Published in final edited form as:

Am J Hum Biol. 2008 ; 20(4): 446–450. doi:10.1002/ajhb.20762.

Relation of Ratio Indices of Anthropometric Measures to Obesity in a Stunted Population

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Abstract

The ratios of anthropometric measures are used to estimate obesity while controlling for allometric scaling. A good index should be uncorrelated with its denominator; this often requires exponentiation of the denominator. The stability of the derived exponents across populations is not known. We obtained subscapular (SUBS) and triceps (TRI) skinfolds, weight (WT), height (HT), waist circumference (WC), fat mass (FM), and fat-free mass (FFM) in a population of Guatemalan adults [height 1.63 ± 0.06 m (868 males); 1.51 ± 0.06 m (1047 females)]. We derived exponents for the indices WT/HT^P , $SUBS/TRI^P$, $TRI/SUBS^P$, WC/HT^P , FM/WT^P , and FM/FFM^P such that the ratios were free from association with their denominators. The derived exponents were (Men: $SUBS/TRI^{0.88}$, $FM/WT^{2.69}$, $FM/FFM^{2.86}$, $WC/HT^{0.68}$, and $WT/HT^{2.17}$; Women: $SUBS/TRI^{0.93}$, $FM/WT^{2.01}$, $FM/FFM^{3.37}$, $WC/HT^{0.47}$, $WT/HT^{2.03}$). For all examined indices the derived exponents differed ($P < 0.05$) from 1 and differed ($P < 0.05$) between men and women. The exponents for the men also differed from those previously published for Brazilian men (JCK Wells and CG Victora [2005]: *Int J Obes* 29:483–489). The derived indices were not more strongly correlated with adiposity than were simple unexponentiated ratios. Although exponentiation of the denominator eliminates the association of index with its denominator, the resulting exponents lack generalizability across populations, especially those where stunting remains prevalent.

The developing countries face a double burden of nutritional problems: Childhood undernutrition, resulting in growth retardation, and adult overnutrition, resulting in overweight and obesity (Uauy et al., 2001). Many anthropometric measures [e.g., body mass index (BMI), waist circumference (WC), percent body fat (%BF)] have been used to rank individuals on health risks associated with obesity (Bosy-Westphal et al., 2006; Pi-Sunyer, 2000). Because these measures do not directly measure adiposity, they fail to distinguish between fat mass (FM) and lean mass (Frankenfield et al., 2001; Wellens et al., 1996). Further, it has been suggested that the optimal cut-points may not be the same in all populations. In particular, the use of the BMI in stunted populations has been questioned (Hall and Cole, 2006; Norgan and Ferro-Luzzi, 1982), and other indices that may be more appropriate for use in describing health risks associated with excess adiposity have been

proposed (Al-Shayji and Akanji, 2004; Benn, 1970; Bosy-Westphal et al., 2006; Wells, 2000; Wells and Cole, 2002).

Ratio indices (e.g., the BMI) were developed in an attempt to account for allometric scaling (the tendency for all linear measures to increase with increases in overall mass) and to describe body tissue distribution. To be used as measures of obesity, ratio indices should satisfy two criteria; they should be correlated with adiposity and they should be independent of association with their denominator (Benn, 1971). Failure of an index to be independent of its denominator can result in residual confounding if the denominator is associated with the risk of disease. The first criterion has been examined at length; however, few have examined whether or not the second criterion is satisfied.

In a population of Brazilians (mean height 1.73 m), Wells and Victora (2005) found that several commonly used indices remained correlated with their denominators, thus failing to satisfy the second criterion (Wells and Victora, 2005). Although the use of indices with exponentiated denominators can eliminate this correlation, (Benn, 1971; Wells and Victora, 2005), the stability of these exponents across populations has not been examined extensively. Optimal indices of adiposity in children differ from those used in adults (Hoffman et al., 2006; Michielutte et al., 1984; Wells, 2000; Wells and Cole, 2002). Further, optimal exponents for weight for height indices vary not only between boys and girls but also by age (Hattori and Hirohara, 2002). Therefore, it would stand to reason that exponents may differ across populations that differ in mean height.

Stunted populations may differ in BF distributions as compared with populations who attain full final height. Stunted populations are at increased risk for central adiposity and health risks associated with obesity (Hoffman et al., 2000; Martins et al., 2004; Soares-Wynter and Walker, 1996). The optimal anthropometric indices in stunted populations are not well established (Hoffman et al., 2006). We therefore examined the characteristics of indices derived from anthropometric measurements in a population subject to stunting in childhood.

MATERIALS AND METHODS

Subject recruitment

Data were collected in 2002–2004 during a follow-up of a longitudinal growth and development study conducted by the Institute of Nutrition of Central America and Panama (INCAP) between 1969 and 1977, in four villages in Eastern Guatemala (Grajeda et al., 2005). We attempted to trace all 2,392 individuals who had participated as children in the original study. Full details on subject tracing and contact are provided elsewhere (Grajeda et al., 2005). Of the original cohort, 272 had died, 102 were considered untraceable, and 163 had migrated out of the country. The target subject population thus consisted of 1,855 (77%) persons known to be living in Guatemala and their spouses.

All individuals who could be contacted were invited to participate, along with their spouse if married. All procedures followed protocols that were approved by the appropriate institutional review boards, and all participants provided written informed consent.

Anthropometry and body composition

Weight was measured to the nearest 0.01 kg using a digital scale (model 1582, Tanita¹, Japan) with participants dressed in their normal underclothes with no shoes or objects in their pockets. Height was measured to the nearest 0.1 cm, with the participants bare footed and standing with their backs to a stadiometer (GPM, Switzerland). WC was measured to the nearest 0.1 cm at the umbilicus using a plastic inextensible measuring tape. Skinfold thicknesses were measured to the nearest 0.1 mm with the use of a Holtain caliper (Holtain,

Crosswell, UK) at tricipital (TRI), and subscapular (SUBS) sites on the nondominant side of the body. All measurements were obtained in duplicate by separate trained anthropometrists. If the difference between the two first measurements was greater than 0.5 kg for body weight, 1.0 cm for height, 1.5 cm for WC or 0.5 mm for skinfold thicknesses, a third measurement was done and the two closest measurements were used. The mean of the two values was calculated. %BF, FM, and fat-free mass (FFM) were estimated using predictive equations (*Women*: %fat = $19.420 + (\text{weight in kg} \times 0.385) - (\text{Height in cm} \times 0.215) + (\text{Abdominal circumference in cm} \times 0.265)$; *Men*: %fat = $-48.472 - (\text{weight in kg} \times 0.257) + (\text{Abdominal circumference in cm} \times 0.989)$) that had been developed among a similar population using hydrostatic weighing as the reference method (Ramirez-Zea et al., 2006).

Statistics

We derived ratio measures (WT/HT, FM/WT, FM/FFM, TRI/SUBS, SUBS/TRI, and WC/HT) that are widely used to describe both relative fat and fat distribution within the body. BMI was computed as WT (kg) divided by HT squared (m^2).

We derived exponents for the denominator of exponentiated ratio measures using log–log regression. The regression coefficient from the log–log regression represents the exponent used in the complex indices WT/HT^P , FM/WT^P , FM/FFM^P , SUBS/TRI^P , TRI/SUBS^P , and WC/HT^P . Those with missing values for either the numerator or denominator for any measure (43 men and 54 women) were excluded from analysis.

We calculated the Pearson correlation coefficient between each simple or exponentiated index and its respective unexponentiated denominator variable. We conducted all analyses within strata of sex. We also compared the derived exponents with those previously derived in a population of Brazilian men (mean height 1.73 meters) (Wells and Victora, 2005).

We performed a sensitivity analysis to assess the impact of outlier values. We identified 88 individuals (39 men; 49 women) whose values were more than three standard deviations from the mean of WT, %BF, SUBS, TRI, FFM, FM, or HT. When these individuals were excluded from the analysis, the estimates did not vary by more than 10%, therefore all individuals were used in the analysis presented.

To assess whether the derived exponents differ by attained height, we divided the population into sex-specific tertiles based on adult height, repeated the log–log regression within each tertile, and compared the resulting coefficients. For all analyses significance was declared at $P < 0.05$.

RESULTS

We obtained complete anthropometric measures from 868 men and 1,047 women (mean age 34.1 years for men and 32.0 years for women). The population was short; mean adult height was 1.63 m (64 in) for men and 1.51 m (59 in) for women (Table 1). Men and women differed with respect to %BF (21.4% for men and 34.8% for women; $P < 0.01$). Women had a mean of 3 live births (range 0–11).

Each simple (unexponentiated) index was correlated (all $P < 0.01$) with its respective denominator. The strongest correlation was observed for the association between FM/WT and WT (men: $r = 0.84$, women $r = 0.95$). In contrast, the correlations between WC/HT and HT and SUBS/TRI and TRI were inverse and below 0.15 in magnitude in both men and women.

The exponents derived from the log–log regression are presented in Table 2. The optimal exponents for all the indices differed ($P < 0.05$) between men and women. The derived exponents for WT/HT^P were 2.17 (95% Confidence Interval (CI) 1.84–2.38) and 2.03 (95% CI 1.66–2.26) in men and women, respectively, not different from the BMI. For each index the resulting index was uncorrelated ($P > 0.05$) with its denominator using Pearson's correlation.

The association of the simple and complex indices with %BF is presented in Table 3. WC/HT was highly correlated with %BF in both men ($r = 0.97$; $P < 0.01$) and women ($r = 0.93$; $P < 0.01$). Using exponentiated denominators the overall correlation increased slightly to 0.99 ($WC/HT^{0.68}$) in men and 0.96 ($WC/HT^{0.47}$) in women. The unexponentiated index $SUBS/TRI$ was not strongly correlated with %BF: 0.26 in men and 0.24 in women. This correlation increased slightly to 0.34 ($SUBS/TRI^{0.88}$) in men and 0.30 ($SUBS/TRI^{0.93}$) in women when using the complex index. The correlations of WT/HT^P , WT/HT , and BMI (WT/HT^2) with %BF were not different ($P > 0.05$) from each other: for all three indices the coefficient was 0.88 in men and 0.98 in women.

It has been suggested that the FM index is a better measure of adiposity than the %BF (Kyle et al., 2003). In our sample, the correlation between these two variables exceeded 0.98 for both men and women, as both are estimates derived using a prediction equation for %BF. Hence, when we repeated all of these analyses with the FM index, the results were consistent (data not shown).

Among the 115 Guatemalan adults for whom we obtained %BF using hydrostatic weighing (Ramirez-Zea et al., 2006), Pearson's correlation of %BF with individual index was somewhat lower for most indices (Table 4) as compared to the correlations with %BF as derived from the prediction equations.

We compared our estimates with those obtained in a population of Brazilian men (Table 5) (Wells and Victora, 2005). For the skin-fold thicknesses ratios, the estimates of the derived exponents are similar but statistically different—the exponent for $SUBS/TRI$ was 0.88 (95% CI 0.83–0.93) in the Guatemalan sample and 0.77 (95% CI 0.57–0.97) for the Brazilian men. As was also true for the Brazilian men, while the correlation between the unexponentiated ratios $SUBS/TRI$ and $TRI/SUBS$ was of course -1.00 in both men and women, the correlations between the exponentiated ratios were -0.75 in men and -0.85 in women (both $P < 0.001$). For measures of mass the coefficients differed—for FM/WT the exponents were 2.69 (95% CI 2.62–2.80) and 2.07 (95% CI 2.03–2.11) in the Guatemalan and Brazilian men, respectively.

In both men and women, the exponents differed according to the degree of stunting for many of the ratios (Table 6). For FM/HT^P , for example, the exponents were 2.06 (95% CI 2.03–2.08), 2.12 (95% CI 2.10–2.15), and 2.13 (95% CI 2.10–2.16) across the three tertiles in women. For the same ratio measure in men, the exponents were 2.82 (95% CI 2.65–2.98), 3.04 (95% CI 2.88–3.21), and 3.02 (95% CI 2.88–3.18).

DISCUSSION

We derived both simple and exponentiated ratio indices of anthropometric measures and examined their utility in estimating obesity while controlling for allometric scaling. This population of Guatemalan adults had been stunted as children and were short as adults (stature averaged 1.63 m for men and 1.51 m for women), as compared with Mexican-Americans in the US (men: 1.69 m, women: 1.58 m) (Ogden et al., 2004). In this population of stunted Guatemalan adults, the simple indices were correlated with their denominators whereas indices with exponentiated denominators were not correlated with their

denominators. The derived exponents, however, differed by stature, differed between men and women, and were not the same between men in our sample and in a Brazilian sample (mean height 1.73) (Wells and Victora, 2005).

Many investigators have searched for an universal index that is not subject to residual confounding and is still able to predict risk from excess adiposity. Ratio indices of anthropometric measures are, by design, composite indices of two measures that are envisaged to have independent impacts on a health state. These indices are used both to control for allometric scaling (changes in mass attributable solely to differences in overall height, such as the BMI) and to provide estimates of mass type (e.g., %BF) or distribution within the body (e.g., the ratio of skinfold thicknesses). The interpretation of associations between ratio measures and health states is inherently problematic owing to the potential for residual confounding, or correlation between the denominator and the index. To remedy the problem of residual confounding, several researchers have advocated the use of log–log regression to create complex indices in which the denominator is raised to an exponent other than one (Benn, 1971; Wells and Victora, 2005). However, little is known about whether exponents derived in one population would be descriptive of other populations with different characteristics.

WT/HT^P has been the most heavily studied index and is the one from which BMI is derived. As demonstrated by Quetelet, in adults, the optimal exponent is ~2 (Heymsfield et al., 2007; Quetelet, 1842). In children, the optimal exponents for WT/HT^P vary by age (Hattori and Hirohara, 2002). Exponents change from roughly 3 at birth (corresponding to the ponderal index) to 2 in adulthood (corresponding to the BMI). In males, the coefficient of log–log regression varied from a high of 3.31 at age 10 to a low of 1.93 at age 17 then progressed toward 2. In females, it varied from a high of 3.12 at age 11 to a low of 1.79 at age 16 before rising again toward 2. Presumably these changes are occurring in response to changes in height and mass (both muscle and adipose tissue) accumulation resulting from pubertal growth. This is particularly important to consider when studying stunted populations. If growth is arrested, as is the case in the stunted population we have studied, it is possible the coefficients obtained would be more similar to those found in adolescents (Hall and Cole, 2006; Norgan and Ferro-Luzzi, 1982).

Indeed, the coefficients for log–log regression varied across tertiles of adult attained height. The optimal exponents were most variable for indices in which height was a constituent. The measures using SUBS and TRI were fairly robust across tertiles of height. However, indices using SUBS and TRI are subject to increased difficulty in obtaining precise measurements under field conditions, and hence these parameters are not as widely used.

A second and perhaps more important component of a good index is the ability to predict obesity related health risks. Bosy-Westphal et al. examined how the indices BMI, %BF, and WC/HT predicted various measures of metabolic load and found that WC/HT was the most strongly correlated with hyperlipidemia and hypertension (Bosy-Westphal et al., 2006). We have shown in this analysis that both %BF and WC/HT are problematic because they remain correlated with their denominators. Although we did not examine the correlation between the derived indices and hyperlipidemia or hypertension, we note that WC/HT and WC/HT^P were more strongly correlated to %BF than BMI, skinfolds ratios, and WT/HT.

Our results are in agreement with Bosy-Westphal et al. who suggested that WC/HT may be the best index for predicting risks associated with obesity. To our knowledge, we are the only group to examine WC/HT^P. Although the exponentiated index was free from association with the denominator, the simple index was not highly correlated with height (–0.11 in men and –0.15 in women). Because the correlation of both indices with %BF

exceeded 0.90, the simple index is just as effective at predicting %BF and the extra step of calculating the exponent for the denominator is likely not justified.

We studied a large sample of individuals and obtained replicate anthropometric measures to reduce within individual variation. The population was short, reflecting childhood stunting. We did not obtain a direct measure of BF, and as %BF was determined using predictive equations that utilize WT and WC in men and WT, HT and WC in women, it is not surprising that our ratio measures were highly correlated with %BF. However, the purpose of this analysis was not to demonstrate the ability of the indices to predict BF. We were examining the variability of log–log regression as a method for freeing each index with its denominator. The method in which %BF was derived would not change these results.

In summary, we have found that complex ratios, although free from residual confounding, are not free of methodological concerns. Although using log–log regression to calculate an exponent would free the index from association with the denominator, a single exponent will not be optimal for all populations. The exponents we found in Guatemalan men differed from those derived in a sample of Brazilian men (Wells and Victora, 2005) and vary by stature. The use of such complex indices does not seem to provide substantial benefit to outweigh these limitations. Further, because %BF is not necessarily indicative of poor health outcomes, future studies examining how well indices predict metabolic risk seem warranted.

Acknowledgments

Contract grant sponsor: NIH; Contract grant numbers: TW-005598, HD-046125.

The authors thank Dr. Reynaldo Martorell of Emory University for access to the data set and comments on an earlier version of the manuscript.

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TABLE 1

Selected characteristics of 1,915 Guatemalan adults

	Males (<i>n</i> = 868)			Females (<i>n</i> = 1047)		
	Mean	SD	Range	Mean	SD	Range
Age (years)	34.1	6.26	20.6–65.0	32.0	5.31	16.0–55.1
Weight (kg)	66.2	11.1	39.6–104.0	60.8	11.85	25.8–127.0
Height (m)	1.63	0.059	1.46–1.85	1.51	0.055	1.18–1.68
BMI (kg/m ²)	25.0	3.67	16.2–38.3	26.7	4.79	16.7–46.5
Triceps skinfold (mm)	9.4	4.03	3.1–32.0	19.7	6.21	4.0–36.9
Subscapular skinfold (mm)	15.2	7.26	5.1–40.1	21.9	8.12	5.4–44.0
Waist circumference (cm)	87.9	9.54	64.3–122.9	92.06	11.7	62.4–153.0
% Body fat ^a	21.4	6.93	4.2–47.0	34.8	7.16	18.2–73.3
Fat-free mass (kg) ^a	51.4	5.27	36.2–69.0	38.8	3.56	20.4–48.03
Fat mass (kg) ^a	14.8	7.11	1.8–47.8	21.9	8.95	5.3–93.1

SD, standard deviation.

^aCalculated from a prediction equation (Ramirez-Zea et al., 2006).

TABLE 2

Exponents for complex ratio indices of anthropometric measurements and respective denominator variables in Guatemalan adults^a

Ratio index	Coefficient	95% CI	SE	P	r ²
Men (n = 826)					
WT-HT	2.17	(1.84, 2.38)	0.14	<0.001	0.23
SUBS-TRI	0.88	(0.83, 0.93)	0.021	<0.001	0.67
TRI-SUBS	0.76	(0.71, 0.78)	0.018	<0.001	0.67
FM-WT	2.69	(2.62, 2.80)	0.042	<0.001	0.83
WC-HT	0.68	(0.48, 0.87)	0.099	<0.001	0.053
FM-FFM	2.86	(2.64, 3.14)	0.13	<0.001	0.37
Women (n = 996)					
WT-HT	2.03	(1.66, 2.26)	0.15	<0.001	0.15
SUBS-TRI	0.93	(0.88, 0.98)	0.025	<0.001	0.58
TRI-SUBS	0.62	(0.57, 0.64)	0.015	<0.001	0.58
FM-WT	2.01	(1.99, 2.04)	0.011	<0.001	0.97
WC-HT	0.47	(0.26, 0.68)	0.11	<0.001	0.019
FM-FFM	3.37	(3.25, 3.53)	0.075	<0.001	0.67

SE, standard error; SUBS, subscapular skinfold (mm); TRI, triceps skinfold (mm); WT, weight (kg); HT, height (m); FM, fat mass (kg); FFM, fat-free mass (kg); WC, waist circumference (cm).

^aDerived from log-log regression using natural log transformations.

TABLE 3

Pearson correlation of percent body fat, calculated using predictive equation, with both simple and complex indices in Guatemalan adults

Simple indices			Complex indices ^a		
	<i>r</i>	<i>P</i>		<i>r</i>	<i>P</i>
Men (<i>n</i> = 826)					
WT/HT	0.88	<0.001	WT/HT ^{2.17}	0.88	<0.001
SUBS/TRI	0.26	<0.001	SUBS/TRI ^{0.88}	0.34	<0.001
TRI/SUBS	-0.22	<0.001	TRI/SUBS ^{0.76}	0.28	<0.001
FM/WT (%BF)	1.00	<0.001	FM/WT ^{2.69}	0.87	<0.001
WC/HT	0.97	<0.001	WC/HT ^{0.68}	0.99	<0.001
FM/FFM	0.99	<0.001	FM/FFM ^{2.86}	0.80	<0.001
Women (<i>n</i> = 996)					
WT/HT	0.98	<0.001	WT/HT ^{2.03}	0.98	<0.001
SUBS/TRI	0.24	<0.001	SUBS/TRI ^{0.93}	0.30	<0.001
TRI/SUBS	-0.30	<0.001	TRI/SUBS ^{0.62}	0.21	<0.001
FM/WT (%BF)	1.00	<0.001	FM/WT ^{2.01}	0.29	<0.001
WC/HT	0.93	<0.001	WC/HT ^{0.47}	0.96	<0.001
FM/FFM	0.97	<0.001	FM/FFM ^{3.37}	0.66	<0.001

SUBS, subscapular skinfold (mm); TRI, triceps skinfold (mm); WT, weight (kg); HT, height (m); FM, fat mass (kg); FFM, fat-free mass (kg); WC, waist circumference (cm).

^aExponents derived from log-log regression using natural log transformations.

Pearson correlation of percent body fat, obtained using hydrostatic weighing, with both simple and complex indices in 115 rural Guatemalan adults

TABLE 4

Simple indices			Complex indices ^a		
	<i>r</i>	<i>P</i>		<i>r</i>	<i>P</i>
Men (<i>n</i> = 57)					
WT/HT	0.70	<0.001	WT/HT ^{2.17}	0.70	<0.001
SUBS/TRI	-0.078	0.56	SUBS/TRI ^{0.88}	0.070	0.61
TRI/SUBS	0.11	0.40	TRI/SUBS ^{0.76}	0.31	0.019
FM/WT	1.00	<0.001	FM/WT ^{2.69}	0.76	<0.001
WC/HT	0.75	<0.001	WC/HT ^{0.68}	0.77	<0.001
FM/FFM	0.99	<0.001	FM/FFM ^{2.86}	0.90	<0.001
Women (<i>n</i> = 58)					
WT/HT	0.82	<0.001	WT/HT ^{2.03}	0.82	<0.001
SUBS/TRI	0.073	0.58	SUBS/TRI ^{0.93}	0.16	0.24
TRI/SUBS	-0.12	0.38	TRI/SUBS ^{0.62}	0.47	<0.001
FM/WT	1.00	<0.001	FM/WT ^{2.01}	0.66	<0.001
WC/HT	0.83	<0.001	WC/HT ^{0.47}	0.86	<0.001
FM/FFM	0.99	<0.001	FM/FFM ^{3.37}	0.71	<0.001

SUBS, subscapular skinfold (mm); TRI, triceps skinfold (mm); WT, weight (kg); HT, height (m); FM, fat mass (kg); FFM, fat-free mass (kg); WC, waist circumference (cm).

Data from Ramirez-Zea et al. (2006).

^aExponents derived from log-log regression in Human Capital population using natural log transformations.

TABLE 5
Exponents for complex ratio indices of anthropometric measurements of adult Brazilian and Guatemalan men

	Guatemala (men) (<i>n</i> = 826)		Brazil (men) (<i>n</i> = 2195)		<i>P</i> ^a
	Coefficient	95% CI	Coefficient	95% CI	
SUBS-TRI	0.88	(0.83, 0.93)	0.77	(0.75, 0.79)	<0.01
TRI-SUBS	0.76	(0.71, 0.78)	0.93	(0.91, 0.95)	<0.01
FM-WT	2.69	(2.62, 2.80)	2.07	(2.03, 2.11)	<0.01
FM-FFM	2.86	(2.64, 3.14)	2.33	(2.27, 2.39)	<0.01

SUBS, subscapular skinfold (mm); TRI, triceps skinfold (mm); WT, weight (kg); FM, fat mass (kg); FFM, fat-free mass (kg); WC, waist circumference (cm).
Brazilian data from Wells and Victoria (2005).

^aStudent's *t*-test.

TABLE 6

Exponents for complex ratio indices of anthropometric measurements in a population of Guatemalan adults, by adult height

	Q1		Q2		Q3	
Men						
Height range	1.40–1.59 m (<i>n</i> = 274)		1.60–1.64 m (<i>n</i> = 279)		1.65–1.85 m (<i>n</i> = 273)	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
WT-HT	3.49	(2.47, 4.49)	4.09	(0.92, 7.25)	4.06	(1.34, 6.79)
SUBS-TRI	0.85	(0.78, 0.93)	0.87	(0.78, 0.96)	0.94	(0.85, 1.03)
TRI-SUBS	0.81	(0.73, 0.88)	0.76	(0.69, 0.84)	0.73	(0.66, 0.80)
FM-WT	2.82	(2.65, 2.98)	3.04	(2.88, 3.21)	3.02	(2.88, 3.18)
WC-HT	0.82	(0.23, 1.41)	1.54	(0.16, 2.94)	−0.09	(−0.73, 0.55)
FM-FFM	3.29	(2.77, 3.81)	3.78	(3.15, 4.40)	3.27	(2.61, 3.95)
Women						
Height range	1.10–1.47 m (<i>n</i> = 335)		1.48–1.52 m (<i>n</i> = 324)		1.53–1.67 m (<i>n</i> = 337)	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
WT-HT	2.43	(1.52, 3.35)	1.08	(−1.03, 3.21)	2.25	(1.25, 3.25)
SUBS-TRI	0.92	(0.84, 0.99)	0.94	(0.84, 1.03)	0.99	(0.89, 1.09)
TRI-SUBS	0.69	(0.64, 0.75)	0.59	(0.54, 0.65)	0.56	(0.51, 0.61)
FM-WT	2.06	(2.02, 2.08)	2.12	(2.10, 2.15)	2.13	(2.10, 2.16)
WC-HT	0.70	(0.05, 1.36)	−0.60	(−2.08, 0.88)	0.60	(−0.11, 1.32)
FM-FFM	3.93	(3.72, 4.13)	4.44	(4.18, 4.70)	4.09	(3.74, 4.43)

SUBS, subscapular skinfold (mm); TRI, triceps skinfold (mm); WT, weight (kg); HT, height (m); FM, fat mass (kg); FFM, fat-free mass (kg); WC, waist circumference (cm).