

Karimollah Hajian-Tilaki (PhD)¹
Behzad Heidari (MD)^{*2}

1. Department of Biostatistics and
Epidemiology, Babol University of
Medical Sciences, Babol, Iran.

2. Department of Internal Medicine,
Ayatollah Rouhani Hospital, Babol
University of Medical Sciences,
Babol, Iran.

*** Correspondence:**

Behzad Heidari, Department of
Internal Medicine, Ayatollah
Rouhani Hospital, Babol University
of Medical Sciences, Babol, Iran.

E-mail: bheidari6@gmail.com

Tel: 0098 11 32199936

Fax: 0098 11 32199936

Received: 3 Dec 2014

Revised: 4 April 2015

Accepted: 20 May 2015

Sex differences of anthropometric indices of obesity by age among Iranian adults in northern Iran: A predictive regression model

Abstract

Background: Background and Objectives: The biological variation of body mass index (BMI) and waist circumference (WC) with age may vary by gender. The objective of this study was to investigate the functional relationship of anthropometric measures with age and sex.

Methods: The data were collected from a population-based cross-sectional study of 1800 men and 1800 women aged 20-70 years in northern Iran. The linear and quadratic pattern of age on weight, height, BMI and WC and WHR were tested statistically and the interaction effect of age and gender was also formally tested.

Results: The quadratic model (age²) provided a significantly better fit than simple linear model for weight, BMI and WC. BMI, WC and weight explained a greater variance using quadratic form for women compared with men (for BMI, R²=0.18, p<0.001 vs R²=0.059, p<0.001 and for WC, R²=0.17, p<0.001 vs R²=0.047, p<0.001). For height, there is an inverse linear relationship while for WHR, a positive linear association was apparent by aging, the quadratic form did not add to better fit.

Conclusion: These findings indicate the different patterns of weight gain, fat accumulation for visceral adiposity and loss of muscle mass between men and women in the early and middle adulthood.

Keywords: Body mass index, Waist circumference, Waist to hip ratio, Quadratic form, Adults

Citation:

Hajian-Tilaki K, Heidari B. Sex differences of anthropometric indices of obesity by age among Iranian adults in northern, Iran: A predictive regression model. *Caspian J Intern Med* 2015; 6(3):128-133.

Caspian J Intern Med 2015; 6(3):128-133

General obesity defined by high body mass index (BMI) and abdominal obesity defined as high waist circumference (WC) or high waist to hip ratio to be major public health problem in both developed and developing countries (1-4). A significant increasing of these indexes was essentially occurred with high caloric dietary habits and low physical activity level. It is well-established that BMI and WC are independent predictors of several cardiovascular risk factors (5) and morbidity (6, 7). In particular, higher WC associated with greater level of visceral adiposity and those with a high WC, has a greater chance of mortality of chronic diseases such as type 2 diabetes and cardiovascular diseases (8-10). In recent decades, the worldwide epidemic of obesity and central obesity has continued to be extended in developing countries (11-16). In particular, Iranian population experienced an increased demographic changes and epidemiologic transition over the past three decades (3, 4). Improving the economic status and modernization of society changed the lifestyles leading to an acceleration in the consumption of high caloric foods and the sedentary behavior with subsequent increase in body mass index (BMI) and waist circumference (WC) in adults population (2, 3, 4, 16) and thus, high prevalence of obesity and central obesity became the major public health problems (2-4, 16).

In this context, the causes of death have been shifted from infectious diseases to non-communicable chronic diseases such as cardiovascular diseases and cancers in Iran. By aging, the fat accumulation in adulthood leads to an accelerated BMI and WC in the elderly with a maximum age of almost 60 years and the loss of muscle mass starts in middle adulthood and continues to old age (17).

Overall, BMI and WC have been influenced by several socio-demographic characteristics in different societies. Their pattern differs with age, gender and other socio-economic factors. The biological variation and association of BMI and WC with age may have different patterns of effect and even it may vary by gender. In this regard, there are few studies in large and representative samples of adult population of Iran.

With a representative sample of adult population living in four large cities in northern Iran, we addressed the following three questions: 1) what proportion of weight, BMI, WC and WHR variances can be explained by age? 2) What are the shapes of these functional relationships in terms of linear and quadratic forms? 3) Does the functional relationship with age vary by gender status?

Methods

Study subjects and population: Study subjects were recruited from our provincial household survey of obesity assessment in a representative sample of population-based cross-sectional study in the North of Iran in 2004. The study design, population and sampling procedure were described previously in details (4). Data were collected from 1800 men and 1800 women, aged 20-70 years, apparently the healthy subjects with no known debilitating or systematic diseases were residence of four large cities in south of Caspian sea. The demographic data such as age and sex were extracted. The protocol was approved by Research and Ethics Committee of Babol University of Medical Sciences. The written informed consent was obtained from all subjects prior to their participation in the study.

Anthropometric Measurements: Height was measured with subject standing barefoot with heels together, arms legs straight and shoulders relaxed and scale to the nearest 0.1 cm and weight was taken to nearest 0.1 kg with a SECA platform scale graduated to the nearest 0.1 kg with subjects standing on platform barefoot. From these two measures,

body mass index (BMI) was calculated by weight in kilogram divided by square of height in meter (kg/m^2). WC was measured on waist diameter at the level of midpoint between iliac crest and lower border of tenth rib. Hip was defined as the widest circumference around the buttocks below the iliac crest. Waist to hip ratio (WHR) was calculated as the waist circumference divided by the hip circumference (both in centimeters). SPSS software was used for statistical analysis.

First, the age-sex descriptive statistics were summarized by means (\pm SD) with 95% confidence intervals (CI) for different measures. Then, the patterns of weight, height, BMI, WC and WHR with age were assessed by linear regression models and the linear and quadratic effect of age on weight, height, BMI, WC and WHR were tested statistically and the interaction effect of age and gender was formally tested in regression model. The linear model was built with respect to gender for predicting anthropometric measures with age and a p-value less than 5% was considered as significant level.

Results

The mean (\pm SD) ages were 38.5 ± 14.3 and 37.5 ± 13.0 years for men and women, respectively. Table 1 presented the mean \pm SD of anthropometric measurements specific for sex and age groups. Men were heavier and taller than women in all age groups ($p<0.001$).

Weight showed a significant increase with age up to 50 years in both sexes and then tends to decrease. An apparent decline of the mean of height with aging was observed in both sexes. The average of BMI values were higher in women than men in all age groups significantly ($p<0.001$) with apparent decline of BMI at age of 50 y for men and 60 y for women.

The slopes of BMI for increasing with age at 20 to 50 years was greater of magnitude in women than and men; the slope of decline trend at age 60 and later was also accelerated in women. Waist circumference also increased significantly with age up to 60 years in both sexes ($p<0.001$). A rapid increase of slope in at the side WC was observed in early adulthood for women compared with men. Overall, the mean of WC was significantly higher in men than women but the differences were not significant in age group of 40-49 years and 60-70 years.

Table 1. The frequency and age-sex specific of mean \pm SD of anthropometric measures and p-value

Anthropometric measures	Age groups (year)	Men (n=1800)		Women (n=1800)		P-value
		n	Mean \pm SD	N	Mean \pm SD	
Weight (kg)	20-29	620	72.5 \pm 12.0	608	62.7 \pm 12.9	<0.001
	30-39	392	76.5 \pm 11.7	447	69.6 \pm 11.8	<0.001
	40-49	347	75.5 \pm 11.4	373	72.7 \pm 12.3	<0.001
	50-59	254	74.8 \pm 11.8	256	72.3 \pm 12.8	0.02
	60-70	196	70.1 \pm 12.4	118	67.8 \pm 12.2	0.12
	Total	1800	74.0 \pm 12.1	1800	68.2 \pm 13.1	<0.001
Height (cm)	20-29	619	174.5 \pm 7.4	608	161.1 \pm 6.2	<0.001
	30-39	391	173.1 \pm 7.2	446	159.9 \pm 6.4	<0.001
	40-49	374	170.9 \pm 7.4	372	158.3 \pm 6.5	<0.001
	50-59	245	170.4 \pm 7.7	256	157.8 \pm 6.8	<0.001
	60-70	196	167.5 \pm 8.2	118	154.5 \pm 7.6	<0.001
	Total	1798	172.2 \pm 7.8	1798	159.3 \pm 6.7	<0.001
BMI(kg/m ²)	20-29	619	23.8 \pm 3.8	608	24.2 \pm 4.7	0.14
	30-39	391	25.6 \pm 3.8	446	27.3 \pm 4.8	<0.001
	40-49	474	25.9 \pm 3.8	372	29.1 \pm 4.9	<0.001
	50-59	245	25.8 \pm 3.7	256	29.1 \pm 5.2	<0.001
	60-70	196	24.9 \pm 4.0	118	28.5 \pm 5.2	<0.001
	Total	1798	25.0 \pm 3.9	1798	26.9 \pm 5.4	<0.001
WC (cm)	20-29	620	86.1 \pm 10.6	607	81.0 \pm 11.8	<0.001
	30-39	392	89.8 \pm 11.8	447	87.9 \pm 12.2	0.02
	40-49	346	91.5 \pm 10.6	373	92.1 \pm 12.4	0.46
	50-59	245	91.9 \pm 11.9	254	94.9 \pm 13.2	0.009
	60-70	196	91.0 \pm 12.4	118	92.8 \pm 13.2	0.23
	Total	1799	89.3 \pm 11.5	1799	87.8 \pm 13.5	<0.001
WHR	20-29	620	0.87 \pm 0.09	608	0.81 \pm 0.11	<0.001
	30-39	392	0.88 \pm 0.12	446	0.82 \pm 0.08	<0.001
	40-49	346	0.89 \pm 0.09	373	0.84 \pm 0.09	<0.001
	50-59	245	0.91 \pm 0.12	253	0.86 \pm 0.09	<0.001
	60-70	196	0.92 \pm 0.09	118	0.87 \pm 0.09	<0.001
	Total	1799	0.89 \pm 0.11	1798	0.83 \pm 0.09	<0.001

SD: standard deviation, BMI: body mass index, WC: waist circumference, WHR: waist to hip ratio

The mean of WHR was significantly higher in men compared with women and also an apparent increase of WHR was observed with age in both sexes. Figures 1 and 2 show the observed plot and the linear and quadratic patterns of BMI versus age for men and women, respectively. Table 2 shows sex-specific intercepts and slopes for the changes of weight, height, BMI, WC and WHR with aging. In both sexes, the quadratic model, including age² provided a significantly better fit than simple linear model for BMI and waist circumference. BMI and WC explained greater variance in quadratic model for women compared with men

(for BMI, R²=0.18, p<0.001 vs R²=0.06, p <0.001 and for WC, R²=0.17, p<0.001 vs R²=0.05, p<0.001). The slopes of quadratic age-related decline were significant in men and women.

The slopes with age in average values of both BMI and WC were of greater magnitude in women compared with men. A significant age-sex interaction effect was detected for both WC and BMI i.e. the changes of slopes of BMI and WC with age varies with sex significantly and a greater positive linear slope and negative slope for quadratic terms were observed for women.

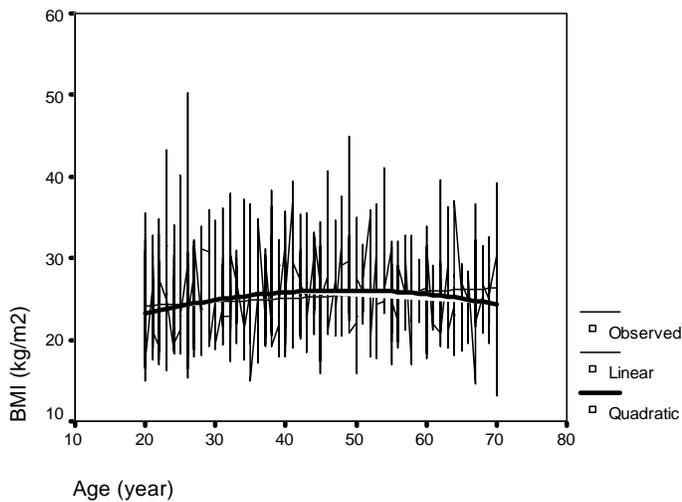


Figure 1. The BMI pattern with age in men

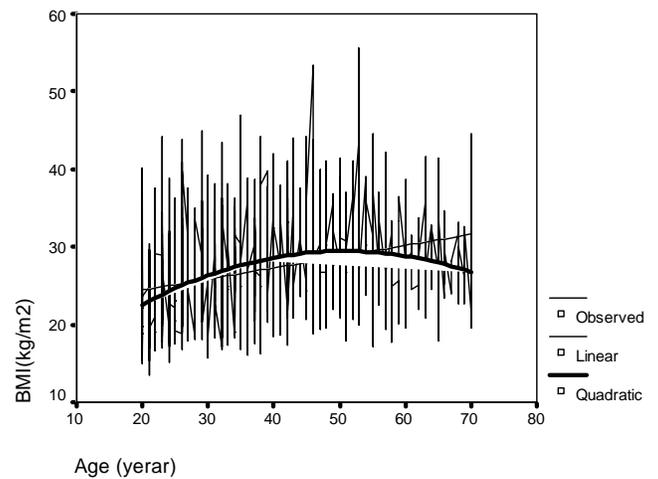


Figure 2. The BMI pattern with age in women

Regression models for weight versus age, the quadratic model including age² provided a significant better fit than the simple linear model in both sexes but weight explained a greater variance using the quadratic model for women than men ($R^2=0.13$ vs $R^2= 0.03$, respectively). While for height, an inverse linear relationship (negative slope) was apparent

by aging and the quadratic form did not add an additional fit on the magnitude of R^2 in both sexes.

In addition, regression model was built for WHR, a positive linear association was revealed by aging and quadratic term did not prompt an additional gain for better fit in terms of R^2 .

Table 2. The regression coefficient of linear and quadratic effect of age on anthropometric measures, R^2 and P-value with respect to gender

Sex	Dependent variables	Model	Intercept	Slope (age)	Slope (age ²)	R ²	P-value
Men	Weight	Linear	74.32	0.009	-	0.00	0.65
		Quadratic	57.32	0.91	-0.01	0.03	<0.001
	Height	Linear	178.4	-0.16	-	0.09	<0.001
		Quadratic	177.87	-0.13	-0.0004	0.09	<0.001
	BMI	Linear	23.3	0.04	-	0.025	<0.001
		Quadratic	17.6	0.35	-0.0036	0.059	<0.001
	WC	Linear	83.45	0.15	-	0.035	<0.001
		Quadratic	73.88	0.67	-0.006	0.047	<0.001
WHR	Linear	0.84	0.001	-	0.02	<0.001	
	Quadratic	0.89	-0.002	-0.0003	0.03	<0.001	
Women	Weight	Linear	58.99	0.24	-	0.06	<0.001
		Quadratic	30.44	1.81	-0.019	0.13	<0.001
	Height	Linear	164.4	-0.14	-	0.07	<0.001
		Quadratic	163.5	-0.08	-0.0007	0.07	<0.001
	BMI	Linear	21.57	0.14	-	0.12	<0.001
		Quadratic	10.68	0.74	-0.007	0.18	<0.001
	WC	Linear	73.49	0.38	-	0.13	<0.001
		Quadratic	53.3	1.49	-0.013	0.17	<0.007
	WHR	Linear	0.77	0.001	-	0.04	<0.001
		Quadratic	0.77	0.001	-	0.04	<0.007

Discussion

The present study provided statistical model for obesity related anthropometric indexes in a relative large representative sample in Iranian adults in northern Iran. Our findings show that the quadratic model, including age² provided a significantly better fit than simple linear model for weight, BMI and waist circumference. A greater magnitude of variance of weight, BMI and WC was explained by quadratic model for women compared with men. A significant age-sex interaction effect was detected for weight, BMI and WC i.e. the changes of slopes of age varies with sex significantly and a greater positive linear slope and negative slope for quadratic terms were observed for women.

Quadratic terms including age² indicated a possible greater acceleration in changing of slopes of obesity-related indexes such as weight, BMI and WC with aging for women compared with men. In women, the slope of BMI was sharper at age of 30-39 years and it tends to decline at age 50-59 years. Then, it switches to be negative slope at age near to 60 years. A similar pattern of slopes for weight and WC as apparent and the switching points were again at age almost 60 years and also the change in declining slope was greater for women than men. In men, in early adulthood, the slope is not as sharp as of women and the changes of switching occurred at age near 50 years. The sharper pattern of slopes of obesity-related indices in women at early and middle adulthood, can be explained by parity, low physical activity and low education level (4).

The positive association of age with total adipose tissue was also found in both genders aged 38-60 years by Oka et al. (18). In another study among Chilean adults, aged 60-99 years, the decline of mean of BMI, weight and WC was observed with age and the degree of decline in slope was also greater of magnitude for women than men (17). However, they reported that the quadratic terms related to decline with age were not statistically significant in men for any anthropometric indices studied. This dissimilarity is related to the range of age of subjects in a Chilean study that was quite different from ours. The rapid changes in slopes of obesity-related indexes in elderly with age in women can be explained by the changes of dietary pattern toward a deficient consumption of most relevant nutrients with significant lower intake of energy, protein, calcium, iron and folic acid in elderly. In a study by Woo et al. in Chinese adults aged 20-88 years, in both sexes, height and lean mass decreased in a linear fashion with age and changes in weight,

BMI and fat mass and percentage of fat with aging were also present in women and followed a quadratic trend (19) that is similar to our results. In contrast, in another study by Chen et al, in Beijing, BMI increased gradually from 21.1 kg/m² in ages 20-29 years to 26.1 kg/m² in ages 70-74 years in women (20). While in our findings, the baseline BMI (24.2Kg/m²) of women in ages 20-29 years was higher and the trend with age differs than those reported in Chinese women (20). Based on our findings, the quadratic model by age alone explained 18%, 17% and 13.0% of variances of BMI, WC and weight among women, respectively. In contrast, Welch and Sowers reported that the quadratic model of age alone accounted for 8% of observed variance in fatness in women aged 18-94 years (21).

In our study, an inverse linear relationship (negative slope) and a linear positive association with age and height and WHR was respectively apparent for both genders and the quadratic form did not add a better fit as determined by R² in estimating height and WHR in both sexes. Among the Chinese adults, aged 20-88 years, in both sexes, height and lean mass decreased in a linear fashion with age. The reduction of average of height with age estimated in our study was also consistent with that reported by Santos et al in Chilean study in elderly (17).

This reduction can be explained by cohort effect due to secular trend for differences in stature because of changing environmental conditions toward improving nutritional status of younger age group in epidemiologic transition. While cross-sectional nature of design of this study restricts to establish clearly this secular trend, similar height changes were also present in other settings studied (17, 22).

A limitation of this study is the design of the study which is cross-sectional, restricting the inferences with regard to body composition changes with aging and it is not adequate for examining the temporal sequence of aging and changing in anthropometric measures and also the secular trend can not be established clearly.

In addition, due to cross-sectional nature of this study, an interpretation of estimated slopes in terms of decline/increase must be performed with caution. Thus, we can only say the apparent changes of slope for anthropometric indexes by age.

In conclusion, our data based on a large representative sample of subjects, suggest that the changes of BMI and WC associated with age are of greater magnitude in women than men indicating the different patterns of weight gain, fat

accumulation for visceral adiposity and loss of muscle mass between men and women in the early and middle adulthood.

Acknowledgments

We would like to thank the Management, Planning and Budget Council of Mazandaran (Iran) for supporting the collection of our source data.

Conflict of interest: There is no conflict of interest that we should disclose.

References

1. Hassan MK, Joshi AV, Madhavan SS, Amonkae MM. Obesity and health related quality of life: a cross-sectional analysis of US population. *Int J Obes Relat Metab Disord* 2003; 27: 1227-32.
2. Azabakht L, Mirmiran P, Shiva N, Azizi F. General obesity and central obesity in representative sample of Tehranian adults: Prevalence and determinants. *Int J Vitam Nutr Res* 2005; 75: 297-304.
3. Azizi F, Azadbakht I, Mirmiran P. Trend in overweight, obesity and central fat accumulation among Tehranian adults between 1998-1999 and 2001-2002. *Tehran Lipid Glucose Study. Ann Nutr Metab* 2005; 49: 3-8.
4. Hajian-Tilaki KO, Heidari B. Prevalence of obesity, central obesity and the associated factors in urban area population aged 20-70 years, in the north of Iran: a population based study and regression approach. *Obes Rev* 2007; 8: 3-10.
5. Ardern CL, Katzmyk PT, Janssen I, Ross R. Discrimination of health risk by combined body mass and waist circumference. *Obes Res* 2003; 11: 135-42.
6. Rexrode KM, Carey VI, Hennekens CH, et al. Abdominal adiposity and coronary heart disease in women. *JAMA* 1998; 280: 1843-8.
7. Jassen I, Katzorzyk PT, Ross R. Waist circumference and not body mass index obesity related health risk. *Am J Clin Nutr* 2004; 79: 384-99.
8. Onat A, Sansoy V, Uysal O. Waist circumference and waist to hip ratio in Turkish adults: Interrelation with other risk factors and association with cardiovascular disease. *Int J Cardiol* 1999; 70: 43-50.
9. Filardo G, Hamilton C. Modeling the effect of body mass index and waist to hip ratio on mortality. *Eur J Epidemiol* 2007; 22: 745-46.
10. Adams KF, Schatzkin A, Haris TB, et al. overweight, obesity and mortality in a large prospective cohort persons 50 to 71 years old. *N Engl J Med* 2006; 355: 779-87.
11. Hajian-Tilaki K, Heidari B, Firouzjahi A, et al. Prevalence of metabolic syndrome and the association with socio-demographic characteristics and physical activity in urban population of Iranian adults: a population-based study. *Diabetes Metab Syndr* 2014; 8: 170-6.
12. Hajian-Tilaki K, Heidari B. Prevalences of overweight and obesity and their association with physical activity pattern among Iranian adolescents aged 12-17 years. *Public Health Nutr.* 2012; 15: 2246-52.
13. Hajian-Tilaki KO, Sajjadi P, Razavi A. Prevalence of overweight and obesity and associated risk factors in urban primary-school children in Babol, Islamic Republic of Iran. *East Mediterr Health J* 2011; 17: 109-14.
14. Hajian-Tilaki KO, Heidari B. Association of educational level with risk of obesity and abdominal obesity in Iranian adults. *J Public Health (Oxf)* 2010; 32: 202-9.
15. Hajian-Tilaki K, Heidari B, Hajian-Tilaki A, Firouzjahi A, Bagherzadeh M. The discriminatory performance of body mass index, waist circumference, waist-to-hip ratio and waist-to-height ratio for hip ration in detection of metabolic syndrome and their optimal cutoffs among Iranian adults. *J Res Health Sci* 2014; 14: 276-81.
16. Hajian-Tilaki K. Metabolic syndrome and its associated risk factors in Iranian adults: A systematic review. *Caspian J Intern Med* 2015; 6: 51-61.
17. Santos JL, Albala C, Lera L, et al. Anthropometric measurements in the elderly population of Santiafo, Chile. *Nutrition* 2004; 20: 452-7.
18. Oka R, Miura K, Sakurai M, et al. Comparison of waist circumference with body mass index for predicting abdominal adipose tissue. *Diabetes Res Clin Pract* 2009; 83: 100-5.
19. Woo J, Kwok T, Lau E, Li M, Yu LM. Body composition in Chinese subjects: relationship with age and disease. *Arch Gerontol Geriatr* 1998; 26: 23-32.
20. Chen R, Lin SQ, Lin X, et al. Effect of age on body composition in healthy Beijing women. *Zhonghua FU Chan Ke Za Zhi* 2008; 43: 36-40.
21. Welch GW, Sowers RM. The interrelationship between body topology and body composition varies with age among women. *J Nutr* 2000; 130: 2371-7.
22. Perissinotto E, Pisent C, Sergi G, Grigoletto F; ILSA Working Group (Italian Longitudinal Study on Ageing). Anthropometric measurements in the elderly: age and gender differences. *Br J Nutr* 2002; 87: 177-86.