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| 16. Abstract The Framingham Relative Weight Index (FRWI) of obesity was described in previous reports as a screening aid for detecting susceptibility to coronary heart disease (CHD). FRWI calculation requires measured values of height and weight but the height and weight values on standard airman medical applications are usually stated estimates of the examinee. Because such stated (unmeasured) data are vulnerable to error, samples from aeromedical certification sources were examined for errors. In a previous study 674 Air Traffic Controllers (ATC) stated their heights at 65 inches or less. These low values were scrutinized as suspect because the minimum height standard for ATC recruits has been 65 inches since 1965. Of 216 corroborated errors 179 were due to incorrectly stated height. The stated-height error exerted a concentrated effect through false overestimation of the FRWI. In a separate study, the stated and measured weights of 206 ATC personnel were compared. The degree of stated-weight error was substantial and was directly proportional to the degree of underweight or overweight. Due to weight understatement by grossly overweight individuals, the 120.0% FRWI classification of obesity based on stated weight is quite conservative. | | | |
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HEIGHT AND WEIGHT ERRORS IN AEROMEDICAL CERTIFICATION DATA

I. Introduction

A physician's comprehensive physical examination usually includes the measurement of height and weight because of their combined relevance to many conditions of major medical concern. An excessive weight gain or loss, or an excessive rate of change in weight per height, readily elicits increased diagnostic attention.

On the standard airman medical application height and weight are requested in inches and pounds, but measurement of these two items at the time of the aeromedical certification examination is not required. These values on the application are usually the airman's stated estimates and are therefore vulnerable to all the possible types of errors of stated (unmeasured) data.

Many epidemiology studies have used height and weight data to determine the presence and degree of obesity in relation to coronary heart disease (CHD). One such characterization of obesity is the well-known Framingham Relative Weight Index (FRWI),¹ as formulated by the Framingham Heart Study (FHS). This index is based on measured values of height and weight.¹ A male whose FRWI is 100.0% has a weight equal to the median weight of all FHS males of his identical height at the 1950 inception of the FHS.¹ The FHS has defined frank obesity as an FRWI of 120.0% or greater.² A complete description of the FRWI, its derivation and formulae have been reported elsewhere.¹ The FHS and many other major epidemiological studies have reported a substantial correlation between obesity and CHD.²⁻¹⁸

The National Health Survey (NHS) at its 1960-1962 inception measured the heights and weights of a population sample statistically sufficient to be representative of the whole American population.¹⁹⁻²⁰ The linear regression equation, calculated from the smoothed means of the weight/height distribution of their male population segment, was virtually identical to that

which describes the males of the FHS at its 1950 inception.²¹ In general, the NHS findings concerning the relation of anthropomorphic correlates of obesity to several types of heart disease²²⁻²⁵ parallel those of the FHS.²⁻⁶

Because of the quantitative relationship established by the FHS between the FRWI and CHD, and because the FRWI may be applicable coincidentally to the whole American male population, this same index was used in two of our statistical studies on screening factors for potential CHD susceptibility in major segments of the male airman population.²¹⁻²⁶ All data used in both these studies²¹⁻²⁶ were obtained from current aeromedical certification files. All data were used on a "best available" basis.

During the first of these two statistical studies²¹ several varieties of height errors were revealed serendipitously. An analysis of these errors evolved as an adjunct to the main purpose of attempting their correction wherever possible. Because of the relevance of these errors to stated height and because all stated-type data are vulnerable to substantial error,⁷⁻²⁷ a convenience sample of stated weights of ATCs from an FAA facility was analyzed for possible errors. The results of the height and weight error analyses are reported here.

II. Methods

Height Error Analysis. In one of our previous statistical studies²¹ the population sample consisted of 23,826 ATC personnel. Of these, we noticed that 104 possessed stated heights of 59 inches or less. We became particularly suspicious during this study that these were errors in height because the minimum height standard for recruitment of new ATC personnel has been 65 inches since 1965.²⁸ We conducted a retrospective examination of the height data on the 674 personnel listed at 65 inches or less. First we examined all available previous aeromedical

certification records of individuals with questionable height data; then, where possible, we certified or corrected the information on the particular individual. Two general types of height error were revealed: stated-height error and data-transfer error.

The stated-height error is ascribable to the airman and occurs during the filling out of the medical application which requests the height in inches. Many airmen enter their correct height in numbers but omit the appropriate symbols for feet and inches. For instance, an airman may enter the number 56 and mean 5 feet-6 inches but if the symbols for feet and inches are not included, the information is transferred into the aeromedical certification data files as 56 inches and a substantial error of 10 inches is introduced into the data system. This magnitude of height error introduced into the calculation of the FRWI results in a gross overestimation of the degree of obesity of the individual.

The second type of height error was ascribable to the key-punch operator during the transfer of data from the airman's application into the aeromedical certification data files. This type of error is of historical interest only, because shortly after 1967 revision of data-transfer procedures and adjunct data-editing checks resulted in its virtual elimination.

Weight Error Analysis. Previous anthropometric studies^{7, 27} showed that stated weight is also vulnerable to a substantial degree of error heavy men tend to underestimate and light ones tend to overestimate their weight. Since stated weight is one of the parameters used in our calculation of the FRWI, any substantial error in stated weight should affect adversely the accuracy of the calculated FRWI. Because of the possibility of this type of error in our use of stated weight, a small aliquot test for errors was conducted at an ATC facility.

TABLE I. Frequency distribution of stated height, correctly stated height, incorrectly stated height and percent incorrectly stated height versus height category.

| HEIGHT CATEGORY (Inches) | FREQUENCY | | | % INCORRECTLY STATED HEIGHT |
|--------------------------------|---------------------------|-------------------------------|---------------------------------|--------------------------------------|
| | STATED HEIGHT (ALL) | CORRECTLY STATED HEIGHT | INCORRECTLY STATED HEIGHT | |
| ≤ 59 | 104 | 0 | 104 | 100.0 |
| 60 | 44 | 4 | 40 | 90.9 |
| 61 | 20 | 1 | 19 | 95.0 |
| 62 | 29 | 16 | 13 | 44.8 |
| 63 | 46 | 34 | 12 | 26.1 |
| 64 | 147 | 135 | 12 | 8.2 |
| 65 | 284 | 268 | 16 | 5.6 |

A CAMI Flight Surgeon was detailed to the articular ATC facility for four discontinuous one-month periods during one calendar year. His primary duty in each period was to examine those personnel whose required annual aeromedical certification examinations were due. A total of 206 such examinations were accomplished in the four months.

Before each examination the examinee filled out the standard airman medical application in the usual manner, including the entry of stated height and stated weight. The Flight Surgeon measured both height and weight in inches and pounds during the examination, using standard medical height and weight scales. In accordance with the FHS procedure, both measurements were obtained on each examinee with shirt and shoes previously removed. The stated weights were compared with the measured weights.

II. Results

Height Error. Of the 674 stated heights of 5 inches or less, a total of 216 were in error.

Incorrectly stated height accounted for 82.8% of these errors. Table 1 presents the frequency distribution of stated height, correctly stated height, incorrectly stated height and percent incorrectly stated height versus height category. One can readily see that the 104 heights stated as 59 inches or less were all in error. The error fell appreciably to 44.8% at the stated height of 62 inches and appeared to be approaching zero asymptotically at the stated height of 65 inches.

These height corrections were made as a small portion of a much larger study²¹ which involved the analysis of data from the entire ATC population of 23,826 personnel. In this study²¹ the distributions of simple parameters such as systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) in an age versus FRWI table format were examined for patterns related to increasing susceptibility to CHD. As illustrated diagrammatically in Figure 1, an increase in a CHD susceptibility parameter in the vector shown by the arrow is indicative of an increasing susceptibility to CHD.²¹ Although

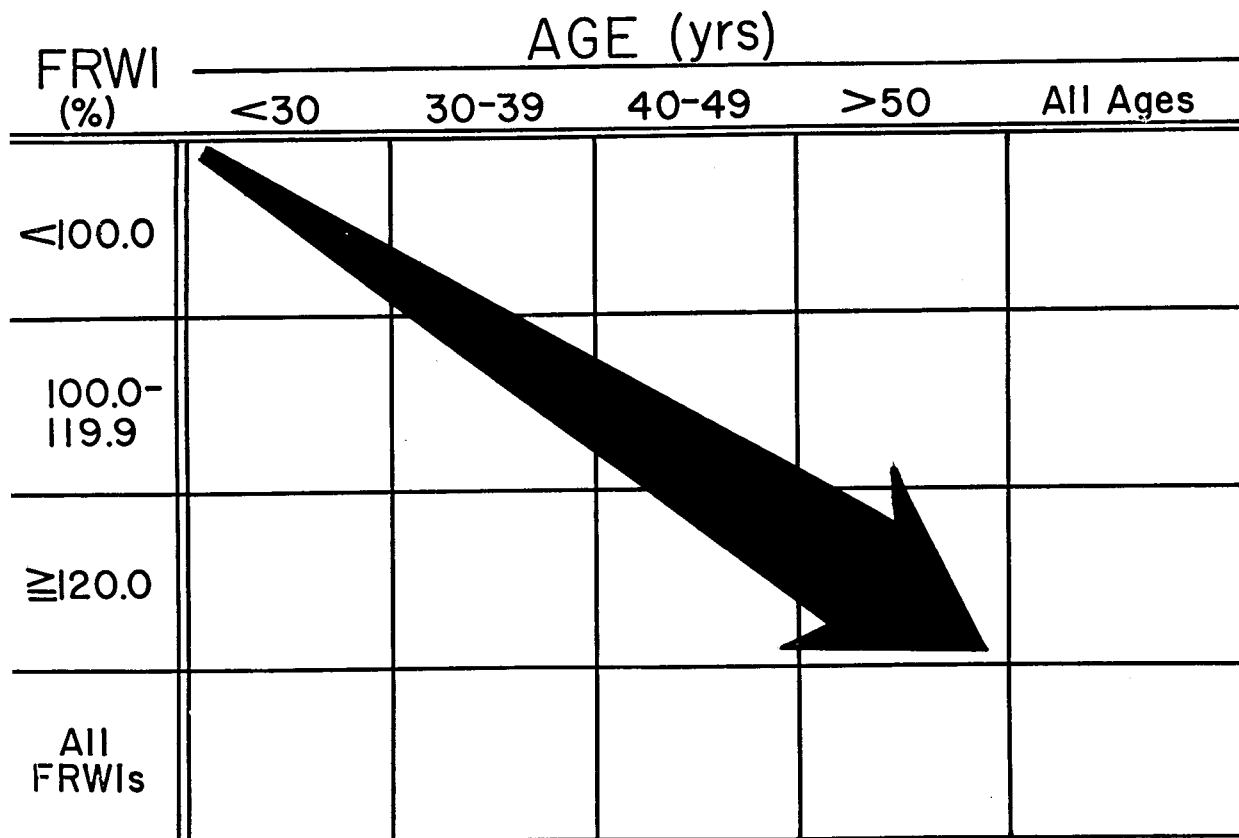


FIGURE 1. Diagrammatic representation of the age versus FRWI table format. The vector arrow indicates the parametric direction of an increasing magnitude of susceptibility to CHD.

TABLE II. Frequency distribution and percent prevalence of stated-height errors in the whole ATC population of 23,826 personnel. In each age/FRWI table cell, the top number is the stated-height error frequency, the middle number is the total number of height data and the bottom number is the percent prevalence of stated-height error.

| FRWI (%) | AGE (yrs) | | | | |
|-------------|-------------------|-------------------|-------------------|-------------------|----------------------|
| | <30 | 30-39 | 40-49 | >50 | All Ages |
| <100.0 | 14 5487 0.3 | 10 4935 0.2 | 4 2086 0.2 | 4 809 0.5 | 32 13,317 0.2 |
| 100.0-119.9 | 32 2861 1.1 | 21 4009 0.5 | 5 1927 0.3 | 1 760 0.1 | 59 9,557 0.6 |
| ≥120.0 | 46 294 15.7 | 50 400 12.5 | 19 194 9.8 | 10 64 15.6 | 125 952 13.1 |
| All FRWIs | 92 8642 1.1 | 81 9344 0.9 | 28 4207 0.7 | 15 1633 0.9 | 216 23,826 0.9 |

none of the average values, per se, of SBP, DBP and HR in each age/FRWI table cell was considered to be medically abnormal, the general pattern of increase in these three parameters with age and FRWI (arrow vector in Figure 1) was considered to be indicative of an increasing CHD susceptibility because the percent prevalence of the medically documented 400 cardiopathology series in the same 23,826 ATC personnel followed the same general pattern.

The effect of 216 height errors on the quantitative distribution of 23,826 height data would ordinarily be considered quite negligible. This would be correct if the errors were distributed diffusely throughout the whole spectrum of height data. However, this was not the case since a concentration of 75.5% of the 216 height errors occurred in the stated-height category of 61 inches or less. A further reflection of this error concentration is shown in Table II wherein the percent prevalence of height error in the

FRWI category was 120.0% or greater exceed by several orders of magnitude those of the two lesser FRWI categories.

An example of the quantitative redistribution of a CHD susceptibility parameter (SBP) caused by the correction of the 216 stated-height errors is shown in Table III. The mean SBP values showed the largest corrected increases in the table cells whose FRWI was 120.0% or greater. In general, the corrections intensify the degree of SBP increase with age and FRWI as diagrammatically represented in Figure 1. Although the total percent prevalence of stated height error was only 0.9%, the concentration of this type of error has a substantial effect on the degree of intensity of a CHD susceptibility screening parameter such as SBP.

Weight Error. In general agreement with previous human anthropometric studies,^{7, 27} the degree of error in stated weight was directly proportional to the degree of underweight or

TABLE III. The quantitative redistribution of mean SBP (in mm Hg) effected by the correction of 216 stated-height errors in the whole ATC population of 23,826 personnel. In each table cell, the upper number is the uncorrected value and the lower number the corrected value of mean SBP.

| FRWI (%) | AGE (yrs) | | | | |
|-------------|-----------|-------|-------|-------|----------|
| | <30 | 30-39 | 40-49 | >50 | All Ages |
| <100.0 | 120.7 | 121.2 | 123.8 | 127.9 | 121.8 |
| | 120.7 | 121.1 | 123.7 | 127.8 | 121.8 |
| 100.0-119.9 | 125.0 | 125.3 | 128.1 | 131.2 | 126.3 |
| | 125.1 | 125.4 | 128.2 | 131.0 | 126.3 |
| ≥120.0 | 129.6 | 130.2 | 132.6 | 133.6 | 130.7 |
| | 130.9 | 131.3 | 133.1 | 136.2 | 131.9 |
| All FRWIs | 122.5 | 123.4 | 126.2 | 129.6 | 124.0 |
| | 122.5 | 123.4 | 126.2 | 129.6 | 124.0 |

overweight. Figure 2 presents a graphical plot of the understatement or overstatement of weight (in pounds) versus the actual FRWI (in percent) calculated from the measured values of height and weight. The linear regression equation for the distribution of plotted points in Figure 2 is $X = 28.3704 - 0.3056Y$. According to his distribution of the 206 data examined, the average understatement of weight at an actual FRWI of 120.0% was 8.3 pounds and the average overstatement of weight at an actual FRWI of 80.0% was 3.8 pounds. Statistical analysis revealed that this regression distribution differed significantly ($p \leq 0.01$) from one manifesting zero understatement or overstatement of weight. Due to such understatement of weight by grossly overweight individuals, when the height data can be assumed to be correct, the FRWI classification of obesity (120.0%) based on stated weight may be viewed as a conservative judgment.

IV. Discussion

Our two previous statistical studies on screening factors for potential CHD susceptibility revealed the usefulness of the FRWI as a quantitative indicator of obesity.^{21 26} As used by the FHS, the FRWI is based on measured values of height and weight;¹ as used in our two CHD screening factor studies,^{21 26} the FRWI was calculated from stated-type data. As directly relevant to both screening studies, the correction of the height and weight data in the directions and general magnitudes indicated in the respective error analyses would serve to strengthen considerably the screening power of the conclusions reached in both those studies.^{21 26} On the standard airman medical application, the replacement of stated height and stated weight by measured values would aid substantially in strengthening the screening power of age/FRWI distributions of CHD susceptibility parameters.

It is hoped that this revelation of stated height and stated weight errors generated at the primary source of the data may aid examining physicians in their continued zealous efforts to provide medical data of the highest quality. As a logical sequitur of improved height and weight

data, CHD susceptibility screening for earlier detection of this disease entity should be enhanced by their use in the FRWI. Any improvement in CHD screening should also result in the enhancement of aviation safety.

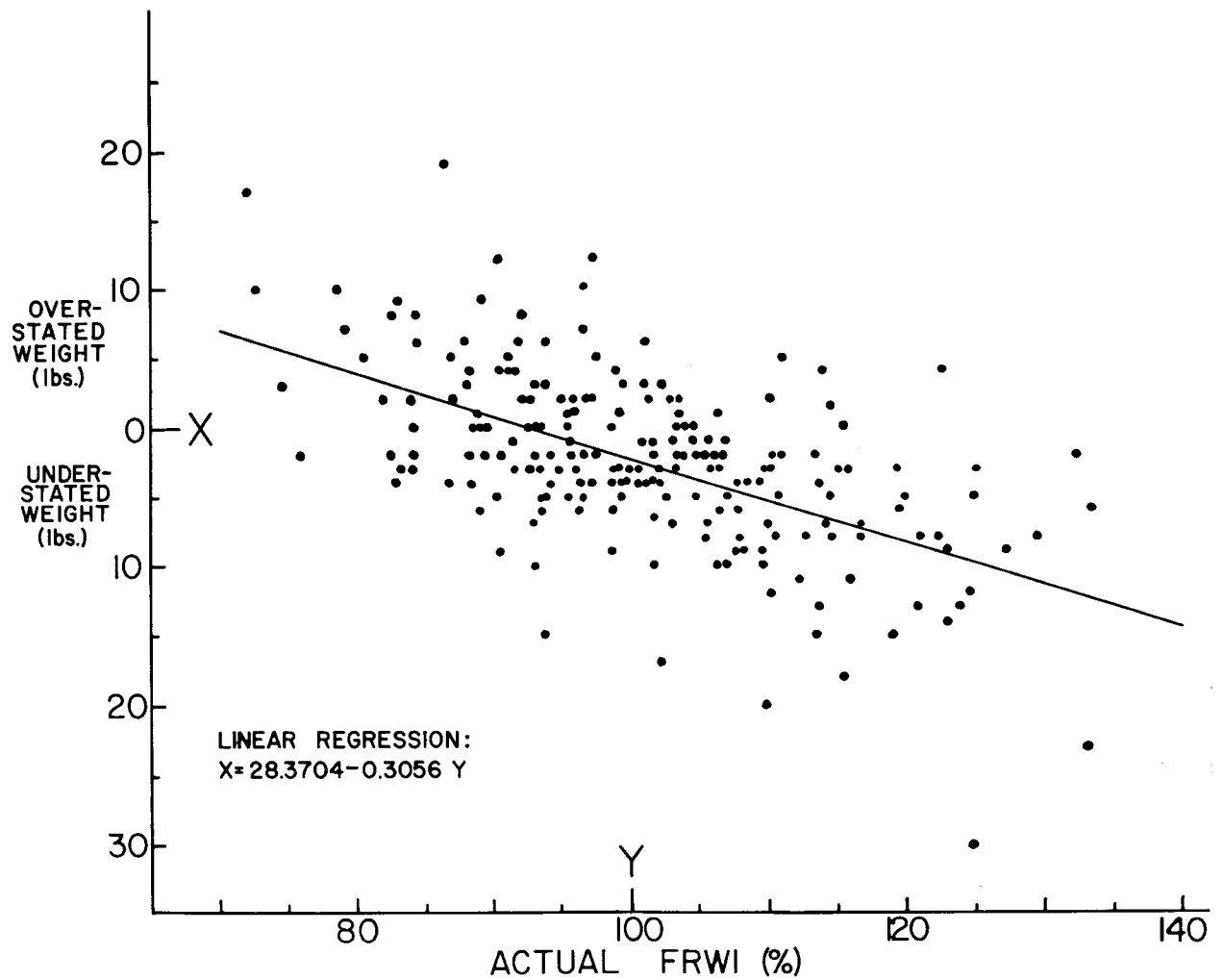


FIGURE 2. A graphical plot of understatement or overstatement of weight (in pounds) versus the actual FRWI (percent) calculated from the measured values of height (in inches) and weight (in pounds).

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