was better at discriminating type-II diabetics from non-diabetics than adiposity in 14 other body locations (e.g., upper abdomen), BMI or body fat percentage.

A Promising New Approach to Measuring Body Mass

The literature just reviewed suggests that the methodical examination of photographs may provide a novel and useful way to assess the relative body mass of human subjects. Furthermore, because facial adiposity is strongly associated with chronic conditions such as hypertension and sleep apnea, the development of new methodologies capable of isolating facial characteristics may lead to other scientific advancements, such as the improved ability to assess the likelihood of developing certain health conditions. However, while this review of the literature has provided scientific justification for expecting a solid relationship between facial characteristics and body mass, it has not addressed the ability of human beings to distinguish lean from heavy persons solely on the basis of facial photographs—and with good reason. A review of the literature produced only one study (Rudin, 1996) that required subjects to estimate weight from photographs. Unfortunately, because this study used crude weight categories and provided no formal assessment of reliability or validity, it did not provide substantial evidence on the ability of researchers to distinguish lean from heavy persons on the basis of photographs.

Furnham and Radley (1989) did find, however, that a group of young subjects (ages 16 to 21) had the ability to rank order drawings depicting naked persons of varying adiposity along a continuum from very thin to obese. Also, Kato and Higashiyama (1998) found that undergraduate subjects were generally able to provide accurate estimates of height based on full-length photographs. Obviously, there are many important differences between the tasks required in these studies and attempting to determine the relative body mass of subjects based on photographs depicting the faces and necks of clothed individuals. Nonetheless, these results are encouraging since they imply that human beings have a refined capacity for differentiation of physical traits based on visual stimuli.

On balance, extant research appears to suggest that there is real promise in developing a new methodology to estimate relative body mass from yearbook photographs. This study represents an initial attempt to construct such a methodology. A sample of 3,027 photographs were randomly selected from the yearbooks of WLS participants and assigned values for relative body mass by a team of six coders. Results of this study demonstrate that the new measure of relative body mass is both valid and reliable, which is exciting news for the WLS and for other longitudinal investigations that currently lack baseline measures of BMI but may be able to access photographs of research participants.

METHODS

Study Population

The Wisconsin Longitudinal Study (WLS) is a random sample of 10,317 persons who graduated from a public, private or parochial high school in Wisconsin in 1957 (Sewell et al., 2004). In this initial wave, the WLS collected information on academic ability, socioeconomic background, attitudes toward higher education, educational and occupational aspirations, and a handful of contextual factors (Hauser, 2005). Subsequent waves in 1964, 1975, 1992-93 and 2003-05 collected data from WLS participants (or their parents) on a wide range of issues that are essential to studies of the life course, including educational and occupational histories, indicators of socioeconomic status, military service, marital status, family characteristics, social participation, psychological well-being, health behaviors and health outcomes (Hauser, 2005; Sewell et al., 2004). Data on the height and weight of WLS participants were also gathered in the 1992-93 and 2003-05 waves, which make it possible to assess BMI change during the U.S. obesity epidemic. Although the WLS is not nationally representative, its participants resemble over two-thirds of Americans who are now entering retirement age in terms of educational attainment and ethnic background (Hauser 2005).

We measured the relative body mass of WLS participants in 1957 by systematically examining photographs that were extracted from high school yearbooks. Through a cluster sampling design that selected schools based on probabilities proportional to size (PPS), a subsample of 93 schools representing 3,130 WLS participants was randomly chosen for inclusion in this study. Because schools were selected on a PPS basis, each of the 10,317 WLS participants had an equal probability of selection into this subsample of 3,130 participants. Yearbooks from 1957 were collected from schools or libraries in the towns where selected schools were located. Photographs of WLS participants, all seniors in 1957, were subsequently extracted through computerized scanning technologies. Due to a small number (103) of missing photographs, the final sample of photographs available for this study was 3,027.

Scale Development

Separate scales for boys and girls were developed to measure the relative body mass of WLS participants in 1957. The term "relative body mass" (RBM) was chosen because the scales were hypothesized to result in proxies for BMI. The justification for this hypothesis was that extracted yearbook photographs generally do not provide direct visual evidence about the height of participants. Therefore, as coders attempt to rate the photographs for relative weight, they should do so independently of height. In this way, the RBM scale is analogous to BMI which, of course, is also a measure of weight that controls for the height of subjects (BMI = weight(kg)/height(m)^2).

Following the lead of Meland (2002) who successfully used WLS photographs to measure physical attractiveness, we designed the RBM scale to have eleven points, two verbal anchors and five photographs (see Figure 1 and Figure 2 for examples of RBM scales for males and females, respectively). Eleven points were chosen because (a) this permitted us to account for the wide array of body types among adolescents in U.S. society and (b) research on attitude measurement has shown that eleven scale points provides an optimal level of reliability (Alwin, 1992, 1997).

In addition, scales that attach verbal labels or other cues (e.g., photographs) to response options are preferable to those that use only numbers, since the latter "probably involve some inherent ambiguity of meaning" (Alwin and Krosnick, 1991:152). Indeed, a number of studies (e.g., Finn, 1972; Peters & McCormick, 1966; Weng, 2004) have found that reliability improves as the share of scale points that display labels increases. However, in a study of measurement error in survey data, Andrews (1984) found that data quality deteriorated when all scale points were labeled. In recognition of the need for clear labels but the potential pitfalls of over-labeling, we provided photographic cues for five of the eleven points on the RBM scale and used the anchoring phrases "Not At All Heavy" at one end and "Extremely Heavy" at the other.

Measures

For each yearbook photograph, six coders recorded a RBM scale score ranging from one to eleven. RBM scores were combined to form the standardized relative body mass index (SRBMI). SRBMI was calculated separately for male and female photos by (1) generating coder-specific *z*-scores, (2) summing *z*-scores across coders and (3) dividing the sum of *z*-scores by the number of coders in the study. That is,

$$\text{SRBMI} = \frac{\sum_{i=1}^{n}[(x_{ijk} - \bar{x}_{ijk}) / \sigma_{ijk}]}{n},$$

where i is an individual coder, n is the number of coders in the study, j is one of the 3,027 WLS participants, k is the participant's gender and x_{ijk} is the series of RBM scale scores for coder i and participant j of gender k, with mean $\bar{x}_{ijk}$ and standard deviation σ_{ijk}.

In some applications, SRBMI was treated as both a continuous and a categorical variable. This permitted the evaluation of possible non-linear associations between SRBMI and outcomes such as chronic disease. It also permitted SRBMI to be divided into standard BMI classifications for adolescents—underweight, normal weight, at risk for overweight, and overweight. Previous research (Ogden, Flegal, Carroll, & Johnson, 2002) has used BMI percentiles from CDC growth charts (Centers for Disease Control and Prevention, 2000) to define underweight at or below the 5^{th} percentile, normal weight between the 5^{th} and 85^{th} percentiles, at risk for overweight between the 85^{th} and 95^{th} percentiles and overweight at or above the 95^{th} percentile. To provide sufficient statistical power for each subgroup, I altered these percentile ranges slightly for body mass categories derived from SRBMI; underweight was defined as being at or below the 10^{th} percentile of

SRBMI, normal weight between the 10th and 80th percentiles, at risk for overweight between the 80th and 90th percentiles and overweight at or above the 90th percentile.

Several measures from the 1993 WLS were used to assess the validity of the RBM scale, including self-reported height, self-reported weight, and several symptoms and conditions indicative of health problems. The WLS measured height and weight in inches and pounds, respectively, which were then converted into a measure of BMI (U.S. Dept. of Health and Human Services 2004). Based on direct measures of height and weight from physical examinations of subjects in the National Health and Nutrition Examination Surveys (NHANES) from 1976-80, 1988-94 and 1999-2002 (McDowell, Engel, Massey, & Maurer, 1981; U.S. Dept. of Health and Human Services, 1996; Centers for Disease Control and Prevention, 2005), the range of BMI in the U.S. population is approximately 12-70. Consistent with this range, values of BMI in the WLS were truncated if they were lower than 12 or greater than 70. This necessitated the recoding of only a single case with a reported BMI of 83. Indicators of obesity (BMI $\geq$ 30) and class II obesity (BMI $\geq$ 35) were also created to estimate the impact of RBM in 1957 on obesity in 1993.

Participants in the 1993 WLS mail survey responded to a series of questions probing whether they had experienced particular health-related symptoms in the past six months. Of the 22 symptoms covered in the WLS, four (muscle aches, back pain or strain, chest pain and shortness of breath) were included in this investigation due to their known associations with obesity (Lean, Han, & Seidell, 1999; Stunkard 1996). WLS participants also responded to a series of questions about chronic conditions that had been diagnosed by a medical professional. Of the seventeen chronic conditions covered in the WLS, four (arthritis, high blood pressure, diabetes and heart trouble) were retained—again due to their known associations with obesity (Manson, Skerrett, & Willett, 2002; Pi-Sunyer 2002; Stunkard 1996). Health symptoms and conditions in 1993 were used to evaluate the criterion-related validity of the RBM scale. Both health symptoms and chronic conditions were coded as dummy variables in this study (i.e., 1=symptom/condition present; 0=symptom/condition not present).

Finally, measures of all-cause and cause-specific mortality were used to provide another assessment of the criterion-related validity of the RBM scale. Determination of death and cause of death was also made by searching the National Death Index (NDI) for WLS participants (National Center for Health Statistics 1999). WLS staff searched the NDI database most recently in October of 2001. Of the 3,027 WLS participants in this study, 159 died between 1979 (the year the NDI came into existence) and 1998. Seventeen participants who had already died by 1979 were eliminated from the mortality analyses. Data from the NDI were matched with cause of death codes from the International Classification of Diseases (World Health Organization 1977) to construct measures of mortality resulting from (1) all causes, (2) all non-accidental causes, (3) all major diseases of the heart, and (4) all malignant cancers. Other major causes of mortality were also examined (e.g., diabetes), but these results were not reported due to insufficient statistical power arising from the low number of deaths from those conditions.

Data Collection

Six individuals were recruited to code photographs of WLS participants. There were three male and three female coders who varied in age from 26 to 33 years. All coders were non-Hispanic White graduate students at the University of Wisconsin-Madison. Prior to coding the photographs, coders signed confidentiality agreements, read a basic set of written coding instructions and received oral instruction during a brief training seminar. Data collection occurred within the WLS main office in the Social Science Building at the University of Wisconsin-Madison over three week period in January of 2005.

Protocol for coding the photographs was straightforward. Coders were instructed to compare the photograph of the WLS participant to the scale photographs located along the top of the computer monitor (see Figure 2). Note that the box at the bottom of the monitor is where the photograph of the WLS participant appeared. Coders were given 10 seconds to make this initial comparison and, using a computer mouse, click the point that corresponded to their impression of where the photograph fit along the scale continuum. The chosen scale point immediately changed color from black to red and coders were presented with the question “Does the red symbol indicate your choice?” Before answering, coders were instructed to examine the facial features of the WLS participant in more detail. If coders subsequently answered “Yes,” they were presented with the next photograph. Coders answering “No” were provided with an opportunity to change their selection before moving on to the next photograph.

After completing the project, each coder independenly re-evaluated 100 male and 100 female photographs that were randomly chosen from the sample of 3,027. Reevaluation of these photographs was not conducted until at least one week after the end of the project to reduce the likelihood of recall bias. Data gathered from this phase of the project were used to assess the intra-rater reliability of individual coders.

Statistical Analyses

SAS 9.1 (2003) was used to manage data, generate descriptive statistics and assess the reliability of the RBM scale. Stata 9.0 (StataCorp, 2005) was used to conduct logistic regression analyses. In these analyses, robust standard errors were generated by accounting for clustering within schools from which WLS participants were sampled.

Coefficient alpha (Cronbach 1951) was used to evaluate inter-rater reliability, which may be expressed as follows:

$$\alpha = \frac{n}{(n-1)}\left[1-\frac{\sum_{i=1}^{n}\sigma_{Yi}^2}{\sigma_X^2}\right],$$

where n is the number of coders in the study, σ_{Yi}^2 is the variation in the RBM scale for coder *i* and σ_X^2 is the total variation in the RBM scale for all coders. Coefficient α is commonly used to assess the degree of internal consistency for measures of unobserved variables (Traub 1994). Coefficients of 0.70 or greater are generally thought to reflect an acceptable degree of internal consistency (Nunnally 1978).

Intra-rater reliability (i.e., the agreement of each coder with herself (or himself) at two different points in time) was evaluated via the test-retest coefficient of reliability (Traub 1994). As noted, each coder reevaluated 200 randomly selected photographs one week after assigning RBM scores to all 3,027 photographs. Under the assumption of parallel tests, test-retest reliability was estimated as the correlation coefficient between RBM scores assigned at these two different times.

Discriminant and criterion-related validity of the RBM scale was assessed by generating correlation matrices of SRBMI, height and BMI. Additionally, the validity of the RBM scale was evaluated by conducting logistic regression analyses to estimate the risk of obesity in 1993 as a function of RBM classification in 1957. Logistic regression analysis was also used to evaluate the effect of RBM in 1957 on reports of illness symptoms and physician diagnosed chronic conditions in 1993. Finally, indicators of mortality were regressed on continuous and categorical forms of SRBMI to evaluate whether RBM in 1957 predicted all-cause and cause-specific mortality in subsequent years. Interaction effects between gender and RBM were explored in logistic regression analyses but are not reported here because in no instance did these interaction effects significantly improve model fit.

RESULTS

Analyses confirmed that the RBM scale is a reliable measure of body mass. For the entire sample of 3,027 photos, Cronbach's α was 0.91 indicating a very high level of agreement between coders. Reliability was not affected by the gender of the WLS subject, as shown by equivalent alpha scores for female photos ($\alpha = 0.91$) and male photos ($\alpha = 0.91$). Correlations between the scores of individual coders and the total inter-item variability were generally high, ranging from 0.65 to 0.80 ($p < 0.05$ in every instance). Intra-rater reliability was also quite good, as evidenced by correlations ranging from 0.66 to 0.88 ($p < 0.05$ in every instance) for the sample of 200 photos that were coded at two different points in time.

Analyses also confirmed that the RBM scale is a valid indicator of body mass. Correlations between SRBMI, height and BMI provided clear evidence of discriminant and criterion-related validity (see Table 1). Impressively, the correlation between SRBMI and height in the full sample of 2,002 photos was 0.00 ($p > 0.05$). This result varied little by gender of the WLS participant, demonstrating that the RBM scale was not confounded by height. Additionally, the association between SRBMI and BMI in the full sample was positive and moderate in strength (r = 0.31; $p < 0.05$), despite the passage of 36 years between measurements. The correlation between SRBMI and BMI was slightly stronger among males (r = 0.34; $p < 0.01$) than females (r = 0.29; $p < 0.01$) in this study.

Perhaps even more impressive was the effect of RBM in 1957 on the risk of obesity 1993. Relative to persons classified as of normal weight in 1957, underweight persons were 40 percent less likely to be obese in 1993 (Odds Ratio (OR) = 0.60; 95% Confidence Interval (CI) = 0.38-0.96). Also, the risk of obesity was 2.74 times higher (CI = 1.92-3.90) among persons at risk for overweight and 3.36 times higher (CI = 2.44-4.64) among overweight persons, showing a graded effect of adolescent RBM on the odds of obesity in middle age. The steepness of this gradient increased when class II obesity was considered. Compared to persons with normal weight in 1957, persons at risk for overweight had over threefold risk (OR = 3.33; CI = 2.05-5.41) and overweight persons had nearly *fivefold* risk (OR = 4.76; CI = 2.90-7.84) of exhibiting class II obesity in 1993. These associations did not vary substantially by gender.

Persons with elevated RBM at baseline tended to report more illness symptoms and chronic conditions in 1993 than other WLS participants. Results from a series of logistic regression analyses of illness symptoms on SRBMI (both in continuous and categorical form) are shown in Table 2. Although the continuous form of SRBMI was a significant predictor of muscle aches only (OR = 1.13; 95% CI = 1.02-1.26), the categorical form of SRBMI significantly predicted three of the four health symptoms. Specifically, persons classified as overweight in 1957 were 1.38 (95% CI = 1.05-1.81) times more likely to report muscle aches, 2.16 (95% CI = 1.35-3.47) times more likely to report chest pain and 1.81 (95% CI = 1.24-2.65) times more likely to report shortness of breath than persons classified as normal weight. Curiously, persons at risk for overweight were significantly less likely than normal weight persons to report shortness of breath (OR = 0.56; 95% CI = 0.33-0.94).

Analyses of chronic conditions diagnosed by a health professional (see Table 3) indicated that the continuous form of SRBMI was a significant predictor of arthritis (OR = 1.19; CI = 1.08-1.31), high blood pressure (OR = 1.25; CI = 1.11-1.41) and diabetes (OR = 1.44; CI = 1.09-1.90). Persons classified as underweight in 1957 were 36 percent less likely than persons classified as normal in weight to report high blood pressure in 1993 (OR = 0.64; 95% CI = 0.42-0.99). Although overweight persons were more likely than normal weight persons to report arthritis (OR = 1.17; 95% CI = 0.87-1.58) and high blood pressure (OR = 1.23; 95% CI = 0.89-1.69) these coefficients did not achieve the criterion of statistical significance. However, overweight persons were significantly more likely than normal weight persons to report diabetes (OR = 2.38; 95% CI = 1.33-4.27) and heart trouble (OR = 1.79; 95% CI = 1.12-2.86). When the continuous and categorical forms of SRBMI are viewed together, the only illness symptom or chronic condition *not* significantly associated with SRBMI was back pain or strain.

According to data from the National Death Index (NDI), SRBMI was a significant predictor of all-cause mortality (OR = 1.25; CI = 1.05-1.49) among WLS subjects between 1979 and 1998 (see Table 4). As expected, the removal of accidental deaths strengthened the association between SRBMI and mortality (OR = 1.32; CI = 1.10-1.59). The continuous form of SRBMI was a particularly strong predictor of heart disease mortality (OR = 1.69; 95% CI = 1.10-2.58) but was not significantly associated with cancer mortality (OR = 1.16; 95% CI = 0.91-1.49). Relative to persons classified as normal weight in 1957, overweight persons had roughly a twofold risk of death from non-accidental causes (OR = 1.91; 1.24-2.94) and a *fourfold* risk of death from heart disease (OR = 3.99; CI = 1.85-8.61). Consistent with results for the continuous form of SRBMI, the categorical SRBMI variables were not significant predictors of cancer mortality, although it is worth noting that all of these coefficients were in the expected direction. For instance, relative to normal weight persons, underweight persons were about 12 percent less likely (OR = 0.88; 95% CI = 0.39-1.96) and overweight persons were about 50 percent more likely (OR = 1.49; 95% CI = 0.76-2.94) to die from cancer.

DISCUSSION

Despite many laudable qualities, the WLS has been limited in etiological investigations of trajectories and consequences obesity by the lack of a baseline measure of body mass. Through the development of the RBM scale, this study has successfully removed that limitation. As hypothesized, the RBM scale was a valid and reliable proxy for BMI. An index summarizing the RBM scores of individual coders (i.e., SRBMI) was uncorrelated with height and moderately correlated with BMI after the passage of 36 years. With a handful of exceptions, continuous and categorical measures of SRBMI also predicted the risk of obesity, illness symptoms, chronic conditions and mortality in later years. Given these encouraging results, scholars who intend to use the WLS to study obesity issues may want to consider combining its rich set of socioeconomic, demographic, psychological and health measures with this new baseline measure of RBM.

Available evidence suggests that the RBM scale is comparable to adolescent BMI in terms of its ability to predict mid-life BMI, morbidity and mortality. Although some investigations such as the Bogalusa Heart Study (Freedman, Kettel Khan, Dietz, Srinivasan, & Berenson, 2001) have detected stronger correlations between adolescent and adult measures of body mass than those reported here, it is important to avoid comparing findings without some context. For instance, the span of time between adolescent and adult measures of body mass was 36 years in the WLS, more than twice as long as the Bogalusa Heart Study. Mortality selection and changes in weight that occurred over the longer time frame in the WLS may be responsible for attenuation in the association between adolescent and adult measures of body mass.

Indeed, there is credible evidence to support this speculation. In a study of British cohort data, Wright, Parker, Lamont, and Craft (2001) reported a correlation of 0.39 between measures of BMI taken at ages 13 and 50. The British cohort was followed for approximately the same length of time (38 years) as the WLS cohort between 1957 and 1993 (36 years). This correlation reported by Wright et al. is nearly identical to the correlation between adolescent RBM and adult BMI among males in the WLS ($r = 0.34$) and not far off that in the combined sample ($r = 0.31$).

Analyses of 508 adolescents in the Harvard Growth Study (Must, Jacquez, Dallal, Bajema, & Dietz, 1992) found that overweight adolescents (defined as BMI $\geq 75^{th}$ percentile) were significantly more likely to report diabetes, coronary heart disease, arthrosclerosis and hip fracture than lean adolescents (defined as BMI between the 25^{th}-

50th percentiles) after 55 years of follow up. To illustrate, subjects in the Harvard Growth Study who were overweight adolescents were 2.1 times more likely to report coronary heart disease and 1.8 times more likely to report diabetes than subjects who were lean adolescents. Similarly, Freedman et al. (2001) found that childhood BMI was a significant predictor of CHD risk factors such as cholesterol, triglycerides, insulin and blood pressure in adulthood. These results compare favorably to those reported in this study. Adolescent measures of RBM were significant predictors of several illness symptoms (muscle aches, chest pain and shortness of breath) and chronic conditions (arthritis, high blood pressure, diabetes and heart trouble) that are indicative of cardiovascular, pulmonary and musculoskeletal distress in adulthood.

Somewhat surprisingly, relatively few studies have investigated the relationship between adolescent obesity and adult mortality. However, the studies that exist are generally quite consistent with the results reported here. For example, Must et al. (1992) found elevated risks of all cause and cause specific (e.g., heart disease) mortality among men—but not women—who were obese as adolescents. However, a longitudinal study of 128,121 Norwegian adolescents (Engeland, Bjørge, Tverdal, & Søgaard, 2004) found that overweight adolescents were at increased risk of adult mortality, regardless of gender. Relative to adolescents with medium BMI (defined as BMI between the 25th-74th percentiles), adolescents with very high BMI (BMI $\geq$ 85th percentile) were 40 percent more likely to have died 29 years later. By way of comparison, adolescents defined as overweight in the WLS were 69 percent more likely to die over the interval than their normal weight peers.

On several occasions, coders raised questions about the proper coding of large individuals—particularly males—with athletic characteristics (e.g., wide necks) and relatively lean builds. Because the RBM scale was developed as a proxy for BMI, coders were instructed to code persons who appeared to be heavy as high on the RBM scale, regardless of whether this was caused by lean mass or fat mass. This raises the possibility of gender differences in RBM but, as noted, interaction effects between gender and RBM did not significantly improve the fit of models explored here.

The inability of the RBM scale to differentiate lean mass from fat mass may be viewed as a limitation of the measure, but it is one shared with the most common adolescent measure of body mass—BMI. Other limitations of this study include the following: First, there were relatively few coders of RBM, making it difficult to assess systematic differences in coding tendencies by gender, age, ethnicity or socioeconomic background. Of course, this was complicated by the similarity of the coders in terms of age, ethnicity and educational attainment. Second, although extracted photographs of WLS participants were generally of similar type and quality, there were some inconsistencies that likely contributed to random error. For instance, coders remarked that certain poses (e.g., profile shots) and clothing options (e.g., turtlenecks) obfuscated facial features—particularly of the neck. Also, all WLS photographs were black and white, which could be disadvantageous relative to color photographs in the measurement of RBM. On a handful of occasions, coders expressed difficulty discerning whether an apparent facial feature (e.g., folds of adipose tissue in the neck) was real or the byproduct of shadows. If available, color photographs could help resolve those difficulties. Third, adult BMI, illness symptoms and chronic conditions were based on self-reports, which may have led to some attenuation in the associations between these outcomes and RBM. Fourth, although the sample size in this study was relatively large, it nevertheless accounted for fewer than one in three WLS participants. This limited the statistical power of this investigation and will present some limitations to future investigations until a measure of RBM is available for all 10,317 participants in the WLS.

In future studies, it would be interesting to develop a measure of relative facial adiposity to complement the RBM scale. The development of a measure designed to isolate deposits of fat in the cheeks and neck from lean facial tissue has the potential to provide a superior indicator of obesity, per se. Understanding the relative impact of lean, fat and total facial mass on the incidence of illness symptoms, chronic disease and mortality could also help improve the understanding of disease etiology and lead to the development of new applications in research and clinical practice. Recall, for instance, that some studies (e.g., Tafeit et al. 2000) have found that characteristics of the face and neck are strong predictors of type-2 diabetes, even when compared to traditional measures such as BMI or body fat percentage.

Future studies may also benefit from the inclusion of a larger and more diverse group of coders. Of course, the inclusion of additional coders would help maximize the reliability of the RBM, although it is worth reiterating that the degree of internal consistency achieved in this study was excellent. Additional coders would also provide more flexibility to retain only individuals who perform well in terms of inter-rater reliability, intra-rater reliability and criterion-related validity. Clearly, humans must possess varying levels of ability with regard to the visual assessment of RBM. Future studies could take advantage of this variation by identifying persons with the highest levels of ability. Furthermore, the inclusion of a more diverse set of coders with respect to age, ethnicity and socioeconomic background could help determine whether important differences exist across these groups. Limited existing research suggests that gender differences in body-image do not distort intersubjective agreement regarding the relative weight of persons in photographs (Rudin 1996), but more research is needed to answer questions regarding the effects of gender and other personal characteristics on coding tendencies.

Despite these limitations and intriguing areas for future study, the development of the RBM scale represents an important methodological development that should pave the way to an expanded set of research questions and projects in the WLS. Other longitudinal studies of adults without measures of body mass in childhood or adolescence may also benefit from development of similar RBM indicators. In such applications, the RBM scale would likely represent an exceptionally valid and reliable form of retrospective questioning, as it has in the WLS. Furthermore, emerging prospective studies of physical and psychosocial health could contribute to knowledge in this area by incorporating RBM measures. Importantly, this would provide opportunities to evaluate RBM measures contemporaneously with more traditional measures of body mass, providing more definitive evidence regarding their similarities and differences. Finally, it is encouraging to consider that while the RBM scale performed admirably in this study, it is a new construct. With additional research, refinements to RBM measures promise to unlock their full potential as refined and legitimate complements to traditional measures of body mass in human populations.

Table 1. Criterion-Related Validity of the Standardized Relative Body Mass Index (SRBMI) in the Wisconsin Longitudinal Study[a]

		Correlation Matrices				
		(1)	(2)	(3)	Mean	Standard Deviation
All Photos (n=2,002)						
SRBMI[b]	(1)	1			0.00	0.84
Height[c]	(2)	0.00	1		67.26	3.89
BMI	(3)	**0.31**	**0.05**	1	26.74	4.72
Female Photos (n=1,105)						
SRBMI	(1)	1			-0.01	0.83
Height	(2)	-0.00	1		64.64	2.58
BMI	(3)	**0.30**	**-0.18**	1	25.99	5.22
Male Photos (n=897)						
SRBMI	(1)	1			0.02	0.84
Height	(2)	-0.04	1		70.48	2.59
BMI	(3)	**0.34**	-0.00	1	27.66	3.82

[a] Statistically significant coefficients (p <0.05) set in bold

[b] Standardized Relative Body Mass Index (SRBMI) measured in 1957

[c] Height, weight and body mass index (BMI) measured in 1993

Table 2. Odds Ratios for Associations Between Relative Body Mass in 1957 and Reported Health Symptoms in 1993[a]

	Health Symptoms Experienced in Prior Six Months			
	Muscle Aches	Back Pain or Strain	Chest Pain	Shortness of Breath
All Cases (n=2,049)				
Continuous Predictor				
SRBMI[b]	**1.13** (1.02-1.26)	1.07 (0.95-1.21)	1.21 (0.96-1.53)	1.10 (0.93-1.31)
Categorical Predictors				
Underweight	0.96 (0.68-1.36)	0.88 (0.64-1.21)	0.99 (0.54-1.84)	1.02 (0.59-1.75)
Normal Weight[c]	1.00	1.00	1.00	1.00
At Risk for Overweight	1.07 (0.82-1.40)	1.06 (0.77-1.44)	0.85 (0.45-1.61)	**0.56** (0.33-0.94)
Overweight	**1.38** (1.05-1.81)	1.19 (0.92-1.55)	**2.16** (1.35-3.47)	**1.81** (1.24-2.65)

[a] 95% confidence intervals (CIs) in parentheses; statistically significant coefficients (p <0.05) set in bold text

[b] Standardized Relative Body Mass Index

[c] Normal Weight is referent category (i.e., fixed at 1.0)

Table 3. Odds Ratios for Associations Between Relative Body Mass in 1957 and Reported Health Conditions in 1993[a]

	Health Conditions Diagnosed by a Medical Professional			
	Arthritis	High Blood Pressure	Diabetes	Heart Trouble
All Cases (n=2,049)				
Continuous Predictor				
SRBMI[b]	**1.19** (1.08-1.31)	**1.25** (1.11-1.41)	**1.44** (1.09-1.90)	1.20 (0.96-1.51)
Categorical Predictors				
Underweight	0.82 (0.56-1.20)	**0.64** (0.42-0.99)	1.06 (0.45-2.52)	1.04 (0.56-1.95)
Normal Weight[c]	1.00	1.00	1.00	1.00
At Risk for Overweight	0.95 (0.68-1.34)	1.03 (0.72-1.47)	1.77 (0.94-3.34)	0.64 (0.32-1.31)
Overweight	1.17 (0.87-1.58)	1.23 (0.89-1.69)	**2.38** (1.33-4.27)	**1.79** (1.12-2.86)

[a] 95% confidence intervals (CIs) in parentheses; statistically significant coefficients (p <0.05) set in bold text

[b] Standardized Relative Body Mass Index

[c] Normal Weight is referent category (i.e., fixed at 1.0)

Table 4. Odds Ratios for Associations Between Relative Body Mass in 1957 and Mortality Indicators from the National Death Index (NDI)[a]

	Mortality Indicator							
	NDI All Cause		NDI Non-Accidental		NDI Heart Disease		NDI Cancer	
All Cases (n=3,010)								
Continuous Predictor								
SRBMI[b]	**1.25**	(1.05-1.49)	**1.32**	(1.10-1.59)	**1.69**	(1.10-2.58)	1.16	(0.91-1.49)
Categorical Predictors								
Underweight	0.90	(0.53-1.52)	0.86	(0.48-1.52)	0.98	(0.29-3.32)	0.88	(0.39-1.96)
Normal Weight[c]	1.00		1.00		1.00		1.00	
At Risk for Overweight	1.22	(0.77-1.94)	1.38	(0.86-2.21)	1.28	(0.49-3.37)	1.01	(0.49-2.07)
Overweight	**1.69**	(1.10-2.58)	**1.91**	(1.24-2.94)	**3.99**	(1.85-8.61)	1.49	(0.76-2.94)

[a] 95% confidence intervals (CIs) in parentheses; statistically significant coefficients (p <0.05) set in bold text

[b] Standardized Relative Body Mass Index

[c] Normal Weight is referent category (i.e., fixed at 1.0)

Figure 1. Model of Relative Body Mass (RBM) Scale Used to Code Male Yearbook Photographs of Participants in the Wisconsin Longitudinal Study (WLS)

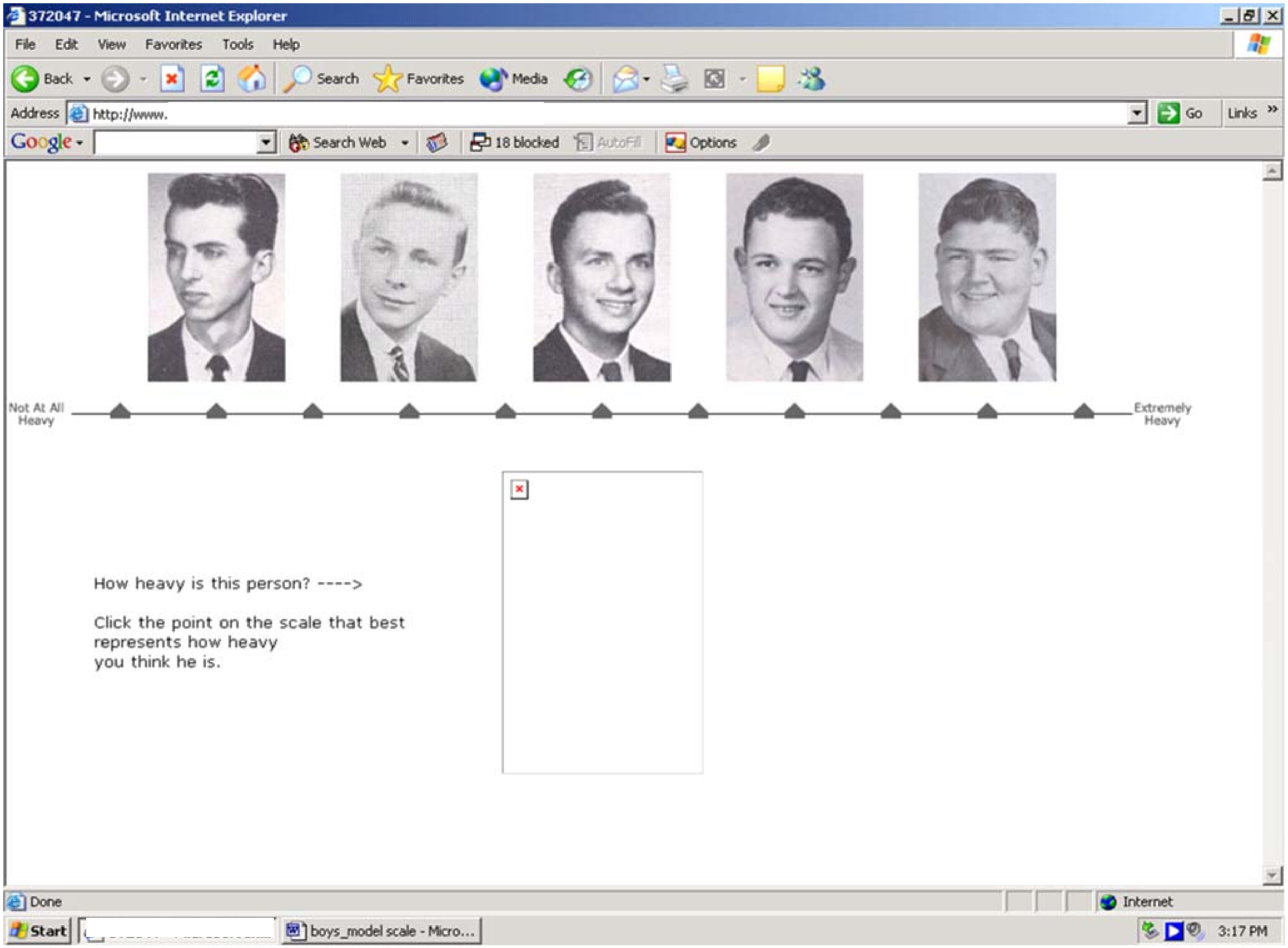
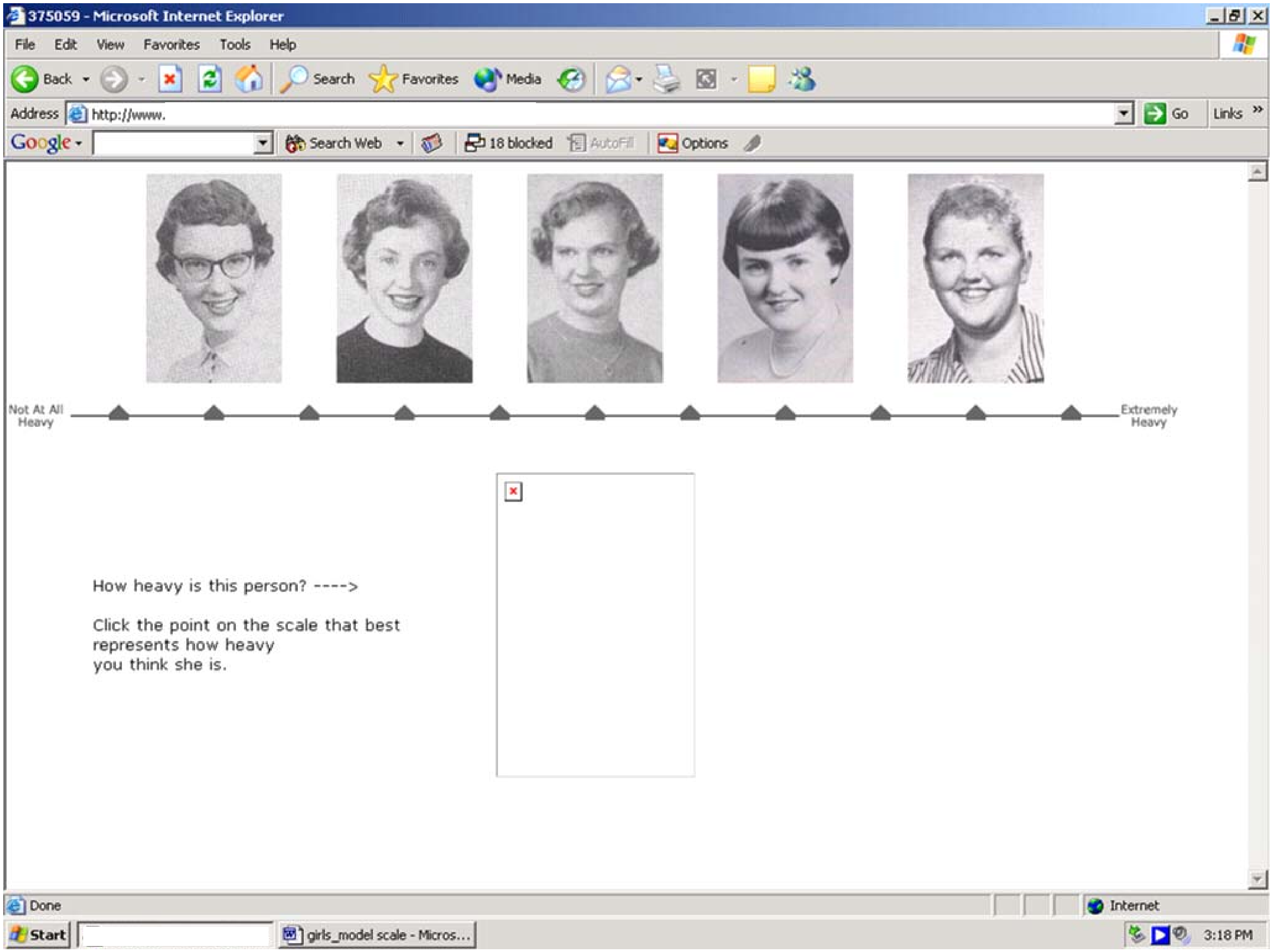


Figure 2. Model of Relative Body Mass (RBM) Scale Used to Code Female Yearbook Photographs of Participants in the Wisconsin Longitudinal Study (WLS)



Reference List

Alwin, D. F. (1992). Information Transmission in the Survey Interview: Number of Response Categories and the Reliability of Attitude Measurement. *Sociological Methodology, 22*, 83-118.

Alwin, D. F. (1997). Feeling Thermometers Versus 7-Point Scales: Which Are Better? *Sociological Methods & Research, 25*, 318-340.

Alwin, D. F., & Krosnick, J. A. (1991). The Reliability of Survey Attitude Measurement: The Influence of Question and Respondent Attributes. *Sociological Methods & Research, 20*(1), 139-181.

Andrews, F. M. (1984). Construct Validity and Error Components of Survey Measures: A Structural Modeling Approach. *The Public Opinion Quarterly, 48*(2), 409-442.

Centers for Disease Control and Prevention. (2000). 2000 CDC Growth Charts: United States. National Center for Health Statistics. URL http://www.cdc.gov/growthcharts/.

Centers for Disease Control and Prevention. (2005). National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data. Hyattsville, MD U.S. Department of Health and Human Services Centers for Disease Control and Prevention http and www.cdc.gov/nchs/about/major/nhanes/datalink.htm.

Cronbach, L. J. (1951). Coefficient Alpha and the Internal Structure of Tests. *Psychometrika, 16*, 297-334.

Engeland, A., Bjørge, T., Tverdal, A., & Søgaard, A. J. (2004). Obesity in Adolescence and Adulthood and the Risk of Adult Mortality. *Epidemiology, 15*(1), 79-85.

Finn, R. H. (1972). Effects of Some Variations in Rating Scale Characteristics on the Means and Reliabilities of Ratings. *Educational and Psychological Measurement, 32*, 255-65.

Freedman, D. S., Kettel Khan, L., Dietz, W. H., Srinivasan, S. R., & Berenson, G. S. (2001). Relationship of Childhood Obesity to Coronary Heart Disease Risk Factors in Adulthood: The Bogalusa Heart Study. *Pediatrics, 108*(3), 712-718.

Furnham, A., & Radley, S. (1989). Sex Differences in the Perception of Male and Female Body Shapes. *Personality and Individual Differences, 10*(6), 653-662.

Hauser, R. M. (2005). Survey Response in the Long Run: The Wisconsin Longitudinal Study. *Field Methods, 17*(1), 3-29.

Kato, K., & Higashiyama, A. (1998). Estimation of Height for Persons in Pictures. *Perception and Psychophysics, 60*(8), 1318-1328.

Laakso, M., Matilainen, V., & Keinänen-Kiukaanniemi, S. (2002). Association of neck circumference with insulin resistance-related factors. *International Journal of Obesity and Related Metabolic Disorders, 26*, 873-5.

Lean, M. E., Han, T. S., & Seidell, J. C. (1999). Impairment of Health and Quality of Life Using New US Federal Guidelines for the Identification of Obesity. *Archives of Internal Medicine, 159*, 837-843.

Levine, J. A., Ray, A., & Jensen, M. D. (1998). Relation between Chubby Cheeks and Visceral Fat. *New England Journal of Medicine, 339*, 1946-47.

Liao, Y.-F., Chuang, M.-L., Huang, C.-S., & Tsai, Y.-Y. (2004). Upper airway and its surrounding structures in obese and nonobese patients with sleep-disordered breathing. *Laryngoscope, 114*(6), 1052-1059.

Manson, J. E., Skerrett, P. J., & Willett, W. C. (2002). Epidemiology of Health Risks Associated With Obesity. edited by Christopher G. Fairburn and Kelly D. Brownell *Eating Disorders and Obesity: A Comprehensive Handbook* (2nd ed., pp. 422-432). New York: The Guilford Press.

McDowell, A., Engel, A., Massey, J. T., & Maurer, K. (1981). Plan and Operation of the Second National Health and Nutrition Examination Survey, 1976-80. *Vital Health Stat 1, 15*(1), 1-144.

Meland, S. A. (2002). *Objectivity in Perceived Attractiveness: Development of a New Methodology for Rating Facial Attractiveness*. MA Thesis: Department of Sociology, University of Wisconsin-Madison.

Mortimore, I. L., Marshall, I., Wraith, P. K., Sellar, R. J., & Douglas, N. J. (1998). Neck and total body fat deposition in nonobese and obese patients with sleep apnea compared with that in control subjects. *American Journal of Respiratory and Critical Care Medicine, 157*, 280-283.

Must, A., Jacquez, P. F., Dallal, G. E., Bajema, C. J., & Dietz, W. H. (1992). Long-term Morbidity and Mortality of Overweight Adolescents. A Follow-Up of the Harvard Growth Study of 1922 to 1935. *New England Journal of Medicine, 327*(19), 1350-1355.

Möller, R., Tafeit, E., Pieber, T. R., Sudi, K., & Reibnegger, G. (2000). Measurement of subcutaneous adipose tissue topography (SAT-Top) by means of a new optical device, LIPOMETER, and the evaluation of standard factor coefficients in healthy subjects. *American Journal of Human Biology, 12*(231-239).

National Center for Health Statistics. (1999). *National Death Index* [Web Page]. URL http://www.cdc.gov/nchs/r&d/ndi/ndi.htm [2005].

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw Hill.

Ogden, C. L., Flegal, K. M., Carroll, M. D, & Johnson, C. L. (2002). Prevalence and Trends in Overweight Among US Children and Adolescents, 1999-2000. *JAMA, 288*(14), 1728-1732.

Örhn, K., Al-Kahlili, B., Huggare, J., Forsberg, C.-M., Marcus, C., & Dahllöf, G. (2002). Craniofacial morphology in obese adolescents. *Acta Odontologica Scandinavica, 60*(4), 193-197.

Paoli J.R., Lauwers, F., Lacassagne, L., Tiberge, M., Dodart, L., & Boutault, F. (2001). Craniofacial differences according to the body mass index of patients with obstructive sleep apnoea syndrome: cephalometric study in 85 patients. *British Journal of Oral and Maxillofacial Surgery, 39* (1), 40-45.

Peters, D. L., & McCormick, E. J. (1966). Comparative Reliability of Numerically Anchored versus Job-Task Anchored Rating Scales . *Journal of Applied Psychology, 50*, 92-96.

Phelps, Erin, Frank F. Furstenberg, and Anne Colby. 2002. *Looking at Lives American Longitudinal Studies of the Twentieth Century*. New York: Russell Sage Foundation.

Pi-Sunyer, X. F. (2002). Medical Complications of Obesity in Adults. C. G. Fairburn, & K. D. Brownell (Eds.), *Eating Disorders and Obesity: A Comprehensive Handbook* (2nd ed., pp. 467-472). New York: The Guilford Press.

Rexrode, K. M., Carey, V. J., Hennekens, C. H., Walters, E. E., Colditz, G. A., Stampfer, M. J., Willett, W. C., & Manson, J. E. (1998). Abdominal Adiposity and Coronary Heart Disease in Women. *Journal of the American Medical Association, 280*, 1843-1848.

Rudin, J. P. (1996). Perceived Weight of Other Persons. *The Journal of Social Psychology, 136*(6), 719-726.

Sadeghianrizi, A. (2003). *Craniofacial Developments in Obese Adolescents* (61 ed.). Master of Medical Science: Karolinska Institutet, Odontologiska Institutionen: Stockholm.

SAS Institute Inc. (2003). *SAS for Windows, version 9.1*. Cary, North Carolina.

Sewell, W. H., Hauser, R. M., Springer, K. W., & Hauser, T. S. (2004). As We Age: A Review of the Wisconsin Longitudinal Study, 1957-2001. K. T. Leicht (Eds.), *Research in Social Stratification and Mobility* (Vol. 20pp. 3-114). New York: Elsevier.

Sierra-Johnson, J., & Johnson, B. D. (2004). Facial fat and its relationship to abdominal fat: a marker for insulin resistance? *Medical Hypotheses, 63*, 783-786.

StataCorp LP. (2005). *Stata Statistical Software: Release 9.* College Station, TX: StataCorp LP.

Stunkard, A. J. (1996). Current Views on Obesity. *American Journal of Medicine, 100*(2), 230-236.

Tafeit, E., Möller, R., Sudi, K., & Reibnegger, G. (2000). ROC and CART Analysis of Subcutaneous Adipose Tissue Topography (SAT-Top) in Type-2 Diabetic Women and Healthy Females. *American Journal of Human Biology, 12*, 388-394.

Traub, R. E. (1994). *Reliability for the Social Sciences: Theory and Applications* (3rd ed.). Thousand Oaks, CA: SAGE.

U.S. Dept. of Education, Center for Education Statistics. NATIONAL LONGITUDINAL STUDY OF THE CLASS OF 1972 [Computer file]. Bibliographic Citation: ICPSR version. Chicago, IL: National Opinion Research Center [producer], 1992. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 1999.

U.S. Dept. of Health and Human Services. (1996). NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY III, 1988-1994 [Computer file]. ICPSR version. Washington, DC: U.S. Dept. of Health and Human Services, National Center for Health Statistics [producer]. Ann Arbor, MI: Interuniversity Consortium for Political and Social Research [distributor], 1998.

U.S. Dept. of Health and Human Services. Centers for Disease Control and Prevention. (2004) *BMI-Body Mass Index: BMI for Adults: Body Mass Index Formula for Adults* [Web Page]. URL http://www.cdc.gov/nccdphp/dnpa/bmi/bmi-adult-formula.htm [2005].

Wallner, S. J., Luschnigg, N., Schnedl, W. J., Lahousen, T., Sudi, K., Crailsheim, K., Möller, R., Tafeit, E., & Horejsi, R. (2004). Body fat distribution of overweight females with a history of weight cycling. *International Journal of Obesity, 28*, 1143-1148.

Weng, L.-J. (2004). Impact of the Number of Response Categories and Anchor Labels on Coefficient Alpha and Test-Retest Reliability . *Educational and Psychological Measurement, 64*(6), 956-972.

World Health Organization (WHO). (1977). *Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, The Ninth Revision.(ICD9)*. Geneva: WHO.

Wright, C. M., Parker, L., Lamont, D., & Craft, A. W. (2001). Implications of childhood obesity for adult health: findings from thousand families cohort study. *BMJ, 323*, 1280-1284.

Young, Copeland H., Kristen L. Savola, and Erin Phelps. 1991. *Inventory of Longitudinal Studies in the Social Sciences*. Newbury Park, Calif.: Sage Publications.

Yu, X., Fujimoto, K., Urushibata, K., Matsuzawa, Y., & Kubo, K. (2003). Cephalometric Analysis in Obese and Nonobese Patients With Obstructive Sleep Apnea Syndrome. *Chest, 124*, 212-218.

Center for Demography and Ecology
University of Wisconsin
1180 Observatory Drive Rm. 4412
Madison, WI 53706-1393
U.S.A.
608/262-2182
FAX 608/262-8400
comments to: ereither@hass.usu.edu
requests to: cdepubs@ssc.wisc.edu