SOMATOTYPE AND BODY IMAGE AS PREDICTORS OF OVERALL AND ABDOMINAL OBESITY IN COLLEGE STUDENTS FROM NORTHERN MEXICO

Arnulfo Ramos-Jiménez[1], Abraham Wall-Medrano[1], Rosa P. Hernández-Torres[2], Miguel Murguía-Romero[3]

[1]Universidad Autónoma de Ciudad Juárez, [2]Universidad Autónoma de Chihuahua, [3]Chihuahua, México, Universidad Nacional Autónoma de México, México

ABSTRACT:

Objective: To maximize somatotype and body image (BI) as predictors of overweight/obesity and abdominal obesity in university students in northern Mexico.

Methods: Body mass index (BMI, kg/m^2), waist circumference (WC, cm), somatotype and self-perception of the BI from 329 college students (17-35 years, 51% males) were evaluated; Sensitivity, specificity, precision and accuracy of said variables were also evaluated, using ROC curves and classification/regression tree analysis.

Results: Average BMI and WC were 24 ± 4 and 79 ± 9 (male) and 25 ± 5 and 81 ± 10 (female). Somatotype and BI changes predicted both BMI (≥ 82.6%) and WC (≥ 87.4%); A somatotype scale ≥ 5.35 (endomorphy), ≥ 4.75 (mesomorphy) and ≤ 1.25 (ectomorphy), or an BI> 3.5 predicted overweight/obesity, while a somatotype ≥ 6.55 (endomorphy), ≥ 5.45 (mesomorphy), ≤ 1.15 (ectomorphy), or a BI ≥ 4.5 predicted abdominal obesity and thinness idealization.

Conclusions: Somatotype and the BI are useful tools to predict overall and abdominal obesity in Mexican college students.

KEYWORDS: Body mass index; Waist circumference; Body image; Abdominal obesity

SOMATOTIPO E IMAGEN CORPORAL COMO PREDICTORES DE LA OBESIDAD GLOBAL Y ABDOMINAL EN ESTUDIANTES UNIVERSITARIOS DEL NORTE DE MÉXICO

RESUMEN

Objetivo: maximizar el somatotipo y la imagen corporal (IC) como predictores de sobrepeso/obesidad y obesidad abdominal en estudiantes universitarios del norte de México. **Métodos:** se evaluaron el índice de masa corporal (IMC, kg/m^2), la circunferencia de cintura (CC, cm), el somatotipo y la autopercepción de la IC de 329 estudiantes universitarios (17-35 años, 51% varones); Se evaluaron además la sensibilidad, especificidad, precisión y certidumbre de dichas variables, usando curvas ROC y análisis de árbol de clasificación/regresión. **Resultados:** El IMC y la CC promedio fueron 24±4 y 79±9 (masculino) y 25±5 y 81±10 (femenino). Los cambios en somatotipo e IC predijeron tanto el IMC (≥ 82.6%) como la CC (≥ 87.4%); Una escala de somatotipo ≥ 5.35 (endomorfia), ≥ 4.75 (mesomorfia) y ≤ 1.25 (ectomorfia), o una IC > 3.5 predijeron sobrepeso/obesidad, mientras que un somatotipo ≥ 6.55(endomorfia), ≥ 5.45(mesomorfia), ≤ 1.15(ectomorfia), o una IC ≥ 4.5 predijeron obesidad abdominal e idealización de delgadez.

Conclusiones: el somatotipo y la IC son herramientas útiles para predecir obesidad general y abdominal en estudiantes universitarios mexicanos

PALABRAS CLAVE: Índice de masa corporal; Circunferencia de cintura; Imagen corporal; Obesidad abdominal.

SOMATÓTIPO E IMAGEM CORPORAL COMO PREDITORES DE OBESIDADE GERAL E ABDOMINAL EM ESTUDANTES UNIVERSITÁRIOS DO NORTE DO MÉXICO

RESUMO

Objetivo: Maximizar somatotipo e imagem do corpo (IC) como preditores de sobrepeso/obesidade e obesidade abdominal em estudantes universitários no norte do México. **Métodos:** Foram avaliados o Indice de massa corporal (IMC, Kg/m^2), a circunferência da cintura (CC, cm) somatotipia e auto-percepção do IC 329 estudantes universitários (17-35 anos, 51% masculino); Sensibilidade, especificidade, precisão e precisão destas variáveis também foram avaliados usando ROC análise curvas e árvore de classificação/regressão.

Resultados IMC e CC foram média 24 ± 4 e 79 ± 9 (macho) e 25 ± 5 e 81 ± 10 (fêmea). Alterações na somatotipo e IC previsto tanto IMC (≥ 82,6%) como CC (≥ 87,4%); Uma escala de somatotipia ≥ 5,35 (endomorph) ≥ 4,75 (mesomorfia) e ≤ 1,25 (ectomorfia), ou CI> 3,5 previu excesso de peso / obesidade, enquanto um somatotipo ≥ 6,55 (endomorph) ≥ 5,45 (mesomorfia) ≤ 1,15 (ectomorfia), ou um IC ≥ 4,5 previu obesidade abdominal e idealização de magreza. **Conclusões:** Somatotipo eo IC são ferramentas úteis para prever a obesidade geral e abdominal em estudantes universitários mexicanos.

PALAVRAS-CHAVE: Índice de massa corporal; Circunferência da cintura; Imagem corporal; Obesidade abdominal

Manuscrito recibido: 16/11/2017
Manuscrito aceptado: 09/08/2018

Contact address: Arnulfo Ramos-Jiménez, Anillo Envolvente del Pronaf y Estocolmo, Ciudad Juárez (32310) Chihuahua, México
Correo-e: aramos@uacj.mx

Overweight/obesity [body mass index (BMI) ≥25 kg/m^2] and abdominal obesity [waist circumference (WC) ≥80 cm women, ≥ 90 cm men] are risk factors for many non-communicable chronic diseases such as type-two diabetes, cancer, cardiovascular disease and metabolic syndrome (Murguía, et al., 2015; Villalobos-Molina, et al., 2015). An increased BMI or WC is also related to other cardio-metabolic risk factors such as hyperuricemia, dyslipidemia, and hyperinsulinemia in young adults (Wall-Medrano, et al., 2016). However, many other anthropometric markers also predict cardio-metabolic derangements and mortality including the human body shape, ponderable, "A" body shape and conicity indexes and waist-to-hip ratio (Krakauer & Krakauer, 2012; Lebiedowska & Stanhope, 2012; Motamed, et al., 2015). The somatotype also describes the human body shape regarding several anthropometric traits (including body weight and height) and consists of numerical ratings for adiposity (endomorphy), skeletal muscle development (mesomorphy) and slenderness (ectomorphy). From an epidemiological standpoint, the metabolic profile of normal weight-to-obese individuals are predicted by their somatotype, mainly by the structure of lean body mass (Galić, et al., 2016), while longitudinal changes in somatotype from early (5 y) to middle (50 y) life (e.g., ectomorphy vs. endomorphy) also predict all-cause and specific-mortality (Song, et al., 2016). That is why somatotype predicts more accurately overall obesity as compared to BMI.

On the other hand, several qualitative scales that evaluate body image (BI) have been validated within specific populations in order to study the prevalence and intrinsic determinants of body image dissatisfaction (BID) at population level (Hernández, de Jesús Saucedo-Molina, Irecta, & Santoncini, 2015; McElhone, Kearney, Giachetti, Zunft, & Martínez, 1999; Zach, et al., 2013). The silhouette matching technique (McElhone, et al., 1999; Pulvers, et al., 2004), the body appreciation scale (Avalos, Tylka, & Wood-Barcalow, 2005) and the body image dimensional assessment (Segura-García, Papaianni, Rizza, Flora, & De Fazio, 2012) are just few examples of a wide range of instruments developed to date. BMI is statistically related to brain anatomy (orbitofrontal volume), and the later with disinhibiting eating disorders in adolescents (Maayan, Hoogendoorn, Sweat, & Convit, 2011) and to BID from adolescence to young adulthood (Bucchianeri, Arikian, Hannan, Eisenberg, & Neumark-Sztainer, 2013), therefore the intrinsic relationship between BMI and BI is warranted, as we also found it in athletes (Ramos-Jiménez et al., 2016) and college students (Ramos-Jiménez et al. 2017a,b). In fact, the rating of BI by the nine-silhouette scale, strongly correlates with BMI (r = 0.81) as well as with the percentage of body fat (r = 0.76) in middle-age Afro-Americans, showing a good discriminative power in obese but not lean subjects (Pulvers et al., 2004); we have found that somatotype, WC and waist-to-height ratio are good predictors of BID (Ramos-Jimenez et al. 2017a). However, most studies on BI have been focused on detecting BID as the discrepancy between the self-perception of BI vs. a desirable BI (bi-variate approach; Figure 1, grey square) (Paap & Gardner, 2011). While the social influence as part of the self-perceived BI construct, also known as the "tripartite influential model" (Vartanian & Dey, 2013), has been studied in very few studies, none of them was performed on Mexicans. Moreover, several authors have attempted to validate BI against BMI and/or anthropometric indexes but conflicting results have been reported, either related to the validation strategy (Gardner, Jappe, & Gardner, 2009; Paap & Gardner, 2011) or to the fact that BMI is not a good predictor of body adiposity (Nevill, Stewart, Olds, & Holder, 2006).

The aim of this study was to maximize somatotype and body image to predict overweight/obesity and abdominal obesity in college students from northern Mexico, using receiver operating characteristic (ROC) curves, Youden's index (J) and classification and regression trees analysis (CART) (Strobl, Malley, & Tutz, 2009; Wall-Medrano, et al., 2016).

METHODS

Subjects

329 college students (17-35 y; 51% male) from the Autonomous University of Ciudad Juarez, México, participated in the study. All students perceived themselves as healthy, and none chronic diseases were diagnosed by a trained physician. Each participant was informed on the purpose of the study and the nature of all evaluations (questionnaire and anthropometry), signed an informed consent to participate in the study and its anonymity was warranted. The research project was approved by the ethics committee of the Autonomous University of Ciudad Juarez. All assessments took place under the supervision of well-trained investigators of public health nutrition and social psychology.

Body image

BI was evaluated by the silhouette matching technique (McElhone, et al., 1999; Pulvers et al., 2004). The scale consisted of nine gender-specific and culturally-adapted contour drawings from leaner (BMI< 20 kg/m^2) to wider (BMI ≥ 30 kg/m^2) shapes, these were categorized as follows: Low (silhouette 1-3), normal (silhouette 4-5), over (silhouette 6-7) weight and obese (silhouette 8-9) persons. The nine silhouette scale was applied to each participant accompanied by the following questions in three non-consecutive moments **(Figure 1)**: How do I look (BI-1), How do I think other people see me (BI-3) and, How do I want to look like (BI-4), while the scale accompanied by the question How do other people see me (BI-2) was applied to at least three other schoolmates, in order to get the average participant's silhouette as perceived by them (social construct). All precautions and recommendations suggested by Gardner et al., (2009) and Pulver et al., (2004) were followed during interviews.

Body shape

To calculate the anthropometric characteristics including BMI, WC, and somatotype of all participants, the Norton & Olds (1996) method was employed as recommended by the International Society for the Advancement of Kinanthropometry (ISAK). 10 anthropometric dimensions [height (cm), weight (kg), 4 skinfolds (triceps, subscapular, supraspinale, medial calf - mm), 2 limb girths (arm flexed and calf - cm) and 2 bone breadths (biepicondylar humerus and femur - cm)], weight (±0.1 kg) with an electronic scale (Tanita mod. 682), height (±0.1 cm) with a fixed stadiometer (Seca mod. 208), circumferences (±0.1 cm) a non-stretch measuring tape (Lufkin W606PM) and skinfolds (±0.1 mm) with a Harpenden caliper (±0.1 mm) were performed by an ISAK certified anthropometrist. WC was measured to the nearest 0.1cm midway between the top of the ileac crest, and the bottom of the rib cage, perpendicular to the long trunk axis, and BMI was calculated; since WC increases in proportion to height, this measure was adjusted according to the Phantom model (Ross & Wilson, 1974):

(WC) × (170.18 cm) × (participant's height, cm^{-1}). **Eq. 1**

BMI was calculated as the weight (kg) divided by the height (m) squared (kg/m^2). Somatotyping was performed as suggested by Norton and Olds (Norton & Olds, 1996). Precision and reliability measurements for skin folds, diameters, and body girths measurements were: percentage of technical error 6.2, 1.5, 1.7, and interclass correlation coefficient 0.98, 0.99, 0.99, respectively.

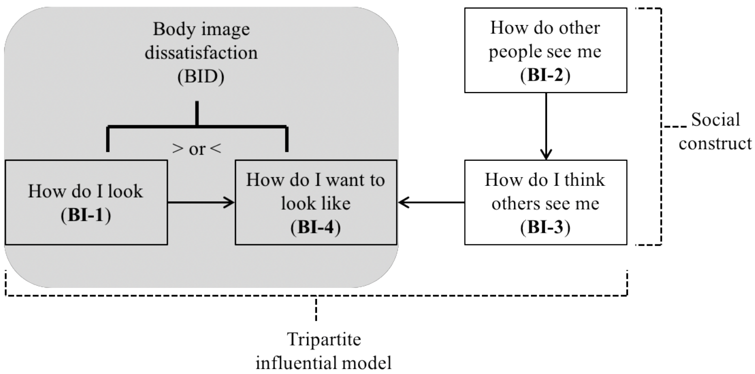

Figure 1. The "tripartite influential model" on self-perceived body image constructs.

Statistical analysis

In order to maximize the somatotype and BI as predictors of BMI and WC in college students, the classification and regression trees (CART) analysis was employed **(Figure 2)**. Sensitivity, specificity, precision and accuracy of generated models were analysed by binary comparisons as suggested by Murguía-Romero, et al., (2015). Sensitivity (Se) was defined as the number of predicted cases correctly diagnosed as unhealthy (BMI ≥25 kg/m^2, WC ≥80 cm women, ≥ 90 cm men) (Villalobos-Molina, et al., 2015); specificity (Sp) as the number of predicted cases accurately diagnosed as healthy (below the aforementioned BMI and WC); positive precision (PC; +) as the number of unhealthy cases correctly predicted; negative precision (PC; -) as the number of healthy cases correctly predicted; and accuracy (AC) was defined as the total number of cases accurately predicted either healthy or unhealthy status. Se and Sp of somatotype's or BI's cutoffs against those mentioned above healthy and unhealthy cut offs were evaluated using crosstabs and receiver operating characteristic (ROC) curves. The discriminant capacity of ROC curves was settled as follows: ≤ 50 without capacity, 50-60 very low capacity, 60-70 low capacity, 70-80 moderate capacity, 80-90 high capacity, and 90-100 very high capacity. Lastly, maximization of BI and somatotype was performed by estimating the Youden's Index (J) (Wall-Medrano, et al., 2016).

J = Sensitivity + Specificity –1 **Eq. 2**

J is defined at their maximum value (Jmax = highest Se and Sp) to select the most reliable cutoff. All statistical analyzes were performed using SPSS ver 21.0. Statistical significance was accepted when α level of $p < 0.05$.

RESULTS

The Average BMI was 24 ±4 (male) and 25 ±5 (female), and WC was 79 ±9 (male) and 81 ±10 (female). According to CART analysis, somatotype predicted 93.5% and 89.8% of participants' BMI and WC with an estimate error of accuracy (EEAC) of 6.5% and 10.2%, respectively **(Table 1)**, while BI predict them by 82.6% and 87.4% with an EEAC of 17.4% and 12.6%, respectively **(Table 2)**. Also, according to Figure 2, ectomorphy (slenderness) was the primary predictor of BMI and WC (100% of normalized importance) as compared to endomorphy (adiposity) or mesomorphy (skeletal muscle development). As to BI, the question how do other people see me (BI-2) was the strongest predictor for BMI (100% of normalized importance) followed by BI-3, BI-1 and BI-4 in decreasing order. BI-2 was also the strongest predictor for WC (100% of normalized importance) followed by BI-1, BI-3 and BI-4 in decreasing order.

The somatotype showed a total discriminant capacity (ROC; % area under the curve) ranging from 86% (endomorphy) to 96% (ectomorphy) toward BMI, and 75% (mesomorphy) to 92% (endomorphy/ectomorphy) toward WC, when using conventional BMI and WC cutoffs **(Table 3).**

Consequently, endomorphy–mesomorphy- ectomorphy (EME) values above 5.35-4.75-1.25 characterized all subjects with a BMI ≥25 kg/m^2 while those above 6.55–5.45–1.15 had abdominal obesity (WC ≥80 cm women, ≥ 90 cm men). Lastly, BI showed a total discriminant capacity ranging from 71% (BI-2) to 88% (BI-3) toward BMI and 76% (BI-2) to 89% (BI-3/BI-4) toward WC **(Table 4)**.

BI-3 and BI-4 showed the highest values and BI-4 the lowest values for Se and Sp to detect the unhealthy state which means a BI cut off of 5.5 while cut offs of 3.5 (BMI) and 4.5 (WC) characterized a thin-idealization state.

DISCUSSION

Somatotype, BMI and WC are expressions of body shape and the first two have been statistically related to self-perception of BI (Madrigal-Fritsch, et al., 1999; Pulvers, et al., 2004). BMI and WC are often used to characterize people with or without risk of cardio-metabolic diseases, although BI and somatotype have not been studied for the same purpose in the Mexican youth. From this study, it can be concluded that somatotype and BI could be surrogate measures to predict overall and abdominal obesity in Mexican college students, with an accuracy of >82% of the associated differences in BMI and WC within the studied population. Mainly, somatotype also showed moderate-high Se and Sp (77% -94%) to correctly predict BMI and WC to a lower extent. Valdés-Badilla et al. (2015) observed low-to-moderate correlations (r, 0.36-0.65) between somatotype, BMI and waist-to-hip ratio, while we recently reported the opposite in athletes (Ramos-Jiménez et al., 2016) and college students (Wall-Medrano et al., 2016) when using WC (normal and height-corrected), BMI and somatotype.

Among somatotype components, ectomorphy was the best predictor of an unhealthy BMI and WC. To calculate both BMI and ectomorphy, weight and height are used in different ratios (weight/height^2 and height/weight^3, respectively) which explain the high predictive value of ectomorphy toward BMI. However, subjects with overweight/obesity (by BMI) and abdominal obesity (by WC) presented endomorphic (≥5.35)– mesomorphic (≥4.75)

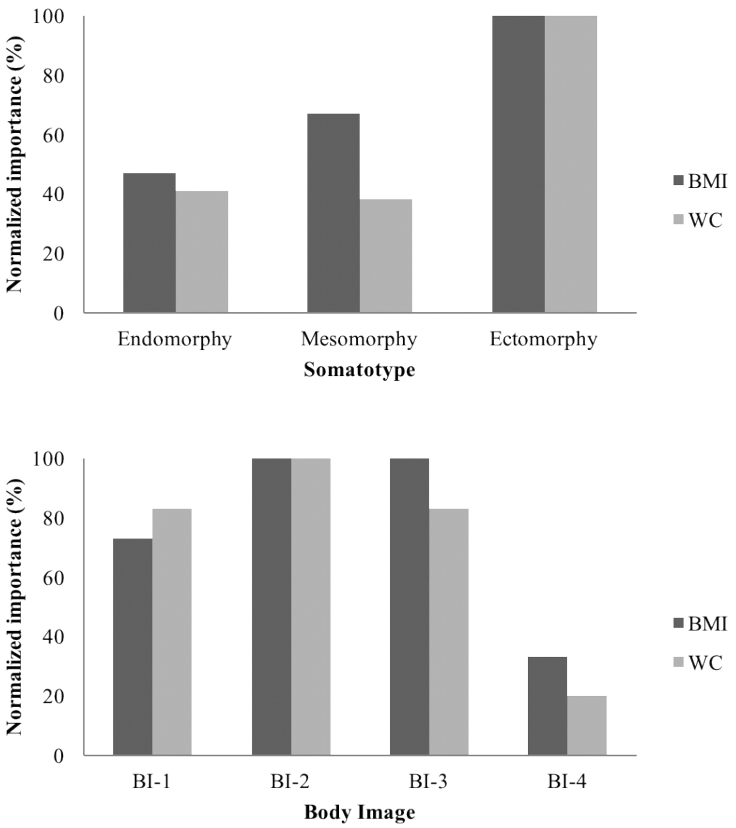

Figure 2. Importance of somatotype and body image as predictors of BMI and WC.

Table 1. Somatotype as predictors of overweight/obesity and abdominal obesity.

	BMI (kg/m²)			WC (cm)		
	Unhealthy	Healthy	PC/AC (%)	Unhealthy	Healthy	PC/AC (%)
Unhealthy	111	11	91.0%	62	12	83.8%
Healthy	8	164	95.3%	18	202	91.8%
Se/Sp (%)	93.3%	93.7%	**93.5%**	77.5%	94.4%	**89.8%**
EEAC (%)		6.5 ± 1.4%			10.2 ± 1.8%	

*Classification and regression trees (CART) analysis. Healthy (18-24.9 kg/m², WC<80 cm women or <80 man), unhealthy (BMI ≥ 25 kg/m², WC≥80 cm women/ ≥90 cm man), precision (PC; +), accuracy (AC), sensitivity (Se), specificity (Sp), Estimate error of accuracy (EEAC).

Table 2. Body image as predictors of overweight/obesity and abdominal obesity.

	BMI (kg/m²)			WC (cm)		
	Unhealthy	Healthy	PC/AC (%)	Unhealthy	Healthy	PC/AC (%)
Unhealthy	94	26	78.3%	47	25	65.3%
Healthy	24	144	85.7%	11	202	94.8%
Se/Sp (%)	79.7%	84.7%	**82.6%**	81.0%	89.0%	**87.4%**
EEAC (%)		17.4 ± 2.2%			12.6 ± 2.0%	

*Classification and regression trees (CART) analysis. Healthy (18-24.9 kg/m², WC<80 cm women or <80 man), unhealthy (BMI ≥ 25 kg/m², WC≥80 cm women/ ≥90 cm man), precision (PC; +), accuracy (AC), sensitivity (Se), specificity (Sp), Estimate error of accuracy (EEAC).

Table 3. Maximization of somatotype cutoffs for predicting standard obesity indicators.

	Overweight/obesity			Abdominal obesity		
	Endo	Meso	Ecto	Endo	Meso	Ecto
Somatotype cutoff	5.35	4.75	1.25	6.55	5.45	1.15
SE (%)	80	82.8	86.6	84	62.2	75
SP (%)	74	77.9	91.8	89	78.6	94.6
Youden index	1.54	1.61	1.784	1.72	1.41	1.70
TDC	86.3	87.6	96	92.0	75.4	92.3

*Overweight/obesity (BMI ≥ 25 kg/m²), abdominal obesity (WC≥80 cm women/ ≥90 cm man); sensitivity (SE), specificity (SP), (TDC) total discriminant capacity (ROC; % AUC).

Table 4. Maximization of body image for predicting standard obesity indicators.

	Overweight/obesity				Abdominal obesity			
	BI-1	BI-2	BI-3	BI-4	BI-1	BI-2	BI-3	BI-4
BMI cutoff point	5.5	4.5	5.5	3.5	5.5	5.5	5.5	4.5
SE (%)	78	89	85	87	92	85	93	71
SP (%)	77	73	78	54	70	80	67	70
Youden index	1.56	1.62	1.63	1.33	1.62	1.65	1.60	1.41
TDC	86	88	88	71	88	89	89	76

*Overweight/obesity (BMI ≥ 25 kg/m²), abdominal obesity (WC≥80 cm women/ ≥90 cm man). Body image (BI) scale: How do I look (BI-1), How do other people see me (BI-2), How do I think other people see me (BI-3) and, How do I want to look like (BI-4); sensitivity (SE), specificity (SP), total discriminant capacity (ROC; % AUC).

somatotypes and an ectomorphism (<1.3); this body shape phenotype is strongly related to an increased risk of non-communicable chronic diseases such as type 2 diabetes (EME: 6.3-6.4-0.6) and metabolic syndrome (6.5-8.7-0.1) in Mexican adults (Ochoa-Martínez, et al., 2012; Urrutia-García, Martínez-Cervantes, Salas-Fraire, & Guevara-Neri, 2015), and hypertension (7.6-6.1-0.6) in Brazilian adults (Almeida, Santos, Rodrigues Filho, Carvalho, & Batista, 2015). Since we have reported, in a preceding study (Wall-Medrano et al., 2016), that BMI is a strong predictor of WC (Jmax= 68-74%) and that Jmax-corrected cutoffs for BMI (27±3; CI 95% 25-28) and WC (85±5; CI 95% 81-88 male; 81±6; CI 95% 75-87 female) predict with moderate-high reliability hypertension, hyperuricemia, dyslipidemias and insulin resistance in 2,683 college students (18.7±2.7 y), somatotyping could also be a predictive tool for cardio-metabolic disturbances, although this was not proven in this study.

BMI and WC were also highly predicted (82.6% and 87.4%) via BI but with a moderate Se and Sp (71-98%). Using the same silhouette matching technique, Madrigal-Fritsch et al., observed a high Se and Sp (>90%) between lean vs. overweight/obese individuals, although the instrument was not reliable (Se and Sp <50%) to discriminate normal weight from lean individuals. On the other hand, Osuna-Ramírez et al., observed a high Se (88%) but a low Sp (48.9%) to predict the BMI of Mexican adults (~42 y). Alvarez, Licea & Pérez, observed a modest correlation (r=0.65, p < 0.001) between the self-perceived BMI, which corresponds to How do I look (BI-1) in this study, a fact that is consistent with our findings between measured BMI & WC and BI-1, BI-2 & BI-3 (r=0.75) but not with BI-4 (r=0.41; data not shown). Since 12% of overweight/obese individuals had a correct perception of their BI, 28% wanted to have a normal weight and 60% wanted to be thinner, it could be concluded that the higher the BMI, the higher the thin-idealization (r=0.79; data not shown)., Considering the corresponding BI cutoffs for BMI (3.5) and WC (4.5), the silhouette matching technique employed here seems to be a reliable tool for predicting overweight/obesity (BMI) and abdominal obesity (WC) since figures from 6 and on in the 9-scale represent unhealthy BMI cutoffs (McElhone, et al., 1999).

Lastly, it is noteworthy that BI-2 (How do other people see me) was the best predictor (100% normalized importance) of unhealthy BMI or WC, which was the only question not answered by the participant. According to Gardner, BI is the mental picture and associated negative feelings related to body measures and contours (shape) of each individual toward themselves, although many other factors contribute to the feeling of dissatisfaction (BID) regarding body size and/or shape (Paap & Gardner, 2011), including the tendency to make appearance-related social comparisons as well as to settle for opinions of peers, partner and media (Vartanian & Dey, 2013). In this and previous works (Ramos-Jimenez, et al., 2017a,b) were applied the silhouette matching technique to detect the “social construct” of self-perceived BI (Figure 1) based on the “tripartite influential model” (Vartanian & Dey, 2013). Surprisingly, peers’ opinion of somebody’s BI (BI-2) was beyond the participant’s self-perception of its body image (BI-1). Considering that women who lack a clearly defined sense of identity regularly compare their appearance to other women and internalize the thin ideal possibly defining their own identity (Vartanian & Dey, 2013), the “social construct” must be analyzed in much more detail in epidemiological studies or as a surveillance issue during weight loss regimens (McElhone, et al., 1999) since BID is a prodromal condition for several eating and body image disorders (Hernández, et al., 2015).

CONCLUSIONS

The body shape (objective/external measurement)/ and BI (subjective/self-perceived) binomium should be studied as complex bidirectional phenomena. “Corporeity” is a social, psychological and biological trait related to the way in which a subject projects itself out of his own body, self-perceiving its BI according to the societies' anthropometric standards. However, the increasing body mass causes several biological (e.g. hormonal) and psychic changes related to the idealization of the body, causing BID; in this sense, previous studies have shown us that body shape (somatotype), composition (adiposity measures) and BI are three different but complementary concepts (Ramos-Jiménez, et al., 2016) useful to describe people in all the tripartite influential dimensions (Figure 1; Vartanian & Dey, 2013), that body shape is a body image determinant (Ramos-Jiménez et al., 2017a) and that BI satisfaction (BIS) is a strong predictor of physical activity/sports participation in university students (Ramos-Jiménez et al., 2017b). In this new study, we have provided compelling evidence on the usefulness of both body shape (somatotype) and BI as statistically reliable yet subjective predictors of overall (BMI≥ 25 kg/m^2) and abdominal obesity (WC≥80 cm women, ≥ 90 cm men) in university students.

The findings reported have an invaluable practical application in epidemiological studies involving the intrinsic biological and psychological dimensions of body weight. The close statistical relationship between somatotype rating and the body silhouette matching technique (BI) reported previously (Ramos-Jiménez, et al., 2017a), the fact that weigh gain and abdominal obesity are strong predictors of other cardio-metabolic derangements (Wall-Medrano, et al. 2016) and the specific/sensitive cut off points for both somatotype and BI to detect overall and abdominal obesity, may help to establish an accurate, yet subjective, way on predicting the cardio metabolic risk while evaluating body image disorders at the same time; however, our study also has some limitations on some limitations that have arisen during its development that limit their extrapolation to other populations similar to the one studied here. For instance, since BI is also determined at a social level and anthropometric standards vary from one community to another, the reliability of BI and somatotype should be retested in further studies involving young individuals from other regions or countries.

REFERENCES

Almeida, A. H. S. D., Santos, S. A. G. d., Rodrigues Filho, E. d. A., Carvalho, P. R. C., Batista, G. R. (2015). Somatotypes, risk factors and waist-height ratio in physically active individuals. *Revista Brasileira de Medicina do Esporte, 21*(4), 271-274.

Álvarez, I. C. M., Licea, V. C., Pérez, M. (2007). El índice de masa corporal y la imagen corporal percibida como indicadores del estado nutricional en universitarios. *Revista de la Facultad de Medicina UNAM, 50*(2), 76-79.

Avalos, L., Tylka, T. L., Wood-Barcalow, N. (2005). The Body Appreciation Scale: development and psychometric evaluation. *Body Image, 2*(3), 285-297.

Bucchianeri, M. M., Arikian, A. J., Hannan, P. J., Eisenberg, M. E., Neumark-Sztainer, D. (2013). Body dissatisfaction from adolescence to young adulthood: Findings from a 10-year longitudinal study. *Body Image, 10*(1), 1-7.

Galić, B. S., Pavlica, T., Udicki, M., Stokić, E., Mikalački, M., Korovljev, D., Adamović, D. (2016). Somatotype characteristics of normal-weight and obese women among different metabolic subtypes. *Archives of Endocrinology and Metabolism, 60*(1), 60-65.

Gardner, R. M., Jappe, L. M., Gardner, L. (2009). Development and validation of a new figural drawing scale for body-image assessment: the BIAS-BD. *Journal of Clinical Psychology, 65*(1), 113-122.

Hernández, I. M. C., de Jesús Saucedo-Molina, T., Irecta, A. P., Santoncini, C. U. (2015). Eating Disorders Associated Risk Factors: Trends from 2007 to 2010. *Revista de Investigacion Clinica*, *67*,54-63.

Krakauer, N. Y., Krakauer, J. C. (2012). A new body shape index predicts mortality hazard independently of body mass index. *PLoS One, 7*(7). doi:10.1371/journal.pone.0039504

Lebiedowska, M. K., Stanhope, S. J. (2012). The Human Body Shape Index (HBSI): An Anthropometric Measure Based on an Age-Related Model of Human Growth Handbook of Anthropometry . *Springer* pp. 139-150.

Maayan, L., Hoogendoorn, C., Sweat, V., Convit, A. (2011). Disinhibited eating in obese adolescents is associated with orbitofrontal volume reductions and executive dysfunction. *Obesity*, *19*(7), 1382-1387.

Madrigal-Fritsch, H., de Irala-Estévez, J., Martínez-González, M. A., Kearney, J., Gibney, M., Martínez-Hernández, J. A. (1999). Percepción de la imagen corporal como aproximación cualitativa al estado de nutrición. *Salud Pública de México, 41*(6), 479-486.

McElhone, S., Kearney, J. M., Giachetti, I., Zunft, H. J. F., Martínez, J. A. (1999). Body image perception in relation to recent weight changes and strategies for weight loss in a nationally representative sample in the European Union. *Public Health Nutrition, 2*(1a), 143-151.

Motamed, N., Perumal, D., Zamani, F., Ashrafi, H., Haghjoo, M., Saeedian, F., Asouri, M. (2015). Conicity Index and Waist-to-Hip Ratio Are Superior Obesity Indices in Predicting 10-Year Cardiovascular Risk Among Men and Women. *Clinical Cardiology, 38*(9), 527-534.

Murguía, M., Flores, R. J., Sigrist-Flores, S. C., Tapia-Pancardo, D. C., Jiménez, A. R., Cruz, R. M., Molina, R. V. (2015). Prevalence of metabolic syndrome in young Mexicans: a sensitivity analysis on its components. *Nutrición Hospitalaria, 32*(1), 189-195.

Nevill, A. M., Stewart, A. D., Olds, T., Holder, R. (2006). Relationship between adiposity and body size reveals limitations of BMI. *American Journal of Physical Anthropology, 129*(1), 151-156.

Norton, K., Olds, T. (1996). Anthropometrica: A textbook of body measurement for sports and health courses (U. o. N. S. W. Press Ed.). Australia.

Ochoa-Martínez, P. Y., Hall-López, J. A., Alarcón-Meza, E., Rentería, I., Botelho Teixeira, A., Lara-Zazueta, H., Martin Dantas, E. H. (2012). Comparison of agility and dynamic balance in elderly women with endomorphic mesomorph somatotype with presence or absence of metabolic syndrome. *International Journal of Morphology, 30*(2), 637-642.

Osuna-Ramírez, I., Hernández-Prado, B., Campuzano, J. C., Salmerón, J. (2006). Índice de masa corporal y percepción de la imagen corporal en una población adulta mexicana: la precisión del autorreporte. *Salud Pública de México, 48*(2), 94-103.

Paap, C. E., Gardner, R. M. (2011). Body image disturbance and relationship satisfaction among college students. *Personality and Individual Differences, 51*(6), 715-719.

Pulvers, K. M., Lee, R. E., Kaur, H., Mayo, M. S., Fitzgibbon, M. L., Jeffries, S. K., Ahluwalia, J. S. (2004). Development of a culturally relevant body image instrument among urban African Americans. *Obesity Research, 12*(10), 1641-1651.

Ramos-Jiménez, A., Chávez-Herrera, R., Castro-Sosa, A. S., Pérez-Hernández, L. C., Hernández-Torres, R. P., Olivas-Dávila, D. (2016). Body shape, image, and composition as predictors of athlete´s performance. In H. Sozen (Ed.), Fitness Medicine (pp. 19-36). Turkey: Ordu University, School of Physical Education and Sports.

Ramos Jiménez, A., Hernández T. R. P., Wall M. A., Urquídez R. R., Barahona. I., Villalobos M. R. (2017a). Body shape as body image determinant in university students. *Nutrición Hospitalaria, 34*(5): 1112-1118 DOI: 10.20960/nh.744.

Ramos J. A, Hernández T. R. P., Urquídez R. R., Wall M. A., Villalobos M. R. (2017b). Body image satisfaction as a physical activity indicator in university students. *American Journal of Health Behavior, 41*(5): 599-607 DOI: 10.5993/AJHB.41.5.9

Ross, W., Wilson, N. (1974). A strategem for proportional growth assessment. *Acta Paediatrica Belgica, 28*, 169-182.

Segura, G. C., Papaianni, M., Rizza, P., Flora, S., De Fazio, P. (2012). The development and validation of the Body Image Dimensional Assessment (BIDA). *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity, 17*(3), e219-e225.

Song, M., Hu, F. B., Wu, K., Must, A., Chan, A. T., Willett, W. C., Giovannucci, E. L. (2016). Trajectory of body shape in early and middle life and all cause and cause specific mortality: results from two prospective US cohort studies. *Thebmj, 353*: i2195.

Strobl, C., Malley, J., Tutz, G. (2009). An introduction to recursive partitioning: rationale, application, and characteristics of classification and regression trees, bagging, and random forests. Psychological Methods. *Psychol Methods, 14*(4): 323. doi: 10.1037/a0016973

Urrutia-García, K., Martínez-Cervantes, T., Salas-Fraire, O., Guevara-Neri, N.

(2015). Somatotype of patients with type 2 diabetes in a university hospital in Mexico. *Medicina Universitaria, 17*(67), 71-74.

Valdés-Badilla, P., Soler, N. S., Godoy-Cumillaf, A., Carmona-López, M. I., Fernández, J. J., Durán-Agüero, S. (2015). Somatotipo, estado nutricional y nivel de glucemia de estudiantes de educación física. *Nutrición Hospitalaria, 32(n03)*, 1261-1266.

Vartanian, L. R., Dey, S. (2013). Self-concept clarity, thin-ideal internalization, and appearance-related social comparison as predictors of body dissatisfaction. *Body Image, 10*(4), 495-500.

Villalobos-Molina, R., Wall-Medrano, A., Rodríguez-Tadeo, A., Urquidez-Romero, R., Hernández-Torres, R. P., Murguía-Romero, M., Medrano-Donlucas, G. (2015). Hypertriglyceridemic-Waist (HTGW) phenotype in university students from two regions of México. *Acta Medica Mediterranea, 31*: 173-178.

Wall-Medrano, A., Ramos-Jimenez, A., Hernandez-Torres, R. P., Villalobos-Molina, R., Tapia-Pancardo, D. C., Jimenez-Flores, J. R., Urquidez-Romero, R. (2016). Cardiometabolic risk in young adults from northern Mexico: Revisiting body mass index and waist-circumference as predictors. *BMC Public Health, 16*: 236. doi:10.1186/s12889-016-2896-1

Zach, S., Zeev, A., Dunsky, A., Goldbourt, U., Shimony, T., Goldsmith, R., Netz, Y. (2013). Adolescents' physical activity habits–results from a national health survey. *Child Care, Health and Development, 39*(1), 103-108.