Association between anthropometric parameters and testosterone deficiency in men

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Abstract

Objectives: Obesity and anthropometric measures are related to the testosterone concentration in men, although debate remains as to which anthropometric parameters are most important. Fat mass or adiposity is an important negative determinant of total serum testosterone level. We aimed to investigate the relationship of anthropometric measurements with serum total testosterone level and to find out the most reliable predictive anthropometric measurements of testosterone deficiency.

Methods: Three hundred and nine male subjects were recruited. Anthropometric measurements: weight, height, waist and hip circumferences were obtained. Body mass index (BMI) and waist-to-hip ratio (W/H) were calculated. Baseline total testosterone (TT) level was estimated.

Results: There was a significant negative correlation between TT level and waist circumference (r = -0.146, p = 0.010), W/H ratio (r = -0.173, p = 0.002) and age (r = -0.559, p = 0.001). The relationship between the response (Testosterone deficiency/ No testosterone deficiency) and the model variables of age (OR = 1.35, p = 0.042) and waist circumference (OR = 1.99, p = 0.035) showed significant odds ratio (OR), while BMI and hip circumference exhibited non-significant OR.

Conclusion: There is evidence for supporting the association between anthropometric measurements and serum total testosterone level. Waist circumference was the most reliable predictor of testosterone deficiency.

Key words: anthropometric measurements, testosterone, men

Introduction

Obesity is a worldwide epidemic which is on the rise in the Asian nations[1]. Obesity is associated with a multitude of health adverse outcomes such as coronary artery disease, osteoarthritis, diabetes mellitus and lowered testosterone (2).

Observational studies have shown a strong association of obesity with low circulating testosterone levels in men. Age-associated decline in testosterone is correlated with the loss of lean body mass and increased fat mass (3). Conversely, there is evidence that healthy ageing by itself is uncommonly associated with marked reductions in testosterone levels (4), because age-related testicular dysfunction is partly compensated by the age-associated increase in pituitary LH secretion (2). However, obesity may blunt this LH rise, leading to hypothalamic-pituitary suppression irrespective of age which cannot be compensated by physiological mechanisms and may result in testosterone deficiency (2). Other than obesity, testosterone deficiency has been shown to be associated with the risk of developing coronary artery disease (5, 6) and its risk factors like diabetes mellitus, hypertension and metabolic syndrome (7, 8).

Therefore obesity may contribute to low testosterone levels in blood in adult men. Hence anthropometric measures are related to the testosterone concentration in men, although debate remains as to which anthropometric parameters are most important in the prediction of testosterone deficiency. Therefore we aimed to investigate the relationship of anthropometric measurements with serum total testosterone level and to find out the most reliable predictive anthropometric measurements of testosterone deficiency.

Materials and methods

This was a hospital based study which included male

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subjects in the age range of 30-70 years. Three hundred and nine study subjects were recruited using convenient sampling. Subjects with a history of recent surgery or major trauma within three months or a history of acute coronary syndrome in the past three months, malignancy, chronic inflammatory disorders, current acute severe infections, dementia or any structural damage to the central nervous system, renal dysfunction, chronic liver disease, alcohol dependency based on the CAGE questions were excluded from the study (10). Those on current therapy with drugs that may alter serum testosterone concentration were also excluded. Patients with endocrine disorders, past history of orchidectomy, thyroidectomy, and testicular problems (undescended testes, testicular injury, tumor or infection) were not recruited to the study. Sample size was calculated using the equation for a descriptive cross-sectional study described by Lwanga SK and Lemeshow S (9).

An interviewer-administered questionnaire was used to collect relevant information from the study subjects. All baseline anthropometric measurements were made by the same investigator, using the same instruments. Height was measured following the standard technique by a portable stadiometer (IUCHI, Yamato Scientific, Japan) with the precision of +/- 0.1 cm and readability up to 200 cm. Weight was measured using a portable beam balance (Bauman, Germany) with the precision of +/- 0.1 kg and readability up to 100 kg. Waist circumference was measured to the nearest 0.1 cm according to the standard technique using a non-stretchable measuring tape. Hip circumference was measured at the maximum protuberance of the buttocks to the nearest 0.1 cm. Mean of the two readings (three times, if difference between two readings was ≥ 0.5 cm) was taken as the final value of each circumference measurement. Body mass index (BMI) and waist-to-hip ratio (W/H ratio) were calculated. Body mass index categories were defined according to the guidelines for Asian adults (11). Serum total testosterone was estimated by an enzyme immune assay kit.

The research project was approved by the Ethical Review Committee of Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka and conducted according to the ethical guidelines outlined in the Declaration of Helsinki. Permission was obtained from all necessary local authorities to conduct the study. Informed written consent was obtained from all the participants.

Data were analyzed using appropriate statistical tests. Continuous variables were examined for normality and presented as mean and SD. Pearson correlation coefficient was used to find out the relationship between continuous variable. Significance was defined when the p value was less than 0.05. Multivariate logistic regression analysis was used to find out the predictors of testosterone deficiency which was defined, using the total testosterone cut off of ≤ 10.4 nmol/L according to American Association of Clinical Endocrinologists (AACE) (12).

Results

Baseline characteristics are shown in table 1.

Table 1. Baseline characteristics

Variable	*Mean ± SD (n = 309)*	*Range*
Age (yrs)	54 ± 9.7	30 - 70
Total testosterone (nmol/L)	13.7 ± 5.8	4.5 - 34.0
BMI (kg/m^2)	22.5 ± 4.2	13.0 - 46.4
Waist circumference (cm)	79.9 ± 10.5	52.5 - 115.5
Hip circumference (cm)	86.6 ± 8.4	45.0 - 121.2
Waist-to-hip ratio	0.92 ± 0.06	0.75 - 1.17

Data presented as mean ± SD, BMI = Body mass index

The scatter plots show the correlation between testosterone and the anthropometric measurements. There was a significant negative correlation between total testosterone (TT) and age (r = -0.559, p = 0.001) (Figure 1.a), waist circumference (r = -0.146, p = 0.010)

(Figure 1.b) and waist-to hip-ratio (r = -0.173, p = 0.002) (Figure 1.c). However, there was no significant correlation between total testosterone and body mass index (r = - 0.028, p = 0.627), hip circumference (r = -0.085, p = 0.138). The prevalence of obesity (BMI > 25 kg/m^2) in the study group was 62 (20%) according to the Asian guidelines.

There were 73 (23.6 %) with testosterone level less ≤10.4 nmol/L indicating testosterone deficiency according to the American Association of Clinical Endocrinologists (12). There were 19 (6.2 %) patients with hypogonadism having TT less than 6.9 nmol/L (12). Based on the odds ratios and the p values in logistic regression analysis, waist circumference showed highest predictive ability of testosterone deficiency (Table 2) out the anthropometric indices.

TT level ≤ 10.4 nmol/L indicates the testosterone deficiency. Response variable was presence or absence of testosterone deficiency. Predictor variables used in the model were age, BMI, waist and hip circumferences. Results of multivariate logistic regression analysis were presented as odds ratio (OR) and confidence intervals (CI). BMI = Body mass index.

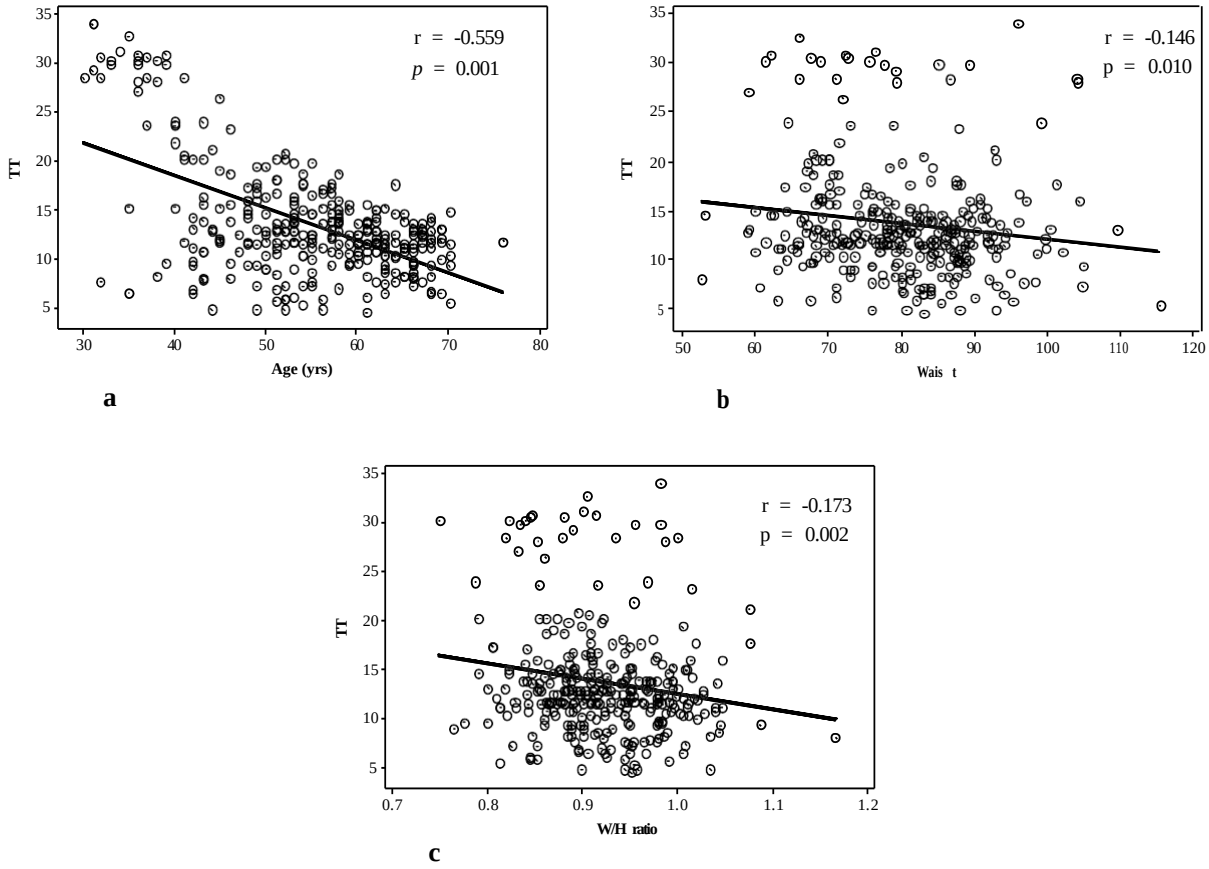

Figure 1. Scatter plots with regression showing the correlation between total testosterone (TT) and (a) age, (b) waist circumference and (c) waist-to-hip-ratio (W/H).

Table 2. Anthropometric measurements as predictors of testosterone deficiency

Variable	*OR*	*95% CI*	*p*
BMI	0.99	0.89 - 1.10	0.861
Waist circumference	1.99	1.24 - 2.92	0.035
Hip circumference	1.02	0.96 - 1.09	0.523
Age	1.35	1.12 - 2.78	0.042

Discussion

Waist circumference, waist-to-hip-ratio and age showed a significant negative correlation with serum total testosterone level, although BMI and hip circumference showed non-significant correlation according to the present study. Age was a significant independent predictor of TT deficiency (<10.4 nmol/L). Waist circumference had the highest odds ratio for testosterone deficiency being the most significant anthropometric predictor, while BMI and hip circumference were not found as significant predictors of testosterone deficiency. It is established that body mass index indicates the general obesity; while wait circumference reflects central obesity and hip circumference demonstrates peripheral obesity. These anthropometric measurements are known to indicate the body fat distribution.

Fat mass or adiposity is an important negative determinant of total testosterone level (13). Most studies confirm that serum free testosterone (FT) and total testosterone (TT) inversely correlates not only with anthropometric parameters such as waist circumference and BMI, but also with total body fat mass measurements in men. De Pergola et al. (2003) showed that FT is inversely correlated with BMI and waist circumference and the fat mass was measured by bioimpedance analysis (14). Dunajska et al. (2004) revealed an inverse correlation between testosterone level and body mass index, waist and, total body fat mass obtained by dual-energy X-ray absorptiometry (15). Another study found a negative association between testoterone and BMI and fat mass (16). Furthermore, Abate et al. (2002) showed a negative correlation between FT and waist circumference, waist-to-hip ratio, skin fold thicknesses, total fat mass and fat distribution in abdominal compartmnts, except

retroperitoneal (17). The findings of our study suggests that central adiposity which is reflected by waist circumference is more associated with the testosterone deficiency. However, we were unable to perform other related biochemical test such as FT and bioavailable testosterone (BT) and to determine the body fat mass due to the financial constraints and the limited facilities available.

There are suggested mechanisms to explain the implication of obesity as a cause of hypotestosteronaemia in men. Low levels of testosterone are expected in men with increased fat mass, because peripheral conversion (by aromatase enzyme) of testosterone to oestrogens is increased (18). In addition, elevated leptin and similar agents in obesity may also act as suppressors of testosterone synthesis at the level of hypothalamic-pituitary-gonadal axis (19) and at testicular level suppressing the testosterone synthesis (20).

Total testosterone showed significant negative correlation with age. It is known that there is an age-related gradual decline of testosterone in men (21). There are different mechanisms that can be used to explain the age-related changes in serum testosterone levels in men. There are primary testicular changes with a diminished testicular secretory capacity and an altered neuroendocrine regulation of the Leydig cells with apparent failure of the feedback mechanisms to fully compensate with aging. Moreover, there is an independent increase of SHBG binding capacity (22). The age-associated increase of SHBG levels is by about 1.2% per year (21), so that the decrease of FT and BT serum levels is larger than that of total serum testosterone (21). Age-related loss of muscle mass is accompanied by fat gain in older adults (23) which may increase peripheral conversion of testosterone to oestrogens (18).

Conclusion

There is evidence to support the inverse association between anthropometric measurements and serum TT level. Waist circumference was the most reliable predictor of testosterone deficiency among the anthropometric measurements.

Conflict of interest

The authors declare that they have no conflicts of interest concerning this article.

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