COMPARISON OF PERCEIVED WEIGHT AS IDEAL AGAINST IDEAL BODY WEIGHT FORMULAS AND BODY MASS INDEX OF 22 KG/M$^2$ IN YOUNG ADULT WOMEN.

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ABSTRACT

Introduction: Formulas of ideal body weight (IBW) including the body mass index (BMI) of 22 kg/m² are used under the assumption to provide a healthy weight. Objective: We compare the perceived ideal body weight (PIBW) with the calculated IBW by formulas and the BMI of 22. Methods: We recruited 705 women (20-25 y). Six common formulas and 2 published equations by our team were used. Results: Group regression analysis determined that including the frame size improves the agreement of formulas of Robinson et al, Hammond and Hamwi with the PIBW (p>0.05). Individually, the concordance analysis (higher % of differences <2 kg: PIBW - IBW by formula), determined that for a measured BMI <20, only the Faspyn 1 formula needs to be adjusted by frame size; while Robinson et al, Hammond, Tokunaga (BMI of 22), Faspyn 2 (BMI of 22) and Broca, are equivalent with the PIBW in different intervals of BMI. Conclusions: According to the BMI perceived as overweight (23.8 kg/m²) and perceived as ideal (21.1 kg/m²), caution is suggested when using the IBW formulas for BMI of 22 as a diagnosis. The IBW formulas and BMI of 22 does not necessarily represent a desirable or aesthetic weight. Key words: ideal body weight formulas, perceived ideal body weight, BMI of 22.

RESUMEN

Introducción: El peso ideal calculado con fórmulas (PIF) y con el índice de masa corporal (IMC) de 22 kg/m2 se emplea bajo el supuesto de proporcionar un peso saludable o estético. Objetivo: Comparar el peso percibido como ideal (PPI) contra el PIF y del IMC de 22. Métodos: Se reclutaron 705 mujeres (20-25 años). Empleamos seis fórmulas comunes y 2 publicadas previamente. Resultados: El análisis de regresión grupal determinó que incluir la complección corporal mejora la concordancia de las fórmulas de Robinson et al, Hammond y Hamwi con el PPI (p>0.05). Individualmente, el análisis de concordancia (porcentaje mayor de diferencias <2 kg: PPI-PIF), determinó que para un IMC <20 kg/m² solo la fórmula de Faspyn 1 debe ajustarse por la complección corporal, mientras que las fórmulas de Robinson et al, Hammond y Tokunaga con el PPI (p>0.05). Individualmente, el análisis de concordancia (porcentaje de diferencias <2 kg: PPI-PIF), determinó que para un IMC <20 kg/m² solo la fórmula de Faspyn 1 debe ajustarse por la complección corporal, mientras que las fórmulas de Robinson et al, Hammond, Tokunaga (IMC de 22), Faspyn 2 (IMC de 22) y Broca, son equivalentes con el PPI en diferentes intervalos de IMC. Conclusiones: de acuerdo con el IMC percibido como sobrepeso (23.8 kg/m²) y percibido como ideal (21.1 kg/m²), las fórmulas de peso ideal y el IMC de 22 deben ser usados con precaución en el diagnóstico de peso ideal ya que no necesariamente representan un peso deseable o estético. Palabras Clave: fórmulas de peso ideal, peso corporal ideal percibido, IMC de 22.
Introduction
People use the internet or applications to know their ideal body weight (IBW) and maintain an aesthetic figure. Also, professionals refer to IBW formulas or body fat analyzers (Tanita® and Inbody®) that employ the BMI of 22 (kg/m²) to suggest a weight that is assumed as healthy and thus establish the objectives of the gain or loss of fat mass or nutritional risk (Bouillanne et al., 2005). There are more than a dozen of IBW formulas and some, such as the proposed by Robinson were generated from tables of the Metropolitan Life Insurance Company of 1959 or MetLife (Shan, Sucher & Hollenbeck, 2006). Robinson et al. as others, proposed a formula to calculate a dose of medication for patients. Other formulas, such as Hamwi, derived from empirical observations (Ramírez, Negrete & Tijerina, 2012), or as in the case of the formula of Broca, from a specific group of soldiers (Rössner, 2007).

The BMI of 22 was observed by Tokunaga, et al (Tokunaga et al., 1991), as an average value of BMI related to low mortality in Japanese population. Similarly, the IBW formulas only provide a punctual weight that represents the average of a group of medium frame size. Therefore, the BMI of 22 and the IBW formulas should be employed to be compared against an average population and not to suggest an individual weight. A study in Australian women 20 to 29 years old (Crawford & Campbell, 1999), reported that 28 per cent of them considered their ideal weight below the BMI <20; while the BMI considered as overweight was 23.7.

The body weight considered or perceived as ideal (PIBW) is the one that the patient wishes to have or that a person would feel better. This is a weight that an individual could find more familiar. Studies reviewed have only compared the IBW formulas among themselves or with the BMI of 22 kg/m² (Shan et al., 2006; Pai & Paloucek, 2000). Others compared the perception of an ideal figure based on images (Craig & Caterson, 1990). It is therefore not clear the agreement between the PIBW and the calculated IBW by formulas and BMI of 22. The objective of this study was to examine if the PIBW is in agreement compared to the calculated IBW by formulas and BMI of 22 in four intervals of BMI. Additionally, it was proposed to investigate: 1) whether including the body frame improves the group and individual agreement between the PIBW and the calculated weight with the IBW formulas, and 2) describe which BMI value is considered as overweight and which is considered ideal in the study group. The present study compares common IBW formulas and others recently proposed by our team, arising from height-weight tables for U.S and Mexican population (Ramírez et al., 2012).

Materials and Method
Design of Study and subject
For the purpose of carrying out the study we followed the recommendations of the Helsinki Declaration and the adoption of the Ethics Committee of the School of Public Health and Nutrition (Faspyn). This is a multi-centered descriptive study involving 4 schools of nutrition in four regions of Mexico: south (Chiapas); center (Hidalgo); northeast (Nuevo Leon) and northwest (Sonora). Women interviewed were 20 to 25 years (with a maximum BMI of 27.9) without cultural relationship with any indigenous group. The subjects were approached and invited to participate in public spaces such as shopping malls of middle socioeconomic level. The sampling was for convenience, with the aim of recruiting intentionally 200 subjects from each of the Nutrition schools. It was established to recruit from a single gender and an age range of 20 to 25 years to prevent the covariance by effect of gender and age. It has been suggested that in this age range is possible to have a reference weight for life (Kuczmarski & Flegal, 2000; Casillas & Vargas, 1980). All the anthropometric measurements and questionnaires were conducted during 2015 by nutritionists within the clinics of the participating schools. A general medical questionnaire was used to determine the health status of subjects, and to discard any pathology or the use of medications that could alter the weight or body composition in the previous three months. We excluded those patients who reported a loss of voluntary or involuntary weight greater than 2 per cent of their usual weight in the last week (Width & Reinhard, 2008). No blood samples were collected and neither blood pressure was measured to determine any cardiovascular risk factor.

Anthropometric measurements and ideal body weight (IBW) formulas
To use the IBW formulas we measured weight, height and elbow breadth by standardized

The frame size was established with the frame size index 2 from Frisancho (1990). Popular IBW formulas were used as well as two formulas developed by our team, which were previously described in detail (Ramírez et al., 2012; Table 1).

Table 1. Ideal body weight formulas used to be compared to the perceived ideal body weight.

<table>
<thead>
<tr>
<th>Author</th>
<th>Ideal body weight (IBW) formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokunaga et al., 1991</td>
<td>IBW kg = (height – 150) × 0.75 + 52</td>
</tr>
<tr>
<td>Robinson et al., 1985</td>
<td>Men: IBW kg = (height – 152) × 0.75 + 52, Women: IBW kg = (height – 152) × 0.67 + 49</td>
</tr>
<tr>
<td>Hamel, 1964</td>
<td>Men: IBW kg = (height – 152) × 0.75 + 52, Women: IBW kg = (height – 152) × 0.67 + 49</td>
</tr>
<tr>
<td>Broca, 1871</td>
<td>IBW kg = height – 100</td>
</tr>
</tbody>
</table>

Note: sex: female = 1, male = 2; age: years; height: cm, unless otherwise indicated.

Briefly, the Faspyn 1 formula is based on data from the Mexican population of 20 to 25 years. The Faspyn 2 formula was calculated on the basis of the BMI of 22 and according to tables published in the Dietary Guidelines for Americans 2010 (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010), which are a modification of the tables from MetLife (Kuczmarski & Flegal, 2000). The adjustment was made of ± 10 per cent from the calculated weight by each formula according to the frame size of each subject (subscript "adj").

Weight perceived as overweight and ideal

The participants were asked 1. – Ideally, how much would you like to weigh at the moment? 2. – In your opinion, what is the most you could weigh and still not consider yourself overweight? These questions were based on the questionnaire applied by Crawford and Campbell (1999). With these two questions, the questionnaire was piloted in 50 women to evaluate the inconsistencies of being self-administered. The weight reported by women was rounded in kg. The calculation for their BMI perceived as ideal (BMIpi) and BMI perceived as overweight (BMIpo) was done as follows:

\[ \text{BMI}_{\text{pi}} = \frac{\text{Weight perceived as ideal Kg}}{\text{Current height m}^2} \]
\[ \text{BMI}_{\text{po}} = \frac{\text{Weight perceived as overweight Kg}}{\text{Current height m}^2} \]

Statistical Analysis

The inferential statistic was made using the software MedCalc version 13.3. (MedCalc Software BVBA, Ostend, Belgium). The first analysis consisted on comparing the average of the current BMI vs. the BMIpi with a t-test for dependent samples. Between these two variables, we analyzed the strength of the linear relationship with the Pearson correlation test. The group and individual agreement from the weight calculated with the IBW formulas and BMI of 22 with the PIBW was examined respectively by regression analysis and concordance tests. With the regression method of Passing & Bablock (1983), the presence of systematic and proportional differences was evaluated. With this method, the result does not depend on the allocation of one method or the other to X or Y. Systematic differences were determined if the intercept A, was ≠ 0. With this, we test whether a method consistently presents positive or negative differences compared with another one. If there is a consistent bias, the differences can be adjusted from the subtraction of the mean of the differences of the other method. The proportional differences were established if the slope B was ≠ 1. Unlike the systematic differences, the proportional differences indicate a direction, and may be more extensive throughout the range of measurements.

The agreement between the calculated weight with the IBW formulas and the BMI of 22 against the PIBW was determined with the method of Bland & Altman (1999). The analysis consists on calculating the differences between two methods (PIBW – IBW formula) and graphic them against the average of their measurements (PIBW + IBW formulas / 2). The limits of agreement of ± 2 standard deviations indicate what size is the extent of the differences between the two methods in 95% of

Agreement of perceived ideal body weight adjusted by frame size ideal and the body weight by formula at different intervals of BMI

When the study sample was divided into the different intervals of established BMI, within each one, we selected the formulas with higher percentage of cases with differences <2 kg between the calculated weight with the IBW formulas and the PIBW (Table 3). The formula set by frame size of the Faspyn 1 was in agreement with the PIBW when the BMI is <21.0.

The formulas of Robinson and Hammond were in agreement with the PIBW when the BMI is between

21.0 and 22.9. When the BMI of the participants is between 23.0 and 24.9, the formulas of Tokunaga and Faspyn 2 correspond best to the PIBW. Finally, the formula of Broca was in agreement when the BMI was between 25.0 and 28.0. All the selected formulas had systematic differences in the different intervals of BMI observed (p <0.05). No formula presented proportional differences against the PIBW (p >0.05; Figs. a, b and c).

Figure 1. Passing and Bablok regression of perceived ideal body weight (PIBW) and the ideal weight estimated with several formulas (IBW) in different ranges of BMI (n= 705).

Body weight perceived as overweight and ideal. The BMI considered as overweight was 23.8 ± 2.7. Those who believe a BMI ≥22.0 as overweight were 73.0%. The BMI perceived as ideal was 21.1 ± 1.8. Those who perceive that their ideal weight is below the BMI of 22.0 were 68.6 %. Women who perceived that their ideal body weight is below the BMI <21 were 52.3%. Only 2.3% of women perceive their ideal weight between 25 and 27.9 of the BMI.

Discussion
In this study we asked if there was an agreement between the perceived ideal body weight (PIBW) and the calculated ideal body weight (IBW) by formula and the BMI of 22 in women of different ranges of BMI. In addition, we examined whether including the frame size improves the agreement between the PIBW and the calculated weight with the IBW formulas, also it was studied which BMI value is considered as overweight and which as ideal in the study group. To our knowledge there are no reports to which we can directly compare our results.
Agreement of perceived ideal body weight adjusted by frame size and the ideal body weight by formula in the total sample

In this study, we found that at a group level, adjusting by frame size improves the agreement between the PIBW and the calculated weight with the IBW formulas of Hammond, Robinson et al, and Hamwi. These formulas did not present proportional or systematic differences regarding the PIBW. However, it is remarkable that, even if they are not adjusted by the frame size, the formulas do not show proportional differences. Since they are maintained in a direction, it may be possible to correct the error by subtracting the mean of the differences. We did not find studies to directly compare our results. However, a study that compared the IBW formulas among them or with the BMI of 22 did not consider the adjustment of the frame size (Shan et al., 2006; Pai & Paloucek, 2000). Rookus, Burema, Deuremberg & Van der Wiel-Wetzesels (1985) pointed out that the adjustment of the body weight by the frame size does not necessarily improve the suggestion of IBW using the tables from MetLife 1983. According to our results, this observation agrees with some formulas when compared to the PIBW. Another interesting result we found was that the formula of Robinson, without adjustment by frame size, had the lowest average value of difference (0.2 kg) with the PIBW. The Robinson formula was derived from the tables of MetLife 1959 where the frame size was arbitrarily defined by an examiner (Kuczmarski & Flegal, 2000). It is accepted that weight when calculated by formula, a 10 per cent of weight is subtracted for a thin frame size and a 10% is added for a robust frame size. This is done under the assumption of correcting weight due to the size of the skeleton, the height and body fat. The % of body fat could be lower for a tall person than that for a short person of the same weight. Likewise, percent of body fat would be lower for a person with a large frame size than for someone with a small frame size with similar height and weight. However, Rookus et al. (1985) also suggests that the use of the frame size might not improve the prediction of % of body fat.

The reason that formulas of Hammond and Hamwi improve the group agreement with the PIBW when they are adjusted by the frame size could be explained by their relationship more than by its methodological structure. Hammond is only the metric system version of the formula of Hamwi, although the first uses a lower limit of height (Pai & Paloucek, 2000). Regarding the BMI of 22, the formula of Tokunaga and Faspyn 2 showed systematic differences with or without adjustment by frame size (Table 2). Again, we did not find studies to directly compare our results. We believe there is little focus on the hypothesis of the agreement between the PIBW and the BMI of 22, because it assumes that both the IBW formulas as well as a BMI of 22 provide a healthy and similar weight to one same subject, regardless of which formula is used (Shan & Sucher, 2006; Pai & Paloucek, 2000). Also, it is wrongly assumed that the BMI of 22 is the average interval internationally accepted (18.5 to 24.9 kg/m²), and that it is the "healthiest" and most aesthetic for any individual.

Agreement of the perceived ideal body weight adjusted by frame size and the body weight by formula at different intervals of BMI

The BMI of 22 represents an average weight associated with the lowest mortality and morbidity in Japanese population, of medium frame size, but it is not a value for individual use (Tokunaga et al., 1991). The BMI of 22 does not consider the differences or individual preferences of an ideal weight considering a current BMI <21 or between 23 and 24.9. To verify the foregoing, we divided the sample in 4 ranges of BMI (<21, 21-22.9, 23-24.9 and 25-27.9) and compared the IBW formulas and BMI of 22 against the PIBW adjusted and not by frame size.

In this study, we demonstrate that at the individual level, including the frame size, improves the agreement between the PIBW and the calculated weight with the Faspyn1adj formula, which was the only one that showed differences <2 kg in 50% of cases when the BMI was <21; while the second with most agreement was Hamwi, with only 32% of the differences <2 kg (Table 3). Figure 1 (a), verifies that the relationship between the PIBW and the IBW Faspyn 1 formula is linear, and presents no proportional error. A study that compared the IBW formulas vs. the tables of the MetLife reported that women of lower height had a BMI close to 20 kg/m², and that the formula of Hammond adjusted better to these women (Shan et al., 2006). In our case, the Faspyn 1 formula was the only in agreement with

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correspond best with the PIBW at different intervals of BMI. According to the BMI perceived as overweight (23.8 kg/m²) and perceived as ideal (21.1 kg/m²), caution is suggested when using the IBW formulas and BMI of 22 as diagnostic values and to establish goals for the gain or loss of body fat. The IBW formulas or BMI of 22 does not necessarily represent the individual desirable weight or aesthetic weight in the entire range of 18.5 to 24.9 of BMI. For example, a woman with a current BMI of 19 would have to increase 8 kg to reach the weight that corresponds to a BMI of 22. Other studies should validate the IBW formulas and the PIBW in women at BMI levels of overweight and thinness with the use of clinical indicators associated with morbidity. In addition, the results in males should also be evaluated.

References


