

The Origin of the “Ideal” Body Weight Equations

Manjunath P Pai and Frank P Paloucek

OBJECTIVE: To provide a historical perspective on the origin and similarity of the “ideal” body weight (IBW) equations, and clarify the terms ideal and lean body weight (LBW).

DATA SOURCES: Primary and review literature were identified using MEDLINE (1966–November 1999) and International Pharmaceutical Abstracts (1970–November 1999) pertaining to ideal and lean weight, height–weight tables, and obesity. In addition, textbooks and relevant reference lists were reviewed.

DATA EXTRACTION: All articles identified through the data sources were evaluated. Information deemed to be relevant to the objectives of the review were included.

DATA SYNTHESIS: Height–weight tables were generated to provide a means of comparing a population with respect to their relative weight. The weight data were found to correlate with mortality and resulted in the use of the terms desirable or ideal to describe these weights. Over the years, IBW was interpreted to represent a “fat-free” weight and thus was used as a surrogate for LBW. In addition, the pharmacokinetics of certain drugs were found to correlate with IBW and resulted in the use of IBW equations published by Devine. These equations were consistent with an old rule that was developed from height–weight tables to estimate IBW. Efforts to improve the IBW equations through regression analyses of height–weight data resulted in equations similar to those published by Devine.

CONCLUSIONS: The similarity between the IBW equations was a result of the general agreement among the various height–weight tables from which they were derived. Therefore, any one of these equations may be used to estimate IBW.

KEY WORDS: ideal body weight, lean body weight, height–weight tables.

Ann Pharmacother 2000;34:1066-9.

Since 1974, more than 200 articles have cited the equation for lean/“ideal” body weight as published by Devine.¹ The equations were provided by Devine (Table 1)¹⁻³ to calculate creatinine clearance given the argument that it would be a better estimate of gentamicin clearance in obese patients. Unfortunately, the equations were not referenced to a particular data set, and so created a controversy over their validity. Attempts were made to better refine the equation for ideal body weight (IBW) through data collected from the Metropolitan Life Insurance Company height–weight tables. However, the equations generated from these tables were strikingly similar to those published by Devine.

This article attempts to explain the reason behind this similarity through a historical perspective on the origin of the IBW equations. In addition, the article clarifies the terms ideal and lean body weight (LBW) to illustrate their distinct definitions.

Lean versus Ideal Body Weight

LBW has been defined as a combination of body cell mass, extracellular water, and nonfat connective tissue.⁴ Anthropometric measures and densitometry by underwater weighing are used to measure LBW when a two-compartmental model (fat mass and fat-free mass) is assumed.⁵ However, this model of measurement has its limitations, which require the use of a four-compartmental model to measure total body potassium, bone mineral density, total

Author information provided at the end of the text.

body water, and total body carbon.⁶ The process is undoubtedly complex and is by no means currently applicable in the clinical setting. In contrast, the term IBW was coined based on historical data of weights for adult men and women that compared the relative mortality of persons of different height–weight combinations.⁷

Height–Weight Tables

The height–weight tables of adult men and women were initially developed to provide a simple means for describing and comparing people with respect to distribution of relative body weight. In addition, height–weight tables were purported to serve as a diagnostic tool for defining under- and overweight.⁸ One of the first height–weight tables was published in 1912 based on measurements and, in some instances, estimates of height (with shoes on) and weight (with clothes on) of life insurance policyholders who had bought their policies between 1885 and 1908.⁹ This table reported average weights at various ages for a given height. A larger sample of additional heights and weights were collected between 1909 and 1927 and were found to be so similar to the 1912 averages that it was not necessary to generate new tables.¹⁰

It was not until 1943 that the Metropolitan Life Insurance Company introduced new standard height–weight tables for men and women.^{11,12} The tables eliminated the age scale with the argument that continued increases in weight during adulthood were not necessary, as growth had terminated. Furthermore, weights were reported as ranges versus single average weight values for height and frame size. However, the frame sizes (small, medium, large) were not defined and were left to the subjective judgment of the examiner. Body frame was later defined and published in the 1959 Metropolitan Desirable Weight Table, which was developed from pooled data of 26 insurance companies in the US and Canada.¹³ The term ‘desirable’ weight became synonymous to ‘ideal’ weight, which was defined as that associated with the lowest mortality.⁸ Further revisions were made in 1983 with the publication of the Metropolitan Height and Weight Tables based on the data derived from the 1979 Build Study.¹⁴ These tables deleted the terms desirable or ideal, as they were commonly misinterpreted as weights that minimized illness, optimized job performance, or meant the best appearance.

Although the use of the Metropolitan Life height–weight tables was popular, they were not the only tables available during the period.⁸ Hathaway and Foard¹⁵ evaluated published and unpublished height–weight data available to the US Department of Agriculture (USDA) and summarized their findings in a bulletin. The weights for height of men and women were based on data from 160 000 students, 20–29 years of age, entering college between 1949 and 1950. The measurements were made in inches for height (without shoes) and in pounds for weight (without clothing). These weights, reported as a range from low to high at a given height, included the middle 50% of the cases. Although these data did not predict mortality, they were assumed to be more accurate weights for heights than those in the Metropolitan Life tables because they were collected from nude subjects.¹⁶ However, an analysis¹⁷ of the data collected by the USDA versus the 1943 Metropolitan Life height–weight tables revealed that they agreed within a few pounds.

The general agreement between the various height–weight tables allowed the development of a simple rule for estimating ideal weight. The purpose of this rule was to provide a simple mechanism of estimating an ideal weight to help determine if a person was obese.¹⁸ This rule was, “For women, allow 100 lbs. for the first 5 feet and 5 lbs. for each additional inch. For men, allow 110 lbs. for the first 5 feet and 5 lbs. for each additional inch.” In addition, a 10% variation above or below the calculated weight was allowed for individual differences.^{16,18}

Ideal Body Weight Equations

The use of the height–weight tables and the rule to estimate IBW began to be used as a reference weight for classification of obesity.¹⁸ In addition, the IBW was assumed by some to be the ‘fat-free’ weight and so served as a surrogate for LBW.¹⁹ For more than a century, the composition of the human body had been under study with the recognition that LBW represented the weight where over 99% of the body’s metabolic processes occurred.⁴ Unfortunately, the systems required to measure LBW were too expensive and complex to use (see earlier section for discussion). The availability of the height–weight tables and the simple rule for estimating IBW provided a solution to this dilemma.¹⁹

Researchers discovered that the pharmacokinetics of some drugs such as digoxin and theophylline correlated better with IBW than with total body weight.¹⁹ As a result, numerous pharmacokinetic studies employed the equations published by Devine¹ for their dosage-regimen design.² However, questions arose over the validity of equations not referenced to a particular data set. Consequently, Robinson et al.² determined through personal correspondence with Devine that the published equations were based on the empiric estimates of his mentor, Dr. Margaret McCarron. Robinson et al. argued that equations for IBW would have to be derived from actual data and not empiric estimates if they were to be applied in future pharmaco-

Table 1. Comparison of Ideal Body Weight Equations Using Height

Reference	Equation
Devine (1974) ¹	men: 50 kg + 2.3 kg/each inch over 5 feet women: 45.5 kg + 2.3 kg/each inch over 5 feet
Robinson et al. (1983) ²	men: 52 kg + 1.9 kg/each inch over 5 feet women: 49 kg + 1.7 kg/each inch over 5 feet
Miller et al. (1983) ³	men: 56.2 kg + 1.41 kg/each inch over 5 feet women: 53.1 kg + 1.36 kg/each inch over 5 feet

netic studies. His group performed regression determinations of median weight versus height using the data from the 1959 Metropolitan Life height-weight tables to generate IBW equations. Influenced by Robinson's work, Miller et al.³ analyzed the 1983 Metropolitan Life height-weight tables to also generate IBW equations.

The equations derived by both Robinson et al.² and Miller et al.³ were strikingly similar to those proposed by Devine¹ (Table 1). When these equations are graphically represented (Figures 1 and 2), they further illustrate this similarity. But how could an empiric estimate so closely match those that were mathematically derived by Robinson et al. and Miller et al.? The answer may be explained by the fact that the IBW equations published by Devine¹ are a kilogram version of the simple rule that was developed empirically from height-weight tables. Hence, the empiric estimate of Devine's mentor was consistent with the simple rule for calculating IBW. In addition, with every generation the height-weight tables demonstrated a trend that adults weigh more but still anticipate similar longevity.⁹⁻¹⁵ This trend explains the higher initial weight for the first 5 feet as one compares the Devine¹ equation with the Robinson et al.² and Miller et al.³ equations (Table 1). Although these equations are notably similar, the work by Robinson et al.² should not be discounted. Their analyses demonstrated that the procedure for weight adjustment could be followed for heights less than 5 feet by simply subtracting the weight per inch factor.

Summary

Height-weight tables were generated to provide a means of comparing a population with respect to their relative weight. The weight data used to compile the Metropolitan Life height-weight tables were found to correlate with the risk of mortality.⁸ This correlation resulted in the use of the terms desirable or ideal to describe these weights. Over the years, IBW was interpreted to represent a fat-free weight and thus was used as a surrogate for LBW.¹⁹ Height-weight tables became an attractive concept due to the complexity and expense of the instruments required to actually measure LBW. In addition, the correlation of the pharmacokinetics of certain drugs to IBW resulted in the use of IBW equations published by Devine.¹⁹ These equations were consistent with an old rule that was developed from height-weight tables to estimate IBW.¹⁸ Efforts to improve the IBW equations through regression analyses of height-weight data resulted in equations that were similar to those published by Devine.^{2,3} This similarity was ultimately a result of the general agreement among the various height-weight tables. Therefore, any one of these equations may be used to estimate IBW.

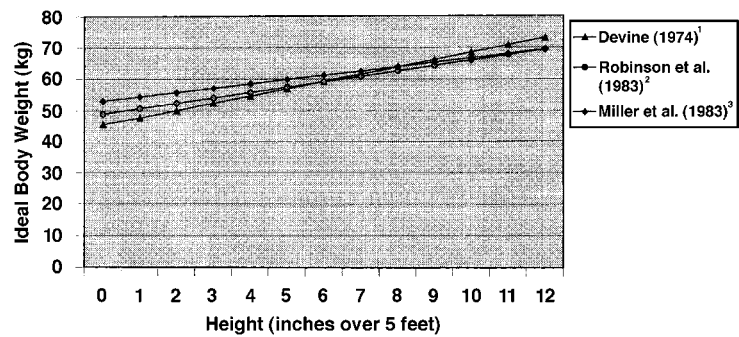


Figure 1. Comparison of ideal body weight equations for women.

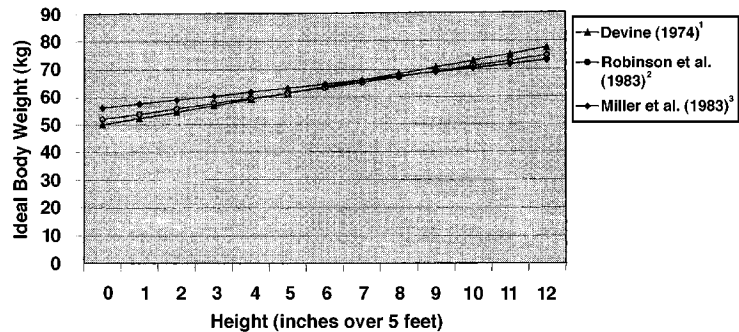


Figure 2. Comparison of ideal body weight equations for men.

Manjunath P Pai PharmD, Infectious Diseases Fellow, Department of Pharmacy Practice, College of Pharmacy, University of Illinois at Chicago, Chicago, IL

Frank P Paloucek PharmD ABAT, Clinical Associate Professor, Department of Pharmacy Practice, College of Pharmacy, University of Illinois at Chicago

Reprints: Manjunath P Pai PharmD, Department of Pharmacy Practice (MC 886), College of Pharmacy, University of Illinois at Chicago, 833 S. Wood St., Rm. 164, Chicago, IL 60612, FAX 312/996-0379, E-mail apai@uic.edu

We thank Joseph S Bertino Jr PharmD and Roger W Jelliffe PhD for provision of necessary resources required to put this manuscript together.

References

- Devine BJ. Gentamicin therapy. *Drug Intell Clin Pharm* 1974;8:650-5.
- Robinson JD, Lupkiewicz SM, Palenik L, Lopez LM, Ariet M. Determination of ideal body weight for drug dosage calculations. *Am J Hosp Pharm* 1983;40:1016-9.
- Miller DR, Carlson JD, Loyd BJ, Day BJ. Determining ideal body weight (letter). *Am J Hosp Pharm* 1983;40: 1622.
- Moore FD. Energy and the maintenance of the body cell mass. *JPEN J Parenter Enteral Nutr* 1980;4:228-60.
- Heymsfield SB, Waki W. Body composition in humans: advances in the development of multicompartmental chemical models. *Nutr Rev* 1991;49:97-108.
- Roubenoff R, Kehayias J. The meaning and measurement of lean body mass. *Nutr Rev* 1991;49:163-75.
- Knapp TR. A methodological critique of the "Ideal Weight" concept. *JAMA* 1983;250:506-10.
- Harrison GG. Height-weight tables. *Ann Intern Med* 1985;103(6 pt 2):489-94.
- Medico-Actuarial Mortality Investigation. *Trans Assoc Life Insur Med Dir Am* 1912:1.
- Seltzer CC, Mayer J. A simple criterion of obesity. *Postgrad Med* 1965;38:A101-7.
- Ideal weights for women. *Stat Bull* 1942;23:6-8.
- Ideal weights for men. *Stat Bull* 1943;24:6-8.

13. New weight standards for men and women. *Stat Bull* 1959;40:1-4.
14. 1983 Metropolitan height and weight tables for men and women. *Stat Bull* 1983;64:1-8.
15. Hathaway ML, Foard ED. Heights and weights of adults in the United States, USDA. Home Economics Research Report No. 10. Washington, DC: US Government Printing Office, 1960.
16. Overton MH, Lukert BP, eds. *Clinical nutrition: a physiologic approach*. Chicago: Year Book Medical Publishers, 1977:36.
17. Hathaway ML. Heights and weights of adults in the United States. *Nutr Rev* 1961;19:193-5.
18. Williams SR. *Nutrition and diet therapy*. Saint Louis: The CV Mosby Company, 1973:483.
19. Ritschel WA, Kaul S. Prediction of apparent volume of distribution in obesity. *Methods Find Exp Clin Pharmacol* 1986;8:239-47.

EXTRACTO

OBJETIVO: Proveer una perspectiva histórica del origen de las formulas que se usan para determinar el peso ideal y comparar las similitudes que existen entre ellas. Además, se intenta clarificar el significado de los términos peso ideal (IBW, por sus siglas en inglés) y peso magro (LBW, por sus siglas en inglés).

FUENTES DE INFORMACIÓN: Se realizó una búsqueda bibliográfica en MEDLINE de artículos y revisiones anteriores en el período de enero del 1966 a noviembre del 1999. Además se revisó la base de datos de IPA de enero del 1970 a noviembre del 1999. Artículos relacionados con el uso de las formulas de peso ideal y peso magro, tablas basadas en estatura y peso y con la obesidad fueron revisados. Algunos libros y otras referencias bibliográficas encontradas en los artículos fueron también usadas.

MÉTODO DE EXTRACCIÓN DE INFORMACIÓN: Todos los artículos identificados a través de la fuente de datos fueron evaluados. Toda aquella información clasificada como importante de acuerdo a los objetivos del artículo también se incluyó.

SÍNTESIS: Las tablas de peso y estatura se establecieron como base para poder comparar a la población con respecto a la variable de peso. Como consecuencia de esto, la información relacionada al peso se comenzó a publicar de acuerdo a su relación con la mortalidad. Esto resultó en el uso de la clasificación del peso como deseable o peso ideal especialmente en campo de la medicina. A través de los años, el IBW ha sido interpretado como un peso libre de grasa y se ha usado como un término intercambiable con el LBW. En el campo de la farmacocinética, la dosis de muchos de los medicamentos se calcula usando el IBW. La formula diseñada por Devine usa una regla antigua que utiliza las tablas de peso y estatura para calcular el IBW. Se han llevado acabo muchos

esfuerzos por mejorar la formula de calcular el IBW utilizando métodos de análisis de regresión. Éstos han resultado en el diseño de formulas similares a las publicadas por Devine.

CONCLUSIONES: La similitud encontrada entre las muchas formulas de calcular el IBW se basa en el hecho de que éstas han sido diseñadas usando tablas de peso y estatura similares. Por lo tanto, se puede concluir que cualquiera de las formulas de calcular IBW pueden ser usadas para estimar el peso ideal.

Magaly Rodríguez de Bittner

RÉSUMÉ

OBJECTIF: Fournir une perspective historique sur l'origine et les similitudes des formules permettant de calculer le poids corporel idéal et préciser les termes "poids idéal" et "poids maigre."

REVUE DE LITTÉRATURE: Les articles fondamentaux ainsi que les articles de revue ont été identifiés à partir d'une recherche dans les banques informatisées MEDLINE (janvier 1966–novembre 1999) et International Pharmaceutical Abstracts (janvier 1970–novembre 1999) en utilisant les termes poids idéal, poids maigre, tables de poids en fonction de la taille, et obésité. De plus, des livres traitant du sujet ont été consultés ainsi que des articles additionnels qui ont été obtenus à partir des bibliographies des articles.

SÉLECTION DES ÉTUDES ET DE L'INFORMATION: Toutes les articles identifiés ont été évalués. De plus, l'information jugée pertinente à l'atteinte des objectifs de cette revue a été traitée.

RÉSUMÉ: Les tables de poids en fonction de la taille ont été développées afin de fournir des outils de comparaison de la population en regard de leur poids relatif. On a observé une corrélation entre ces données et la mortalité, ce qui a conduit à l'emploi des termes "désirable" ou "idéal" pour qualifier les différentes mesures de poids. Au cours des années, le poids corporel idéal (PCI) a été interprété comme l'équivalent du poids maigre et ces deux termes ont été utilisés indifféremment. De plus, la pharmacocinétique de certains médicaments est liée au PCI et a conduit à l'utilisation des formules de PCI, tel que publié par Devine. Ces formules sont en accord avec la vieille façon d'estimer le PCI à l'aide des tables de poids en fonction de la taille. Des efforts pour améliorer ces formules par des analyses de régression des données poids taille ont été faits et les formules résultantes sont similaires à celles de Devine.

CONCLUSIONS: La similitude entre les formules de calcul du poids corporel idéal est le résultat d'un consensus parmi toutes les tables de poids en fonction de la taille duquel elles sont dérivées. En conclusion, n'importe laquelle de ces formules peut être utilisée pour estimer le poids corporel idéal.

Denyse Demers