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When the Frame is Part of the Picture

In the United States, height-weight tables linked to life expectancy have been in use for more than 70 years.[1] In 1942–43, the Metropolitan Life Insurance Company developed tables of "ideal weights" with the laudable intent of encouraging members of the public to aim for a weight somewhat below the average for their height.[2,3] Evidence was already available from medico-actuarial data that when overweight occurred after the age of 35, it was associated with a shortened life span.[4,5]

In 1959, Metropolitan Life replaced the ideal weight tables with new "desirable weight" tables[6] based on the findings of the Build and Blood Pressure Study (BBPS) published in 1959.[7] The 1959 BBPS encompassed the mortality experience of nearly five million insured persons over a span of almost 20 years. Twenty-six insurance companies in the US and Canada made their data available to this project. These new tables, which soon received worldwide recognition, were derived directly from relative weights of insurance policy holders associated with the lowest mortality rates. The 1959 Metropolitan Life tables distinguished among persons with small, medium, and large frames; however, in contrast to the 1942–43 tables, this division by frame size took into account limited anthropometric data collected in 1946 by the US Army Quartermaster Corps on 2,650 American-born White male separatees aged 25 years.[8] Based on these data, the insured population that fell within the desirable weight range was divided into quartiles, with the lowest designated "small frame," the highest "large frame," and the middle two, "medium frame." Unfortunately, in 1959, Metropolitan Life failed to provide any criteria that could be used to assign individuals to a particular frame size category.

Nevertheless, it was increasingly recognized that frame size is a valid consideration when one is assessing relative weight.[8,9] People of the same height can differ widely from one another in their skeletal dimensions which, in turn, have been shown to correlate with lean body mass.[10] For example, broadly built people, irrespective of their body fat content, tend to have a larger muscle mass than do narrowly built people.[8,11] Thus, when a reference table is used in the assessment of the relative fatness of an individual, it is helpful to be able to correct for frame size.

Although the 1959 Metropolitan Life tables did not provide any objective basis for assigning individuals to a particular frame category, the 1983 Metropolitan Life tables[12] attempt to avoid this defect by determining frame size from elbow breadth (bicondylar breadth of the humerus). The reference values for elbow breadth were obtained from the 25th and 75th percentiles within height categories for United States adults who were studied in the first National Health and Nutrition Examination Survey (NHANES I) during 1971–74.[13] Thus, Metropolitan Life has provided supplementary tables giving the ranges of elbow breadths for men and women of "medium frame" at various heights.[12] Measurements lower than those listed indicate that the individual under consideration has a small frame while higher measurements indicate a large frame.

Elsewhere in this issue of the Journal, Himes and Bouchard[14] report studies that call into question the appropriateness of Metropolitan Life's choice of elbow breadth as a measure of frame size. These authors point out that frame measurements are assumed to provide an estimate of fat-free mass and to have little or no association with body fat. The implication is that a suitable measure of frame permits discrimination between persons who are overweight because of a large lean body mass and those whose excess weight results principally from stored fat. Himes and Bouchard tested this hypothesis in 437 Canadian men and women of French descent, 18–59 years of age. Six body breadths were measured as possible indexes of frame size: shoulder, elbow, wrist, hip, knee, and ankle. These measurements were then correlated with fat-free mass (derived from measurement of body density), with partial correlations controlling for height. The frame size variables also were correlated with body fat measures, with partial correlations controlling for fat-free mass.

The results showed that there was little variation among frame measures in their partial correlations with fat-free mass. The strength of these partial associations with fat-free mass was sufficient to provide differences in mean fat-free mass among groups classified by terciles of each frame size. However, there was considerable variation in frame-size associations with body fat. Breadths of shoulder, elbow, hip, and knee all had partial correlations with per cent body fat when controlling for fat-free mass; however, wrist and ankle breadths did not. Thus, when Himes and Bouchard plotted differences among means of per cent body fat according to tercile groupings of frame size, adjusted for associations with fat-free mass, it was found that, when elbow breadth was used as the frame variable, per cent body fat increased from 20.3 to 25.4 per cent between frame terciles 1 and 3 for men, and from 28.0 to 34.3 per cent between frame terciles 1 and 3 for women. In contrast, when wrist or ankle breadths were used as the frame variables, there were no changes in per cent body fat among the frame terciles in either men or women.

As Himes and Bouchard point out, elbow breadth already has been recommended for use in conjunction with the 1983 Metropolitan tables. Thus, for example, men and women with a large frame (inferred from elbow breadth) will be substantially fatter than men and women with a medium frame. This outcome is obviously undesirable if the purpose of classifying by frame is to correct for differences in fat-free mass, thereby permitting the focus to remain on variations in body fat content.

As regards the use of elbow breadth to denote frame size, there is no inherent reason why a more satisfactory index could not be used with the 1983 tables, if one could be found. Presumably, Metropolitan Life selected elbow breadth because national reference data are available on this index from NHANES I. Comparable reference data on wrist and ankle breadths do not appear to exist and, as Himes and Bouchard admit, their sample is too small to serve as a reference for the North American population.

Several points need to be made with respect to the use of indexes of body frame size in the interpretation of height-weight data. First, when calipers are used to measure various bony breadths, the presence of subcutaneous fat can compromise the validity of the measurement. The risk of such an error would seem highest for the shoulders, hips, and knees. However, subcutaneous fat could invalidate the measurement of elbow breadth, particularly in obese females. It would seem logical that the ankle and wrist are relatively free of this source of error. Obviously, use of radiographs could show the true bony breadths of the elbows and other body breadths; in this way, any confounding effect of subcutaneous tissues could be better assessed.

Apart from the possible role played by subcutaneous fat in confounding the relationship of specific bony breadths such as elbow breadth to fat-free mass, one must consider a possible relation between overall fatness and fat-free mass. Obese people are not merely thin people who carry an extra burden of fat.[15] On the average, obese individuals have a larger muscle mass than do nonobese people; in addition, their body frame size is larger.[16,17] This difference in frame size, which is clearly disclosed by the NHANES I data,[16] seems too consistent to be simply an artefact caused by subcutaneous fat overlying the condyles of the elbow.

Finally, the relation of body frame size to morbidity and mortality requires further investigation. The NHANES I data have shown that US adults who are overweight but not obese are at increased risk of having hypertension and hypercholesterolemia.[18] These are individuals who are overweight by body mass index (kg/m^2) criteria but who are not obese by skinfold thickness criteria. The NHANES I data also show that, on the average, people who are overweight but not obese have a larger frame than do normal weight nonobese people.[18] Thus, as a determinant of fat-free mass, body frame could also be a factor that contributes to the predisposition of an individual to certain risk factors for premature cardiovascular disease.

The putative interrelationships among frame size, fat-free mass, and body fat content clearly deserve further investigation. The paper by Himes and Bouchard is a useful step in this direction.

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