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Determination of Ideal Body Weight for Drug Dosage Calculations

J. Daniel Robinson, Stefan M. Lupkiewicz, Lisa Palenik, Larry M. Lopez, and Mario Ariet

Formulas for ideal body weight (IBW) in men and women were derived from the Metropolitan Life Insurance Company height and weight tables.

Regression determinations of median weight versus height were performed for men and women. A program for a minicomputer was developed to generate plots for small, medium, and large frame sizes and for subjects of all frame sizes. Equations for ideal body weight were derived from the resulting data.

For men of all frame sizes, IBW = 51.65 kg + 1.85 kg/inch of height >5 feet. For women of all frame sizes, IBW = 48.67 kg + 1.65 kg/inch of height >5 feet. More accurate estimates of IBW by frame size can be obtained using equations derived from the plots for men and women of each frame size.

Estimates of IBW obtained by the widely used empirical method probably contain only minor errors. However, formulas derived from actual height and weight data should be used in pharmacokinetic determinations of dosage regimens for some drugs.

Index terms: Computers; Dosage; Equations; Metropolitan Life Insurance Company; Pharmacokinetics; Size; Weight

It has been determined that blood concentrations of some drugs, e.g., theophylline[1] and digoxin,[2] correlate more closely with dosages based on ideal body weight (IBW) rather than on total body weight. For other drugs, e.g., gentamicin,[3] tobramycin,[4] and amikacin,[5] it has been demonstrated that dosages based on IBW plus a fraction of the "fat weight" correlate best with resultant blood concentrations. If IBW estimates are not used in obese patients, toxic blood concentrations of potentially dangerous drugs may develop.

Recent studies at our institution prompted a search for literature documentation of the most appropriate formula for IBW.[6,7] More than 100 recent clinical pharmacokinetics articles dealing with dosage-regimen design, many by prominent researchers in the area of clinical pharmacokinetics,[1–5] were reviewed. It was found that all of them except one[8] referred to a method suggested by Devine.[9] Citations of Devine's work are also common in literature describing creatinine clearance estimates,[9–13] which affect dosage-regimen design. Personal correspondence[a] revealed that Devine's highly quoted formulas for IBW estimates (IBW men = 50 kg + 2.3 kg/inch of height greater than 5 feet; IBW women = 45 kg + 2.3 kg/inch of height greater than 5 feet) were based on empirical estimates of his mentor, Dr. Margaret McCarron, at the University of Southern California.

Clinical pharmacokinetics has become an extremely important basis for dosage-regimen design. Pharmacokinetics is mathematically based; hence, IBW should be estimated using formulas derived from actual data, and estimates such as those proposed by Devine should be replaced. Our purpose was to establish mathematically derived formulas for IBW that can be clinically tested by researchers engaged in designing drug-dosage regimens based on literature averages of pharmacokinetic variables.

Methods

In searching the literature on obesity, we discovered that the most commonly cited reference that predicted IBW was a set of tables published by the Metropolitan Life Insurance Company.[14] The tables are for adults over age 25, one for men and one for women. The subjects in the tables range in height from 5 ft 2 in to 6 ft 4 in for men and 4 ft 10 in to 6 ft for women. Each table lists the ideal weight ranges for small-, medium-, and large-framed individuals. The median weight for each inch of height was calculated.

We performed regression determinations of median weight versus height for each of the frame sizes and for the total of all frame sizes for men and for women. Since 5 ft was the base in the currently used formulas for IBW,[9] we chose this value for the origin. Computer programs were developed by two of the authors[b] using an HP-2100 minicomputer with a Zeta plotter to generate the data.

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Results

For all frame sizes, the appropriate equations, determined from the slopes and intercepts in Figures 1 and 2, are as follows:

$$\text{IBW (men)} = 51.65\ \text{kg} + 1.85\ \text{kg/inch of height} > 5\ \text{feet} \quad (1)$$

$$\text{IBW (women)} = 48.67\ \text{kg} + 1.65\ \text{kg/inch of height} > 5\ \text{feet} \quad (2)$$

Figures 3–5 present the slopes and intercepts for men of various frame sizes, and Figures 6–8 present the same information for women.

Discussion

Since equations 1 and 2 may be difficult to recall from memory, they can be simplified with only a slight loss of accuracy to

$$\text{IBW (men)} = 52\ \text{kg} + 1.9\ \text{kg/inch of height} > 5\ \text{feet} \quad (3)$$

$$\text{IBW (women)} = 49\ \text{kg} + 1.7\ \text{kg/inch of height} > 5\ \text{feet} \quad (4)$$

More accurate estimates of IBW can be calculated using equations derived from Figures 3–8. Although estimates of body frame size are usually empirical, equations from Figures 3–8 may improve estimates of IBW and drug volumes of distribution (liters/kg) based on IBW. This deserves further study.

The estimates of IBW in previous pharmacokinetic studies probably contain only minor errors, since the Devine method[9] overestimated the intercept but underestimated the slope. For patients of average height, the two errors help to cancel each other; more error is present for those individuals who are unusually tall or short. For a man of typical height (5 ft 9 in), the error is 2.3%, while the error is 3.8% for a height of 5 ft and 5.3% for a height of 6 ft 4 in. For a woman of typical height (5 ft 5 in), the error is 1%, while the error is 7.1% for a height of 5 ft and 5.3% for a height of 6 ft. Thus, in most clinical situations, the empirically derived formula of Dr. McCarron appears to provide a very good estimate.

Frequently, we have been asked whether the same weight per inch can be subtracted for women less than 5 feet tall. Our data in Figure 2 demonstrate that this procedure can be followed for women at least 4 ft 10 in and probably for those less than 4 ft 10 in.

Another common question is, "Shouldn't the weight per inch for women be less than that for men?" Slopes of the lines in Figures 1 and 2 demonstrate that the weight per inch for women is about 12% less than the comparable value for men.

Conclusion

Although the empirical estimates proposed by Dr. McCarron and published by Devine[9] are fairly accurate estimates of IBW, formulas derived from actual IBW tables should be used in determining dosage regimens for some drugs.

[a] Devine BJ. Letter to Robinson JD. 1982 Sep 3.
[b] Robinson and Lupkiewicz.

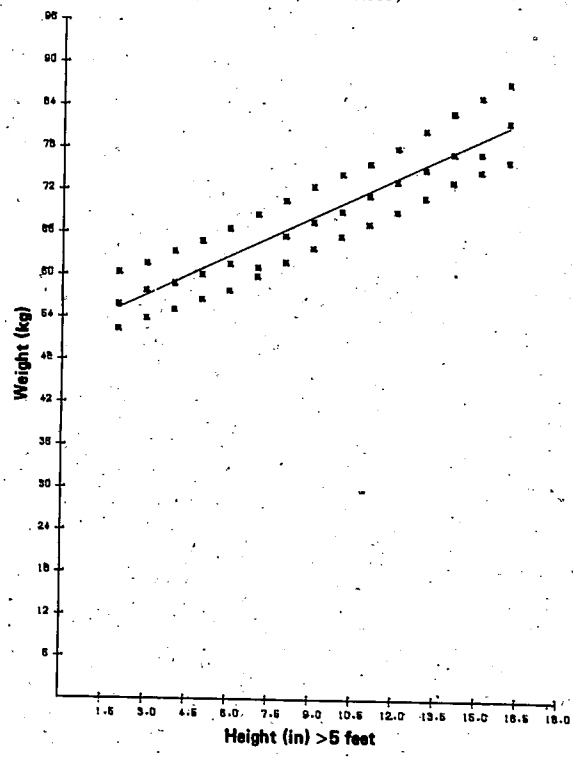


Figure 1. Weight versus height for men of all frame sizes. (Slope = 1.85, S.E. = 0.13; intercept = 51.65, S.E. = 0.46; $R^2 = 0.819$)

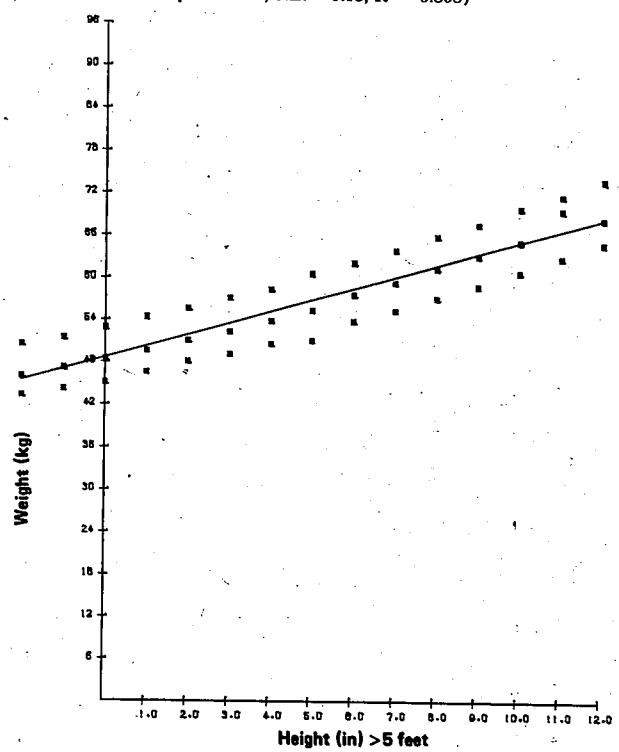


Figure 2. Weight versus height for women of all frame sizes. (Slope = 1.65, S.E. = 0.12; intercept = 48.67, S.E. = 0.18; $R^2 = 0.808$)

Figure 3. *Weight versus height for small-framed men. (Slope = 1.77, S.E. = 0.03; intercept = 48.15, S.E. = 0.16;* $R^2 = 0.997$)

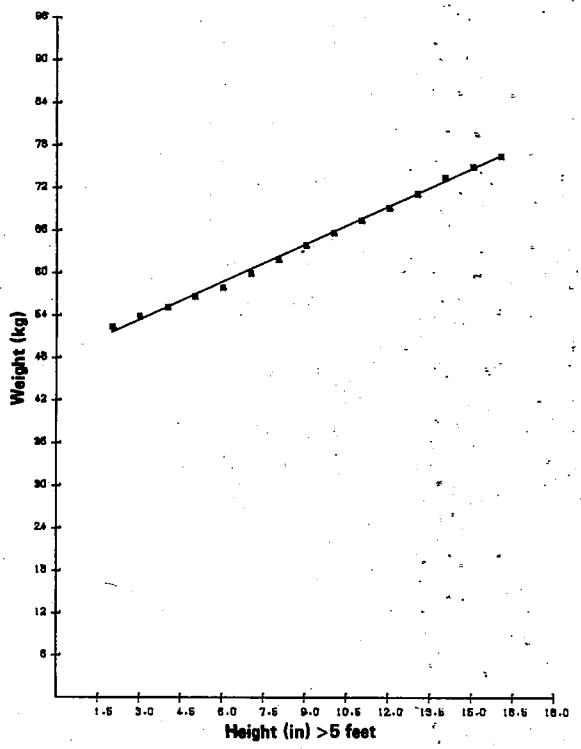


Figure 4. *Weight versus height for medium-framed men. (Slope = 1.82, S.E. = 0.06; intercept = 51.33, S.E. = 0.39;* $R^2 = 0.984$)

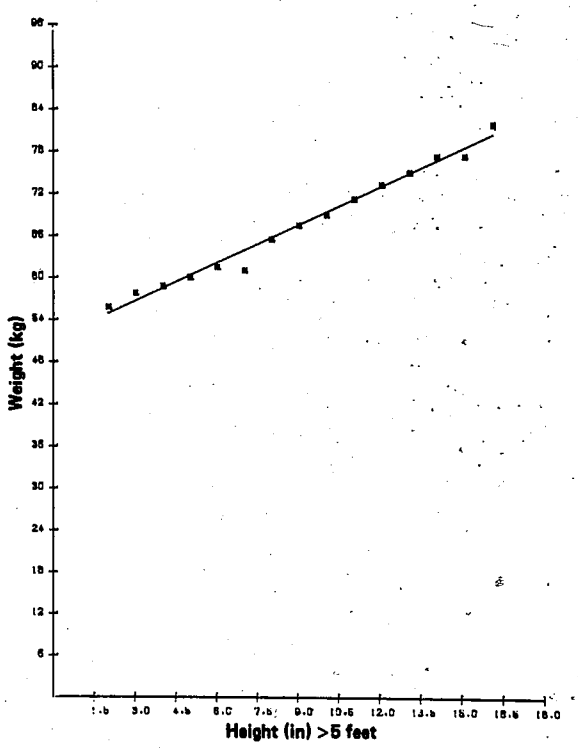


Figure 5. *Weight versus height for large-framed men. (Slope = 1.95, S.E. = 0.04; intercept = 55.48, S.E. = 0.22;* $R^2 = 0.995$)

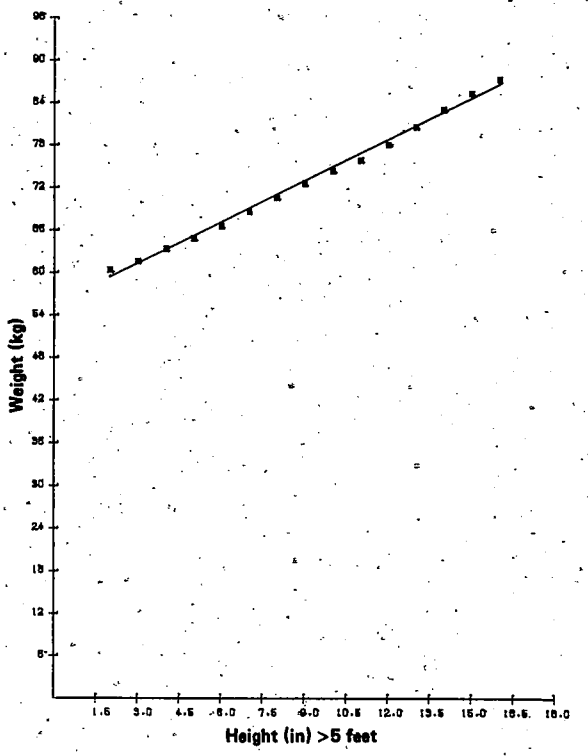


Figure 6. *Weight versus height for small-framed women. (Slope = 1.55, S.E. = 0.05; intercept = 45.14, S.E. = 0.12;* $R^2 = 0.988$)

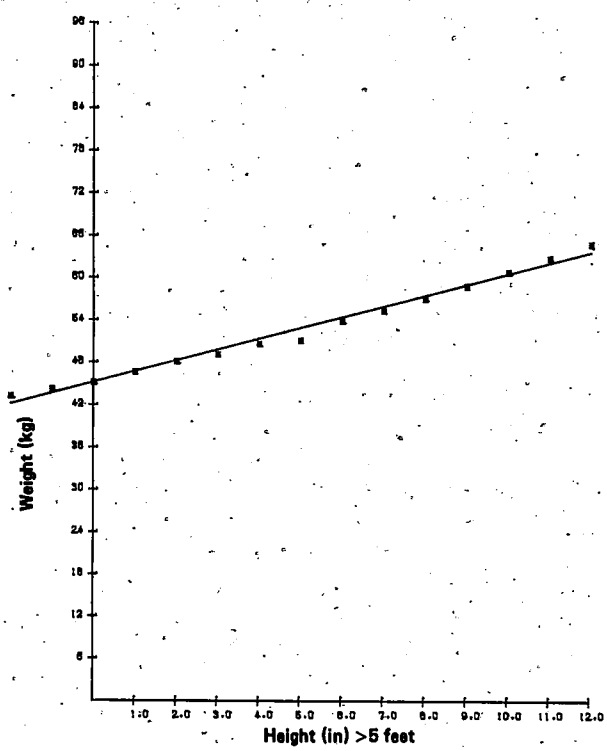


Figure 7. Weight versus height for medium-framed women. (Slope = 1.71, S.E. = 0.06; intercept = 48.13, S.E. = 0.16; $R^2 = 0.983$)

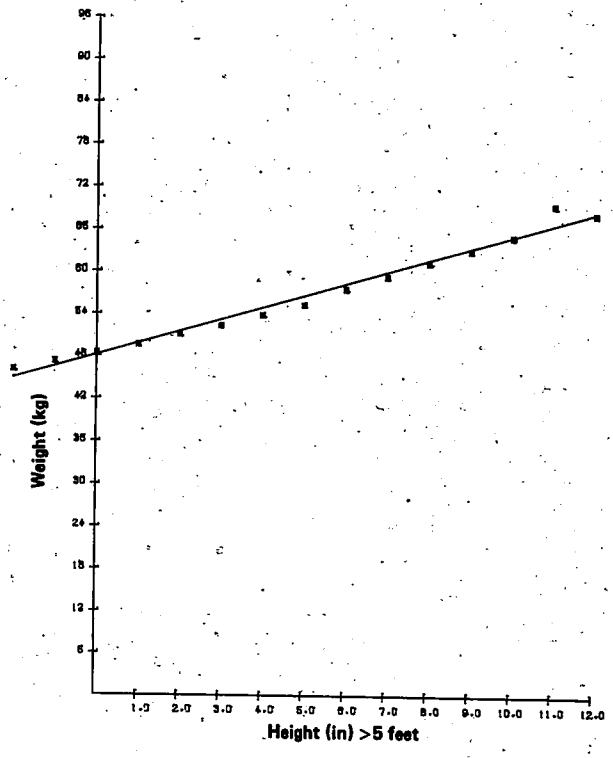
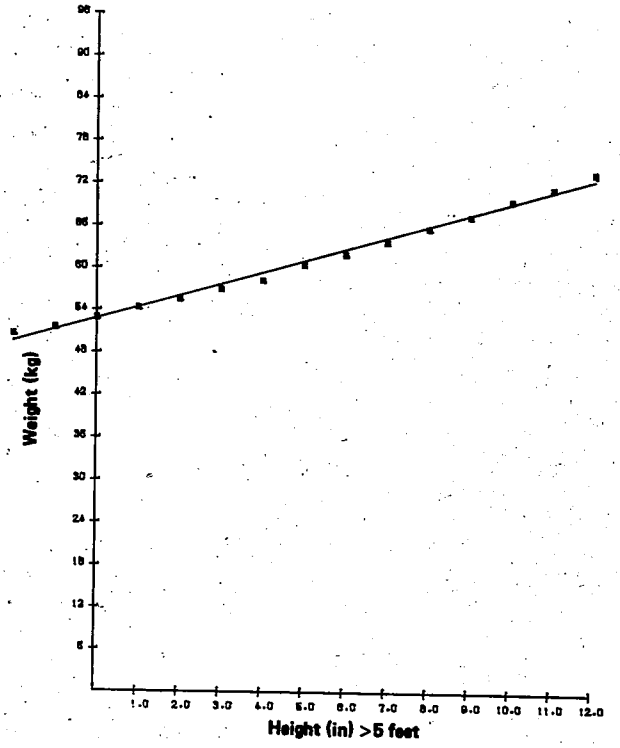


Figure 8. Weight versus height for large-framed women. (Slope = 1.69, S.E. = 0.04; intercept = 52.74, S.E. = 0.10; $R^2 = 0.993$)



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