

# Association of Marital Status and Marital Transition With Metabolic Syndrome: Tehran Lipid and Glucose Study

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**Background:** Most existing reports indicate that body weight gradually increases following marital status and thereby enhances health status and decreases mortality; however, the association between marital status and the metabolic syndrome (MetS) has not been thoroughly investigated in a longitudinal study.

**Objectives:** The aim of this study was to investigate the potential effects of marital status and marital transition on MetS during a 9.6-year follow-up in Tehran Lipid and Glucose Study.

**Patients and Methods:** For this study, 5221 participants (2060 males and 3161 females), aged 15 to 90 years at baseline, were followed for a median of 9.6 years. Marital status was categorized as consistent marital status and marital transition. We measured *MetS risk z score* and its components and calculated their changes. Then the effects of marital status and marital transition on *MetS risk z score* and its components were assessed using multivariable linear regression.

**Results:** In comparison to participants who were married, no significant changes in MetS risk z score was found in single participants. Employed females in the transition to married group had significant increase in *MetS risk z score* than single employed females. No significant changes in *MetS risk z score* were observed between widowed/divorced subjects and compared to consistently married subjects.

**Conclusions:** Marital status may affect *MetS risk z score* differently in both genders.

**Keywords:** Marital Status; Metabolic Syndrome X; Marital Transition

## 1. Background

Metabolic syndrome (MetS) refers to the constellation of metabolic abnormalities including glucose intolerance, abdominal obesity, dyslipidemia, and hypertension (1). The prevalence of MetS in Iran is high; with a prevalence rate of over 30% in the adult population, this epidemic would escalate over the next decade (2, 3). In a previous study among adults of Tehran with 9.6-year follow-up, the incidence of MetS by adult treatment panel III and international diabetes federation criteria was 31 and 39 per 1000 population per years, respectively (4). This syndrome was associated with an increased risk of chronic diseases, including diabetes, cardiovascular disease (CVD), and chronic kidney disease (5, 6). Genetic, metabolic, environmental, and social factors have all been reported as the risk factors for MetS (7, 8). Social factors, which are determined by the education level, occupation, income, and marital status, may influence MetS and its components by affecting environmental factors such as dietary behavior, food intake, and physical activ-

ity as important contributing factor to MetS (9, 10). Although social factors such as education level, occupation, and income have been well studied for their association with MetS (11-13), marital status, as an important feature of social factors, has not been evaluated in that regard (14, 15). Few studies have investigated the associations between marital status and MetS, most of them have cross-sectional design that investigated current marital status (16-18), and few studies investigated the effect of change in marital status on MetS and its components (19).

## 2. Objectives

Hence, the aim of this study was to investigate the association of marital status and marital transition with MetS and its components in a sample population in Tehran, who were selected from participants of the Tehran Lipid and Glucose Study (TLGS).

## 3. Patients and Methods

The TLGS is a community-based prospective study,

aimed at preventing noncommunicable disease by development of a program to promote healthy lifestyles and reduce noncommunicable disease risk factors. This study is being conducted on a sample of residents under the coverage of three medical health centers in District 13 of Tehran, the capital of Iran. Details of the survey have been reported elsewhere (20). In the TLGS, 15005 individuals, aged  $\geq 3$  years, living in district 13 of Tehran, were selected by multistage cluster random sampling methods and were tracked (21); participants underwent physical examination and completed follow-up questionnaires to update information on marital status and medical histories (21). The baseline survey was performed in 1999 and follow-up surveys took place every three years. For the present study, of 15005 individuals, 12030 subjects, aged  $\geq 15$  years, were evaluated in the cross-sectional phase 1 of TLGS from 1999 to 2001; at baseline 694 participants were excluded because they did not have complete baseline data. In addition, 6115 participants were excluded, because they did not have all the relevant information for the covariate adjustment and complete data on components of MetS at three follow-ups or they experienced inconsistent transitions between consecutive time points. The final sample included 5221 participants (2060 males and 3161 females), aged 15 to 90 years, who were followed for a median period of 9.6 years. Compared with nonresponders ( $n = 6115$ ), respondents ( $n = 5221$ ) had no difference regarding the mean of their age ( $40.1 \pm 19.2$  vs.  $42.2 \pm 19.8$  year) and body mass index (BMI) ( $26.1 \pm 4.4$  vs.  $25.9 \pm 4.1$  kg/m<sup>2</sup>), but were more likely to be single in 1999 (30.4% vs. 19.4%;  $P < 0.001$ ). In addition, there was no significant difference between physical activity level, smoking status, and occupational status among responders and nonresponders.

### 3.1. Assessment of Variables

Weight was measured while the participants were minimally clothed and not wearing shoes, using digital scales (Seca, Hamburg, Germany) and measures were rounded to the nearest 100 g. Height was measured while participants were standing without shoes, with their shoulders in a normal position, using a tape fixed to the wall, and measures were rounded to the nearest 0.5 cm. BMI was calculated as weight (kg) divided by square of height (m<sup>2</sup>). Waist circumference (WC) was measured at the level of the umbilicus, using an outstretched tape meter, without pressure to body surfaces and was rounded to the nearest 0.5 cm. Systolic and diastolic blood pressure (SBP and DBP, respectively) were measured twice in a sitting position on the right arm, after 15 minutes rest and the mean of the two measurements was considered as the subject's blood pressure.

Physical activity level was assessed in the first phase of the TLGS using Lipid Research Clinic questionnaire (22). Cigarette smoking status was categorized as current smoker, nonsmoker, or ex-smoker. Additional covariate

information including age, educational levels, occupational status, medical history, and current use of medications was obtained using an oral questionnaire.

### 3.2. Laboratory Measurements

After 12 to 14 hours of overnight fasting, blood samples were drawn from all study participants into vacutainer tubes in a sitting position. All blood analyses were done at the TLGS research laboratory on the day of blood collection, and analyses were conducted using a Selectra 2 autoanalyzer (Vita Scientific, Spankeren, the Netherlands). Serum triglyceride (TG) concentrations were measured using TG kits (Pars Azmoon Inc., Tehran, Iran) by the enzymatic colorimetric test with glycerol phosphate oxidase. HDL cholesterol was measured after precipitation of the apolipoprotein B-containing lipoproteins with phosphotungstic acid. Fasting blood sugar (FBS) was assayed using an enzymatic colorimetric method with glucose oxidase technique. Inter-assay and intra-assay coefficients of variations were both 2.2% for FBS, 2%, 0.5% for HDL and total cholesterol, 1.6% and 0.6% for TG, respectively.

### 3.3. Definitions of Marital Situations

Marital status was categorized into marital transition and consistent marital status. Marital transition was categorized as transition "to" and "out" of marriage; "transition to marriage status" included change in marital status from divorced, widowed, or single to married whereas "transition out of marriage" included change in marital status from married to divorced or widowed during the follow-up. Subjects who did not experience marital transitions during follow-up were categorized as having "consistent marital status" including consistent single, married, and divorced/widowed. The category of marital transition and marital status resulted in ten possible categories (Table 1). Because of the limited numbers of participants in the widowed and divorced, these subjects were considered as a single category. Therefore, the main analyses were performed for five categories including consistent single, consistent married, consistent divorced/widowed, transition to married, and transition out of marriage.

### 3.4. Definition of Metabolic Syndrome Risk z Score

A z score was computed as the number of SD units from the sample mean, i.e.  $z = [(value - mean)/SD]$ , for each of the component of MetS. A continuous MetS risk z score was derived by summing the z score of WC, SBP, DBP, FBS, HDL cholesterol, and TG concentrations; this z score was then divided by six to product the MetS risk score with units of SD (23).

### 3.5. Statistical Analysis

The SPSS (version 15.0; SPSS Inc, Chicago, IL) was used for all statistical analyses. One-way ANOVA and Chi square

**Table 1.** Marital Status Changes Between Baseline and Follow-up in Study Participants: Tehran Lipid and Glucose Study, 1999-2011<sup>a</sup>

	Males	Unemployed Females	Employed Females
Single-Single	191 (9.8)	43 (1.9)	171 (23.3)
Married-Married	1464 (74.9)	1775 (79.3)	215 (29.3)
Divorced-Divorced	3 (0.2)	11 (0.5)	12 (1.6)
Widowed-Widowed	3 (0.2)	111 (5.0)	69 (9.5)
Single-Married	245 (12.3)	57 (2.5)	218 (29.7)
Single-Divorced/Widowed	1 (0.1)	2 (0.1)	6 (0.8)
Married-Divorced	19 (1.0)	15 (0.7)	12 (1.6)
Married-Widowed	23 (1.2)	214 (9.5)	17 (2.3)
Divorced-Remarried	3 (0.2)	3 (0.1)	8 (1.2)
Widowed-Remarried	2 (0.1)	8 (0.4)	5 (0.7)

<sup>a</sup> Data are presented as No. (%).

were used respectively for quantitative and qualitative variables to detect differences in general characteristics. Changes in components of MetS and MetS risk z score were calculated as follows:

(component of MetS and MetS risk z score at follow-up - the component of MetS and MetS risk z score at baseline) / components of MetS and MetS risk z score at baseline

Multivariable adjusted linear regression model was used to estimate the association of consistent marital status and marital transition with changes in component of MetS and MetS risk z score. In consistent marital status, components of MetS and the MetS risk z score of single or widowed/divorced participants were compared to those of married ones. For transition to married, the reference group consisted of participants who were consistently single during follow-up. For transition out of marriage, the reference group consisted of subjects who were consistently married during follow-up. In multivariable models, we controlled for age (continuous), smoking status (smoker, nonsmoker, and ex-smoker), and physical activity (light, moderate, and heavy), and education levels (primary and secondary, high school, and university), and duration of change in marital status.

There was a significant effect of interactions by sex on the association of marital status and MetS z score. In addition, among females, there was a significant effect of interactions by occupational status on the association of marital status and marital transition with MetS z score. Therefore, the analysis was done separately according to sex and among females by occupations.

#### 4. Results

The mean age of participants at baseline was 40.5 ± 15.2 years. Baseline characteristics of the participants according to marital status are shown in Tables 2 and 3. In both sexes, widowed/divorced subjects were older and

less educated in comparison with married and single subjects. Except for age, there was no significant difference in characteristics between subjects in transition to and out of marriage.

Table 4 shows multivariable mean changes of the components of MetS and MetS risk z score among consistent marital status. In comparison to changes in participants who remained consistently married, DBP of single males and females (both employed and unemployed) was decreases by -5.4 (95% CI, -8.1 to -2.7), -4.3 (95% CI, -8.6 to -0.1), and -4.3 mm Hg (95% CI, -8.1 to -0.6), respectively. Moreover, in comparison with married males, single males had a significant decrease in FBS and a significant increase in BMI, WC, and TG concentrations after controlling for confounding factors. In comparison to married participants, no significant changes in MetS risk z score were found in consistently single participants. Among widowed/divorced subjects, no significant changes were observed in components of MetS and MetS risk z score in comparison with married subjects.

Table 5 shows multivariable mean changes in components of MetS and the MetS risk z score among participants with marital transition. In comparison to those who remained consistently married and in the transition to married status, males and females (both employed and unemployed) had BMI increases by 2.9 (95% CI, 0.45-5.3), 10.3 (95% CI, 5.6-14.9), and 7.6 kg/m<sup>2</sup> (95% CI, 4.9-10.4), respectively. In comparison to single employed females, employed females with transition to married status had significant decreases in HDL cholesterol concentrations and a significant increase in WC, TG concentrations, and MetS risk z score after controlling for confounding factors. In comparison to married subjects and after controlling for confounding factors, no significant changes were found in MetS risk z score and its components among all participants in the transition out of married status, except for employed females who had a significant decrease in SBP.

**Table 2.** Baseline Characteristics of Participants According to Marital Status and Marital Transition Among Males; Tehran Lipid and Glucose Study, 1999-2011<sup>a,b,c</sup>

	Consistent Marital Status			Marital Transition	
	Single	Married	Widowed/Divorced	Transition to Marriage	Transition Out of Marriage
<b>Male, No.</b>	191	1463	5	250	43
<b>Age, y</b>	20.5 ± 6.0	47.4 ± 12.7	63.0 ± 12.6	23.2 ± 7.0	53.95 ± 18.8
<b>Physical Activity, %</b>					
Light	28.1	19.2	42.9	30.8	20.9
Moderate	26.1	14.9	14.3	24.3	23.3
Heavy	43.3	63.9	42.9	44.9	55.8
<b>Level of Education, %</b>					
Primary and Secondary	54.0	53.0	86.1	51.3	76.1
High School	35.7	41.8	11.7	40.4	20.6
University	10.3	5.1	2.2	8.3	3.3
<b>Occupational status, %</b>					
Employed	10.9	20.1	40.2	77.3	13.2
Unemployed	89.1	79.9	59.8	22.7	86.8
<b>Current Smoker, %</b>	12.7	22.8	0.0	14.3	18.6
<b>BMI at Baseline, kg/m<sup>2</sup></b>	22.4 ± 4.8	26.4 ± 3.7	25.1 ± 3.5	23.5 ± 4.4	24.6 ± 3.8
<b>WC, cm</b>	76.6 ± 12.4	90.7 ± 10.4	87.2 ± 13.6	79.6 ± 11.9	87.0 ± 10.7
<b>SBP, mm Hg</b>	112.9 ± 12.8	121.7 ± 17.9	119 ± 18.9	115.3 ± 12.3	123 ± 19.2
<b>DBP, mm Hg</b>	74.8 ± 9.7	78.7 ± 10.5	76.4 ± 10.4	74.3 ± 10.0	77.2 ± 10.9
<b>FBS, mg/dL</b>	88.2 ± 8.3	99.1 ± 29.5	105.0 ± 31.7	87.3 ± 11.3	97.3 ± 19.4
<b>TG, mg/dL</b>	130 ± 81.3	193 ± 121	174 ± 86.2	138 ± 82.1	185 ± 116
<b>HDL cholesterol, mg/dL</b>	40.4 ± 9.3	38.0 ± 8.8	33.8 ± 4.0	39.2 ± 8.7	41.3 ± 10.8
<b>MetS risk z score</b>	0.03 ± 0.5	0.024 ± 0.52	-0.14 ± 0.5	0.04 ± 0.5	0.03 ± 0.5

<sup>a</sup> Abbreviations: BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; TG, triglyceride; MetS, metabolic syndrome; and NA, not applicable.

<sup>b</sup> Values are presented as mean ± SD or percentage.

<sup>c</sup> A z score was computed as the number of SD units from the sample mean, ie,  $z = [(value - mean)/SD]$ , for each of WC, SBP, DBP, FBS, TG concentrations, and HDL cholesterol. The z scores were assumed and then divided by six to produce the MetS risk z score.

**Table 3.** Baseline Characteristics of Participants According to Marital Status and Marital Transition Among Females; Tehran Lipid and Glucose Study, 1999-2011<sup>a,b,c</sup>

	Consistent Marital Status			Marital Transition	
	Single	Married	Widowed/Divorced	Transition to Marriage	Transition Out of Marriage
<b>Female, No.</b>	214	1991	204	299	266
<b>Age, y</b>	23.5 ± 9.6	40.5 ± 11.5	57.4 ± 10.8	21.4 ± 9.5	51.8 ± 12.8
<b>Physical Activity, %</b>					
Light	25.6	25.8	28.4	30.4	26.7
Moderate	22.0	11.5	16.3	22.2	16.6
Heavy	50.7	61.4	54.3	47.4	56.8
<b>Level of Education, %</b>					
Primary and Secondary	10.9	20.1	40.2	77.3	13.2
High School	89.1	79.9	59.8	22.7	86.8
University					
<b>Occupational status, %</b>					
Employed	35.7	41.8	11.7	40.4	20.6
Unemployed	10.3	5.1	2.2	8.3	3.3
<b>Current Smoker, %</b>	2.9	2.6	0.9	0.4	1.5
<b>BMI at Baseline, kg/m<sup>2</sup></b>	22.7 ± 3.9	27.2 ± 4.4	28.6 ± 4.1	22.5 ± 4.3	28.4 ± 4.7
<b>WC, cm</b>	74.0 ± 8.8	88.3 ± 11.7	92.9 ± 10.7	73.6 ± 10.1	91.9 ± 12.1
<b>SBP, mm Hg</b>	108.5 ± 11.8	117 ± 18.0	129 ± 20.4	107 ± 11.3	127 ± 22.8
<b>DBP, mm Hg</b>	74.1 ± 8.6	77.7 ± 10.2	80.4 ± 9.5	72.6 ± 8.8	80.8 ± 11.1
<b>FBS, mg/dL</b>	86.6 ± 8.4	95.5 ± 28.4	115.4 ± 52.2	86.4 ± 9.2	102 ± 38.2
<b>TG, mg/dL</b>	112.7 ± 60.4	162 ± 99.2	209 ± 123.7	105 ± 66.8	185 ± 129
<b>HDL Cholesterol, mg/dL</b>	45.7 ± 11.3	44.5 ± 11.0	44.9 ± 10.5	45.3 ± 11.2	45.3 ± 10.9
<b>MetS Risk z Score</b>	0.037 ± 0.4	0.038 ± 0.5	0.03 ± 0.5	0.05 ± 0.5	0.04 ± 0.5

<sup>a</sup> Abbreviations: BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; TG, triglyceride; MetS, metabolic syndrome; and NA, not applicable.

<sup>b</sup> Values are presented as mean ± SD or percentage.

<sup>c</sup> A z score was computed as the number of SD units from the sample mean, ie,  $z = [(value - mean)/SD]$ , for each of WC, SBP, DBP, FBS, TG concentrations, and HDL cholesterol. The z scores were summed and then divided by six to produce the MetS risk z score.

**Table 4.** Multivariate Mean Percent Changes in Metabolic Syndrome Risk z Score and its Components During Follow-up Among Single and Widowed/Divorced Subjects in Comparison With Consistently Married Subjects; Tehran Lipid and Glucose Study, 1999-2011<sup>a,b</sup>

	Single						Widow/Divorce					
	Males (Rf. Married Males)		Unemployed Females (Rf. Married Unemployed Females)		Employed Females (Rf. Married Employed Females)		Males (Rf. Married Males)		Unemployed Females (Rf. Married Unemployed Females)		Employed Females (Rf. Married Employed Females)	
BMI, kg/m <sup>2</sup>	MP	CI	MP	CI	MP	CI	MP	CI	MP	CI	MP	CI
Model 1	13.6 <sup>c</sup>	12.1 to 15.0	-3.9	-22.5 to 14.6	2.8 <sup>c</sup>	0.4 to 5.3	NA	NA	-4.2	-15.3 to 6.7	-3.1 <sup>c</sup>	-5.8 to -0.4
Model 2	6.7 <sup>c</sup>	5.0 to 8.4	-4.1	-22.8 to 14.6	0.5	-2.6 to 3.7	NA	NA	-3.9	-15.6 to 7.7	0.6	-2.7 to 4.0
<b>WC, cm</b>												
Model 1	13.6 <sup>c</sup>	12.3 to 14.9	-2.7	-6.0 to 0.6	2.0	-0.4 to 4.5	NA	NA	-1.2	-3.2 to 0.7	-3.3 <sup>c</sup>	-6.2 to -0.4
Model 2	7.1 <sup>c</sup>	5.6 to 8.6	-4.0 <sup>c</sup>	-7.5 to -0.5	2.1	-1.1 to 5.4	NA	NA	1.5	-1.0 to 4.1	-0.3	-4.6 to 3.0
<b>SBP, mm Hg</b>												
Model 1	-1.9	-3.8 to 0.02	-3.4	-7.3 to 0.4	-4.6 <sup>c</sup>	-7.2 to -1.9	NA	NA	0.3	-2.0 to 2.7	-0.2	-3.6 to 3.2
Model 2	-2.1	-4.5 to 0.3	-3.4	-7.5 to 0.7	-1.7	-5.3 to 1.8	NA	NA	0.4	-2.6 to 3.4	2.3	-2.6 to 7.2
<b>DBP, mm Hg</b>												
Model 1	1.4	-0.7 to 3.6	-2.1	-6.2 to 2.0	-4.4 <sup>c</sup>	-7.2 to -1.6	NA	NA	-2.8 <sup>c</sup>	-5.3 to -0.4	-5.5 <sup>c</sup>	-8.8 to -2.1
Model 2	-5.4 <sup>c</sup>	-8.1 to -2.7	-4.3 <sup>c</sup>	-8.6 to -0.1	-4.3 <sup>c</sup>	-8.1 to -0.6	NA	NA	0.2	-2.9 to 3.3	2.8	-1.8 to 7.4
<b>FBS, mg/dL</b>												
Model 1	-6.1 <sup>c</sup>	-9.5 to -2.7	-6.5	-14.4 to 1.4	-3.0 <sup>c</sup>	-5.9 to -0.3	NA	NA	-2.4	-7.4 to 2.4	0.6	-3.8 to 5.1
Model 2	-8.3 <sup>c</sup>	-12.4 to -4.1	-5.0	-13.1 to 3.1	0.8	-2.9 to 4.6	NA	NA	-3.6	-9.8 to 2.6	-0.1	-6.1 to 6.0
<b>TG, mg/dL</b>												
Model 1	4.8	-4.6 to 14.3	-8.5	-23.6 to 6.5	-16.4 <sup>c</sup>	-27.1 to -5.7	NA	NA	-9.1	-18.1 to 0.1	-23.6 <sup>c</sup>	-36.8 to -10.5
Model 2	25.5 <sup>c</sup>	17.6 to 33.3	-13.9	-29.8 to 1.9	-8.4	-22.7 to 5.8	NA	NA	-2.3	-14.2 to 9.4	-18.5	-38.3 to 1.3
<b>HDL Cholesterol, mg/dL</b>												
Model 1	-2.8	-6.3 to 0.7	-0.4	-7.7 to 7.0	6.7	1.7 to 11.8	NA	NA	-3.4	-7.9 to 0.9	1.9	-4.3 to 8.3
Model 2	-2.1	-6.4 to 2.2	-1.3	-9.1 to 6.3	2.4	-4.3 to 9.2	NA	NA	-2.5	-8.2 to 3.2	1.3	-8.1 to 10.8
<b>MetS Risk z Score</b>												
Model 1	0.16	-6.7 to 19.7	-16.0	-12.6 to 9.4	-29.8	-40.8 to 17.8	NA	NA	6.2	-10.6 to 13.5	16.6	-7.7 to 21.0
Model 2	0.14	-7.4 to 17.2	-17.8	-11.6 to 10.8	-23.9	-42.8 to 19.5	NA	NA	9.4	-10.0 to 17.8	17.1	-10.0 to 22.4

<sup>a</sup> Abbreviations: Rf, reference group for comparison; NA, non-applicable; MP, mean percent; CI, confidence interval; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood glucose; TG, triglyceride; and MetS, metabolic syndrome.

<sup>b</sup> Model 1 was adjusted for age (continuous), smoking status (smoker, nonsmoker, and ex-smoker), physical activity (light, moderate, and heavy), education levels (primary and secondary, high school, and university), duration of change in marital status, and baseline variables. Model 2 was further adjusted for BMI.

<sup>c</sup> P < 0.05.

**Table 5.** Multivariate Mean Percent Change in Metabolic Syndrome Risk z Score and its Components During Follow-up; Tehran Lipid and Glucose Study, 1999-2011<sup>a,b</sup>

	Transition to Married Status						Transition Out of Married Status					
	Males (Rf. Consistently Single Males)		Unemployed Females (Rf. Consistently Single Unemployed Females)		Employed Females (Rf. Consistently Single Employed Females)		Males (Rf. Consistently Married Males)		Unemployed females (Rf. Consistently Married Unemployed Females)		Employed Females (Rf. Consistently Married Employed Females)	
	MP	CI	MP	CI	MP	CI	MP	CI	MP	CI	MP	CI
<b>BMI, kg/m<sup>2</sup></b>												
Model 1	-0.01	-2.5 to 2.5	11.4 <sup>c</sup>	6.6 to 16.3	7.8 <sup>c</sup>	5.1 to 10.5	1.32	-1.3 to 4.0	-3.2	-11.3 to 4.7	0.3	-3.8 to 4.4
Model 2	2.9 <sup>c</sup>	0.45 to 5.3	10.3 <sup>c</sup>	5.6 to 14.9	7.6 <sup>c</sup>	4.9 to 10.4	2.8 <sup>c</sup>	0.3 to 5.3	-2.9	-11.4 to 5.6	0.6	-3.3 to -0.12
<b>WC, cm</b>												
Model 1	-0.7	-3.2 to 1.7	8.4 <sup>c</sup>	3.2 to 13.6	5.5 <sup>c</sup>	3.0 to 8.2	1.5	-0.9 to 4.0	-1.2	-2.7 to 0.3	2.7	-1.5 to 7.0
Model 2	2.1	-4.0 to 4.5	8.2 <sup>c</sup>	2.6 to 13.8	5.4 <sup>c</sup>	2.8 to 8.1	2.7 <sup>c</sup>	0.2 to 5.3	1.4	-0.4 to 3.2	3.1	-1.4 to 7.7
<b>SBP, mm Hg</b>												
Model 1	-0.8	-2.7 to 1.2	0.9	-3.3 to 5.2	2.0	-0.4 to 4.4	1.2	-2.7 to 5.2	-0.1	-1.9 to 1.7	-6.3 <sup>c</sup>	-11.1 to -1.4
Model 2	-0.2	-2.3 to 1.8	0.5	-3.6 to 4.6	1.8	-0.6 to 4.3	1.1	-3.1 to 5.4	-0.6	-2.7 to 1.5	-5.6 <sup>c</sup>	-10.7 to -0.5
<b>DBP, mm Hg</b>												
Model 1	2.7	-0.3 to 5.7	2.8	-2.1 to 7.9	1.3	-1.5 to 4.3	3.6	-0.6 to 8.0	-2.7 <sup>c</sup>	-4.6 to -0.8	-5.5 <sup>c</sup>	-10.2 to -0.8
Model 2	2.4	-0.7 to 5.6	2.2	-3.0 to 7.5	1.5	-1.4 to 4.4	3.5	-0.9 to 8.1	-1.3	-3.5 to 0.9	-4.7	-9.6 to 0.1
<b>FBS, mg/dL</b>												
Model 1	6.0 <sup>c</sup>	2.8 to 9.2	1.8	-2.9 to 6.7	-0.7	-3.2 to 1.7	-0.4	-7.5 to 6.6	1.1	-2.4 to 4.7	-1.8	-6.5 to 2.9
Model 2	3.8 <sup>c</sup>	0.5 to 7.4	2.5	-2.1 to 7.3	-0.3	-2.7 to 2.2	-0.3	-8.0 to 7.4	-1.7	-5.9 to 2.4	-2.0	-7.1 to 3.1
<b>TG Concentrations, mg/dL</b>												
Model 1	11.1	-1.8 to 23.9	7.2	-8.8 to 23.4	17.2 <sup>c</sup>	7.2 to 27.3	-1.5	-16.7 to 13.7	-11.9 <sup>c</sup>	-18.6 to -5.2	-18.4	-38.1 to 1.2
Model 2	11.1	-2.5 to 24.8	6.6	-10.8 to 24.1	17.8 <sup>c</sup>	7.7 to 27.9	3.6	-12.3 to 19.7	-5.7	-13.8 to 2.4	-17.6	-38.7 to 3.5
<b>HDL Cholesterol, mg/dL</b>												
Model 1	-5.2 <sup>c</sup>	-9.3 to -1.1	-1.9	-11.3 to 7.4	-5.9 <sup>c</sup>	-11.1 to -0.7	0.8	-6.4 to 8.1	-0.1	-3.4 to 3.2	3.9	-5.3 to 13.2
Model 2	-4.9	-9.3 to 0.5	-2.1	-12.2 to 7.9	-6.0 <sup>c</sup>	-11.2 to -0.7	0.1	-7.8 to 7.9	0.6	-3.4 to 4.6	4.5	-5.3 to 14.4
<b>MetS Risk z Score</b>												
Model 1	-11.9	-41.9 to 18.0	-23.1	-27.3 to 18.7	23.2 <sup>c</sup>	18.7 to 26.6	19.6	-34.7 to 26.9	39.8	-26.9 to 106	57.4	-12.0 to 64.9
Model 2	-16.1	-48.5 to 16.3	-21.5	-24.2 to 15.9	19.1 <sup>c</sup>	12.5 to 25.5	19.8	-30.7 to 25.3	26.1	-38.7 to 91.1	55.2	-12.7 to 63.7

<sup>a</sup> Abbreviations: Rf, reference group for comparison; NA, non-applicable; MP, mean percent; CI, confidence interval; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood glucose; TG, triglyceride; and MetS, metabolic syndrome.

<sup>b</sup> Model 1 was adjusted for age (continuous), smoking status (smoker, nonsmoker, and ex-smoker), physical activity (light, moderate, and heavy), education levels (primary and secondary, high school, and university), duration of change in marital status, and baseline variables. Model 2 was further adjusted for BMI.

<sup>c</sup>  $P < 0.05$ .

## 5. Discussion

Our findings showed that marital status might affect the MetS differently with regard to sex and occupations. In comparison to married males, consistently single males showed an incremental trend in BMI, WC, and TG concentrations without any changes in MetS risk z score. In the transition to married status, there was also an incremental trend in BMI and WC in males and employed

females; however, only employed females had an increase in MetS risk z score.

Although several cross-sectional and longitudinal studies have shown that married subjects are more often overweight and obese than unmarried subjects (24-28), others have reported that marriage is associated with many health benefits including decreased cardio-

vascular morbidity and mortality (29). In their report, Ortega et al. observed that sex affects the relation between obesity, cardiometabolic risk (CMR) factors, and marital status (30). In the current study, consistently single males had increased BMI and WC in comparison with married males. Although levels of components of MetS including DBP and FBS had decreased, no significant changes were observed in MetS risk z score in single males. Among consistently single females, both employed and unemployed, no significant changes in components of MetS and MetS risk z score were observed in comparison to married females. In contrast, although the BMI increased in both sexes in the transition to married status, only employed females had an increase in MetS risk z score over time. Our results were inconsistent with those of a prospective study that showed fitness levels had not changed among married females, but had declined in married males (30). In the Health and Lifestyle Survey, although single status was associated with a favorable profile including good health, high education level, and nonsmoker status, all-cause mortality was higher in comparison to married subjects (29). It is not still clear how marital status is associated with obesity and health status. However, healthy lifestyle such as healthy eating behavior might be sufficiently powerful to overshadow any detrimental effects of weight gains (31-33). In the ATTICA study, after controlling for eating patterns, no significant association was found between marital status and BMI as well as CVD risk factors, which implies that eating patterns may mediate the association between CVD risk factors and marital status (34). Physiologic pathways, based on the stress/social support model, may explain the effect of marital status on health (35).

Although previous studies had mostly focused on the association of marital status and marital transition with BMI and WC, the current study focused on the association of marital status and marital transition with other components of MetS including lipid profiles, FBS, SBP, DBP, and MetS risk z score over time. Except a decrease in BP, we found no significant changes in components of MetS in employed or unemployed consistently single females over time; however, among females in the transition to married status, an increase in BMI and WC was observed. Consistent with a previous study (36), occupational status affected the association between marital transition and MetS among females in this study; employed females had significant increases in their MetS risk z score during follow-up, which was in line with previous studies that showed transition to marriage has a negative effect on health status (30, 37). Nonetheless, our findings were not consistent with those of some conducted studies in different countries. Reynolds et al. compared data from two similar epidemiologic surveys in elderly American and Japanese populations and showed that among Americans, marital status was associated with an increase in body weight, while there was

not such an association among a Japanese population (38). Among British females, being single was significantly associated with higher all-cause mortality (29).

Marital transition may be associated with health changes. Marital termination, in terms of divorce or widowhood, has been associated with increase in CVD risk factors (34), unfavorable lipid profiles (39), higher BMI and WC (27), higher inflammation markers (39), and higher incidence of MetS (40) and CVD events (39). In the current study, we investigated the effect of consistently widowed/divorced status and transition out of marriage on CVD risk factors over time and found no differences in components of MetS and the MetS risk z score among consistently divorced/widowed males and employed or unemployed females in comparison to married participants. However, in comparison with consistently married males, transition out of marriage was associated with increased BMI and WC in males. Therefore, components of MetS differed between participants with consistently widowed/divorced status and those with transition out of marriage status. This difference might explain the inconsistent results of the cross-sectional studies among divorced and widowed subjects because most studies had not considered the duration of changes in marital status (28, 41). In the current study, the transition out of married status was associated with increased BMI and WC; however, some components of MetS decreased among females. Contrary to our results, in a three-year follow-up study, transition out of marriage was associated with increase in fitness levels in males, whereas a tendency toward decreased fitness was observed among females (30). It was also shown that over a ten-year follow-up, males who had divorced had no statistically significant weight change in comparison to those who had remained consistently married (42). Another study reported that divorced males mirrored married ones in obesity status, while divorced females had lower odds of being overweight or obese than the married ones had (43). In contrast, while widowed males had almost equivalent risks for obesity and abdominal obesity than married males had (28), many more widowed females had the tendency to gain weight than married ones had (28, 44).

Our study had some limitations. First, nutrition data and in particular, energy intake was not gathered for all participants. Second, we could not investigate the relationship between components of MetS and child-bearing among females, since data on parity were not available. In addition, data on outcomes of CVD was not available to draw a comparison among various marital statuses.

In conclusion, marital transition including "to or out of married status" is associated with an increased prevalence of CVD, especially among employed females. While consistent marital status is not associated with changes in CVD risks in females, further studies should investigate the association between marital status and

outcomes of CVD and other non-communicable diseases.

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## Authors' Contributions

Study concept and design: Fereidoun Azizi and Somayeh Hosseinpour Niazi; analysis and interpretation of data: Somayeh Hosseinpour Niazi and Farhad Hosseinpour Niazi; drafting of the manuscript: Somayeh Hosseinpour Niazi, Parvin Mirmiran, and Arefeh Fallah; critical revision of the manuscript for important intellectual content: Somayeh Hosseinpour Niazi, Parvin Mirmiran, Farhad Hosseinpour Niazi, Arefeh Fallah, and Fereidoun Azizi; statistical analysis: Somayeh Hosseinpour Niazi and Farhad Hosseinpour Niazi; and study supervision: Fereidoun Azizi.

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