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Agreement between aesthetic body weight and healthy body weight in a sample of spanish woman with excess weight: a cross-sectional study

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Abstract

Aesthetic BW (aesBW) is defined as a %FM=32 in women, while healthy BW (hBW) is defined as a Visceral Fat Area (VFA)<100 cm2. Both are calculated by the equations: aesBW=BWi-[(%FMi-32)x1.59] and hBW=BWi-[(VFAi-100)/4.42]. The Guidelines for reporting reliability and agreement studies were followed. The aim was to evaluate the agreement between the aesBW and hBW in a sample of women with overweight. Cross-sectional study. Inclusion criteria: women aged≥18 years, overweight (30≤%FM<40) or obesity (%FM≥40) and VFA≥100 cm2. Height, body composition, aesBW and hBW were computed. A paired Student´s t-test was applied along with a a scatter plot and a simple regression. A "survival agreement plot" was applied, agreement was considered good, if in at least 75% of cases, d│aesBW-hBW│<4 kg and Effect Size (ES)=t x√((2×(1-r)^)/n). was estimated. SPSS v. 25. was employed. n=360, %FM=43.73±5.64, d(aesBW-hBW)=-1,1192±3,72 kg. In 226 cases hBW>aesBW versus 134 cases aesBW>hBW. The d│aesBW-hBW│<4 kg in 68,3% of cases (75,4% and 64,2% in cases where aesBW>hBW and hBW>aesBW). The ES=0.084 was moderate. hBW systematically overestimated aesBW by around 1 kg. At a global level there is poor agreement. By subgroups agreement is good in cases where aesBW>hBW but poor in cases where hBW>aesBW respectively.

Keywords:

- Obesity
- Weight loss
- Ideal body weight
- Aesthetic body weight
- Healthy body weight

Introducción

Obesity is a complex, multifactorial, chronic, and relapsing disease, associated with increased morbidity and mortality, which has reached a pandemic scale. While the CoViD19 pandemic appears to be in remission, the obesity pandemic goes on propagating worldwide. The prevalence of obesity is higher in women than in men, across all age groups and the prevalence of excess weight raises with age, reaching a zenith between 50-65 years-old and showing a slight decline thereafter. The prevalence of overweight and obesity in the european región of the EU is nearly a 60% (1). For this reason, it poses a public health challenge.

The treatment of obesity is based on a low-energy diet, physical activity, psychological therapy, pharmacological treatment and metabolic surgery. The first line of intervention and the foundational basis of treatment, regardless of the implementation of other adjunctive therapies, is the change in habits that promote a healthy lifestyle (2).

The need to characterize the phenotype in obesity is acquiring great prominence, since there is not a single type of obesity but rather as many obesities as individuals. This approach will facilitate the personalized treatment and contribute to the development of precision medicine (3).

Body Weight (BW) loss is the main reason for medical consultation, with "health" as the predominant reason over "aesthetics", as weight and the presence of comorbidities increases. BW loss is associated with an improvement in glycemic control and dyslipemia, which leads to a reduction in cardiometabolic complications. The comorbidity and the magnitude of its reduction is weight-dependent. While modest weight losses of 5-10% over 6 months translate into improvements in Insulin Resistance (IR), Type 2 Diabetes Mellitus (T2DM), High Blood Pressure (HBP) and Cardiovascular Disease (CVD), greater weight losses of around 15% are required to achieve improvements in the Metabolic Dysfunction-Associated Fatty Liver Diseases (MAFLD) and Obstructive Sleep Apnea Syndrome (OSA) (4).

In this context, deep phenotyping of body composition takes on particular relevance, as it allows for the discrimination of the quality of weight loss (5). Achieving a BW that maximizes the loss of Fat Mass (FM), particularly Visceral Fat Area (VFA), to decrease cardiometabolic risk and minimizes the loss of Skeletal Muscle-Mass (SMM), as well as its long-term maintenance, are the primary goals of treatment.

The target BW should be agreed upon between the patient and the healthcare professional, taking into account factors such as age, sex, initial BW, weight history, cardiometabolic risk, feasibility of long-term weight loss maintenance, etc. Nevertheless, BW is not a good measure of body composition. In fact, for the same BW and weight there is a gradient of infinite body compositions.

Classic approaches to estimate target BW are based on (6):

1. Estimation from height-weight tables (ht-BW).
2. Ideal BW (iBW) prediction equations.
3. Body Mass Index, defined as BMI= P(kg)/[T(m)]2.

Historically, the concept and definition of target BW have been controversial, among other reasons, due to the absence of a standardized operational definition, estimations based on different paradigms (ht-BW tables, iBW prediction equations and BMI), obsolete strategies that fail to capture the body composition of the contemporary population and the existence of multiple ht-BW tables and iBW prediction equations (6).

As regards the first ht-BW table, it dates back to 1912 and corresponds to subjects assessed with clothing and footwear. The most recent one is from 1960 which incorporates individuals aged 20-29. The most widely used ht-BW tables are the 1959 Metropolitan Life Insurance tables which are a function of BW, Ht and body frame size with a later update incorporating the 1979 database Build Study database in 1983 (6).

As concerns the prediction equations there are multiple iBW prediction equations, with height being the usual variable. The foundational formula is that of Dr. Hamwi GJ from 1964. Devine BJ, Robinson et al., and Miller et al. developed new equations via linear regression, although the structure of the equations remains the same, and the coefficients vary subtly. More recently, authors such as Lemmens HJ et al have proposed simpler equations (6).

In relation to the quotient P(kg)/[T(m)]2, it was developed by the statistician Adolphe Quetelet (1796-1874) and denominated the Quetelet Index, later renamed BMI in the 20th century by the physiologist Ancel Keys (1904-2004) who applied it in a study of 12 samples that included 7,426 healthy subjects (6). According to the BMI categories established by the International Obesity Task Force, the target BW corresponds to a BW with a BMI within the normal range 18.5≤BMI<24.9, that is to say 18.5 x T(m)2≤BW goal<24.9 x T(m)2. The BW values corresponding to a BMI within the normal range are associated with lower morbidity and mortality in caucasian individuals aged < 74 years. The BMI-mortality distribution follows a U-shape, but when adjusted for the smoking habit, alcohol consumption and age, it becomes linear (reverse causality: morbid conditions induce low BMI). For BMI values >30, the mortality risk is increased, while values of 25<BMI≤30 correspond to a grey zone, where the risk depends on the number of comorbidities.

We are not aware of any equations that incorporate body composition variables related to adiposity and lean mass.

Aesthetic BW (aesBW) was defined as the weight corresponding to a %FM within normal range according to Gallagher (women: 32%) and healthy BW (hBW) was defined as a Visceral Fat Area (VFA) <100 cm2. Both are determined by the following equations: aesBW=BWi-[(%FMi-32)x1.59] and hBW=BWi-[(VFAi-100)/4.42], where BWi, %FMi and VFAi represent baseline values according to a previous study that proposed an operational definition of the quality of weight loss (5).

The Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were developed to improme the methodological quality and reporting of agreement studies (7).

The objective of this study is to evaluate the agreement between the aesBW and hBW in a sample of overweight or obese women.

Material and methods

Cross-sectional study. A consecutive series of patients who attended a private clinic for weight loss and signed an informed consent form. The inclusion criteria were: women aged≥18, overweight (30≤%FM<40) or obesity (%FM≥40) and VFA≥100 cm2. Height (SECA 222 stadiometer) and body composition (BIA, Inbody 770) were assessed.

The aesBW was calculated as: BWi-[(%FMi-32)x1.59] and the hBW as: BWi-[(VFAi-100)/4.42].

A pair t-Student test was applied to evaluate whether there were differences between aesBW and hBW.

A scatter plot was built with d(aesBW-hBW) on the y-axis and mean (aesBW-hBW) on the x-axis and a simple regression was applied to detect whether proportional bias existed.

Good agreement was defined as cases where at least a 75% of the differences=d│aesBW-hBW│<4 kg. This threshold was chosen because for every 4 kg of weight gained, the BMI increases by 2 units.

The Bland-Altman plot is the method traditionally used to evaluate agreement between two measurement methods for quantitative variables. The criteria for its application include: measurement of the same variable in the same subjects, continuous data, the presence of a statistically significant constant bias (difference), the curve of the differences follows a normal distribution and homocedasticity (the magnitude of differences should remain constant across the range of measured values, not systematically increasing or decreasing) (8).

Ludbrook recommends calculating the regression line that best fits to predict the differences from the means. If regression curve slope differs from zero, there is proportional bias. In that scenario a log-transformation can be performed and the procedure repited, or other methods can be applied (9). The latter option was chosen.

If any of the criteria for applying the Bland Altman method were not met, "the survival agreement plot" will be applied, plotting d│aesBW-hBW│on the x-axis and the proportion of cases with d│aesBW-hBW│≥4 kg on the y-axis, for the global level (10) and for the cases where aesBW>hBW and hBW>aesBW respectively (11).

The Effect Size (ES) was estimated using the equation from Dunlap et al. (17) ES=t x√((2×(1-r)^)/n). (12). SPSS v. 25. was used for the analysis.

Results

Sample of n=360 with excess weight (BMI=30.71±5.17 kg/m2, %FM= 43.73±5.64, ALMI=7.07±0.76 kg/m2). The aesBW=61.73±10.62 kg and hBW=62.85±7.93 Kg.

Variable	$\bar{x}$±SD	Min-Max
Age (años)	47±13	18-78
Wt (kg)	80,38±13,9	53-139,5
Ht (m)	1,62±0,06	1,42-1,8
BMI (kg/m2)	30,71±5,17	21,7-47,9
FM (%)	43,73±5,64	30,6-57,3
FM (kg)	35,65±10,06	21,10-73,4
FM_ra (kg)	3,17±1,5	1,5-10
FM_la (kg)	3,19±1,5	1,5-10
FM_t	17,42±4,18	10,5-29,7
FM_rl (kg)	5,27±1,47	3-12,1
FM_ll (kg)	5,23±1,45	2,9-12
VFA (cm2)	177,48±43,1	101,9-289
aesBW	61,73±10,62	35,83-106,75
hBW	62,85±7,93	47,16-104

n: sample size; $\bar{x}$: Mean; SD: Standard Deviation; Wt: weight; Ht: height; BMI: Body Mass Index; FM: fat mass; FM_ra: Fat Mass right arm; FM_la: Fat Mass left arm; FM_t: Fat Mass trunk; FM_rl: Fat Mass right leg; FM_ll: Fat Mass left leg; FFM: Fat Free Mass; VFA: Visceral Fat Area; aesBW: aesthetic Body Weight; hBW: healthy Body Weight.

Table 1: Descriptive statistics of body composition parameters related to adiposity.

Tables 1 and 2 show the body composition parameters related to adiposity and lean mass respectively.

A strong correlation was found between aesBW and hBW (r Pearson=0.961).

The paired t-Student test revealed the existence of a difference (d)=aesBW-hBW=-1.1192±3.72 kg (IC 95%: -1.5;0.73), statistically significant (p=0.00) between the prediction of aesBW and hBW.

Variable	$\bar{x}$±SD	Min-Max
FFM (kg)	44,72±5,65	30,3-66,1
LM (kg)	42,16±5,35	28,4-62,3
LMra (kg)	2,4±0,45	1,29-5,1
LMla (kg)	2,37±0,45	1,28-5
LMrl (kg)	6,93±1,02	4,46-11,78
LMll (kg)	6,9±1	4,36-11,66
ALM (kg)	18,6±2,73	11,85-30,97
ALMI (kg/m2)	7,07±0,76	5,06-10
SMM (kg)	24,46±3,39	15,80-36,3
Ei	0,383±0,006	0,37-0,41

FFM: Fat Free Mass; LM: Lean Mass; LMra: Lean Mass right arm; LMla: Lean mass left arm; LMrl: Lean Mass right leg; LMll: Lean Mass left leg; ALM: Appendicular Lean Mass; ALMI: Appendicular Lean Mass Index; SMM: Skeletal Muscle Mass; Ei: Edema Index.

Table 2: Descriptive statistics of body composition parameters related to lean mass.

Chart 1: Scatter plot: d(aesBW-hBW) y media [(aesBW+hBW)/2]

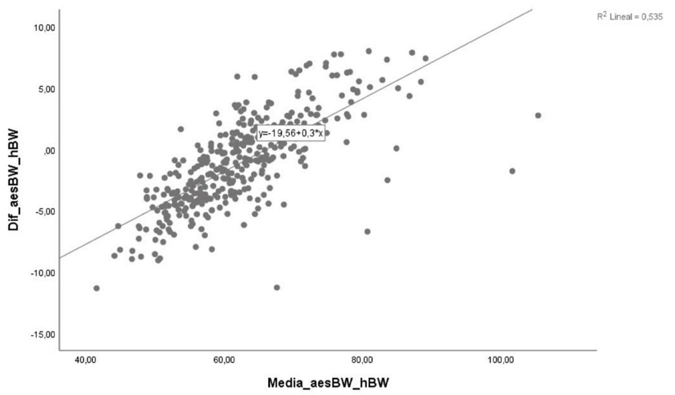


Chart 1 (scatter plot) which presents the difference (aesBW-hBW) against the mean [(aesBW+hBW)/2] highlights the existence of a systematic bias. An upward trend is observed, where the difference (aesBW-hBW) grows as the mean increases.

Table 3 presents the simple regression model, where d(aesBW-hBW)=-19.560+0.3xmedia (aesBW-hBW) (R2=0.535) and β1=0,3 (p=0.00) indicating a strong goodness of fit of the model: F (1.358)=412.15 (p=0.00). The mean explained 53.5% of the variability in the difference.

Model	B	Typical error	β	p
Constant	-19,560	0,918		0,000
mean [(aesBW+hBW)/2]	0,296	0,015	0,732	0,000

Table 3: Simple regresión model to predict d (aesBW-hBW) a from mean [(aesBW+hBW)/2].

The existence of a proportional bias prevents the Bland-Altman method from being applied. By default, the "survival agreement plot" was applied.

Chart 2: Survival-agreement plot for all cases.

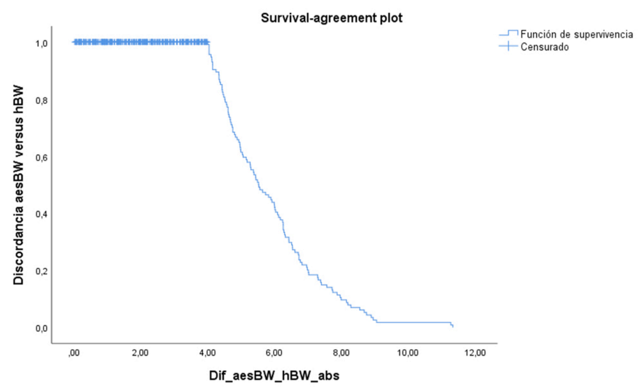
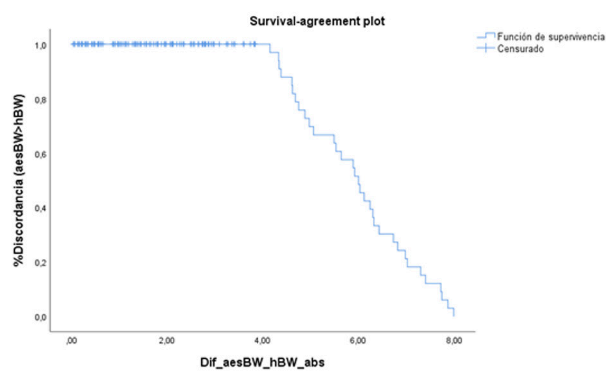


Chart 2 shows the d|aesBW-hBW|(x-axis) and the proportion of cases with d|aesBW-hBW|≥4 kg (y-axis). In 68.3% of the cases d|aesBW-hBW|<4 kg.

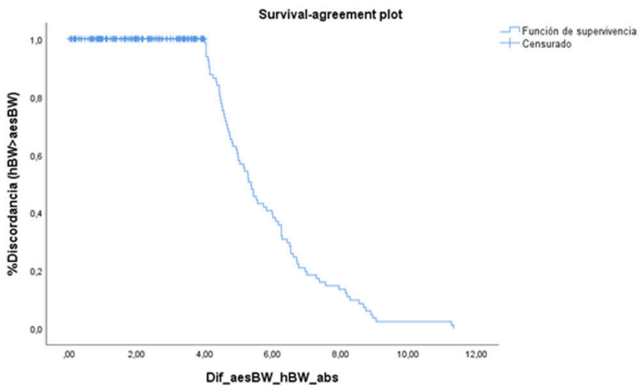
In 226 cases, aesBW<hBW and in 134 cases, aesBW>hBW, respectively.

Char 3: Survival-agreement plot for all cases where aesBW>hBW.



Charts 3 and 4 show d│aesBW-hBW│(x-axis) and the proportion of cases with d│aesBW-hBW│≥4 kg (y-axis) by subgroups: those where aesBW>hBW and hBW>aesBW respectively.

Chart 4: Survival-agreement plot for cases where hBW>aesBW.



Casos discordantes	aesBW-hBW≥4	hBW-aesBW≥4	Totales
nº	33	81	114
%	33/134=24.6	81/226=35.8	
Casos concordantes	aesBW-hBW<4	hBW-aesBW<4	
nº	101	145	246
%	101/134=75.4	145/226=64.2	
Totales	aesBW>hBW 134	aesBW<hBW 226	360

Table 4: Discordant cases, concordant cases and proportions.

Table 4 shows the discordant cases, concordant cases and proportions.
d│aesBW-hBW│<4 kg in 75.4% of the cases where aesBW>hBW and in 64.2% of the cases where aesBW<hBW respectively.
The ES=0.084 was moderate.

Discussion

The target BW that a patient with excess weight should achieve must be the result of a consensus between the healthcare professional and the patient. However, since BW is not a good reflection of body composition, the target %FM and LM should also be taken into account. We are not aware of any studies that have proposed prediction equations for the target BW, that incorporate body composition variables, with the exception of the preliminar study mentioned (5). The main limitation of that study is its small sample size and that it only includes parameters related to adiposity. The ideal formula should also incorporate parameters linked to lean mass.
The concept of target BW is controversial for the following reasons:
1) Lack of harmonization of the terminology: iBW, adjusted BW (adjBW), hBW, lean BW (lBW), etc.
2) Outdate tables and equations: Ht-BW tables and iBW prediction equations are very old and do not capture the body composition of the contemporary population.
3) Different underlaying concepts. BW-ht tables and iBW prediction equations refer to different concepts. Both ht-BW and BMI correspond to BW associated with lower morbidity and mortality, whereas iBW prediction equations correspond to pharmokinetic for drug dosing, where a good correlation between the iBW and lBW was found.
4) Lack of consensus: There are multiples tables and prediction equations for iBW.
5) Biased asumptions: Prediction equations assume that iBW correlates with Lean Mass (LM).
6) Equation variables: BMI does not differentiate between FM and FFM.
7) Validity of equations: there is no gold standard method for estimating target BW. Additionally, some equations, sucha as Devine BJ´s are based on empirical estimations rather than data inferred from a population sample.
AesBW and hBW are strongly correlated. hBW is more ambitious than aesBW. On a global level (without discriminating by cases), there is not a good agreement between hBA and aesBW, as the difference│aesBW-hBW<4 kg in 68.3% (<75% as established a priori) of cases. At the subgroup level (discriminating when aesBW>hBW versus aesBW<hBW) there is a good agreement only in the cases where aesBW>hBW.

Conclusions

The absolute difference between aesBW and HBW is small, with hBW overestimating the aesBW by approximately 1 kg. The goal defined by hBW is more ambitious than that of aesBW. Overall, there is poor agreement between hBW and aesBW. At the subgroup level, good agreement exists in cases where aesBW>hBW. Further studies are required to develope prediction equations for target BW based on body composition parameters related to adiposity and lean mass.

Conflicts of interest

The authors declare not to have conflicts of interest.

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