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Ideal body weight: a commentary

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Abstract

Background & Aims: The Ideal Body Weight (IBW) model has provided dietitians and researchers with a quick method of risk assessment but is known to be imperfect. IBW formulas were developed from anthropometric measurements of life-insurance policy holders obtained between 1885 and 1908, providing statistics of mortality, organized by sex and age. Actuaries of the U.S. life insurance companies published data on the impact of overweight/obese status and mortality risk. Research of the same era repeatedly revealed either no significance or an inverse relationship. The intent of this text is to draw attention to the complexity and overall discussion of utility of the IBW method.

Methods: Reviewed relevant literature from the development of IBW through the recent findings in 2014.

Results: Height, weight, and frame fail to consider comorbidities and genetics. IBW formulas assume that weight increases as a linear function of height. Weight has been shown to increase not just as a function of height, but also of volume: body width, trunk length, and musculature. Depending on standards of practice, several equations may be used.

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Credit Statement
Tara M. Holmes: Conceptualization, Methodology, Resources, Writing – Original Draft, Writing – Review & Editing, Supervision, Project administration
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Conclusions: The IBW model is utilized but not limited to creating enteral and parenteral feeding plans, avoiding malnutrition, aiding weight management, identifying transplant eligibility, and determining inclusion or exclusion from research studies. Socially, the significance around "ideal" can impact a weight-centric mentality and negatively affect a large portion of the population. Every individual has a distinct "ideal" body weight based on genetics, environment and lifestyle, which could be represented and assessed effectively with new tools.

Keywords

Ideal body weight; BMI; predictive formulas; Met Life tables; nutrition assessment

I. Introduction

Ideal body weight (IBW) is defined as weight for height at the lowest risk of mortality. This definition results from a century's research on the association between anatomical characteristics and health. Employing weight, height, and frame size, IBW is calculated via height-weight tables[1,2,3,4,5,6]. IBW can also be calculated using one of many predictive formulas[4]. The cost-effective and efficient nature of the IBW model has provided healthcare practitioners and researchers a practical method of risk assessment. The model is based on Metropolitan Life Insurance Company (MLIC) data and has persisted with scrutiny[7]. Opponents criticize the manner of data collection, validity of subsequent IBW formulas, and the strength of the alleged association between obesity and health[4,5]. To define the modern placement of the IBW model in healthcare and research, it is necessary to critically analyze former findings. The preceding article functions as an examination and commentary on the development and clinical utility of the IBW model. It is not the intent of this text to deprive healthcare practitioners and researchers of numerical domains for risk assessment, but instead to draw attention to the complexity and overall discussion of utility of the IBW method

II. Development of the Ideal Body Weight Model

Uncovering the association between obesity and health advanced during the twentieth century through a partnership between the Actuarial Society of America and the Association of Life Insurance Medical Directors of America[4,8,9]. The collaboration led to the publication of *The Medico-Actuarial Mortality Investigation,* providing statistics of mortality for weight and height of insured persons. Anthropometric measurements of life-insurance policy holders were obtained between 1885 and 1908. While these provided reference values for average weight, the inability of the average weight to exhibit the lowest risk of mortality ultimately failed to create standard values for "ideal" weight[5]. This publication defined standard values of weight, and thus the origin of "ideal" weight.

To assess and publish standard values of weight, the MLIC partnered with statistician L.I. Dublin[8]. Anthropometric measurements were taken from four million MLIC policy holders and longevity was established as the primary criteria for "ideal" weight[8]. The data failed to obey normal distribution which Dublin attributed to the idea of variability in skeletal frame size or breadth[8]. Frame size by elbow breadth was found to be the most accurate and consistent across [3,8,10] and was subsequently linked to total body fat and fat free mass[11]. To account for frame size, recorded heights were classified as having either a small, medium, or large frame[3,12]. Additionally, Dublin removed the age component of the standard values, arguing that weight should not vary after growth has ceased[9]. Dublin's initiatives catalyzed publication of *The National Standards for Weight by Sex and Body Frame MLIC 1942-43*[8]. Finally, standard values indicated for the assessment of excess weight in relation to health were available to practitioners and researchers.

In the middle of the twentieth century, the Society of Actuaries along with 26 insurance companies examined the impact of obesity and blood pressure on health via *The Build and Blood Pressure Study*[8]. Weights were recorded from policy holders between 1935 and 1953; subjects were then followed until 1954 and risk of mortality was determined. Subsequently, the *Revised MLIC 1959 Standard Tables based on association with mortality* incorporated the updated data.

It is necessary to observe the development of BMI when commenting on the IBW method as the two inevitably converge. BMI, the ratio between weight and height, was first proposed by Belgian mathematician Adolphe Quetelet. In the 1835 publication, *A Treatise on Man and the Development of His Aptitudes*, Quetelet concluded an individual's weight increased as a function of their height squared[4]. This formula is expressed by dividing weight in kilograms by height in meters squared and offers a ratio, known as the Quetelet Index[8].

This formula remained unvalidated for decades. In the late twentieth century, validity was considered using data from the fourth iteration of the Framingham Heart Study[4]. Resulting research led to the adoption and rebranding of the Quetelet Index as BMI. Convergence of these indices occurred through The Fogarty Center Conference on Obesity (FCCO) in 1973[8]. The FCCO recommended acceptable ranges of weight for height. Employing Dublin's frame sizes, the FCCO set acceptable weight from the lowest perimeter of the *small* frame to the highest perimeter of the *large* frame; weight for height was then converted into BMIs, culminating in acceptable BMI ranges. The FCCO's acceptable ranges were later adopted by the USDA in the first edition of the *Dietary Guidelines for Americans* and by the National Health and Nutrition Survey 1976-80 (NHANES II).

IBW and BMI both address a relationship between health and mortality. Both are useful in large scale population studies due to the simplicity, low intensity and burden on the patients, and the information is readily available for anyone to use[5,6]. However, BMI is difficult to calculate without a calculator available. Both tools can be useful for generic target weight or weight loss goals but lack specificity in clinical care. They both fail to address body composition and overall nutritional status and cannot account for the metabolically healthy obese or the obesity paradox, where above-normal BMI can be protective in certain disease states[5,6]. During the second iteration of *The Build and Blood Pressure Study* in 1979, "desirable" weights were observed to have modestly increased[8]. Consequently, the *Revised MLIC 1983 tables* published slightly increased weights. Additionally, "ideal" and "desirable" were redacted from the tables due to misinterpretation of the terminology[8,9].

For a timeline of the development of the IBW model see Figure 1.

III. Clinical Utility of the Ideal Body Weight Model

Depending on the setting or healthcare center standards of practice, several different equations may be used. Access to Indirect Calorimetry to determine Resting Energy Expenditure is limited in acute care settings, and the use of standard predictive equations without stress factors may not be appropriate. Despite inconsistency, the potential options available may not be enough. As outlined in the history of predictive equations, it is known that not all demographics and comorbidities are considered for the most common and supported predictive equations. In the clinical setting, it is important to assess what additional benchmarks can be interwoven into predictive equations and tables that determine IBW. Demographic information, including sex/gender, age, and race/ethnicity are all important factors. The disease state of patients could also factor into the formulas used in identifying ideal needs.

Accompanying clinical judgement, the IBW model is utilized but not limited to creating enteral and parenteral feeding plans in obese populations, avoiding malnutrition in pediatric populations, aiding in development of goals for weight management, identifying transplant eligibility in cases of increased adiposity in the abdominal region, and determining inclusion or exclusion from research studies. Bariatric surgery prerequisites are also based on these equations, as are certain dosing requirements during parenteral nutrition in any population. IBW may be used in driving mechanical ventilation settings, thereby increasing the importance of a specified personal assessment of what an IBW should be. Additionally, exclusion criteria for research studies often include narrow weight parameters, and while exceptions can be made with the necessary approvals, there is theoretically no room for clinical judgement when working within these criteria and statistical analysis. These equations are used throughout the patient care process and assessment of needs constantly requires updating based on patient response. While this begs for simplicity in equations for fast application, the level of nuance per patient demands a more complex approach. The more complex a needs assessment becomes, the more likely the diagnostic process could be delayed.

IV. Criticism of the Ideal Body Weight Model

During the twentieth century, actuaries of the U.S. life insurance companies collected, analyzed, and published data on the impact of overweight/obese status and mortality risk [6,8]. Prior to this analysis, underweight policyholders were charged higher premiums due to the correlation between low weight and tuberculosis[7]. The overt bias and monetary incentives of U.S. life insurance actuaries was in part enabled by the subjective, inconsistent methods used in collecting measurements. Approximately 20% and 10% of weight and height data were self-reported for the *Revised MLIC 1959 Standard Tables based on association with mortality*, and *Revised MLIC 1983 tables,* respectively.

Furthermore, all MLIC tables failed to obtain anthropometric measurements without garments and utilized inconsistent factors to account for these variables[7]. Aside from weight and height data, frame size has also been under scrutiny. Without any evidence to guide the theory, frame size was defined, measured, and reported arbitrarily by the MLIC and Dublin.

Evidence of self-selection also exists within the samples from which data were collected[7]. Approximately two to three percent of policy holders were of overweight/obese status (defined as 20% to 30% above their "ideal" weight for height) and were made to pay higher premiums. However, the actual national occurrence of overweight/obese status at the time was between six and seven percent. This implies that policyholders paying higher premiums acquiesced due to additional health risks that were not disclosed to insurers, a behavior known as "selecting against the insurer."

While the U.S. life insurance companies dominated much of the discussion, there has been no lack of research on obesity and health[7]. Research of the same era repeatedly revealed either no significance or an inverse relationship between obesity and mortality, most of which was ignored by the U.S. life insurance companies.

V. Ideal Body Weight Predictive Formulas

Memorization of the IBW tables is cumbersome, and healthcare practitioners realistically prefer simple formulas that can be quickly employed[5]. Numerous IBW formulas have been developed to suit this purpose: Devine, Robinson et al, Miller et al, Broca, Hamwi, and Hammond[4,7]. While many of the formulas were derived from the MLIC Standard tables, some evolved from unknown origins.

Refinement of the IBW predictive formulas grew from the need to determine best practices for pharmacological dosing of patients. In the *Revised MLIC 1959 Standard Tables*, Robinson et al replaced the Devine IBW predictive formula[4] as the latter relied on anecdotal observation, the former deployed regression analysis of median weight for height at three frame sizes, offering a more validated approach.

When the MLIC tables were later updated, Miller et al – through the same methods as Robinson et al – developed an updated IBW predictive formula[4]. To account for anthropometric measurements including apparel, Miller et al subtracted five and three pounds for men and women, respectively. Additional predictive formulas include Broca, Hamwi, and Hammond; however, no method of development for these predictive formulas have been reported. Analysis has revealed significant similarities; likely due to the use of weight for height tables as source data[4,9]. Consequently, researchers have concluded them to be comparable[4,9].

Statistical comparison of predictive formulas has revealed variation between "ideal" weights at different heights[4]. IBW predictive formulas have failed to produce consistent BMIs across heights.

For a table of IBW predictive formulas see Table 1.

VI. Criticism of the Predictive Formulas: Ideal Body Weight and Body Mass Index

Despite flaws within the methods employed for the IBW tables, they have been central to development of the IBW predictive formulas and acceptable BMI. Consequently, regardless of whether the formulas are reliable, the standard used to determine validity (i.e., IBW tables) may itself lack the ability to measure what it intends to[4,7,8,9]. While frame size has been shown to possess a stronger correlation than stature to weight, researchers have found a significant variation in frame sizes between Caucasians and African Americans[13]. Additionally, the WHO found that some Asian populations with a BMI between 22-25 kg/m^2 still had higher risk for comorbidities like DM2 and CVD[14] despite frame. Such findings may warrant further investigation and stratification of frame size, IBW, and BMI by race.

Some have argued against the robustness of the predictive formulas[4,5]. IBW formulas assume that weight increases as a linear function of height. However, weight has been shown to increase not just as a function of height, but also of volume: body width, trunk length, and musculature. BMI attempts to account for this issue through squaring of the height. However, some have claimed this does not entirely repair the concern of weight as a function of height since there are still flaws with the upper and lower extremes of stature.

Overall, researchers have argued that IBW and BMI are too general, and the predictive formulas' intention is to measure lean body mass[4,5]. Additionally, height, weight, and frame fail to consider comorbidities and genetics[4,5,14].More refined technologies exist to do so: bio-electrical impedance (BIA), dual-energy x-ray absorptiometry (DXA), and Air Displacement Plethysmograph (ADP) which can be costly and time-consuming. In addition to IBW and BMI, there are several other body weight metrics available: Lean body weight (LBW), predicted normal weight (PNW), adjusted body weight (ABW), and fat free mass to name a few (FFM)[15]. LBW and PNW are predictive equations that both utilize sex and BMI in the calculations. These equations aim to represent the expected fat free weight and normal weight of an obese person. Both equations employ BMI and are subject to similar limitations. ABW was intended for better medication dosing in obese populations, but similarly utilize IBW and is subject to similar limitations. The FFM equation has potential. The data was produced from total body water, bone density, and body potassium measurements to determine if BMI could estimate FFM but was developed from an animal model and validated in one small study. IBW and LBW are important options when calculating medication, nutrition, or ventilation prescriptions in obese or critical care populations. Obesity and critical care status can impact certain medications' ability to metabolize properly in the body. Using actual weight may be more beneficial in obese populations when hydrophobic drugs are given in intervals, but LBW would be preferred for long infusions. The higher fat mass may cause medication to accumulate in slow dosing setups. Low weight patients (under 18.5 BMI) are also complicated based on critical care status. Depending on the reason for their low weight, some clinicians will use pediatric calculations using actual weight, however medication metabolism still varies in adults.

VII. Conclusion

The discussion regarding the dichotomy of exactness and flexibility is highlighted in this commentary. The IBW model has provided healthcare practitioners and researchers a quick and mostly effective method of risk assessment but is known to be imperfect.

Practitioners have found ways to manipulate the predictive equations to help them provide recommendations in acute care situations. Feed patients to meet their needs at goal weight but understand it is approximate. Assess and treat quickly, but also be thoughtful and consider all angles. Consider all disease states, track your thought process and math, and use clinical judgement.

Ambulatory and research use the same predictive numbers, but not always in the same way. Clinical judgement also applies to the outpatient setting, but when working with numbers and diagnostic definitions, there is typically less flexibility. In research settings, all patients in a study should be compared to the same standards for statistical significance, but those standards may not be appropriate for a diverse demographic. A researcher might be able to correct for the variations in equations if the equations were appropriately manipulated, otherwise they could be stranded with unintended cohorts. Research volunteers are included or excluded from participation based on hard cutoff points in tables that fail to reflect important demographic characteristics. Depending on the patient care scenario, it is necessary to use clinical judgement with regards to IBW estimates. It is an ever-evolving attempt to better the care delivered.

On the social level, the significance around “ideal” can impact a weight-centric mentality and unintentionally negatively affect a large portion of the population. Every person has a different “ideal” body weight based on their genetics, environment, and lifestyle, and not every person can fit into a neat mathematical table. Most of the tables don’t address demographics other than simple black or white races, and there are several important people who are not represented; mixed race, nonbinary, transgender, intersex, little people, disabled, or any number of co-morbidities.

Additionally, is race an appropriate demographic to use for differentiation at all? Race is a social construct and not biologically significant according to the Human Genome project, suggesting race may not be a necessary factor in determining IBW and overall health status. However, equal representation is important. Should the IBW tables/equations be updated? Should they be differentiated by more representative demographics? How many tables is too many? Should there be a shift in terminology from “ideal body weight” to “realistic body weight” or “functional body weight”? Can a universal calculator/app be developed to plug in basic demographics and health considerations to decrease the reliance on physical tables and improve speed of assessments? How can we use technology to our advantage with clinical assessments?

Further exploration into these questions is needed to learn about how we can move forward in research and clinical care.

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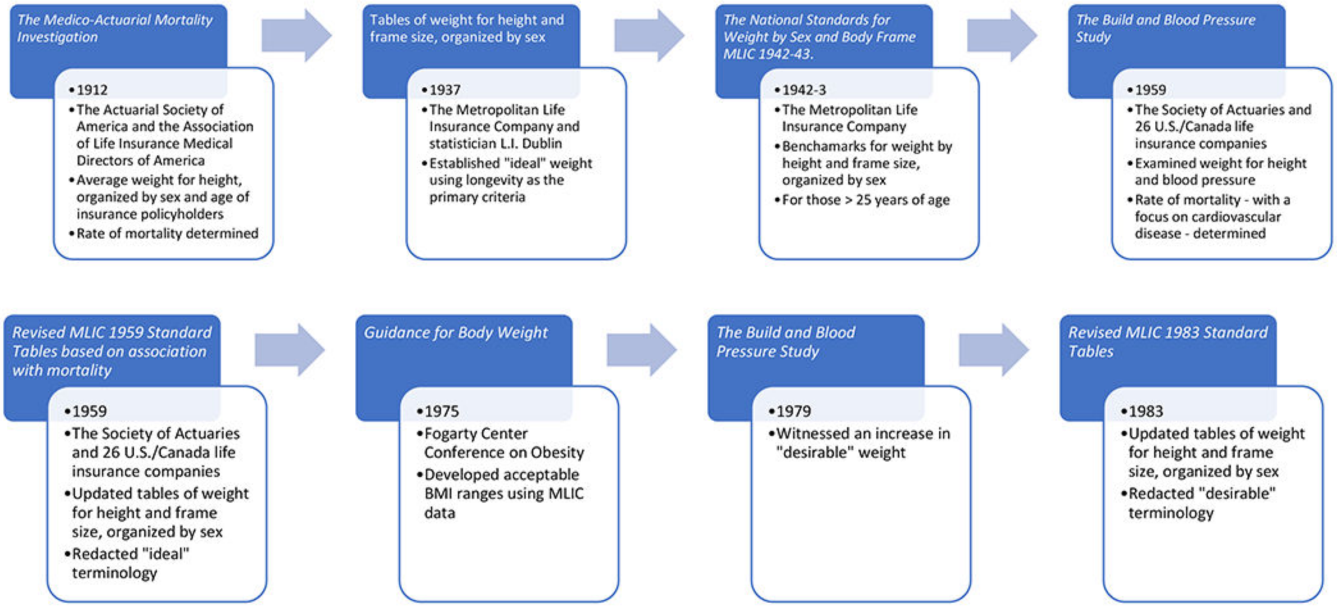

Figure 1:
Timeline of the development of the IBW model

- Dark blue box represents the title of the publication (book, article, table)
- Blue outlined white box represents the year of publication, attribution and brief summary of publication results
- Top row, read from left to right, light blue arrows pointing in the direction of the progression. Bottom row, read from left to right, light blue arrows pointing in the direction of the progression.
- Each publication in the timeline a catalyst for the next project/development in the ideal body weight timeline

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Table 1:

IBW predictive formulas

Author(s)	Year	Predictive Formula
Devine	1974	IBW (men) = 50 kg + (2.3 kg per inch over 5’)
		IBW (women) = 45.5 kg + (2.3 kg per inch over 5’)
Robinson et al	1983	IBW (men) = 52 kg + (1.9 kg per inch over 5’)
		IBW (women) = 49 kg + (1.7 kg per inch over 5’)
Miller et al	1983	IBW (men) = 55.7 kg + (1.39 kg per inch over 5’)
		IBW (women) = 53 kg + (1.33 kg per inch over 5’)
Broca	1871	IBW (kg) = height (cm) − 100
Hamwi	1964	IBW (men) = 106 lb + (6 lb per inch over 5’)
		IBW (women) = 100 lb + (5 lb per inch over 5’)
Hammond	2000	IBW (men) = 48 kg + (1.1 kg per cm over 150)
		IBW (women) = 45 kg + (0.9 kg per cm over 150)