



## Short Communication

## Lifestyle changes and prevention of metabolic syndrome in the Heart of New Ulm Project

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## ABSTRACT

Prior research has shown that unhealthy lifestyles increase the risk for developing a number of chronic diseases, but there are few studies examining how lifestyle changes impact metabolic syndrome. This study analyzed the association between two-year changes in key lifestyle risk metrics and incident metabolic syndrome in adults. A retrospective cohort study was conducted using data from metabolic syndrome free adults in the Heart of New Ulm Project (New Ulm, MN). The outcome was incident metabolic syndrome observed two years after baseline in 2009. The primary predictor was change in optimal lifestyle score based on four behavioral risk factors, including smoking, alcohol use, fruit/vegetable consumption, and physical activity. In the analytical sample of 1059 adults, 12% developed metabolic syndrome by 2011. Multivariable regression models (adjusted for baseline lifestyle score, age, sex, education, cardiovascular disease, and diabetes) revealed that a two-year decrease in optimal lifestyle score was associated with significantly greater odds of incident metabolic syndrome (OR = 2.92; 95% CI: 1.69, 5.04;  $p < 0.001$ ). This association was primarily driven by changes in obesity, fruit/vegetable consumption, and alcohol intake. As compared to improving poor lifestyle habits, maintaining a healthy lifestyle seemed to be most helpful in avoiding metabolic syndrome over the two-year study timeframe.

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## 1. Introduction

Over one-third of U.S. adults have a clustering of risk factors known as metabolic syndrome (Aguilar et al., 2015), which includes some combination of insulin resistance, abdominal adiposity, dyslipidemia, and/or hypertension. The prevalence of metabolic syndrome increases with age and larger body sizes (Ervin, 2009). Individuals with metabolic syndrome have a high risk of morbidity and mortality due to cardiovascular disease (CVD) and type 2 diabetes (Hu et al., 2004).

Metabolic syndrome patients are advised to control their risk factors and make general improvements to their lifestyle habits such as increasing physical activity, avoiding tobacco, and eating healthful foods (Kaur, 2014). Though several studies have examined the influence of baseline lifestyle risk factors on the development of various chronic health conditions (Pronk et al., 2010; Chiuve et al., 2006), there are few studies examining how real-world lifestyle changes influence the development of metabolic syndrome, with prior studies limited to how lifestyle interventions can mitigate metabolic syndrome components (Yamaoka and Tango, 2012; Wang et al., 2017). This limits clinical and programmatic guidance on which lifestyle improvements are most

important to prevent metabolic syndrome complications in the general population. The purpose of this study was to examine the association between 2-year changes in key lifestyle risk factors and incident metabolic syndrome in adults who were part of a large community health improvement project.

## 2. Methods

## 2.1. Design and setting

This study is a secondary analysis of data from participants in the Heart of New Ulm (HONU) Project heart health screening program. As described elsewhere (Boucher et al., 2008; VanWormer et al., 2012), HONU is a 10-year community health initiative designed to reduce the attack rate of myocardial infarctions and burden of CVD risk factors in the New Ulm, MN area. There are multiple individual and environmental interventions as part of HONU. Census data indicates there are approximately 13,000 adults that reside in the target ZIP code (56073). Screenings are a major facet of the HONU Project and were conducted throughout New Ulm in both 2009 and 2011 (VanWormer et al., 2012). A screening involved a ~30 minute in-person visit with data collected on health behaviors, anthropometrics, and fasting blood glucose and lipids.

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## 2.2. Sample

A retrospective cohort was assembled using data from HONU heart health screenings conducted in years 2009 (baseline) and 2011 (follow-up). Eligibility criteria for this analysis were: (1) participated in both HONU screening years, (2) resident of the target 56073 ZIP code, (3) age 18–79 years, (4) free from metabolic syndrome at baseline, and (5) all measures present in the analytic dataset. The use of data for this study was approved by Allina Health's Institutional Review Board and all screening participants signed informed consents.

## 2.3. Measures

### 2.3.1. Metabolic syndrome

The outcome was incident metabolic syndrome observed at the follow-up screening. As defined by the American Heart Association (Grundy et al., 2005), this includes the presence of at least three of the following five conditions: (1) abdominal obesity (waist circumference  $\geq 40$  inches if male or  $\geq 35$  inches if female), (2) high blood pressure (systolic  $\geq 130$  mm/Hg or diastolic  $\geq 85$  mm/Hg or current high blood pressure medication), (3) low HDL cholesterol ( $<40$  mg/dL if male or  $<50$  mg/dL if female), (4) high triglycerides ( $\geq 150$  mg/dL), and/or (5) high blood glucose ( $\geq 100$  mg/dL or current use of glucose control medication). Blood pressure and glucose control medication use was self-reported at screenings.

### 2.3.2. Lifestyle changes

Based on previous research that identified 'optimal' clustering of modifiable lifestyle risk factors predictive of mortality and other related outcomes (Pronk et al., 2010; Chiuve et al., 2006; Khaw et al., 2008), a HONU optimal lifestyle score (HOLS) was created that included body mass index (BMI) plus four behavioral factors: smoking, alcohol use, fruit/vegetable consumption, and physical activity. HONU screening items are discussed in more detail elsewhere (VanWormer et al., 2012), but briefly, smoking was assessed with a single item asking participants to indicate if they were never, current, or former smokers. Alcohol use was assessed with a modified version of a World Health Organization screener and reported in drinks per week. Fruit/vegetable consumption was assessed with a single-item and reported as servings per day. Physical activity was assessed using questions from the Behavioral Risk Factor Surveillance System and reported in minutes per week of (moderate intensity-equivalent) physical activity. BMI was measured with a digital scale and stadiometer, and was calculated as weight in kilograms divided by height in meters squared. For each HOLS component, an individual scored 2 points for meeting the optimal level. The HOLS was the sum of each of the five components, with a possible score ranging from 0 to 10 points. Optimal thresholds for each component were: non-smoker, 0–14 alcoholic drinks/wk,  $\geq 5$  serv/d of fruits/vegetables,  $\geq 150$  min/wk of moderately equivalent physical activity, and BMI  $<30$  kg/m<sup>2</sup>. For analytical purposes, the difference between 2009 and 2011 HOLS was categorized as greatly improved (increased by  $\geq 4$  points), modestly improved (increased by 2 points), stayed the same (reference category), or decreased (decreased by  $\geq 2$  points). The HOLS metric was also used as an educational tool in that participants received advice from health coaches immediately after screening, including opportunities for improving their risk. A publicly available HOLS calculator was available on the HONU website for individuals to assess their updated score ([www.heartsbeatback.org/individuals/online-tools/hearts-beat-back-lifestyle-score](http://www.heartsbeatback.org/individuals/online-tools/hearts-beat-back-lifestyle-score)). Based on their known association with HOLS factors, considered covariates were baseline HOLS, age, sex, education, history of CVD, and history of non-gestational diabetes. These were self-reported from screening surveys.

## 2.4. Statistical analyses

Multivariable logistic regression was used with metabolic syndrome in 2011 as the outcome and HOLS change between 2009 and 2011 as the primary predictor. All covariates were included in adjusted models. All analyses were done using the PWSA statistical packages version 18.0 (SPSS Inc., Chicago, IL).

## 3. Results

There were 1725 age- and residency-eligible individuals who participated in the 2009 and 2011 screenings (44% of all 2009 participants). An additional 636 individuals were excluded because they had metabolic syndrome at baseline and another 30 were excluded due to missing data. The final analytical cohort included 1059 individuals. As outlined in Table 1, 12% went on to develop metabolic syndrome by 2011. Compared to those who did not develop metabolic syndrome, those who did were significantly older, less likely to have a college degree, and more likely to have had CVD and/or diabetes at baseline. HOLS increased by 0.4 points across the study sample, going from a mean  $\pm$  SD of  $7.4 \pm 1.7$  points in 2009 to  $7.8 \pm 1.7$  points in 2011. More specifically, 29% improved their HOLS, 57% remained stable, and 14% decreased their HOLS over the 2-year study timeframe.

In the main multivariable regression model (see Table 2), a two-year decrease in HOLS was associated with significantly greater odds of incident metabolic syndrome as compared to stable HOLS (OR = 2.92; 95% CI: 1.69, 5.04;  $p < 0.001$ ). Increased HOLS was generally associated with lower, though not significant, odds of incident metabolic syndrome as compared to stable HOLS. Several covariates, including lower baseline HOLS, older age, CVD, and diabetes, were also associated with significantly higher odds of metabolic syndrome.

The magnitude of HOLS improvement was greater among those who did not develop metabolic syndrome relative to those who did, with a higher proportion of participants with metabolic syndrome (21%) seeing a decline in HOLS between 2009 and 2011 compared to those who did not (13%). Because it was unclear what drove this difference, a sensitivity analysis was conducted using the same procedures from the main analysis. But this analysis gauged the independent contribution of change in each HOLS component by disaggregating the HOLS metric and categorizing each lifestyle factor as improved, stable, or declined (based on HOLS threshold values). Full model details are not shown, but changes in three of the five HOLS factors, obesity, fruit/vegetable consumption, and alcohol intake, were significant in the adjusted model. Individuals who went from a BMI of  $<30$  to  $\geq 30$  kg/m<sup>2</sup> (OR = 7.65; 95% CI: 3.45, 17.00;  $p < 0.001$ ), went from eating  $\geq 5$  to  $<5$  serv/d of fruits/vegetables (OR = 3.94; 95% CI: 1.29, 12.08;  $p = 0.016$ ), or

**Table 1**  
Characteristics of adults who participated in the Heart of New Ulm Project heart health screening program in 2009 and 2011, stratified by those who did and did not develop metabolic syndrome over two years (n = 1059).

	Did not develop metabolic syndrome <sup>a</sup> (n = 936)	Developed metabolic syndrome (n = 123)	p
Age (years)	50.2 $\pm$ 12.8	53.7 $\pm$ 12.1	0.004
Sex			
Male	33%	37%	0.357
Female	67%	63%	
Race			
White	97%	95%	0.268
Not White	3%	5%	
Education			
College/graduate degree	40%	28%	0.008
No college degree	60%	72%	
Cardiovascular disease	2%	9%	<0.001
Diabetes	1%	7%	<0.001
HOLS (points)	7.4 $\pm$ 1.7	7.8 $\pm$ 1.7	<0.001

<sup>a</sup> Values are reported as mean  $\pm$  SD or percent of column total.

**Table 2**

Association between change in optimal lifestyle score and risk of metabolic syndrome, adjusted for baseline covariates, between 2009 and 2011 among adults in the Heart of New Ulm Project (n = 1095).

	Metabolic syndrome <sup>a</sup>
HONU <sup>b</sup> optimal lifestyle score change	
Increased $\geq 4$ points vs. no change	0.52 (0.22, 1.24) p = 0.141
Increased 2 points vs. no change	0.62 (0.37, 1.05) p = 0.074
Decreased $\geq 2$ points vs. no change	2.92 (1.69, 5.04) p < 0.001
Baseline HONU optimal lifestyle score (points)	0.40 (0.30, 0.52) p < 0.001
Age (years)	1.03 (1.01, 1.04) p = 0.003
Sex	
Male vs. female	0.94 (0.62, 1.45) p = 0.787
Education	
College/graduate degree vs. no college degree	0.69 (0.44, 1.08) p = 0.104
Cardiovascular disease	
Yes vs. no	3.04 (1.26, 7.29) p = 0.013
Diabetes	
Yes vs. no	5.64 (2.01, 15.83) p = 0.001

<sup>a</sup> Values are reported as odds ratio (95% confidence interval) of incident metabolic syndrome. Values > 1.00 indicate that, relative to the reference category (or a 1-unit increase for continuous predictors), the odds of metabolic syndrome increased.

<sup>b</sup> HONU = Heart of New Ulm Project.

went from 0 to 14 to > 14 alcoholic drinks/wk (OR = 6.22; 95% CI: 1.06, 36.67; p = 0.043) over two years had significantly greater odds of incident metabolic syndrome.

#### 4. Discussion

The incidence rate of metabolic syndrome in this sample of Midwest adults was slightly greater than that observed in other populations (Santos et al., 2010; Hadaegh et al., 2013). Over the relatively short 2-year timeframe, the development of metabolic syndrome was more common in those whose lifestyle habits worsened. Interestingly, maintaining a high HOLS over two years, as compared to improving HOLS over that same timeframe, was most helpful in terms of avoiding metabolic syndrome. Also, baseline CVD or diabetes was fairly strong predictors of incident metabolic syndrome at follow-up.

Moderate alcohol consumption is generally protective against metabolic syndrome, but heavy drinking is known to increase blood pressure, triglycerides, and body weight (Kaur, 2014). As expected due to its close (though imperfect) correlation with waist size, increased BMI was strongly associated with metabolic syndrome. However, after holding BMI change constant in adjusted analyses, decreased fruit/vegetable consumption also persisted as a significant independent predictor of incident metabolic syndrome. This is consistent with cross-sectional analyses of Iranian teachers by Esmailzadeh et al. (2006), where women in the highest quintiles of both fruit and vegetable intake in that study had 34% and 30%, respectively, lower odds of metabolic syndrome compared to those in the lowest quintiles. Two studies conducted in southern Europe demonstrated that individuals adhering to the Mediterranean diet, which tends to be high in fruits and vegetables, had reduced prevalence and incidence of metabolic syndrome (Panagiotakos et al., 2007; Tortosa et al., 2007). Low fruit/vegetable consumption was also associated with prevalent metabolic syndrome in specific sex-ethnicity groups in the Bogalusa Heart Study (Yoo et al., 2004).

The mechanism by which decreased fruit/vegetable consumption may reduce the risk of metabolic syndrome is not completely understood. Diets rich in fruit and vegetables tend to reduce inflammatory markers (Esmailzadeh et al., 2006; Esposito et al., 2004) and are

associated with improvements in individual subcomponents of metabolic syndrome (Azadbakht et al., 2005). The most common risk factor cluster observed in metabolic syndrome patients appears to be obesity, high blood pressure, and impaired glucose tolerance (Ervin, 2009). A dietary pattern high in fruits and vegetables protects against each of these isolated risk factors (Azadbakht et al., 2005), which may partially explain its significant association with metabolic syndrome in our study, even after adjusting for obesity.

Some caution should be exercised in interpreting these findings. The analytical sample was relatively large, but follow-up loss did occur relative to the baseline screening sample and those with available data over two years could have differed on other influential characteristics. Change in HOLS was modest overall and only two data collection points were analyzed, with limited precision regarding the temporality (or overlap) of outcome and exposure measurements. The rural, homogeneous HONU source population also limits generalizability. With the exception of BMI, all HOLS components were self-reported. Though the HOLS was a practical assessment in the context of this community-based screening program, such self-report instruments are subject to recall bias.

#### 5. Conclusions

This study demonstrated that declining lifestyle factors, particularly increased body weight and alcohol intake, as well as decreased fruit/vegetable consumption, over two years is associated with higher odds of incident metabolic syndrome. Current recommendations to maintain a healthy body weight and eat an adequate amount of fruits and vegetables to help prevent chronic disease (Eyre et al., 2004) are supported by our findings. As intimated by Sotos-Prieto et al. (2015), future clinical trials may be helpful to determine the interventional utility of composite lifestyle metrics like the HOLS, as well as the degree to which maintaining a healthy lifestyle over the long-term helps adults avoid, or at least delay, metabolic syndrome complications.

#### Transparency document

The Transparency document associated with this article can be found, in online version.

#### Conflict of interest statement

The authors declare that there are no conflicts of interest.

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