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Self-reported health and behavioral factors are associated with metabolic syndrome in Americans aged 40 and over

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ABSTRACT

To determine whether behavioral factors differ among metabolic conditions and self-reported health, and to determine whether self-reported health is a valid predictor of metabolic syndrome (MetS). A total of 2997 individuals (≥40 years old) were selected from four biennial U.S. National Health and Nutrition Examination Surveys (2007–2014). A set of weighted logistic regression models were used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs)Individuals with light physical activity are more likely to have MetS and report poor health than those with vigorous physical activity with OR = 3.22 (95% CI: 2.23, 4.66) and 4.52 (95% CI: 2.78, 7.33), respectively. Individuals eating poor diet have greater odds of developing MetS and reporting poor health with OR = 1.32 (95% CI: 1.05, 1.66) and 3.13 (95% CI: 2.46, 3.98). The aforementioned relationships remained significant after adjustment for demographic and socio-economic status. A potential intervention strategy will be needed to encourage individuals to aggressively improve their lifestyle to reduce MetS and improve quality of life. Despite the significant association between self-reported health with MetS, a low sensitivity indicated that better screening tools for MetS, diabetes and cardiovascular disease are essential.

1. Introduction

Metabolic syndrome (MetS) is an accumulation of metabolic abnormalities characterized by central obesity, hyperglycemia, dyslipidemia and hypertension which confers an increased risk of developing type II diabetes mellitus and cardiovascular diseases (IDF, 2006). Individuals with MetS are also at increased risk of morbidity and mortality from stroke, and myocardial infarction compared to those without the syndrome (Kaur, 2014). In the United States, the number of individuals diagnosed with MetS rose from 47 million in 2000 to 76 million in 2009 with only a slight decrease in 2010 (Saylor and Friedmann, 2015). From 2011 to 2012, the overall prevalence of MetS stood at 34.7% of the US population with the greatest burden in those 60 years and older (Aguilar et al., 2015).

The likelihood of developing MetS has been attributed to behavioral factors such as smoking, poor diet, lack of physical activity and alcohol consumption (Owen and Reisin, 2015; Lee et al., 2005). These behavioral factors are also associated with self-reported health (Gallagher et al., 2016). Hence, understanding the relationship between MetS and self-reported health status can potentially provide information for identifying key risk groups. Self- reported health status is an important indicator of morbidity and has been found to be a stronger predictor of quality of life outcomes than other measures of morbidity (Bayliss et al., 2009). Collecting self-reports is more cost-effective and it can potentially be more complete than a medical record review (Lash et al., 2007).

Unlike previous studies which focus on single risk factors and small samples (Alkerwi et al., 2009; Sun et al., 2012), this study simultaneously investigates the relationship between various poor behavioral factors on developing MetS using a representative sample of the US population. Additionally, this study aims to identify specific metabolic risk factors that may significantly contribute to poor self-reported health status and the relationship of MetS and self-reported health.

2. Material and methods

2.1. Study sample

A total of 2997 individuals were selected from four biennial National Health and Nutrition Examination Surveys (2007–2014); this cross-sectional sample was representative of the US civilian noninstitutionalized population obtained through a complex multistage probability sample design.

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2.2. Outcome variables

2.2.1. Metabolic syndrome and self-reported health status

MetS consists of a cluster of five risk factors: (1) waist circumference ≥ 35 in. for women and ≥40 in. for men; (2) Fasting blood glucose ≥100 mg/dL; (3) Serum triglycerides ≥150 mg/dL; (4) Blood pressure ≥ 135/85 mm Hg; and (5) HDL ("good") cholesterol <40 mg/dL for men or <50 mg/dL for women. MetS was defined as an individual has three or more risk factors (Saylor and Friedmann, 2015).

Participants' self-reported health statuses were calibrated on a Likert scale as being excellent, very good, good, fair and poor. For the purposes of the analysis, self-reported health statuses were collapsed into 2 groups, and referred to as good and poor health.

2.3. Behavioral factors

Behavioral factors were represented by four variables: smoking status, alcohol use, physical activity and diet. These factors are widely used to as predictors of other chronic disease including diabetes and cardiovascular disease (Sun et al., 2012). However, few articles used these four factors simultaneously. The smoking frequency of current smokers was categorized as every day and some days. Alcohol consumption indicated whether a participant drank >12 alcohol beverages last year. One drink was indicated by a 12 oz. beer, a 5 oz. glass of wine or 1.5 oz. of liquor. Metabolic equivalent of task (MET) was used to measure the intensity level of physical activity and to indicate the rate of energy consumption for a specific activity. Physical activity was categorized into three intensity levels - light, moderate and vigorous according to MET score (Ainsworth et al., 2000). The participants self-evaluated the quality of their diet using a five level Likert scale including excellent, very good, good, fair and poor which was reclassified as good (excellent/very good/good) and poor (fair/poor).

2.4. Demographic and socio-economic status (SES) variables

These included age, gender, race, family income, and education. With respect to family income, categories were established based on the ratio of family income to the federal poverty threshold (FTP), adjusted for family size and composition. There were three levels described as poor (PIR (poverty income ratio) < 1), near poor (1 ≤ PIR < 3) and non-poor (PIR ≥ 3). Education reflected the highest grade completed by the participant, and described as <12 years (middle and elementary school), 12 years (high school) and >12 years (college and graduate School).

2.5. Statistical methods

We used NHANES 2007–2014 to calculate the prevalence of MetS and poor self-reported health status in the overall population stratified by demographics, SES status and health behaviors factors. A series of weighted logistic regressions were used to determine the relationship between behavioral factors, the presence of MetS and self-reported health. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated. Rao-Scott chi-square test was used to determine bivariate association between metabolic risk factors and self-reported health. All analyses were performed on SAS 9.4 and a $p < 0.05$ was used to indicate statistical significance.

3. Results

The analysis was conducted for 2997 adults aged 40 years and over who completed the mobile examination center (MEC) examination, laboratory and behaviors data in NHANES 2007–2014. Table 1 presents the prevalence of MetS and self-reported poor health within each group. The prevalence of MetS was 36.59% and 45.37% among participants aged 40–59 years and 60 years and older, respectively. More men (41.07%) had MetS than women (39.38%). Mexican Americans had a higher prevalence of both MetS (47.22%) and poor self-reported health (42.33%) compared to other races. MetS was more common among individuals in the 'near poor' wealth category (43.96%) while poor self-reported health was more prevalent among those in the lowest economic status (SES) (44.20%). Compared to those who drank more alcohol (>12 drinks/yr), participants who consumed less alcohol (<12 drinks/yr) had a higher prevalence of MetS (51.34%) and poor self-reported health (33.86%). Nonsmokers had a lower percentage of poor self-reported health (20.10%) than smokers who smoked every day (33.19%).

Table 1
Weighted prevalence (95% CI) of self-reported health condition and metabolic syndrome within each groups of explanatory variables from 2007 to 2014.

Explanatory variables (n)	Poor self-reported health % (95% CI)	Metabolic syndrome % (95% CI)
Overall	40.3 (38.0, 42.7)	24.9 (22.9, 26.8)
Age (years)		
40–59 (1446)	24.5 (21.7, 27.2)	36.6 (33.3, 39.8
60 and over (1551)	25.5 (22.8, 28.1)	45.4 (42.1, 48.7)
Gender		
Male (1778)	25.45 (22.8, 28.2)	41.1 (37.9, 44.3)
Female (1219)	24.1 (21.3, 26.9)	39.4 (35.9, 42.9)
Race		
Mexican American (362)	42.3 (36.6, 48.1)	47.2 (41.3, 53.1)
Other Hispanic (283)	37.2 (30.8, 43.6)	39.2 (32.8, 45.6)
Non-Hispanic White (1618)	21.8 (19.5, 24.2)	40.2 (37.3, 40.1)
Non-Hispanic Black (570)	35.3 (31.0, 39.7)	36.4 (32.1, 40.7)
Other race (164)	26.2 (17.6, 34.9)	43.2 (32.3, 54.1)
Family PIR		
Poor (807)	44.2 (39.6, 48.8)	41.0 (36.5, 45.6)
Near poor (1220)	28.0 (24.8, 31.2)	44.0 (40.3,47.7)
Non-poor (970)	14.2 (11.5, 17.0)	37.2 (33.4, 41.1)
Education		
<12 (947)	43.3 (39.1, 47.5)	44.0 (39.8, 48.4)
12 (730)	23.3 (19.4, 27.1)	43.3 (38.5, 48.0)
>12 (1320)	17.7 (15.1, 20.3)	37.3 (33.9, 40.7)
Current smoking		
Not at all (966)	20.1 (17.9, 22.9)	41.2 (38.2, 44.1)
Some days (159)	33.6 (22.1, 45.1)	43.3 (31.8, 54.7)
Every day (1872)	33.2 (29.3, 37.1)	38.2 (34.1, 42.4)
Alcohol consumption		
≥12 drinks (2527)	23.6 (21.5, 25.7)	38.7 (36.2, 41.3)
<12 drinks (470)	33.9 (28.5, 39.2)	51.3 (45.5, 57.2)
Physical activity		
Vigorous (297)	8.0 (4.5, 11.4)	20.7 (15.1, 26.4)
Moderate (839)	15.6 (12.6, 18.5)	38.0 (33.7, 42.4)
Light (1861)	33.8 (30.9, 36.6)	46.0 (42.9, 49.1)
Diet		
Good (2146)	17.9 (15.8, 19.9)	38.1 (35.4, 40.8)
Poor (851)	45.3 (40.7, 49.8)	46.7 (42.1, 51.4)

Table 2 shows the association between four behavioral factors (smoking, alcohol consumption, physical activity and diet) and poor self-reported health as well as MetS with a set of weighted logistics regression models. Physical inactivity and poor diet were significantly associated with poor self-reported health. Light smokers who smoked some days in the past month are more likely to report poor health than non-smokers with an odds ratio of 1.36 (95% CI: 1.03, 1.72). Participants that engaged in light physical activity were more likely to report poor health than those engaged in vigorous physical activity, with an odds ratio of 3.33 (95% CI: 1.99, 5.57). Eating a poor diet was associated with a higher likelihood of reporting a poor health (odds ratio: 3.19, 95% CI: 2.47, 4.12) when compared to good diet. These significant observed relationships were remained after adjustment for demographics and SES.

As showed in Table 2, consumers of <12 alcoholic drinks/yr were more likely to have MetS than those who consumed >12 drinks/yr with an odds ratio of 1.51 (95% CI: 1.15, 1.96). Individuals that engaged in light and moderate physical activity had a higher likelihood of having

Table 2
Association between lifestyle factors and health condition and metabolic syndrome.

	Model 1 OR (95% OR CI)	Model 2 OR (95% OR CI)	Model 3 OR (95% OR CI)
Health condition (probability = poor)			
Smoking			
No at all (reference)			
Some days	1.38 (1.08, 1.76)**	1.65 (1.25 2.17)***	1.36 (1.03, 1.72)*
Every day	1.76 (1.01, 3.07)*	1.77 (0.99, 3.29)	1.63 (0.89, 2.96)
Alcohol consumption			
≥12 drinks (reference)			
<12 drinks	1.51 (1.09, 2.0)**	1.37 (1.01, 1.85)*	1.12 (0.81, 1.54)
Physical activity			
Vigorous (reference)			
Moderate	1.98 (1.19, 3.30)***	1.90 (1.13, 3.19)*	1.71 (1.00, 2.91)*
Light	4.52 (2.78, 7.33)***	4.13 (2.52, 4.20)***	3.33 (1.99, 5.57)***
Diet			
Good (reference)			
Poor	3.13 (2.46, 3.98)***	3.27 (2.55, 4.20)***	3.19 (2.47, 4.12)***
Metabolic syndrome (probability = yes)			
Smoking			
No at all (reference)			
Some days	1.03 (0.64, 1.66)	0.81 (0.63, 1.03)	1.09 (0.67, 1.78)
Every day	0.74 (0.59, 0.92)*	1.01 (0.68, 1.78)	0.79 (0.62, 101)
Alcohol consumption			
≥12 drinks (reference)			
<12 drinks	1.51 (1.15, 1.96)**	1.49 (1.14, 1.96)*	1.49 (1.12, 1.49)*
Physical activity			
Vigorous (reference)			
Moderate	2.28 (1.55, 3.35)***	2.19 (1.48, 3.23)***	2.17 (1.47, 3.21)***
Light	3.22 (2.23, 4.66)***	3.05 (2.010, 4.44)***	3.00 (2.05, 4.38)***
Diet			
Good (reference)			
Poor	1.32 (1.05, 1.66)*	1.35 (1.07, 1.71)*	1.35 (1.06, 1.71)*

Model 1: only included four lifestyle factors. Model 2: adjusted for age, gender and race/ethnicity, in addition to the lifestyle factors. Model3: additionally adjusted for the SES.
* $p < 0.05$.
** $p < 0.001$.
*** $p < 0.0001$.

MetS than those that engaged in vigorous physical activity with odds ratios of 3.22 (95% CI: 2.23, 4.66) and 2.28 (95% CI: 1.55, 3.35), respectively. Individuals eating a poor diet were more likely to have MetS than those who consuming a good diet, with an odds ratio of 1.32 (95% CI: 1.05, 1.66). After adjusting for demographics and SES status, the aforementioned relationships kept significant.

As seen in Table 3, there was a significant relationship between MetS and poor self-reported health ($p < 0.0001$). Individuals with MetS had a higher prevalence of self-reported poor health with an odds ratio of 1.90 (95% CI: 1.54, 2.35). Participants with abnormal waist circumference were more likely to rate their health status as poor than those with normal waist circumference (OR = 1.27, 95% CI: 1.03–1.59). Similarly, individuals with abnormal cholesterol levels including low HDL-C or high triglycerides were more likely to report poor health than those without the accompanying risk with an odds ratio of 1.67 (95% CI: 1.34, 2.09) and 1.66 (95% CI: 1.33, 2.06), respectively.

4. Discussion

This present study found that diet quality and physical activity intensity are significantly associated with self-reported health status and MetS. More specifically, individuals eating a poor diet have higher odds of reporting poor health status and having MetS than those eating a good diet. Physically inactive individuals are more likely to report poor health and MetS than those engaged in vigorous physical activity.

Metabolic risk factors such as obesity, insulin resistance, inflammation, stress and hypertension which characterize the process of aging may be responsible for the increased presence of MetS in the elderly observed in this study (Bonomini et al., 2015). On the other side, aging, insulin resistance and cardiovascular disease are further exacerbated by MetS (Bonomini et al., 2015). The higher prevalence of MetS in Mexican Americans is supported by other studies which indicate that metabolic

Table 3
Bivariate association between risk factor of metabolic syndrome and self-reported health.

	Poor self-reported health		
	Weighted prevalence % (std. err)	Odd ratio (95% CI)	p-Value*
Fasting glucose (≥100 mg/dL)			0.0597
No (N = 1064)	22.47 (1.62)		
Yes (1933)	26.41 (1.27)	1.23 (0.99, 1.55)	
Waist circumference >35" women; >40" men			0.0292
No (1183) (ref.)	22.08 (1.53)		
Yes (1814)	26.54 (1.30)	1.27 (1.03, 1.59)	
Hypertension (>135/80 mm Hg)			0.0620
No (1827) (ref.)	23.59 (1.25)		
Yes (1170)	27.41 (1.64)	1.22 (0.99, 1.51)	
Low HDL-C <50 mg/dL women; <40 mg/dL men			<0.0001
No (2131) (ref.)	22.07 (1.12)		
Yes (966)	32.15 (2.04)	1.67 (1.34, 2.09)	
High triglycerides >150 mg/dL			<0.0001
No (2007) (ref.)	21.62 (1.12)		
Yes (990)	31.34 (1.63)	1.66 (1.33, 2.06)	
Metabolic syndrome			<0.0001
No (1718) (ref.)	19.97 (1.18)		
Yes (1279)	32.15 (1.71)	1.90 (1.54, 2.35)	

Yes or no under each risk factor indicate whether the condition is worse than thresholds of risk factor of diagnosed metabolic syndrome.
* p-Value for association is calculated from Rao-Scott Chi-square test for survey data.

risk factors are more common in this racial group than others, particularly in women (Ford et al., 2002; Beltrán-Sánchez et al., 2013). This has been attributed to the rapid increase of both abdominal obesity in Mexican American women and hyperglycemia in Mexican American men (Beltrán-Sánchez et al., 2013).

Among the four behavioral risk factors considered in this study, physical activity, diet and alcohol consumption were significantly associated with MetS. Physical activity and diet play an important role in preventing and treating metabolic risk factors. Regular physical activity has a stronger effect on metabolic risk factors when associated with weight loss (Thompson et al., 2003). In the long term, epidemiological studies suggest that increased levels of moderate-intensity physical activity and maintenance of good cardiorespiratory fitness would decrease the likelihood of developing MetS (Lakka and Laaksonen, 2007). Dietary patterns such as the Mediterranean diet have been shown to decrease the risk and progression of MetS (Esposito et al., 2013). At a basic level, diets low in saturated fats, and rich in fiber, monounsaturated oils, vitamins and minerals have been found to be protective against MetS (de Leão et al., 2011).

The odds of metabolic syndrome were significantly lowered with high alcohol consumption (≥12 drinks/yr) compared with lower alcohol consumption (<12 drinks). Our findings are similar to studies which show an increasing likelihood of MetS at low levels of alcohol intake in women (Park et al., 2003; Wilsgaard and Jacobsen, 2007). Nonetheless, there were wide between-study variations of the relationship of alcohol consumption to MetS (Wannamethee et al., 2006; Bhanushali et al., 2013). A 2014 meta-analysis of six cohort studies suggests a more conventional association of high alcohol intake with increased risk of MetS and vice versa (Sun et al., 2014). The category of an annual intake of twelve or more (≥12) drinks includes a broad spectrum of patterns of alcohol use and abuse, which may dilute the protective effect of non-alcohol use (Alkerwi et al., 2009); Further, the category of non-users may include former drinkers that have given up alcohol due to poor health (Lin et al., 2015). Therefore, our results regarding alcohol consumption should be interpreted with caution.

Poor living habits (physical inactivity/suboptimal diet) were positively associated with both MetS and self-reported poor health. Further, low HDL-C, high triglycerides, abnormal waist circumference and a diagnosis of MetS were all significantly associated with poor self-reported health, while high fasting glucose levels and hypertension exhibited a marginal association. Despite the observed significant association of self-reported health with metabolic risk factors and MetS, the weighted percentages of individuals reporting poor health in those categories were <40% in all cases, suggesting a low sensitivity of the self-reported health questions relative to these disorders (Table 3). The reasons for this lack of sensitivity cannot be explored further with our data, but we can think of 4 contributing factors: First, the threshold of each component of MetS is lower than the clinically diagnosed standard for overt disease. For example, some individuals may consider themselves to be in good health even though some measures are abnormal. Second, MetS is not an absolute risk predictor but only indicates higher risk of developing type II diabetes and cardiovascular disease compared to individuals without MetS. Moreover, there is no specific medical treatment for MetS other than lifestyle changes such as increase of physical activity. (Alberti et al., 2009) Third, undiagnosed disease, such as type II diabetes, may lead to under-reporting of poor health status. Fourth, even though self-reported health status is a quick and easy health monitoring tool, it is subject to a variety of biases such as culture and personal perception of health (Baker et al., 2004; Liu, 2014). Additional research is required to determine the clinical significance of our findings and the validity of self-report of current health status as indicator of metabolic risk.

This study has several limitations. First, the nature of cross sectional study design prevents the assessment of causality. Second, the time difference between the survey and our present study may impact generalizability. Lastly, self-reports of health status reflect individuals' perceptions of health and it also could be biased by various interviewer factors and no available information on its validation.

5. Conclusions

Two modifiable health behaviors: physical inactivity and poor diet, are significantly associated with MetS and self-reported health, which indicates that lifestyle changes could improve quality of life and reduce MetS. Despite of a significant association between self-reported health with MetS, a low sensitivity indicated that better screening tools for MetS, diabetes and cardiovascular disease are essential to lower the prevalence of undiagnosed disease.

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