The Influence of the Age, Period, and Cohort Effects on 15-year Changes in Weight and Waist Circumference in Adults: Tehran Lipid and Glucose Study (TLGS)

Maryam Barzin
Research Institute for Endocrine Sciences
Shayan Aryannezhad
Research Institute for Endocrine Sciences
Mohammad Bagheri
Research Institute for Endocrine Sciences
Maryam Mahdavi
Research Institute for Endocrine Sciences
Majid Valizadeh
Research Institute for Endocrine Sciences
Fereidoun Azizi
Research Institute for Endocrine Sciences
Farhad Hosseinpanah (fhospanah@endocrine.ac.ir)
Research Institute for Endocrine Sciences

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Abstract

Objective

To examine the effects of age, period, and birth cohort on weight and waist circumference (WC) changes among the participants of the Tehran Lipid and Glucose Study from 1999 to 2015.

Methods

This prospective cohort study included 4895 participants aged ≥ 20 years (41.3% men), who were divided based on sex into eleven 10-year age groups. Analyses were conducted to explicitly assess the effects of age vs. period on weight and WC changes. We also implicitly assessed weight and WC variations regarding different cohorts and period-specific experiences across various age groups.

Results

Upon 15 years of follow-up, the mean weight of men increased from 75.2 ± 12.3 to 80.5 ± 14.3 kg, and this trend was accompanied by an increase in WC from 88.8 ± 10.9 to 97.8 ± 10.4 cm. Men in all age cohorts tended to have a rise in their weight with aging throughout the follow-up period (coefficient for age: 0.69, 95% CI: 0.45–0.93). Considering WC changes, all age cohorts had a rising trend throughout the follow-up period with aging (coefficient for age: 0.77, 95% CI: 0.57–0.96). Women in all age cohorts tended to have a rise in their weight throughout the follow-up period with aging (coefficient for age: 1.48, 95% CI: 1.28–1.68). Considering the changes of WC, all age cohorts had an ascending trend throughout the follow-up period with aging (coefficient for age: 1.32, 95% CI: 1.14–1.50).

Conclusion

The rise in weight and WC was strongly age-dependent in both sexes. The men born in the recent birth cohorts and the women born in earlier birth cohorts had the most alarming weight and WC gains. More efforts must be spent on obesity prevention policies, especially for younger men.

Background

Obesity is highly prevalent in developed and developing countries (1–3). In the recent decades, Iran, as a developing country, has been experiencing an alarming rise in the prevalence of obesity; over an 8-year period, the overall prevalence of obesity in the country increased from 13.6 % in 1999 to 22.3 % in 2007 (OR = 1.08 per year) (4). We previously reported increasing trends in obesity and abdominal obesity in both genders in Iran's capital, Tehran. Based on our report on Tehran population, using a GEE model, the overall risk of obesity and abdominal obesity increased by 36 % and 34 % at the end of study (from 1999 to 2011) (5).

There are different patterns regarding the trend of obesity, which are explainable by many sociodemographic, socioeconomic, and lifestyle factors. To explore these patterns, it is necessary to assess weight and waist changes in individuals over time (i.e., the age effect) and based on population-wide behavioral changes and other age-independent exposures (i.e., the period effect), as well as based on intra-individual differences in the people born in different times (i.e., the birth-cohort effect) (6). Rising trends in body mass index (BMI) and waist with ageing, as observed in cross-sectional studies, could be the result of the age and birth-cohort effects. On the other hand, increases in BMI and waist circumference (WC) with ageing, as reported in longitudinal studies, might be due to period effects. The simultaneous assessment of the age, period, and birth-cohort effects on BMI and WC requires longitudinal analyses with repeated measures in the same individuals (7–9).

Over the last a few decades, Iran has experienced an epidemiological transition from a traditional to a western lifestyle (10). There are no recent studies evaluating age and/or cohort effects on BMI and WC based on repeated measurements in Iran. Here, we investigated the effects of age, period, and birth-cohort on weight and WC changes in the framework of a prospective cohort study within a 15-year follow up period.

Material And Methods

Study Population

The Tehran's Lipid and Glucose Study (TLGS) is a longitudinal cohort, which commenced in 1999 with the objective of determining the prevalence of non-communicable diseases among urban residents of Tehran, as a representative sample of the total population of Iran's capital. A multistage stratified cluster random sampling technique was used to select 15,010 people aged ≥ 3 years old. From this population, only individuals above 20 years of age who participated in the phase I (1999–2001), phase III (2006–2008), and phase V (2012–2015) of the study were enrolled. The interval between two assessments was approximately three years. The details of the study have been published elsewhere (11). After excluding the subjects aged < 20 years (n = 4647), those with cancer (n = 44), pregnant participants (n = 80), the patients using glucocorticoids (n = 211), and the participants who lost the follow-up or had not participated in all the three phases (n = 5133), the data of 4895 subjects were used in this longitudinal study. These individuals included 2024 men (41.3%) and 2871 women (58.7%) who attended the phases I, III, and V of TLGS with a median follow-up of 13.0 (IQ: 12.3–13.9) years.

This study was approved by the Research Ethics Committee of the Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, and informed written consent was obtained from all subjects. All procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Measurements And Definitions

Weight and height were determined using a digital electronic weighing scale (Seca 707; range: 0.1–150 kg, Hanover, MD, accuracy of up to 100 gr) and a tape meter stadiometer, respectively. Waist circumference was measured at the level of the umbilicus by a trained individual, and BMI was calculated as weight (kg)/height (m^2) (12). Educational level was categorized into ≤ 12-year education (primary school, secondary school, and high-school diploma) and > 12 years of education (i.e., university level). Smoking status was categorized into yes/no, 'Yes' meaning tobacco smoking (cigarette, pipe, or water pipe) at the time of examination and 'no' as no smoking at the time (ex- or never-smokers). Information on leisure-time physical activity (LTPA) were collected using a Persian-translated form of the Modifiable Activity Questionnaire (MAQ) (11), which was categorized into the light or non-active (MET < 600 min/week) and moderate/vigorous or active (MET ≥ 600 min/week) groups (13). Marital status was regarded as either married or unmarried (including never-married, widowed, and divorced).

Statistical Analysis

Continuous variables were expressed as mean ± SD and categorical variables as number (percent). These variables were compared between respondents and non-respondents using *t*-test for continuous variables and Chi square for categorical variables. A series of repeated measures models were used to assess differences in anthropometric factors between the three phases. Differences in categorical factors (i.e., smoking, physical activity, marital status, and education) along the follow-up period were analyzed using the generalized estimated equation (GEE) method with an autoregressive working correlation structure and a logistic model. Post-hoc Bonferroni correction was used for pairwise comparisons. Analyses were stratified by sex and age group. Mixed effects models with fixed and random individual-level effects and random slopes were used to assess differences in anthropometric factors among individuals over time. The stratified models included age and age-squared, as well as age interaction with year to determine how the survey year may vary by age. Figures were stratified by age groups to provide insights into the period-specific effects of covariates. All analyses were performed in the SPSS statistical software package (SPSS for Windows; SPSS Inc., Chicago, IL, USA; Version 20.00), and mixed effects models were conducted using Stata's XTMIXED program. Statistical significance was considered two-tailed.

Results

The mean age of study participants at baseline was 41.4 ± 13.0 years, and 58.6% of the participants were women. After 15 years of follow-up, mean weight in men increased from 75.2 ± 12.3 to 80.5 ± 14.3 kg, and this trend was accompanied by an increase in mean WC from 88.8 ± 10.9 to 97.8 ± 10.4 cm. Women also showed elevations in mean weight (from 67.6 ± 12.0 to 71.7 ± 12.6 kg) and mean WC (from 87.3 ± 12.4 to 95.8 ± 12.1 cm) in this period. More detailed characteristics of study population across different phases of the study are available in Table 1. In comparison with those who completed the follow-up and entered the study (the respondent group, n = 4895), non-respondents (n = 5133) were older and had lower BMIs (supplementary Table 1).

Table 1
Sex-specific characteristics of study population across phases I, III, and V.

		Phase I	Phase III	Phase V	$P_{I–III}$ [a]	$P_{III–V}$	$P_{I–V}$
Men (N = 2024)							
	Weight (kg)	75.2 ± 12.3	78.9 ± 13.2	80.5 ± 14.3	< 0.001	< 0.001	< 0.001
	WC (cm)	88.8 ± 10.9	96.4 ± 10.1	97.8 ± 10.4	< 0.001	< 0.001	< 0.001
	BMI (kg/m^2)	26.0 ± 3.9	27.2 ± 4.0	27.5 ± 4.3	< 0.001	< 0.001	< 0.001
	Smoking (non-smokers)	1516 (75.4)	1549 (77.8)	1609 (79.7)	0.006	0.011	< 0.001
	Physical activity (active)	408 (20.3)	228 (19.6)	208 (19.4)	0.431	> 0.999	> 0.999
	Marital status (married)	1698 (83.9)	1903 (94.2)	1966 (97.2)	< 0.001	< 0.001	< 0.001
	Education (> 12 years)	374 (18.5)	488 (24.5)	545 (26.9)	< 0.001	< 0.001	< 0.001
Women (N = 2871)							
	Weight (kg)	67.6 ± 12.0	70.2 ± 12.1	71.7 ± 12.6	< 0.001	< 0.001	< 0.001
	WC (cm)	87.3 ± 12.4	90.8 ± 12.6	95.8 ± 12.1	< 0.001	< 0.001	< 0.001
	BMI (kg/m^2)	27.5 ± 4.8	28.9 ± 4.9	29.9 ± 5.4	< 0.001	< 0.001	< 0.001
	Smoking (non-smokers)	2783 (97.6)	2731 (97.3)	2771 (96.9)	0.978	0.348	0.058
	Physical activity (active)	760 (26.7)	240 (13.8)	166 (12.9)	< 0.001	> 0.999	< 0.001
	Marital status (married)	2597 (90.5)	2732 (95.2)	2758 (96.2)	< 0.001	< 0.001	< 0.001
	Education (> 12 years)	251 (8.8)	377 (13.4)	449 (15.7)	< 0.001	< 0.001	< 0.001

	Phase I	Phase III	Phase V	P_{I-III} [a]	P_{III-V}	P_{I-V}

WC, waist circumference; BMI, body mass index.

Data are presented as mean ± SD or n (%).

[a] Adjustment for multiple comparisons with Bonferroni correction (comparisons with phase1 and phase3)

Cohort-specific mean weight and WC values in the study population have been presented in Table 2. Rising trends in mean weight and WC in each age cohort were observed for both genders (except for the weight of ≥ 70 years old men and WC of ≥ 70 years old women). Additionally, sex-specific mixed effects were estimated on weight and WC changes in the studied population, adjusted for age, age squared, time, time*age, smoking, physical activity, education, and marital status (Tables 3 and 4). In Figs. 1 and 2, adjusted estimated means of weight and WC in six age cohorts have been shown according to the mean age of the group in each phase of the study.

Table 2
Sex-specific weight and waist circumference of different age cohorts of study population across phases I, III, and V.

			Weight (kg)				**Waist Circumference (cm)**			
	Age cohort (years)	**N**	**Phase I**	**Phase III**	**Phase V**	P trend	**Phase I**	**Phase III**	**Phase V**	P trend
Men	**20–29**	371	73.9 ± 13.9	82.5 ± 14.3	86.5 ± 14.7	< 0.001	82.5 ± 11.4	95.3 ± 10.9	98.4 ± 10.7	< 0.001
	30–39	576	76.9 ± 12.9	81.4 ± 14.0	83.9 ± 14.5	< 0.001	88.1 ± 10.5	96.3 ± 10.5	98.4 ± 10.8	< 0.001
	40–49	442	76.0 ± 11.1	78.8 ± 11.7	80.0 ± 12.6	< 0.001	90.3 ± 9.7	96.7 ± 9.3	97.7 ± 9.5	< 0.001
	50–59	336	75.4 ± 11.2	76.5 ± 11.3	76.9 ± 12.0	< 0.001	92.2 ± 9.9	97.4 ± 9.3	98.1 ± 9.9	< 0.001
	60–69	250	72.9 ± 11.7	73.1 ± 11.7	71.7 ± 12.1	< 0.001	92.0 ± 10.7	96.9 ± 10.3	96.1 ± 10.9	< 0.001
	≥ 70	49	69.0 ± 8.6	69.3 ± 9.3	67.9 ± 10.8	0.130	90.4 ± 8.8	95.8 ± 9.6	95.5 ± 11.6	< 0.001
	Total	2024	75.2 ± 12.3	78.9 ± 13.2	80.5 ± 14.3	< 0.001	88.8 ± 10.9	96.4 ± 10.10	97.8 ± 10.1	< 0.001
Women	**20–29**	618	62.0 ± 12.2	66.9 ± 12.7	70.3 ± 13.0	< 0.001	78.3 ± 11.3	82.1 ± 11.5	89.0 ± 10.9	< 0.001
	30–39	816	67.3 ± 11.8	70.7 ± 12.2	72.9 ± 12.5	< 0.001	84.7 ± 11.0	88.5 ± 11.5	94.2 ± 11.4	< 0.001
	40–49	706	71.3 ± 11.4	73.1 ± 11.5	73.9 ± 12.4	< 0.001	91.3 ± 11.1	94.8 ± 11.3	99.1 ± 11.5	< 0.001
	50–59	496	70.4 ± 10.9	71.1 ± 11.6	71.3 ± 11.8	< 0.001	93.9 ± 10.5	97.3 ± 11.0	100.7 ± 11.2	< 0.001
	60–69	215	66.9 ± 10.1	66.8 ± 10.1	65.9 ± 10.9	0.014	94.5 ± 10.2	96.7 ± 10.9	98.8 ± 11.5	< 0.001
	≥ 70	20	61.6 ± 8.6	60.8 ± 6.7	58.1 ± 7.5	0.010	92.1 ± 9.7	93.6 ± 7.6	94.3 ± 9.7	0.545
	Total	2871	67.6 ± 12.0	70.2 ± 12.1	71.7 ± 12.6	< 0.001	87.3 ± 12.4	90.8 ± 12.6	95.8 ± 12.1	< 0.001

Data are presented as mean ± SD.

Table 3

Sex-specific mixed effects estimates on weight of study population, coefficient (95 % CI).

	Coefficient (95 % CI)	P-value
Men		
Age	0.69(0.45, 0.93)	< 0.001
Age^2	-0.008(-0.01, -0.006)	< 0.001
Time (Ref : Phase I)		
Phase III	6.97(5.06,8.87)	< 0.001
Phase V	10.42(6.71,14.13)	< 0.001
Time*age (Ref : Phase I)		
Phase III *age	-0.06(-0.10,-0.02)	0.003
Phase V *age	-0.07(-0.14, 0.004)	0.066
Smoking (Ref: non-smoker)	-1.11(-1.66,-0.55)	< 0.001
Physical activity (Ref: high)	0.59(0.27, 0.90)	< 0.001
Education (Ref: >12 year)	-0.69(-1.39,-0.001)	0.050
Spouse: (Ref: married)	-3.05(-3.82,-2.29)	< 0.001
Women		
Age	1.48(1.28,1.68)	< 0.001
Age^2	-0.01(-0.02,-0.01)	< 0.001
Time (Ref : PhaseI)		
Phase III	-2.00(-3.57,-0.42)	0.013
Phase V	-5.08(-8.21,-1.94)	0.002
Time*age (Ref : Phase I)		
Phase III *age	0.08(0.04, 0.11)	< 0.001
Phase V *age	0.16(0.10, 0.23)	< 0.001
Smoking (Ref: non-smoker)	-1.43(-2.47,-0.39)	0.007
Physical activity (Ref: high)	0.35(0.10, 0.59)	0.005
Education (Ref: >12 year)	1.43(0.77, 2.08)	< 0.001
Marital status: (Ref: married)	-3.93(-4.73,-3.13)	< 0.001

	Coefficient (95 % CI)	P-value
Model includes age, age-squared, study phase year, age interacted with study phase year, smoking, education, and marital status.		

Table 4
Sex-specific mixed effects estimates on waist circumference of study population, coefficient (95 % CI).

	Coefficient (95 % CI)	P-value
Men		
Age	0.77(0.57, 0.96)	< 0.001
Age^2	-0.006(-0.008,-0.004)	< 0.001
Time (Ref : Phase I)		
Phase III	9.49 (7.88, 11.10)	< 0.001
Phase V	10.44(7.39, 13.49)	< 0.001
Time*age (Ref : Phase I)		
Phase III*age	-0.06(-0.10,-0.03)	< 0.001
Phase V*age	-0.06(-0.12,-0.001)	0.045
Smoking (Ref: non-smoker)	-1.12(-1.63,-0.61)	< 0.001
Physical activity (Ref: high)	0.77(0.48, 1.07)	< 0.001
Education (Ref: >12 year)	-0.33(-0.95, 0.29)	0.295
Spouse: (Ref: married)	-3.11(-3.83,-2.40)	< 0.001
Women		
Age	1.32(1.14, 1.50)	< 0.001
Age^2	-0.010(-0.013,-0.008)	< 0.001
Time (Ref : Phase I)		
Phase III	-4.87(-6.57, -3.17)	< 0.001
Phase V	-2.84(-5.90, 0.23)	0.070
Time*age (Ref : Phase I)		
Phase III*age	0.13(0.09, 0.16)	< 0.001
Phase V*age	0.13(0.07, 0.19)	< 0.001
Smoking (Ref: non-smoker)	-0.76(-2.12, 0.60)	0.274
Physical activity (Ref: high)	0.80(0.46, 1.15)	< 0.001
Education (Ref: >12 year)	2.63(1.83, 3.42)	< 0.001
Spouse: (Ref: married)	-5.25(-6.26,-4.24)	< 0.001

	Coefficient (95 % CI)	P-value
Model includes age, age-squared, study phase year, age interacted with study phase year, smoking, education, and marital status.		

Subgroup Gender Analysis

Men in all age cohorts showed a rise in weight with aging throughout the follow-up period (coefficient for age: 0.69, 95 % CI: 0.45, 0.93). However, as shown in Fig. 1-A, this rise was more prominent in younger cohorts at phase III (coefficient for time*age: -0.06, 95 % CI: -0.10, -0.02), indicating a significant negative cohort effect. Considering WC changes, all age cohorts had a rising trend with aging throughout the follow-up (coefficient for age: 0.77, 95 % CI: 0.57, 0.96). Significant negative cohort effects were observed at phases III and V (coefficient for time*age: -0.06, 95 % CI: -0.10, -0.03 and − 0.06, 95 % CI: -0.12, -0.001, respectively) (Fig. 2-A). Moreover, it was observed that higher physical activity, smoking, lower education, and not being married were associated with lower weight and WC.

Women in all age cohorts showed a rise in weight throughout the follow-up with aging (coefficient for age: 1.48, 95 % CI: 1.28, 1.68). However, this trend was influenced by a positive cohort effect at both phases III and V (coefficient for time*age 0.08, 95 % CI: 0.04, 0.11 and 0.160, 95 % CI: 0.10, 0.23, respectively), meaning that older age cohorts were more likely to gain weight with time (Fig. 2-A). Regarding WC changes, all age cohorts displayed a rising trend throughout the follow-up period with aging (coefficient for age: 1.32, 95 % CI: 1.14, 1.50). In line with weight changes, this trend was influenced by a positive cohort effect at both phases III and V (coefficient for time*age 0.13, 95% CI: 0.09, 0.16 and 0.13, 95 % CI: 0.07, 0.19, respectively) (Fig. 2-B). Regarding the effects of other variables, a higher physical activity, smoking, a higher education, and not being married were associated with lower weight and WC.

Discussion

In this 15-year population-based longitudinal study, gender-specific changes of weight and WC in the adult population of Tehran were evaluated. The rises in weight and WC were strongly age-dependent throughout the follow up period. Increases in weight and WC were more prominent in younger and older birth cohorts in men and women, respectively.

A large body of evidence suggests that weight, BMI, and WC increase throughout most of adult life (14–17), which is in line with our findings regarding the positive age effects observed in both genders. A prospective longitudinal study in Norway recently showed that mean weight in middle-aged men and women (aged 26–54 years) increased significantly during a 10-year follow-up while it reduced in elderly men and women (aged 60–69 years); however, mean WC increased throughout the follow up in all age groups (18). The recent findings were completely in accordance with those of the present study. We observed an overall positive age effect on weight in both genders which in combination with the observed inverse association of weight with age squared suggested an inverted U-shaped relationship between age and weight gain. This implies that the rapid weight gain seen in young and middle-aged men and women will most likely be reversed in the elderly. The weight reduction with aging reported in the elderly could be a result of decreased appetite and calorie intake, as well as substantial loss of muscle mass due to the aging process (19). However, in older men and women, despite a drop in weight, WC increased over years, which could be a result of body composition changes. Age has been shown to affect body composition with older people having higher proportions of the adipose tissue to the lean mass (20). Furthermore, age affects the distribution of the adipose tissue, with more intra-abdominal and visceral adipose tissues vs. peripheral subcutaneous fat mass being observed in the elderly (21). Besides, spinal degenerative changes and a consequent reduction in height during the aging process could explain the increase of WC despite decreased or sustained weight in this age group (22).

In this study, significant negative cohort effects were observed on weight and WC in adult men, indicating notable general and central weight gain in the youngest compared with older birth cohorts. This finding was consistent with the observations of previous studies (7, 9, 23–29). Iran, as a country located in the Middle East and north Africa region, is subjected to a dramatic epidemiological transition from a traditional to a modern nutrition and lifestyle (30). This modernization and associated lifestyle changes by encouraging sedentary habits and excess calorie intake have increased the risk of obesity and overweight in the new generations of Iranians, and as a consequence, the prevalence of obesity among children and adolescents has increased (31–33). Overweight or obese children and adolescents are likely to remain so in adulthood, and this may explain why people who were born in the most recent birth cohorts were more susceptible to weight and WC elevations than older individuals born in the years of economic and social instability. Moreover, in older men, the negative cohort effect could be partially explained by reduced calorie intake and aging-associated loss of appetite (19). In addition, exposure to stress might lead to unhealthy behaviors which could contribute to weight gain as well (34). Another explanation for the observed association of weight gain with younger birth cohorts could be more job commitments of younger generations and their less time for physical exercises and self-care, delivering them more prone to obesity. In contrast, the individuals born in earlier birth cohorts spent their youth in more active lifestyles and were less exposed to cumulative obesogenic health behaviors (35, 36). Another explanation for the negative impact of birth cohort on men could be related to the survival bias which might be a consequence of premature mortality among older obese individuals (37). In contrast to our findings, a study on Chinese adults found that being overweight was more common among middle-aged men born between 1950 and 1975 and revealed that the prevalence of overweight among Chinese adults decreased rapidly in the most recent birth cohorts (i.e., after 1975) (38). The observed difference between the two studies may be due to economic and social differences between the two populations. China has become one of the world's fastest growing economies since the 1980s and with increased access to health information and the implantation of new health policies, has somehow managed to overcome the epidemiological transition (39).

In women; however, we observed a positive cohort effect on weight. Regarding the difference between men and women in this area, both biological and social factors may be accountable for justifying the reported disparity between the two genders. The younger women born in recent birth cohorts are more likely to have higher education, have fewer pregnancies, and adhere to feminine beauty standards paying a premium for slimness as a desirable body form (40). Moreover, menopausal changes affect women in their later years, making elderly women more prone to obesity (41, 42). Another factor contributing to the observed gender disparity may be a higher health awareness level among young women rather than men (43).

We are aware that our research may have some limitations. First, since our subjects were only urban residents in Tehran, our findings cannot be extrapolated to the entire country's population. Second, in order to reach solid conclusions about the influence of the period effect on weight and WC, more measurements and longer follow-up periods are needed. Third, the body composition of the participants was not recorded in our study; therefore, we could not speculate to what degree the reported weight fluctuations might correspond to body fat percentage changes. Moreover, we did not take into account the effects of the participants' dietary intake and nutritional habits on their weight and WC. However, the current study has several strengths worth mentioning. Anthropometric measurements were performed by trained staff instead of relying on self-reports, increasing the accuracy of measurements. Moreover, our research included participants from a wide adult age spectrum and birth cohorts, who were tracked for 15 years and underwent three measurement intervals.

In conclusion, this study demonstrated rising age-dependent trends in the weight and WC of Tehranian adult men and women. However, there were substantial gender-specific cohort effects, indicating that the men born in recent birth cohorts and the women born in earlier birth cohorts had the most alarming trends in gaining weight and WC. Given Iran's epidemiological transition state, it seems that the nation has a heterogeneous tendency for weight gain, and our findings suggest that effective population-based obesity preventive measures should be targeted towards gender, age, and birth cohort, as the most potent determinants of obesity.

Declarations

Ethics approval and consent to participate:

Informed consent was obtained from all participants. All methods were performed in accordance with the relevant guidelines and regulations (Declaration of Helsinki). This study was approved by the Ethics Committee of the Institute of Endocrinology and Metabolism of Shahid Beheshti University of Medical Sciences

Consent for publication:

Not Applicable.

Avalibility of data and materials:

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interest:

The authors declare that they have no financial or non-financial competing interests.

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Author Contributions.

M.B, M.Band S.A.designed the study and prepared the manuscript and approved the final manuscript as submitted. M.M. analyzed and interpreted the data. M.V. and F.A. supervised the project, drafted the initial manuscript, and approved the final manuscript as submitted. F.H. conceptualized and designed the study, interpreted the data and critically revised the manuscript and approved the final manuscript as submitted.All authors reviewed the manuscript.

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Figures

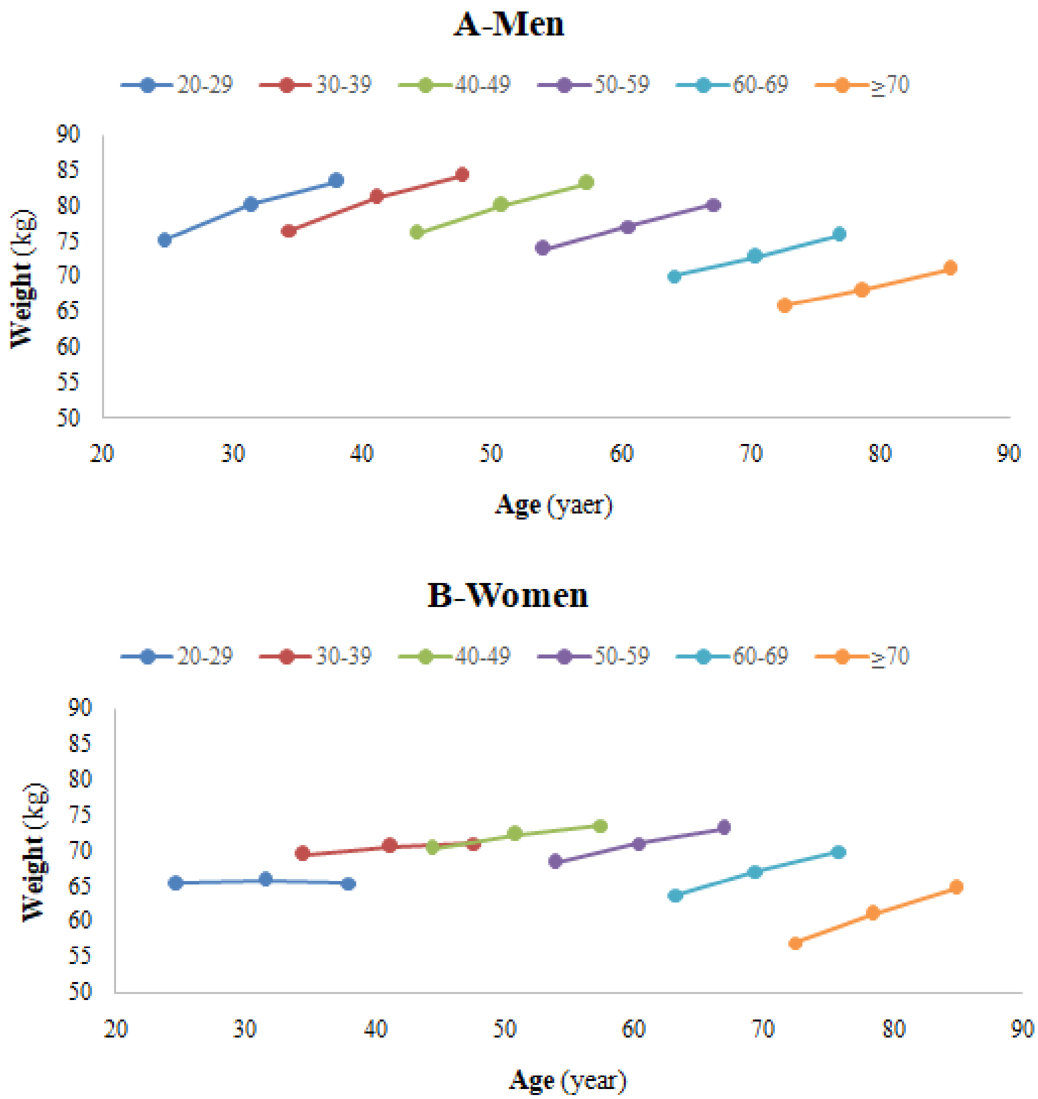

Figure 1

Trends of weight in different age cohorts of study population across phases I, III, and V; in men (A) and women (B).

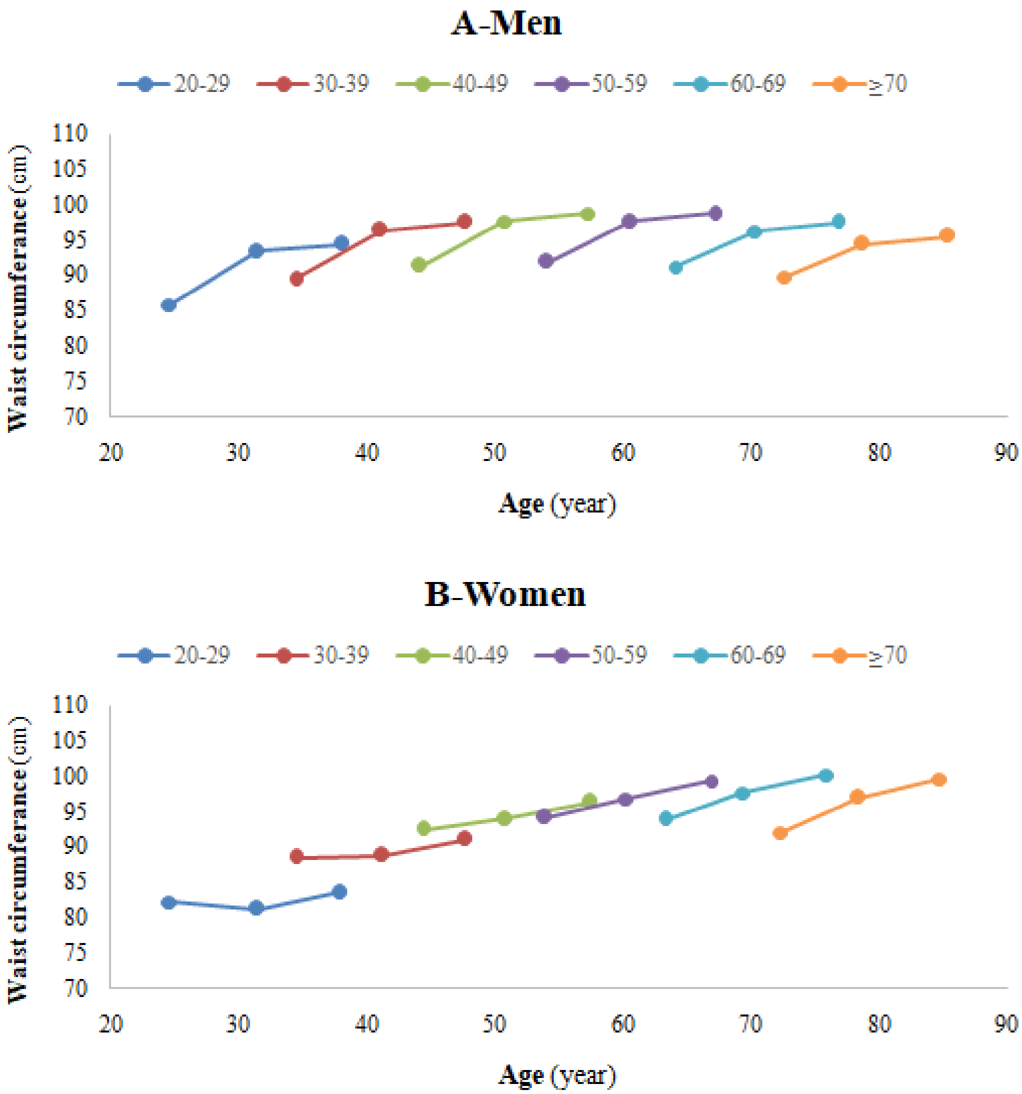

Figure 2

Trends ofwaist circumferencein different age cohorts of study population across phases I, III, and V; in men (A) and women (B).

Supplementary Files

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- SuppTable1.docx