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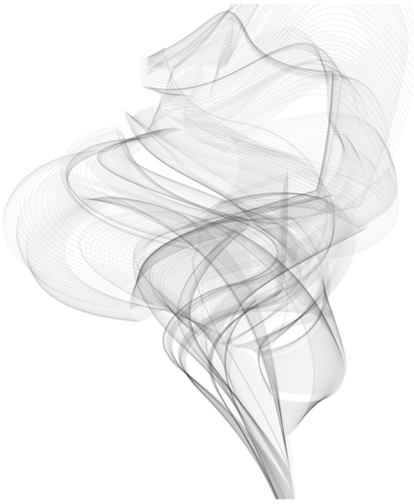

Visual estimation of body weight status in adults

Tânia de Jesus Jorge

Supervised by:

Prof.ª Doutora Ana Patrícia Diogo Padrão Ferreira

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Master's Degree in Metabolic Diseases and Eating Behavior

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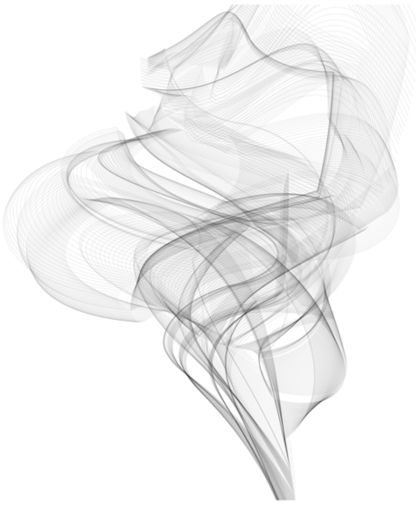

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The printing of this dissertation was approved by the Coordinating Committee of the Scientific Council of the Faculty of Medicine of Lisbon meeting on December 18th, 2018.

Dedicated to

My family

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List of Abbreviations

BMI	Body Mass Index
IMC	Índice de Massa Corporal
NHANES	National Health and Nutrition Examination Survey
OMS	Organização Mundial de Saúde
WHO	World Health Organization

Abstract

Background: Self-reported weight and height are often inaccurate. Self-selected figure from body image scales and its corresponding BMI are often high correlated with measured BMI in adults. Validity on visual estimation of others' body weight by using body image scales are poorly studied. It might have particular interest in epidemiological studies with high population samples when it is not possible to directly measure weight and height.

Aims: To test the ability of trained observers to accurately classify adult individuals by observation regarding weight status and to verify inter-observer concordance

Methods: A cross-sectional survey was performed at a laboratory of clinical analyzes from May to June 2018. A sample of 127 adults (over 18 years of age), 70 women and 57 men was included. Data collection on age, weight, height and BMI was done by structured observations (variables in categories) and anthropometric measures. Age and anthropometric measures were compared between sexes using t-test for independent samples (parametric variables). Shapiro-Wilk test was performed to test variables for normality. Sensitivity, specificity and likelihood ratios (positive likelihood and negative likelihood) were assessed to validate the accuracy of estimating obesity or overweight/obesity by trained paired observers. Chi-square tests and Fisher's exact tests were performed to assess the association between correct identification of obese and non-obese individuals and overweight/obese and non-overweight/obese according to the sex of observer, sex of participant and age of participant. Kappa statistic was performed to test inter-observer reliability for estimated height, weight and BMI categories.

Results: Less than half (41.4%) of obese individuals (BMI ≥ 30 kg/m2) and 72.8% of overweight/obese participants were correctly identified. Despite the higher sensitivity in estimating overweight, it was 11.5 times more likely to identify obesity than overweight (including obesity) (LR+ = 11.5 and LR+ = 3.4, respectively). Sex of observer, sex of participant and age of participant were shown to be statistically associated with the estimation of obesity and overweight: women observers estimated obesity more accurately than men observers (56.8% vs. 14.3%, p=0.002); overweight men participants were more correctly identified than women participants (80.0% vs. 65.6%, p=0.029); specificity was 100% for non-obese men participants (p = 0.014) and for non-overweight/obese women (p = 0.002). Older age increased sensitivity to detect obesity (from 20.0% for 18-34 years old to 54.2% for 55 years old or more) and slightly decreased sensitivity to detect overweight/obesity (from 79.2% for 18-34 years old to 76.8% for 55 years old or more). Agreement between observers was moderate to substantial for height (κ = 0.62), weight estimates (κ = 0.46) and BMI estimates (κ = 0.51).

Conclusions: Accuracy of estimated weight status was moderate to low. Nevertheless, observers were able to distinguish normal weight from overweight with high sensitivity and specificity.

Keywords: estimated weight, body mass index, anthropometric measures

Resumo

O peso é uma medida antropométrica de elevado interesse em estudos epidemiológicos, tanto em estudos de prevalência como em estudos de associação com diversas patologias, mortalidade, custos em saúde, entre outros. Numa altura em que a obesidade é já considerada pela Organização Mundial de Saúde (OMS) como a epidemia do século XXI, (re)conhecer o excesso de peso em nós próprios e nos outros, como por exemplo em filhos, é fundamental para a mudança necessária.

Em estudos populacionais é frequente recorrer-se a dados de peso e altura auto-reportados os quais podem ser imprecisos. Os indivíduos tendem a subestimar o peso e superestimar a altura, o que resulta numa subestimação do índice de massa corporal (IMC), a medida mais usada para categorizar o peso dos participantes como baixo peso, peso normal, excesso de peso e obesidade. Quando não é possível medir e pesar diretamente os participantes, especialmente em amostras populacionais grandes onde são necessários muitos recursos físicos e humanos, é questionável se estimar o peso e altura por observação pode ser mais preciso do que as medidas auto-reportadas pelos participantes.

O Índice de Massa Corporal (IMC) identificado por classificação da auto-imagem através escalas de imagem corporal tem mostrado ter uma boa correlação com o IMC medido em adultos. A validade da estimativa visual do peso corporal de outros com recurso a escalas de imagem corporal ainda é pouco estudada.

A presente dissertação tem como principal objetivo aprofundar o conhecimento sobre a capacidade de observadores treinados em classificar o peso de indivíduos adultos por meio de observação com recurso a escalas de imagem corporal.

A dissertação divide-se em dois capítulos: o primeiro é uma revisão da literatura existente sobre o uso de escalas de imagem corporal, o uso do peso e altura auto-reportados e o método de estimativa visual do peso; o segundo descreve o estudo experimental desenvolvido para testar a exatidão da estimativa do estado ponderal por observação e verificação da concordância entre observadores.

O estudo de desenho transversal realizou-se num laboratório de análises clínicas de maio a junho de 2018 com uma amostragem de 127 adultos (acima de 18 anos de idade), 70 mulheres e 57 homens. Os dados de idade, peso, altura e IMC foram obtidas tanto por meio de estimativas por observações como por medições antropométricas. A idade e as medidas antropométricas foram comparadas entre os sexos pelo teste *t-student* para amostras independentes (variáveis paramétricas). O teste de Shapiro-Wilk foi realizado para testar as variáveis quanto à normalidade. A sensibilidade, especificidade e razões de verossimilhança (verossimilhança positiva e verossimilhança negativa) foram calculadas para validação da exatidão das estimativas de obesidade e excesso de peso. Os testes *chi-square* e o teste de *Fisher* permitiram avaliar a associação entre a correta identificação de obesidade e excesso de peso e o sexo do observador, sexo do participante e idade do participante. Determinou-se a estatística *kappa* a fim de testar a concordância entre observadores para a altura, peso e IMC estimados.

Os principais resultados do estudo foram: 1. menos da metade (41,4%) dos indivíduos obesos (IMC ≥ 30 kg/m2) e 72,8% dos participantes com excesso de peso/obesidade foram corretamente identificados; apesar da maior sensibilidade em estimar o excesso de peso do que a obesidade, foi 11,5 vezes mais provável identificar obesidade do que excesso de peso (incluindo obesidade) (LR + = 11,5 e LR + = 3,4, respetivamente) / 2. o sexo de observador, sexo do participante e

idade do participante associaram-se com significado estatístico com a estimativa de obesidade e excesso de peso: as mulheres estimaram a obesidade com maior exatidão do que os homens (56,8% vs. 14,3%, $p = 0,002$); os participantes homens com excesso de peso foram mais corretamente identificados do que mulheres participantes (80,0% vs. 65,6%, $p = 0,029$); a especificidade foi de 100% para homens não obesos ($p = 0,014$) e para mulheres com excesso de peso ($p = 0,002$); o aumento de idade aumentou a sensibilidade para detetar a obesidade (de 20,0% para 18-34 anos para 54,2% para 55 anos ou mais) e diminuiu levemente a sensibilidade para detetar o excesso de peso (de 79,2% para 18-34 anos para 76,8% para 55 anos ou mais) / 3. a concordância entre os observadores foi moderada a substancial para a altura ($\kappa = 0,62$), peso ($\kappa = 0,46$) e IMC ($\kappa = 0,51$).

Os observadores treinados classificaram o estado ponderal com uma exatidão moderada a baixa. Dado que os observadores foram capazes de distinguir o peso normal do excesso de peso com alta sensibilidade e especificidade, hipotetizámos que a estimativa de peso por observação pode, em determinadas circunstâncias e objetivos de estudo, ser utilizada com eficácia.

É necessária mais investigação comparativa entre o peso auto-reportado e o peso estimado por observação com uso de escalas de imagem corporal para compreender se o método de observação pode ser um método mais exato do que o peso auto-reportado.

Palavras-chave: estimativa peso, índice de massa corporal, medições antropométricas.

Introduction

In epidemiological studies, with high population samples, it becomes a practical requirement to make a direct measurement that allows us to access the anthropometric data of all participants. Numerous physical and human resources are required, as well as enormous control throughout the data collection procedure. Thus, despite all the limitations that are pointed out, self-reported weight and height are often used in epidemiological studies.

Studies have shown that individuals tend to underestimate their weight and to overestimate their height resulting in an underestimation of body mass index (BMI), which is more pronounced in women [1,2]. It is still interesting to verify that from different countries there are differences in the discrepancy between the measured weight and the self-reported weight [3,4], which leads us to believe that the culture itself also greatly influences the way we perceive weight and body image.

When the goal is to relate BMI with disease risk, such as cardiovascular disease, in cohort studies, despite the weak association between self-reported weight and measured weight, there is still a strong correlation with disease risk [5].

The present investigation intends to test the capacity of trained inquirers to estimate body weight in adults and correctly assess BMI by using body image scales.

This thesis is organized in two chapters. The first one is a review of the existing literature regarding the use of body image scales, accuracy of self-reported measures and visual estimation of body size.

Chapter two describes the experimental study developed to test the accuracy of assessing BMI in adults using body image scales.

Chapter I – Literature Review

1. Self-Reported and Visual Estimated Weight Status

Self-Reported Weight Status

Self-assessment of body image is a multidimensional construction by which individuals describe the internal representations of their body structure and physical appearance in relation to themselves and others. In large cohort studies, data are often collected through self-administered questionnaires.

Multiple investigations have documented misperceptions of weight status by adults: self-reports overestimate height and underestimate weight, which leads to an underestimation of the BMI [1,3,5,6,7,8].

Studies found that gender, age, social-demographics and BMI of respondents are correlated with self-reported measurements. Differences according to sex were found as women classify themselves better than men [8,9] and men show a greater likelihood of misperceiving overweight status as normal than women [10,11]. In respect to the age of participants, misperceiving overweight as normal occurs with greater frequency in the elderly [12]. The less educated and those with low incomes are also more likely to misperceive overweight as normal [6,13]. It was also reported that self-reported BMI may not accurately reflect measured BMI in middle-income countries, but the direction of this discrepancy varies by country [6].

When exploring how discrepancy between reported and measured weight has changed over time, research from NHANES data has shown that the number of overweight people who perceive themselves as overweight is declining as obesity rates rise [14]. Despite those facts, Wright et al. 2015 found that self-reported anthropometric variables remain suitable for use in analyses of associations with disease outcomes in cohort studies over at least a decade of follow-up [5].

Data from the Third National Health and Nutrition Examination Survey (NHANES III) on validity of self-reported height, weight and BMI showed that, in older age groups (ages > 60 years), the mean error between measured and self-reported values for height and BMI was higher [12].

Spencer et al. noticed the same influence of age in self-reported measurements in the large cohort of 4808 participants from EPIC-Oxford. They provided further evidence on other factors influencing variations in the accuracy of self-reported measures as BMI was underestimated in both sexes but the extent of underestimation increased with the increasing of BMI category from normal to obese and with older age [8].

According to Sánchez-Villegas et al., who had a representative sample of the European Union (7155 men and 8077 women), the influence of sex and BMI on the self-perception of body weight status is similar to the previous referred studies: underweight men and women classified themselves better than other groups and, overall, women are more accurate in self-perception of weight than men [9].

Estimated Weight Status

Several studies have investigated visual weight estimates. Most of those studies occurred at emergency departments where doctors, nurses and other health staff are asked to classify the BMI of patients to correctly administered drug-dose and to decide whether giving or not weight counselling. The main findings of those studies were that healthcare providers accuracy to estimate patients weight ranged mostly from 40% to 70% [15-19]. According to a systematic review from 2014, when estimating patient weight within 10% error (most commonly used outcome measure) as an outcome measure, doctors were accurate in 57.5% of patients (range 50-66%), nurses were accurate in 60.9% of patients (range 50-75%) [20]. Kahn CA et al reported that estimation of BMI 18.5 to 30 was more accurately than estimation of BMI < 18.5 or BMI > 30 [18]. Weight appears to have an effect on body weight estimations as overweight and obese status were commonly underestimated and underweight status was overestimated [16, 21, 22].

Women physicians recognized the overweight status of their patients more readily than men and physician of both genders were less likely to recognize overweight status among patients who were male [23].

Personal BMI of individuals who estimate the body weight status of others individuals may also be correlated with the accuracy of estimation: participants with higher BMI were less likely to notice the same percentage of weight gain than participants with lower BMI, as reported elsewhere [24].

Cross-cultural differences have been reported when describing attitudes toward obesity status and its recognition. Robison and Hogenkamp 2015 reported that US participants were worse at recognizing obesity than UK participants and were also significantly more likely to believe that obese males did not need to consider losing weight in comparison to UK and Swedish participants [25]. When testing the number of observers, three observer panel gave better weight estimates than one or two individuals [26]. It was then hypothesized that using the mean or the median of several visual estimates may be a practical solution for body weight estimation when weighing patients is not possible [15].

2. Use of Body Image Scales in Assessing Body Weight Status

Body image scales are instruments designed to determine perceptions of weight status using pictorial images of women and men. From the literature, silhouette-based matching tests have been used to assess body image perceptions since measuring body image perceptions with accuracy has been proved to be difficult [27]. There are many body image scales, over 50 scales according to Thompson 2004, but few have been validated [28].

Stunkard Figure Rating Scale [29] was the first developed instrument of figural stimuli and it is one of the best-known and overall validated body image scale among different cultures and races. According to the literature, Stunkard scale is the body scale more widespread in experimental studies and its figures were shown to have a good correlation with measured BMI [30,31]. Validation of Stunkard scale as an instrument to assess nutritional status was confirmed by Sorensen et al [31].

Stunkard scale was originally developed as a psychological tool for assessment of body image dissatisfaction as respondents have to choose two silhouettes: the one they believe to be the most representative of their current body size and another that corresponds to their ideal body size. The difference between current body size and ideal body size has been interpreted as a measure of body dissatisfaction [32]. Stunkard scale consists in two series, one for men and another for women, with nine schematic figures numbered from 1 to 9 ranging from very thin to very obese [29]. Later in 2001, Bulik et al established BMI norms for each silhouette from Stunkard scale in a Caucasian population-based study (n= 16 728 females and 11 366 males) ranging in age from 18-100 years [30]. That research represented a substantial advance as, from that point, Stunkard silhouettes were widely used in epidemiological studies.

Subsequently, several other body image scales were developed. Harris et al 2007 [33] developed gender-specific body size guides containing ten bodies that were then administered to 400 adults. Psychometric analyses showed that those body size guides were valid and reliable instruments since there were high correlations between the BMI of respondents and the BMI of the current body selected by respondents.

Body image scales are widely used in epidemiological studies, not only to evaluate body dissatisfaction but also as an instrument to self-estimates and others' estimates of weight and body size.

According to a systematic review from 2012 on development, adaptation and validation of silhouettes for self-assessment of nutritional status, there are several publications that found a moderate to good correlation between silhouettes scales and nutritional status in adults and a much lower correlation in children and adolescents (34). Bell et al. reported that silhouettes scales are useful in assessing body image perceptions, both in individuals with eating disorders as well as in obese individuals (35).

Tehard et al. reported a correlation of 0.78 between measured BMI and self-reported silhouette. According to this study, being overweight, having small height, being younger and having a lower level of education were all associated with a more favorable perception of body silhouette (36).

Body silhouettes were also shown to be useful to quantify body composition measures in children, including fat mass index and fat-free mass index (37)

Chapter II – Accuracy of assessing BMI in adults using body image scales

1. Relevance of the Study

Weight status is of interest in epidemiological studies both in estimating prevalence and trends studies as well as in studies of disease prevention, assessment of risk, co-morbidities, mortality and economic burden of the overweight and obesity epidemic. In large population studies, data on weight and height are often collected by self-reporting and then used to calculate body mass index (BMI) as one of the most popular measures to categorize participants as underweight, normal weight, overweight or obese.

Previous studies have shown that self-reported weight and height are often inaccurate with individuals underestimating their weight and overestimating their height resulting in an underestimation of BMI [(1,3,5,6,7,8)].

Silhouette-based matching tests have been used to assess body image perceptions [(27)]. The corresponding BMI of the chosen silhouette had shown a high correlation with measured BMI in adults [(33)].

Assigning body weight in adults by the selection of the silhouette from Stunkard Figure Rating Scale [(29)] has been reported to have a good correlation with measured BMI [(30)]. Validation of Stunkard scale as an instrument to assess nutritional status was confirmed by Sorensen et al [(31)].

It was then hypothesized that estimated measures by trained paired observers using body image scales might be used in assessing body weight status of adult individuals instead of using self-reported measures when it is not possible to perform anthropometric measures.

2. Aims

The main objectives of this study were:

• To test the ability of trained observers to accurately classify adult individuals by observation regarding weight status;

• Verify the concordance between observers in estimating weight, height and BMI categories of adult individuals.

3. Methods

3.1. Study design

The data used in the present study was obtained from an analytic cross-sectional study conducted from May to June 2018. Trained observers classified adult individuals by observation regarding weight, height and weight status categories using Stunkard Figure Rating Scale. Anthropometric measures were obtained by trained researchers.

3.2. Sample

Sample consisted of adults of both sexes. Individuals were clients of a laboratory selected among the clients who were there for clinical analyzes after being admitted for blood collection. While in the waiting room, one of the observers invited all clients to join the study after explaining the objectives and procedures involved.

Patients with age equal to or greater than 18 years of age of both sexes able to stand up to obtain objective measures of weight and height were considered eligible for the present study. Excluded from the sample were wheelchair, pregnant and other individuals with clinical conditions that interfere with weight and height measurements, such as edema, amputations and orthopedic problems.

3.3. Ethics

Ethical approval for this study was obtained from the Committee of Ethics of Hospital Center Lisbon-North/Faculty of Medicine of Lisbon prior to the commencement of data collection. The study also received favorable opinion from Scientific Committee of Faculty of Medicine of Lisbon.

Informed consent was obtained from all individual participants included in study ***(appendix 1)***. Participation was voluntary and anonymous and subjects were informed that they were able to withdraw the study at any time. Participants were identified only by a numeric code which was then used in analysis to match signed informed consent, estimates and measures obtained for each participant. Anthropometric measures were performed in closed specific zone in order to ensure privacy.

3.4. Instrument

Estimates Form **(appendix 2)** was used by trained observers. Observers filled in the *Estimates Form* by choosing only one option among the categories for height, weight and Stunkard's figure. The nine figures from Stunkard's scale (nine figures for women and nine figures for men) were numbered from 1 to 9 and each one was identified with its corresponding BMI according to Bulik et al [30].

Participant Questionnaire **(appendix 3)** were then filled in by a third trained element who measured the weight and height of the participant and asked its birth date.

Socio-demographic and anthropometric data of each observer including sex, age, weight, height, education and occupational status were also assessed through the *Observers Form* **(appendix 4)**

3.5. Procedure

3.5.1 Observers Training

Observers training aimed to give the observers all the theoretical knowledge about the present study as their objectives, methods and procedures. It was also intended that the observers trained their capacities of estimating weight status and applied the acquired knowledge, asked questions and get to know the potential difficulties they may encounter in the real context.

The training allowed all the observers to leave to the field with a standard preparation, according to the following protocol:

1. Theoretical exposition on the Stunkard et al. Scale of Silhouettes on:

a) its statement of reasons and what it consists of;

b) the silhouettes that compose it;

c) the BMI corresponding to each silhouette;

2. Practical exercise to classify each silhouette through BMI:

In training room, silhouettes were randomly projected on a white board. Each silhouette was randomly shown three times. Observer had to write down the BMI category corresponding to each projected figure.

3.5.2. Data collection

Data were collected from May to June 2018 during the morning periods. In total, there were six observers, working in pairs, and one collaborator who measured the participants. One pair of two observers asked individually each participant who agreed to participate to stand in front of a white wall down. The two observers positioned in the frontal plane towards the participant at a distance approximately of 3 meters and then estimated the measures. Then, a coordinating element of the team accompanied the participant to a separate room for collection of data on sex and age and to measure weight and height. It should be noted that there was no communication between the observers and the third element that performed the anthropometric measurements. The participant was identified only by the numeric code.

Anthropometric Measures

Anthropometric measurement was carried out according to the Portuguese Guideline “Procedimentos Antropométricos na Pessoa Adulta” [Anthropometric Procedures in the Adult Person] issued by Directorate-General of Health (DGS) [38].

Height was measured to the closest 0.1 centimeter, using a SECA® Portable Stadiometer HR001. Participants were asked to stand up straight against the vertical backboard of the stadiometer, with the body weight evenly distributed and both feet flat on the platform. Subjects stood with their scapula, buttocks and heels resting against the backboard, the neck was held in a natural non-stretched position, the heels were touching each other, the toe tips formed a 45° angle and the head was held straight with the inferior orbital border in the same horizontal plane as the external auditive conduct (Frankfort’s plane).

Weight was measured to the nearest 100g using a digital scale (TANITA® TBF-300A). All anthropometric measurements were performed without any type of constriction that can modify the actual body structure, requiring the person to remove shoes, heavy cloths, all accessories and jewellery prior to weighing.

Body mass index (BMI) was estimated and subjects were classified according to WHO reference values [39].

3.6. Outcome Measures

3.6.1 Socio-Demographic Characteristics and Anthropometric Measures of Participants

Sex and birth date of the participant were assigned using the *Participant Questionnaire* by the third element of the team who performed anthropometric measures. Participant's age was computed from the date of birth variable.

BMI values were grouped according to WHO categories for BMI into (1) underweight (BMI < 18,5 kg/m2), (2) normal weight (BMI 18,5-24,9 kg/m2), (3) overweight (BMI 25,0-29,9 kg/m2), (4) obese (BMI ≥ 30,0 kg/m2).

3.6.2. Estimated Measures

Height, weight and BMI categories of participants estimated by paired observers were obtained from the *Estimates Form.*

Height was recorded in the following categories*:* (1) less than 144 cm, (2) 145-154 cm, (3) 155-164 cm, (4) 165-174 cm, (5) 175-184 cm, (6) 185 cm or over. After regrouping, 3 new categories were computed: (1) less than 154 cm, (2) 155-164, (3) 165 cm or more.

Weight was recorded in the following seven categories: (1) less than 44 kg, (2) 45-54 kg, (3) 55-64 kg, (4) 65-74 kg, (5) 75-84 kg, (6) 85-94 kg, (7) 95 kg or over. It was then recoded into only 3 categories for the statistical analysis: (1) less than 54 kg, (2) 55-74 kg, (3) 75 kg or over

BMI categories estimates were given by the number of the figure of Stunkard's scale chosen by the observer from figure 1 to 9, each one identified with its corresponding BMI according to Bulik et al [30]. BMI values were grouped according to WHO categories for BMI into four classes: (1) underweight (BMI <

18,5 kg/m2), (2) normal weight (BMI 18,5-24,9 kg/m2), (3) overweight (BMI 25,0-29,9 kg/m2), (4) obese (BMI ≥ 30,0 kg/m2).

3.7. Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics Subscription and STATA.

Descriptive statistics were used to calculate the overall mean age, height, weight and BMI measured. Categorical variables as sex and estimated measures by observation for height, weight and BMI were summarized as counts and percentages. Continuous variables were compared between sexes using t-test for independent samples (parametric variables). Categorical dichotomous variables were tested using the Chi-square test. Shapiro-Wilk test was performed to test variables for normality.

Sensitivity, specificity and likelihood ratios (positive likelihood and negative likelihood) were assessed in order to validate the accuracy of estimating obesity and overweight/obesity by trained paired observers. The correct identification of obesity and overweight/obesity categories among female observers, male observers and the overall of estimations was tested. Chi-square tests and Fisher's exact tests were performed to assess the association between correct identification of obese and non-obese individuals and overweight/obese and non-overweight/obese according to the sex of observer, sex of participant and age of participant.

Inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among raters for estimated height, weight and BMI categories.

Level of significance was set at 0.05.

4. Results

4.1 Socio-Demographic and Anthropometric Measurements of Observers and Participants

Among the observers, four were women and two were men, aged from 23 to 41 years old (31.0 ± 8.6 years). Mean weight of observers was 66.0 ± 9.4 kg and mean height was 169.2 ± 9.2 cm. BMI ranged from 20.7 to 25.5 kg/m^2 (mean ± SD = 22.9 ± 1.7 kg/m^2). All observers were finishing their undergraduate degree in nutrition except one observer who was in her first year of physiotherapy.

Socio-demographic and anthropometric data of participants are shown in Table 1. The sample included 127 participants, 70 women and 57 men, aged between 19 and 89 years (mean ± SD, 50.3 ± 16.3 years).

In regard to participants' BMI, 3.9% were underweight, 25.2% were normal weight, 48.0% were overweight and 22.8% were obese. In both sexes, the majority of participants were overweight or obese (64.3% women and 78.9% men, p=0.006).

Men were significantly taller (mean ± SD: 171.5 ± 1.1 cm vs. 159.7 ± 0.8 cm, p<0.001) and heavier (mean ± SD: 79.1 ± 1.6kg vs. 68.3 ± 1.4kg, p < 0.001) than women, but their mean BMI was not statistically different (mean ± SD: 26.9 ± 0.5kg/m2 vs. 26.8 ± 0.5 kg/m2, p=0.90).

Table 1. Age and Anthropometric Measurements of participants

		Total (n = 127)	Women (n = 70)	Men (n = 57)	p-value
Age (years), *mean* ± *SD*		**50.3 ± 16.3**	**47.9 ± 1.7**	**53.4 ± 2.5**	0.058 †
		n (%)	**n (%)**	**n (%)**	
	18-34	24 (18.9%)	15 (21.4%)	9 (15.8%)	
	35-54	53 (41.7%)	33 (47.1%)	20 (35.1%)	
	≥ 55	50 (39.4%)	22 (31.4%)	28 (35.1%)	0.127 ‡
Height (cm), *mean* ± *SD*		**164.9 ± 9.6**	**159.7 ± 0.8**	**171.5 ± 1.1**	< 0.001* †
		n (%)	**n (%)**	**n (%)**	
	≤ 154	14 (11.0%)	13 (18.6%)	1 (1.8%)	
	155-164	52 (40.9%)	42 (60.0%)	10 (17.5%)	
	≥ 165	61 (48.0%)	15 (21.4%)	46 (80.7%)	< 0.001* ‡
Weight (kg), *mean* ± *SD*		**73.1 ± 12.9**	**68.3 ± 1.4**	**79.1 ± 1.6**	< 0.001* †
		n (%)	**n (%)**	**n (%)**	
	≤ 54	11 (8.7%)	10 (14.3%)	1 (1.8%)	
	55-74	63 (49.6%)	41 (58.6%)	22 (38.6%)	
	≥ 75	53 (41.7%)	19 (27.1%)	34 (59.6%)	< 0.001* ‡
BMI (kg/m2), *mean* ± *SD*		**26.9 ± 4.1**	**26.8 ± 0.5**	**26.9 ± 0.5**	0.90 †
		n (%)	**n (%)**	**n (%)**	
	< 18,5	5 (3.9%)	4 (5.7%)	1 (1.8%)	
	18,5-24,9	32 (25.2%)	21 (30.0%)	11 (19.3%)	
	25,0-29,9	61 (48.0%)	24 (34.3%)	37 (64.9%)	
	≥ 30	29 (22.8%)	21 (30.0%)	8 (14.0%)	0.006* ‡

† T-test for independent samples; ‡ Chi-square test; * significant ($p<0.05$); BMI – Body mass index.

4.2 Validity on estimating BMI by trained observers

Sensitivity of estimated obesity was 41.4%. When estimated overweight/obese status combined, sensitivity was higher than the sensitivity for obese status alone with 72.8% of overweight/obese participants being correctly classified.

Specificity, which was the proportion of non-obese and non-overweight/obese participants that were incorrectly classified as obese or overweight/obese, was higher for obesity alone than for the combined status of overweight/obese (96.4% vs. 78.4 %).

It was more than 45% probably to correctly classifying obesity (positive LR = 11.5). For non-obese participants, probability of identifying them as non-obese was about 15% less likely then identifying them as obese (negative LR = 0.61).

For the combined status of overweight and obesity, it was about 20% more likely to correctly classify it (positive LR = 3.4).

The negative LR for overweight/obesity was 0.35 which means that, among non-overweight/obese participants, the probability of incorrectly classifying them as overweight/obese was about 25% more likely than correctly classifying them as non-overweight/obese.

In table 3, sex of observer, sex of participant and age of participant were shown to be statistically associated with the estimation of obesity and overweight.

Women observers classified obesity with higher sensitivity than men observers (56.8% vs. 14.3%, p=0.002). When combining obesity with overweight status, sensitivity increased for both sexes, mainly for men observers but it remained lower than for women observers, although not statistically significant (76.6% for women observers vs. 66.7% for men observers, p=0.146). Specificity, positive likelihood ratio and negative likelihood ratio were all lower for obesity and overweight together than for obesity alone among both sexes of observers. Sensitivity to detect overweight/obesity was higher among men participants than among women participants (80.0% vs. 65.6%, p=0.029). Sensitivity to detect obesity alone was lower than to detect overweight/obesity (50.0% for women participants vs. 38.1% for men participants, p=0.411). Specificity both for obesity and for overweight/obesity was statistically associated with the sex of participant.

The probability of incorrect classification of overweight and obesity was less than 25% for both sexes and it was higher than for obesity alone (less than 15%, negative LR = 0.54 for women / negative LR = 0.62 for men). A man classified as obese and a woman classified as overweight/obese were definitely obese and overweigh/obese respectively (infinite positive LRs).

Although not statistically significant, the sensitivity to detect obesity increased with the age of participants (from 20.0% for 18-34 years old to 54.2% for 55 years old or more). Sensitivity to detect overweight/obesity together was 1.5 to 4-fold higher than sensitivity to detect obesity alone but no such trend with age was observed. Those findings showed that it was more likely to identify obesity among older participants but less likely to identify overweight. When regrouped age at only two categories (< 50 years and ≥ 50 years), sensitivity to detect obesity and overweight/obesity together were similar to the sensitivity values when three age categories were considered. Classifying an obese participant as obese was less likely with increasing age as the probability of correctly classifying obesity varied from 100% for the age of 18-34 years to approximately 40% for the age of 55 years old or more (infinite positive likelihood ratio and LR+ = 8.1, respectively).

Specificity was 100% for the younger age of 18 to 34 among obese participants and decreased for older ages (97.6% for 35-54 years and 93.4% for 55 years old or more), without statistically significance. The same trend was observed for specificity to detect overweight/obesity together, although specificity values were lower.

Identifying overweight/obesity was over than 45% accurately among 18-34 years old participants (LR+ = 9.5) and near 15% accurately for 55 or more years old participants (LR+ = 2.0).

Table 2. Sensitivity, Specificity and Likelihood-Ratios of Estimated Measures (Obesity, Overweight/Obesity)

	Sensitivity	Specificity	Likelihood Ratio	
			Positive (LR+)	Negative (LR-)
Weight status				
Obesity	41.4 %	96.4%	11.5	0.61
Overweight and Obesity	72.8 %	78.4 %	3.4	0.35

Table 3. Sensitivity, Specificity and Likelihood-Ratios of Estimated Obesity and Overweight/Obesity by observation, according to Sex of Observer, Sex of Participant and Age of Participant

	Obesity				**Overweight and Obesity**			
	Sensitivity	**Specificity**	**Likelihood Ratio Positive (LR+)**	**Likelihood Ratio Negative (LR-)**	**Sensitivity**	**Specificity**	**Likelihood Ratio Positive (LR+)**	**Likelihood Ratio Negative (LR-)**
Sex of Observer								
Female	56.8 %	95.0%	11.4	0.45	76.6 %	76.6 %	3.3	0.31
Male	14.3 %	98.7%	11.0	0.87	66.7 %	81.5 %	3.6	0.41
	p = 0.002* ‡	p 0.184 ‡			p 0.146 ‡	p 0.623 ‡		
Sex of Participant								
Female	50.0 %	92.9 %	7.0	0.54	65.6 %	100 %	∞	0.34
Male	38.1%	100%	∞	0.62	80.0 %	68.0 %	2.5	0.29
	p 0.411 ‡	0.014 * F			p 0.029* ‡	p 0.002* ‡		
Age of Participant (years)								
18-34	20.0 %	100 %	∞	0.8	79.2 %	91.7 %	9.5	0.23
35-54	37.5 %	97.6 %	15.6	0.64	66.2 %	78.1 %	3.0	0.43
≥ 55	54.2 %	93.4 %	8.21	0.49	76.8 %	61.1 %	2.0	0.38
	p= 0.161	p= 0.206 F			p= 0.249	p= 0.059		
< 50 or ≥ 50 years								
< 50	33.3 %	100 %	∞	0.67	69.2 %	85.4 %	4.7	0.36
≥ 50	50.0 %	93.0 %	7.1	0.54	75.5 %	65.4 %	2.2	0.37
	p 0.198 ‡	p 0.014* F			p 0.350 ‡	p 0.046* ‡		

‡ Chi-square test; F Fisher's Exact test; * significant (p<0.05); BMI – Body mass index.

4.3. Inter-observer reliability analysis

As shown in table 4, agreement between observers was substantial for height estimates (κ = 0.62) and moderate for weight estimates (κ = 0.46) and BMI estimates (κ = 0.51). In relation to Stunkard figures, the agreement between the chosen figures by the two observers, was low (κ = 0.29).

When estimating height, the agreement between observers increased with increasing height: for height under 154 cm observers the agreement was 38% and for participants with height over 165 cm the agreement was 79%.

Among weight estimates, the agreement between observers ranged from 0.42 for weight of 55-74 kg to 0.50 for weight over than 75 kg, $p<0.001$.

In regard to the agreement across BMI categories there was no meaningful variation. Kappa ranged between 0.43 for overweight to 0.62 for normal weight, $p<0.001$.

The higher agreement between observers for the selected Stunkard figures was for the first and the last figures (κ = 0.49 for figure 1, κ = 0.50 for figure 2 and κ = 0.66 for figure 8). For figures from 3 to 7, κ values ranged from 0.16 (figure 5) to 0.32 and 0.33 (figure 3 and 4 respectively).

Table 4. Concordance between observers

	Kappa	**p-value**
Height (cm)	**0.62**	**< 0.001* ‡**
≤ 154	0.38	
155-164	0.55	
≥ 165	0.79	
Weight (kg)	**0.46**	**< 0.001* ‡**
≤ 54	0.48	
55-74	0.42	
≥ 75	0.50	
BMI (kg/m2)	**0.51**	**< 0.001* ‡**
< 18,5	0.49	
18,5-24.9	0.62	
25,0-29,9	0.43	
≥ 30	0.45	
< 25 or ≥ 25 kg/m2	0.66	**< 0.001* ‡**
Stunkard Figures	**0.29**	**< 0.001* ‡**
Fig. 1 – BMI 18.3 ♀ / 19.8 ♂	0.49	
Fig. 2 – BMI 19.3 ♀ / 21.1 ♂	0.50	
Fig. 3 – BMI 20.9 ♀ / 22.2 ♂	0.32	
Fig. 4 – BMI 23.1 ♀ / 23.6 ♂	0.33	
Fig. 5 – BMI 26.2 ♀ / 25.8 ♂	0.16	
Fig. 6 – BMI 29.9 ♀ / 28.1 ♂	0.27	
Fig. 7 – BMI 34.3 ♀ / 31.5 ♂	0.25	
Fig. 8 – BMI 38.6 ♀/ 35.2 ♂	0.66	
Fig. 9 – BMI 45.4 ♀/ 41.5 ♂	n.a	

‡ Chi-square test; * significant (p<0.05); BMI – Body mass index.

5. Discussion

It was reported that estimating weight status by choosing a silhouette from a body image scale, had a high correlation with measured BMI [30,31,33]. Our findings also showed that visual estimation of obesity among adult individuals by trained observers using body image scales was moderate sensitive (72.8% for overweight/obesity; 41.4% for obesity) and highly specific (78.4% for overweight/obesity; 96.4% for obesity). These results are similar to those reported in studies where healthcare providers estimate patients' weight with an accuracy from 40% to 70% [15-19].

When combining the obesity status with overweight, in order to test the ability of observers to correctly distinguish normal weight from overweight (including obesity), sensitivity of estimated overweight status increased. The likelihood ratios, both positive and negative, of estimating overweight/obesity also decreased when compared to estimating obesity alone. It was more likely to correctly classify overweight overall (including obesity), than obesity alone which may be due to the underestimation of obesity as reported elsewhere [42]. Underestimate obesity more than overweight might be explained by normal visual perceptual biases as contraction bias which means that the weight of obese bodies will be underestimated all the more so as the BMI increases and by Weber´s law which predicts that change in body size will become progressively harder to detect as their BMI increases [43-46]. These normal visual perceptual biases are supported by visual normalization theory in which exposure to larger body sizes had changed the range of body sizes which are perceptually judged as being "normal". We should also consider the effect of weight bias caused by negative believes about obese individuals and its related stereotypes. Data indicate that a wide range of media portray overweight and obese individuals in a stigmatizing manner [47] and, additionally, even health professionals whose careers emphasize research or clinical management of obesity (as the observers of the present study who were all finishing their undergraduate degree in nutrition except one observer) exhibited a significant pro-thin and anti-fat bias, indicating pervasive and powerful stigma [48].

When assigning weight-based descriptors to individuals to assess physician perception of patient weight, women physicians recognized the overweight status of their patients more readily than men [23]. In our study, women were also more accurately in visual body weight estimation than men although. Women observers estimated obesity with a statistically higher sensitivity than men observers, but there were no differences in specificity and positive likelihood ratios (both women and men observers identified obesity with a high specificity and a high positive likelihood ratio). On other side, negative likelihood ratio for estimating obesity was higher for men observer. When combining obesity with overweight status, sensitivity increased for both sexes, mainly for men observers but it remained lower than for women observers, although not statistically significant. Specificity, positive likelihood ratio and negative likelihood ratio were all lower for obesity and overweight together than for obesity alone among both sexes of observers. Nevertheless, we had a small number of observers that do not allow us to make significant assumptions.

Sex of participant has shown differences in estimating overweight/obesity. Overweight/obese men were more accurately classified than overweight/obese women. This finding is similar to the reported elsewhere where physicians of both genders were also less likely to recognize overweight status among patients who were male [23].

Obesity was estimated with moderate sensitivity for older participants: only half of obese participants with 55 years old or more were correctly classified. It was reported that elderly misperceive with greater frequency of self-reported overweight and obesity: they are misperceiving with greater frequency in the elderly. Data from the Third National Health and Nutrition Examination Survey (NHANES III) showed that for age groups > 60 years, the mean error between measured and self-reported values for height and BMI was higher [12]. In EPIC-Oxford, another large cohort of 4808 participants, the extent of underestimation also increased with the increasing of BMI category from normal to obese and with the increasing in age [8].

Inter-observer judgments were significant reliable for height estimates and it increased with increasing height. For weight estimates, BMI and chosen silhouettes the judgements were moderate to low reliable.

For this study, a previous training for observers was performed. Even so, the training was not sufficient to reach reliable estimated measures but might have improved the concordance between observers. It was reported that, when testing the number of observers, three observer panel gave better weight estimates than one or two individuals [26].

To our knowledge this study is the first that intended to classify body weight in adults by paired trained observers using body image scales.

Limitations of the study are the small number and two-dimensional figures from Stunkard scale, although validation studies have shown that, even with these possible short-comings, this scale presented higher correlations between current body size and BMI than new scales [(30)]. The small number of observers limited the analysis of possible personal confounders for the estimations. Repeated observations may have led to increased attention among observers and consequently estimated weight bias.

Further research about differences in accuracy of self-reported measures and estimated measures by trained observers using body image scales is needed.

6. Conclusion

Accuracy of estimated weight status was moderate to low. Nevertheless, observers were able to distinguish normal weight from overweight with high sensitivity and specificity.

Agreement between observers' judgments was substantial for height that increased with increasing height. For weight estimates, BMI and chosen silhouettes the judgements were moderate to low reliable.

Development of simple, easy to use instruments that incorporate pictorial images with known BMI could address some of the limitations associated with direct and self-reported measures and providing an easy-to-use instrument with few physical and human resources that might be of particular interest in field surveys.

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Appendices

Appendix 1 – *Informed Consent*

Nº PARTICIPANTE ____________________

CONSENTIMENTO INFORMADO, LIVRE E ESCLARECIDO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO
de acordo com a Declaração de Helsínquia[1] e a Convenção de Oviedo[2]

Por favor, leia com atenção a seguinte informação. Se achar que algo está incorrecto ou que não está claro, não hesite em solicitar mais informações. Se concorda com a proposta que lhe foi feita, queira assinar este documento.

Título do estudo: Predição de categorias de IMC por observação, com recurso a escalas de imagem corporal

Enquadramento: Tânia de Jesus Jorge, aluna do Mestrado em Doenças Metabólicas e Comportamento Alimentar na Faculdade de Medicina da Universidade do Lisboa, a realizar um trabalho de investigação no âmbito da Dissertação final de Mestrado, subordinado ao tema *Predição de categorias de IMC por observação, com recurso a escalas de imagem corporal*, e sob a orientação da Prof.a Doutora Patrícia Padrão e coorientação da Prof.a Doutora Isabel do Carmo, vem solicitar o seu consentimento para efetuar medições antropométricas para utilizar esses dados na realização do seu trabalho.

Explicação do estudo: A recolha de dados é feita exclusivamente pela medição antropométrica do participante. É medido o peso, altura e perímetro da cintura. A seleção do participante é aleatória simples por entre indivíduos com idade superior a 18 anos que se deslocam aos postos de colheita do Laboratório Beatriz Godinho entre os dias 16 e 31 Maio de 2017. As medições são efetuadas num contacto único com o participante, com a duração prevista de 5 minutos.

Condições e financiamento: Não há despesas pessoais para o participante em qualquer momento. Também não há compensação financeira relacionada com a realização do estudo. A participação é voluntária e o participante está ausente de prejuízos, assistenciais ou outros, caso não queira participar.

Confidencialidade e anonimato: A recolha de dados é anónima (não há registo de dados de identificação do participante), confidencial e de uso exclusivo para o presente estudo. É garantida a privacidade do participante aquando das medições antropométricas.

A Investigadora,
Tânia de Jesus Jorge
Nutricionista em Centro Hospitalar de Leiria / Nutriente – Nutrição e Saúde
Tlf: 915 991 560
Email: tania.jorge@nutriente.pt

Assinatura: ... ...

o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o

Declaro ter lido e compreendido este documento, bem como as informações verbais que me foram fornecidas pela pessoa que acima assina. Foi-me garantida a possibilidade de, em qualquer altura, recusar participar neste estudo sem qualquer tipo de consequências. Desta forma, aceito participar neste estudo e permito a utilização dos dados que de forma voluntária forneço, confiando em que apenas serão utilizados para esta investigação e nas garantias de confidencialidade e anonimato que me são dadas pela investigadora.

Nome: ... ...

Assinatura: ... ...

SE NÃO FOR O PRÓPRIO A ASSINAR POR IDADE OU INCAPACIDADE
(se o menor tiver discernimento deve também assinar em cima, se consentir)
NOME: ... ...
BI/CD Nº: .... DATA OU VALIDADE ___ /..... /........
GRAU DE PARENTESCO OU TIPO DE REPRESENTAÇÃO: ....
ASSINATURA ... ...

ESTE DOCUMENTO É COMPOSTO DE 1 PÁGINA E FEITO EM DUPLICADO:
UMA VIA PARA O/A INVESTIGADOR/A, OUTRA PARA A PESSOA QUE CONSENTE

[1] http://portal.arsnorte.min-saude.pt/portal/page/portal/ARSNorte/Comiss%C3%A3o%20de%20%C3%89tica/Ficheiros/Declaracao_Helsinquia_2008.pdf

[2] http://dre.pt/pdf1sdip/2001/01/002A00/00140036.pdf

Appendix 2 - *Estimates Form*

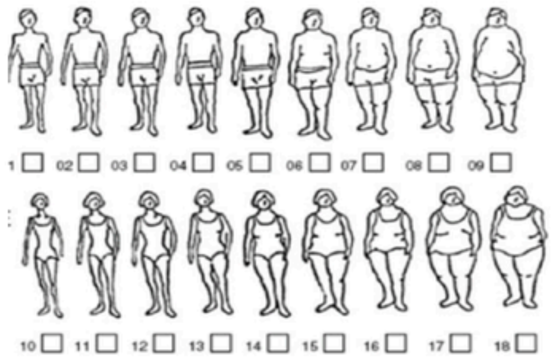
Nº PARTICIPANTE ________________ **COLABORADOR Nº**______

Sexo Feminino ☐ Masculino ☐

Idade (anos)	
18 – 24	
25 – 34	
35 – 44	
45 – 54	
55 – 64	
>65	

Peso(kg)	
<44	
45 – 54	
55 – 64	
65 – 74	
75 – 84	
85 – 94	
>95	

Altura (cm)	
<144	
145 – 154	
155 – 164	
165 – 174	
175 – 184	
>185	



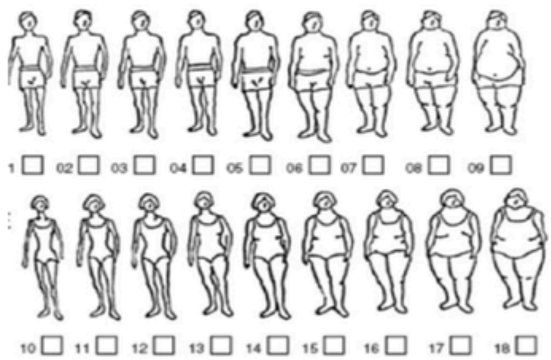
Nº PARTICIPANTE ________________ **COLABORADOR Nº**______

Sexo Feminino ☐ Masculino ☐

Idade (anos)	
18 – 24	
25 – 34	
35 – 44	
45 – 54	
55 – 64	
>65	

Peso(kg)	
<44	
45 – 54	
55 – 64	
65 – 74	
75 – 84	
85 – 94	
>95	

Altura (cm)	
<144	
145 – 154	
155 – 164	
165 – 174	
175 – 184	
>185	



Appendix 3 – *Participant Questionnaire*

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Nº PARTICIPANTE ________________ **COLABORADOR Nº** ______
Sexo Feminino ☐ Masculino ☐ **Data Nascimento** ____________
Peso ________ **Altura** ________ **Perímetro Cintura** ___________ IMC

Appendix 4 - *Observers Form*

PERFIL COLABORADOR

Nº _________________

Nome ____

Data de nascimento ______________________

Estudante ______ Trabalhador Estudante _____

Ano ___________ Profissão_________________

Área (s) de Formação ____

Peso___________ Altura___________ IMC______________

Appendix 5 – *Original Article Submitted for Publication*

Accuracy of assessing weight status in adults using body image scales

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Abstract

Purpose: To test the ability of trained observers to accurately classify adults by observation regarding weight status.

Methods: Cross-sectional survey with 127 adults, 70 women. Height and weight were estimated in categories and weight status was recorded using Stunkard's body figures by two trained observers. Height and weight were also measured using standardized procedures. Body Mass Index (BMI) was computed and subjects were classified according to World Health Organization cut-offs both from objective measurements as from the BMI assigned to each figure. Sensitivity, specificity and likelihood ratios were calculated to assess the accuracy of estimating weight status by observation. Chi-square and Fisher's exact tests were performed to assess the association between correct identification of weight status according to the sex of observer and of participant, and participant's age. Kappa statistic was performed to test inter-observer reliability.

Results: Less than half (41.4%) of obese individuals and 72.8% of overweight/obese participants were correctly identified. Sex of observer and of participant and participant's age were shown to be statistically associated with the estimation of obesity and overweight. Agreement between observers was moderate to substantial for height (κ = 0.62), weight (κ = 0.46) and BMI estimates (κ = 0.51).

Conclusions: Trained observers were able to distinguish normal weight from overweight/obesity with high sensitivity and specificity. Accuracy of estimated weight status was moderate to low.

Keywords: age, weight, body mass index, anthropometric measures

Introduction

Weight status is of interest in epidemiological studies both in estimating prevalence and trends as well as in studies of disease prevention, assessment of risk, co-morbidities, mortality and economic burden of the overweight and obesity epidemic. In large population studies, data on weight and height are often collected by self-reporting and then used to calculate body mass index (BMI) as one of the most popular measures to categorize participants as underweight, normal weight, overweight or obese [1-3].

Previous studies have shown that self-reported weight and height are often inaccurate with individuals underestimate their weight and overestimating the height resulting in an underestimation of BMI [4-10]. Silhouette-based matching tests have been used to assess body image self-perceptions [11] since the corresponding BMI of the chosen silhouette had shown a high correlation with measured BMI in adults [12]. Specifically, assigning self-reported weight status in adults by the selection of the silhouette from Stunkard Figure Rating Scale [13] has been reported to have a good correlation with measured BMI [14]. Validation of Stunkard scale as an instrument to assess nutritional status was confirmed by Sorensen et al [15]. There is however lack of data on the validity of the weight status estimation performed by trained observers using this type of silhouettes.

For the present investigation, it was hypothesized that estimated measures by trained observers using body image scales might be used in assessing weight status of adult individuals when it is not possible to perform anthropometric measures.
This investigation intends to test the ability of trained observers to accurately classify adult individuals by observation regarding weight status and to assess the concordance between observers in estimating weight, height and BMI categories of adult individuals.

Methods

Study design and sample

Data used in the present study was obtained from an analytic cross-sectional study conducted from May to June 2018 in a convenience sample of adults of both sexes (n = 127) recruited after being admitted for blood collection in a public laboratory in Leiria (Portugal). While in the waiting room, one collaborator invited each participant to join the study after explaining the objectives and procedures involved. Participants able to stand up to obtain subjective and objective measures of weight and height were considered eligible for the present study. Excluded from the sample were wheelchair, pregnant and other individuals with clinical conditions that interfere with weight and height measurements, such as edema, amputations and orthopedic problems.

Procedure Data collection

Trained observers classified participants by observation regarding categories of weight, height and weight status, the later using Stunkard Figure Rating Scale [13].

A pair of two observers asked individually each participant to stay in front of a white wall down. Then, the two observers positioned in the frontal plane towards the participant at a distance approximately of three meters and estimated height, weight and weight status.

After the observation, participant went to a separate room where one trained researcher performed anthropometric measurements using standard procedures and collected data on sex and age.

It should be noted that there was no communication between the observers and this researcher.

Estimated Measures by observation

Height and weight were recorded in categories as follows:

Height: (1) less than 144 cm, (2) 145-154 cm, (3) 155-164 cm, (4) 165-174 cm, (5) 175-184 cm, (6) 185 cm or over. *Weight*: (1) less than 44 kg, (2) 45-54 kg, (3) 55-64 kg, (4) 65-74 kg, (5) 75-84 kg, (6) 85-94 kg, (7) 95 kg or over.

Due to the low percentage of participants in some categories, variables were recoded into new categories as follows:

Height: (1) less than 154 cm, (2) 155-164, (3) 165 cm or more. Weight: (1) less than 54 kg, (2) 55-74 kg, (3) 75 kg or over.

BMI categories estimates were given by the number of the figure of Stunkard's scale chosen by the observer from figure 1 to 9, each one identified with its corresponding BMI according to Bulik et al [14] (Table 4). Weight status of each participant was then classified according to the World Health Organization (WHO) cut-offs [18] into four classes: (1) underweight (BMI < 18.5 kg/m2), (2) normal weight (BMI 18.5- 24.9 kg/m2), (3) overweight (BMI 25.0-29.9 kg/m2), (4) obese (BMI ≥ 30.0 kg/m2).

Anthropometric Measures

Anthropometric measurements were carried out according to the Portuguese Guideline "Procedimentos Antropométricos na Pessoa Adulta" [Anthropometric Procedures in the Adult Person] issued by Directorate-General of Health [16] and *"International standards for anthropometric assessment"* [17]. Height was measured to the closest 0.1 centimeter, using a SECA® Portable Stadiometer HR001. Weight was measured to the nearest 100g using a digital scale (TANITA® TBF- 300A). BMI was calculated and subjects were classified according to WHO cut-offs [18].

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics® Subscription for Macintosh Operating System and STATA® version 11.0 for Windows®. Descriptive statistics were used to calculate the overall mean age, height, weight and BMI measured. Categorical variables as sex and estimated measures by observation for height, weight and BMI were summarized as counts and percentages. Continuous variables were compared between sexes using t-test for independent samples. Categorical dichotomous variables were compared using the Chi-square test.

Sensitivity, specificity and likelihood ratios were assessed in order to assess the accuracy of estimating obesity and overweight/obesity by trained paired observers. The correct identification of obesity and overweight/obesity categories among female observers, male observers and the overall of estimations was tested. Chi-square tests and Fisher's exact tests were performed to assess the association between correct identification of obese and non-obese individuals and overweight/obese and non-overweight/obese according to the sex of observer, sex of participant and age of participant.

Inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among raters for estimated height, weight, Stunkard figures and BMI categories.

Level of significance was set at 0.05.

Results

Demographic and Anthropometric Measurements of Observers and Participants

Among the observers, four were women and two were men, aged from 23 to 41 years old. Mean weight of observers was 66.0 ± 9.4 kg and mean height was 169.2 ± 9.2 cm. BMI ranged from 20.7 to 25.5 kg/m^2 (mean ± SD = 22.9 ± 1.7 kg/m^2). All observers were undergraduate students in the field of health sciences.

Demographic and anthropometric data of participants are shown in Table 1. The sample included 127 participants, 70 women and 57 men, aged between 19 and 89 years (mean ± SD, 50.3 ± 16.3 years).

In regard to participants' BMI, 3.9% were underweight, 25.2% were normal weight, 48.0% were overweight and 22.8% were obese. In both sexes, most of participants were overweight or obese (64.3% women and 78.9% men, p=0.006).

Validity on estimating BMI by trained observers

As shown in Table 2, sensitivity of estimated obesity was 41.4%. When estimating overweight/obese status combined, sensitivity was higher than for obese status alone: 72.8% of participants were correctly classified. Specificity was higher for estimated obesity than for combined status of overweight/obese (96.4% vs. 78.4 %).

It was more than 45% probably to correctly classifying obesity (positive LR = 11.5). For the combined status of overweight and obesity, it was about 20% more likely to correctly classify it (positive LR = 3.4).

Among non-overweight/obese participants, the probability of incorrectly classifying them was about 25% more likely (negative LR = 0.35).

In table 3, sex of observer, sex of participant and age of participant were shown to be associated with the estimation of obesity and overweight. Women observers classified obesity with higher sensitivity than men observers (56.8% vs. 14.3%, p=0.002). When combining obesity with overweight status, sensitivity increased for both sexes, mainly for men observers but it remained lower than for women observers, although not statistically significant (76.6% for women observers vs. 66.7% for men observers, p=0.146). Specificity, positive likelihood ratio and negative likelihood ratio were all lower for obesity and overweight together than for obesity alone among both sexes of observers.

Sensitivity to detect overweight/obesity was higher among men participants than among women participants (80.0% vs. 65.6%, p=0.029). Specificity both for obesity (92.9% for female and 100% for male) and for overweight/obesity (100% for female and 68% for male) was statistically associated with the sex of participant. The probability of incorrect classification of overweight and obesity was less than 25% for both sexes and it was higher than for obesity alone (less than 15%, negative LR = 0.54 for women / negative LR = 0.62 for men). A man classified as obese and a woman classified as overweight/obese were definitely obese and overweigh/obese respectively (infinite positive LRs).

Although not statistically significant, older age of participant increased sensitivity to detect obesity (from 20.0% for 18-34 years old to 54.2% for 55 years old or more). When regrouped age at only two categories (< 50 years and ≥ 50 years), sensitivity to detect obesity and overweight/obesity together were similar to the sensitivity values when three age categories were considered. Identifying overweight/obesity was over than 45% accurately among 18-34 years old participants (LR+ = 9.5) and near 15% accurately for 55 or more years old participants (LR+ = 2.0).

Inter-observer reliability analysis

As shown in table 4, there was a substantial agreement between observers for height ($\kappa = 0.62$) that increased with increasing height. For weight estimates ($\kappa = 0.46$), BMI estimates ($\kappa = 0.51$) and Stunkard Figures ($\kappa = 0.29$) the judgements were moderate to low reliable.

Discussion

Our findings showed that visual estimation of obesity among adult individuals by trained observers using body image scales was moderate sensitive (72.8% for overweight/obesity; 41.4% for obesity) and highly specific (78.4% for overweight/obesity; 96.4% for obesity). These results are similar to those reported in studies where healthcare providers estimate patients' weight with an accuracy from 40% to 70% [19-24].

When combining obesity status with overweight, in order to test the ability of observers to correctly distinguish normal weight from overweight (including obesity), sensitivity of estimated overweight status increased. It was more likely to correctly classify overweight overall (including obesity), than obesity alone which may be due to the underestimation of obesity as reported elsewhere [25-26]. Underestimate obesity more than overweight might be explained by normal visual perceptual biases as contraction bias which means that the weight of obese bodies will be underestimated all the more so as the BMI increases and by Weber´s law which predicts that change in body size will become progressively harder to detect as their BMI increases [27-30]. These normal visual perceptual biases are supported by visual normalization theory in which exposure to larger body sizes had changed the range of body sizes which are perceptually judged as being "normal". We should also consider the effect of weight bias caused by negative believes about obese individuals and its related stereotypes. Data indicate that a wide range of media portray overweight and obese individuals in a stigmatizing manner [31] and, additionally, even health professionals whose careers emphasize research or clinical management of obesity exhibited a significant pro-thin and anti-fat bias, indicating pervasive and powerful stigma [32].

When assigning weight-based descriptors to individuals to assess physician perception of patient weight, women physicians recognized the overweight status of their patients more readily than men [33]. In our study, women were also more accurately in visual body weight estimation than men as women observers estimated obesity with a statistically higher sensitivity than men observers, but we had a small number of observers that do not allow us to make significant assumptions.

Sex of participant has shown differences in estimating overweight/obesity. Overweight/obese men were more accurately classified than overweight/obese women. This finding is similar to the reported elsewhere where physicians of both genders were also less likely to recognize overweight status among patients who were female [33].

For this study, a previous training for observers was performed. Even so, the training was not sufficient to reach reliable estimated measures but might have improved the concordance between observers. It was reported that, when testing the number of observers, three observer panel gave better weight estimates than one or two individuals [34].

To our knowledge this study is the first that intended to classify body weight in adults by paired trained observers using body image scales.

Limitations of the study are the small sample size and the use of two-dimensional figures from Stunkard scale, although validation studies have shown that, even with these possible short-comings, this scale presented higher correlations between current body size and BMI than other scales [14]. The small number of observers limited the conclusions in regard to sex of observer.

Conclusion

Accuracy of estimated weight status was moderate to low. Nevertheless, observers were able to distinguish normal weight from overweight with high sensitivity and specificity.

Development of simple, easy to use instruments that incorporate pictorial images with known BMI could address some of the limitations associated with direct and self-reported measures and providing an easy-to-use instrument when it is not possible to perform anthropometric measures.

Compliance with Ethical Standards

The authors declare they have no conflict of interest.

All procedures performed involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments. Ethical approval for this study was obtained from the Committee of Ethics of Hospital Center Lisbon-North/Faculty of Medicine of Lisbon. Informed consent was obtained from all individual participants included in the study. Participation was voluntary and anonymous and subjects were informed that they were able to withdraw the study at any time. Participants were identified only by a numeric code which was then used in analysis to match signed informed consent, estimates and measures obtained for each participant. Anthropometric measures were performed in closed specific zone in order to ensure privacy.

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Table 1. Age and Anthropometric Measurements of Participants

		Total	Women	Men	p-value
Age (years), *mean* ±		**50.3 ± 16.3**	**47.9 ± 1.7**	**53.4 ± 2.5**	0.058
		n (%)	**n (%)**	**n (%)**	
	18-34	24 (18.9)	15 (21.4)	9 (15.8)	
	35-54	53 (41.7)	33 (47.1)	20 (35.1)	
	≥ 55	50 (39.4)	22 (31.4)	28 (35.1)	0.127
Height (cm), *mean* ±		**164.9 ± 9.6**	**159.7 ± 0.8**	**171.5 ± 1.1**	< 0.001
		n (%)	**n (%)**	**n (%)**	
	≤ 154	14 (11.0)	13 (18.6)	1 (1.8)	
	155-164	52 (40.9)	42 (60.0)	10 (17.5)	
	≥ 165	61 (48.0)	15 (21.4)	46 (80.7)	< 0.001
Weight (kg), *mean* ±		**73.1 ± 12.9**	**68.3 ± 1.4**	**79.1 ± 1.6**	< 0.001
		n (%)	**n (%)**	**n (%)**	
	≤ 54	11 (8.7)	10 (14.3)	1 (1.8)	
	55-74	63 (49.6)	41 (58.6)	22 (38.6)	
	≥ 75	53 (41.7)	19 (27.1)	34 (59.6)	< 0.001
BMI (kg/m2), *mean* ±		**26.9 ± 4.1**	**26.8 ± 0.5**	**26.9 ± 0.5**	0.90
		n (%)	**n (%)**	**n (%)**	
	< 18.5	5 (3.9)	4 (5.7)	1 (1.8)	
	18.5-24.9	32 (25.2)	21 (30.0)	11 (19.3)	
	25.0-29.9	61 (48.0)	24 (34.3)	37 (64.9)	
	≥ 30	29 (22.8)	21 (30.0)	8 (14.0)	0.006

BMI – Body mass index.

Table 2. Sensitivity, Specificity and Likelihood-Ratios of Estimated Measures (Obesity,

Participants'	Sensitivity	Specificity	Likelihood Ratio	
			Positive (LR+)	Negative (LR-)
Weight status				
Obesity	41.4 %	96.4%	11.5	0.61
Overweight and	72.8 %	78.4 %	3.4	0.35

Overweight/Obesity)

Table 3. Sensitivity, Specificity and Likelihood-Ratios of Estimated Obesity and Overweight/Obesity by observation, according to Sex of Observer, Sex of Participant and Age of Participant

	Obesity				Overweight and Obesity			
	Sensitivity	**Specificity**	**Likelihood Ratio Positive (LR+)**	**Negative (LR-)**	**Sensitivity**	**Specificity**	**Likelihood Ratio Positive (LR+)**	**Negative (LR-)**
Sex of Observer								
Female	56.8%	95.0%	11.4	0.45	76.6%	76.6%	3.3	0.31
Male	14.3%	98.7%	11.0	0.87	66.7%	81.5%	3.6	0.41
	p=0.002	p=0.184			p=0.146	p=0.623		
Sex of								
Female	50.0%	92.9%	7.0	0.54	65.6%	100%	∞	0.34
Male	38.1%	100%	∞	0.62	80.0%	68.0%	2.5	0.29
	p=0.411	p=0.014			p=0.029	p=0.002		
Age of								
18-34	20.0%	100%	∞	0.8	79.2%	91.7%	9.5	0.23
35-54	37.5%	97.6%	15.6	0.64	66.2%	78.1%	3.0	0.43
≥ 55	54.2%	93.4%	8.21	0.49	76.8%	61.1%	2.0	0.38
	p=0.161	p=0.206			p=0.249	p=0.059		
< 50 or ≥ 50								
< 50	33.3%	100%	∞	0.67	69.2%	85.4%	4.7	0.36
≥ 50	50.0%	93.0%	7.1	0.54	75.5%	65.4%	2.2	0.37
	p=0.198	p=0.014			p=0.350	p=0.046		

BMI – Body mass index.

Table 4. Concordance between observers regarding estimates of height, weight, BMI and Stunkard Figures

	Kappa	**p-value**
Height (cm)	**0.62**	**< 0.001**
≤ 154	0.38	
155-164	0.55	
≥ 165	0.79	
Weight (kg)	**0.46**	**< 0.001**
≤ 54	0.48	
55-74	0.42	
≥ 75	0.50	
BMI (kg/m2)	**0.51**	**< 0.001**
< 18.5	0.49	
18.5-24.9	0.62	
25.0-29.9	0.43	
≥ 30	0.45	
< 25 or ≥ 25 kg/m2	0.66	**< 0.001**
Stunkard Figures	**0.29**	**< 0.001**
Fig. 1 – BMI 18.3 ♀ /	0.49	
Fig. 2 – BMI 19.3 ♀ /	0.50	
Fig. 3 – BMI 20.9 ♀ /	0.32	
Fig. 4 – BMI 23.1 ♀ /	0.33	
Fig. 5 – BMI 26.2 ♀ /	0.16	
Fig. 6 – BMI 29.9 ♀ /	0.27	
Fig. 7 – BMI 34.3 ♀ /	0.25	
Fig. 8 – BMI 38.6 ♀/	0.66	
Fig. 9 – BMI 45.4 ♀/	n.a	

BMI – Body mass index