

The Relationships Between Lifestyle Behaviors, Health Perceptions, and Psychosocial Outcomes of Metabolic Syndrome Severity

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Purpose: The prevalence of metabolic syndrome (MetS) continues to increase. The severity of MetS can be defined by the number of components or, more recently, a continuous MetS severity score (MetSSS). However, studies that examine lifestyle factors predictive of MetS severity, in general, are lacking. This study aims to compare lifestyle behaviors (eg, physical activity and diet), health perceptions (eg, overall and mental health perceptions), and psychosocial outcomes (eg, perceived stress and social support) among people with a varied number of MetS components and to evaluate associations with MetSSS.

Patients and Methods: This cross-sectional study utilized baseline data from a randomized controlled trial of 618 participants with MetS recruited from 5 different sites across the US. We collected data using accelerometers, standard questionnaires, bloodwork, and doing physical measurements. We used a series of separate linear regression models (unadjusted and adjusted) to evaluate differences in lifestyle behaviors, health perceptions, and psychosocial factors between people with 3, 4, and 5 MetS components. We conducted additional linear regression models (unadjusted and adjusted) to assess the association between these same variables and a continuous MetSSS.

Results: Lifestyle behaviors, health perceptions, and psychosocial factors were not different among people with 3, 4, and 5 MetS components. However, in the adjusted models, a lower MetSSS was associated with more average daily steps ($\beta = -631.69, p < 0.001$), healthier overall health perception ($\beta = -0.14, p = 0.014$), more social support for physical activity from friends ($\beta = -0.89, p = 0.011$) and more social support for healthy eating from friends ($\beta = -0.42, p = 0.015$).

Conclusion: The MetSSS was shown to be more sensitive to modifiable lifestyle factors compared to the number of MetS components, indicating the importance of using the MetSSS in lifestyle interventions targeting MetS to achieve MetS remission.

Keywords: metabolic syndrome severity, health, behaviors, metabolic syndrome treatment

Introduction

Approximately 42% of US adults suffer from metabolic syndrome (MetS),¹ and its prevalence significantly increased from about 16% to 20% of young adults (aged 20 to 39 years) from 2011–2012 to 2015–2016.² MetS is diagnosed by the coexistence of ≥ 3 out of 5 cardiometabolic risk factors (ie, MetS components): high blood pressure; central obesity; elevated triglycerides; elevated fasting glucose, and low high-density lipoprotein (HDL) cholesterol.³ Each risk factor has an established cut-off value (sex-specific for some) that indicates presence of risk.³ A MetS diagnosis is associated with higher risks for cardiovascular disease morbidity and mortality, diabetes, liver and kidney disease, cancer, cognitive decline, and cirrhosis.^{4,5}

A diagnosis of MetS can have varying severity. The most common approach to measuring severity is based upon the number of 5 diagnostic criteria that are met (ranging from 3 to 5 components). A greater number of MetS components (ie, cardiometabolic risk factors) elevates risks for cardiovascular disease,⁶ diabetes,⁷ and all-cause mortality.⁸ Typically,

central obesity (high waist circumference) and low HDL are the two most common components of a MetS diagnosis combined with high blood pressure or elevated triglycerides.⁹ The current binary cut-off (eg, “normal” or “high”) oversimplifies the data and ignores gradations of risk. Individuals just below a cut-off are treated as “normal”, while those just above it are considered “at risk”, even though their actual risk may be equivalent. Further, these cut-offs do not adjust for race, but race may impact the MetS components.¹⁰ The cut point of triglycerides at greater than 150 mg/dl may be inappropriate for non-Hispanic Blacks, who, on average, show lower triglyceride levels.¹¹ Therefore, establishing true MetS severity may be more complex than simply counting the number of components that meet diagnostic targets. Recently, to address these issues, metabolic syndrome severity scores (MetSSS) have been created that produce a continuous measure of severity representing the spectrum of MetS and accounts for sex and race.^{12–14} One rigorously constructed yet practically useful score was introduced by Gurka et al, (2014) who performed a confirmatory factor analysis on National Health and Nutrition Examination Survey (NHANES) (1999–2010), which included data from non-Hispanic-White, non-Hispanic-Black, or Hispanic (Mexican-American/other Hispanic) participants, ranging from 20 to 64 years old. The confirmatory factor analysis findings led to the development of the sex and race/ethnic-specific equations to calculate MetS severity as a continuous variable. However, these scores are not yet widely used in clinical practice nor has the clinical definition of MetS changed from binary cut-offs. The diagnosis of MetS and MetS remission continues to rely upon the number of cardiometabolic risk factors that coexist.

The fundamental root of MetS is widely understood to be a lifestyle characterized by poor dietary quality and physical inactivity.^{15–18} More recently, chronic stress has been identified as an additional fundamental root with direct and indirect influences on MetS.¹⁹ Physical activity can positively affect each component of MetS.²⁰ Improving the quality of foods, modifying macronutrient distribution, and adhering to an energy-restrictive dietary pattern can also positively affect the components of MetS.²¹ Mindfulness is associated with lower waist circumference but no other clinical components of MetS.²²

To our knowledge, no study has evaluated the association between lifestyle factors such as health behaviors, health perceptions, and psychosocial characteristics and the number of MetS components among individuals with MetS. Moreover, only two studies evaluated associations between lifestyle behaviors and MetSSS. One cross-sectional study found that self-reported physical activity and diet quality were significantly associated with lower MetSSS in older adults with MetS.²³ A prospective study found anti-inflammatory diets and moderate to vigorous physical activity predicted lower MetSSS over one year in older adults with MetS.²⁴

Identifying relationships between lifestyle factors and MetS severity in terms of number of components and severity score may help in the development of more robust interventions to promote MetS remission. We sought to compare lifestyle behaviors, health perceptions, and psychosocial factors among people with 3, 4, and 5 components of MetS and to evaluate the association between these lifestyle factors and the MetSSS.

Materials and Methods

Study Design

This cross-sectional study utilized the baseline data from a multisite randomized controlled trial of participants with MetS (ClinicalTrials.gov number NCT04036006). Baseline data completion was required before being randomized into the trial. Supplemental information on the methods of the parent trial can be found in the trial’s design and baseline cohort paper.²⁵

Recruitment

Recruitment for the parent trial was conducted in four waves across five separate sites in the United States and completed between June 2019 and February 2022. Participants were eligible for the trial if they met the diagnostic criteria for MetS by having 3 or more MetS components at baseline examination including: high blood pressure (systolic >130 mmHg or diastolic >85 mmHg or anti-hypertensive drug therapy); central obesity (waist circumference >102 cm for males and >88 cm for females); high triglycerides (>150 mg/dL or drug treatment for elevated triglycerides); elevated fasting glucose (>100 mg/dL or drug treatment for elevated glucose), and low HDL cholesterol (<40 mg/dL for males, <50 mg/dL for females, or drug treatment for low HDL cholesterol).³ Participants with safety issues, logistical barriers, and treatments that could confound

trial results were excluded. Potential participants were not eligible for the trial if they had a diagnosis of diabetes, heart disease, stroke, moderate or severe depression, history of bariatric surgery, history of an eating disorder within the last five years, mobility limitations, hearing disabilities, or use of a medication impacting appetite or weight.

Measures and Instrumentation

Social Demographic and Health History

Participants completed a questionnaire measuring sociodemographic items, such as race, education level, financial strain (ie, how hard it is to pay for basic needs) and a comprehensive health and psychiatric history.

MetS Severity

MetS Components

The measurement of blood pressure and waist circumference followed NHANES protocols.²⁶ HDL cholesterol, triglycerides, and fasting glucose were measured through a fasted blood sample using Quest Diagnostics. Use of medications was evaluated through self-reported prescription medications and the review of pill bottles.²⁷ Number of MetS components was summed for each participant. Participants were organically separated into groups based on the number of the components met. Specific combinations of MetS components within each group were not evaluated as the diagnosis is based on the number of components met and not specific component combinations.

MetS Severity Score

A continuous metabolic severity score for each participant – based on gender- and race-specific equations – was calculated.¹² A higher MetSSS indicates an unhealthier MetS severity.

Lifestyle Behaviors Outcomes

Physical Activity

Moderate and vigorous physical activity minutes/week and the daily average of steps per day over one week were objectively measured using an accelerometer. Participants wore an accelerometer on their right hip for 7 consecutive days for at least 10 hours each day.²⁸

Diet

Frequency of intake of fruit and vegetable servings, only vegetable servings, and sweetened beverages were used as diet outcomes. Participants completed items relating to fruit and vegetable intake and vegetable-only intake (excluding white potatoes, cooked dried beans, and vegetables in mixture such as omelets, casseroles, etc.) from the National Cancer Institute (NCI) All Day Screener.²⁹

Mindfulness

Total mindfulness score from the 39 Likert Item Five-Facet Mindfulness Questionnaire (FFMQ) was used, where higher scores indicate more mindfulness behaviors.³⁰

Health Perception Outcomes

Health Perceptions

Overall health perception and mental health perception to evaluate the health perceptions of participants were used. We recorded a Likert scale item, including answers: “poor”, “fair”, “good”, “very good”, and “excellent” to score 1–5, respectively, with a lower score indicating poorer health. Overall self-rated health was measured using the Short Form Health Survey (SF-36).³¹ The Mental Health Subscale of the SF-36 was used to evaluate mental health perception where higher scores indicated better perceived mental health.³¹

Psychosocial Outcomes

Cohen Perceived Stress Scale

We totaled a perceived stress score from 14 Likert scale items ranging from “never”, “almost never”, “sometimes”,

“fairly often”, or “very often” and scored 0–4, respectively.³² We reverse-coded items as necessary. Scores could range from 0 to 56, with higher scores indicating higher perceived stress.

Sallis' Social Support for Diet and Physical Activity

We used family social support for physical activity, friend social support for physical activity, friend social support for healthy eating (encouragement), and family social support for healthy eating (encouragement) as the social support measures of the study. We calculated family and friend social support scores from the 13 Likert items, which scored 1 to 5.³³ Higher scores indicated higher social support for physical activity. Friend social support for eating (encouragement) and family social support (encouragement) scores were calculated from 10 Likert items, scored 1 to 5.³³ Higher scores indicated higher social support for healthy eating.

Procedures

The Rush University Institutional Review Board was the central review board for all trial sites and approved all study procedures (IRB ORA # 18092408), which were in accordance with the Declaration of Helsinki. Before collecting baseline data, participants provided informed consent to participate in the trial. Baseline data were collected in 3 steps by trained research personnel at each site. First, participants completed self-reported questionnaires (eg, demographics and eligibility questionnaires, SF-36, NCI All Day Screener, and BRFSS). Participants then completed 2 lab visits. The first visit participants received an accelerometer to wear for 7 consecutive days, 10 hours/day and completed food and beverage logs (all intake over 3 weekdays and 1 weekend day). The second in-person visit included a blood draw after a 12-hour fast, physical measurements (eg, height, weight, waist circumference, and blood pressure), and completion of remaining self-reported data (eg, FFQM, social support for diet and physical activity, and perceived stressed).

Data Analysis

We reviewed the data for normality, and outliers. We conducted log transformations for total moderate and vigorous physical activity, total fruit and vegetable servings, and total vegetable only servings due to non-normality issues. We calculated descriptive statistics for all variables used in the analyses. We used SAS 9.4³⁴ for the analyses and defined statistical significance at $p < 0.05$.

We used a series of separate linear regression models, both unadjusted and adjusting for age, sex, race/ethnicity, education, and financial strain, to evaluate differences among participants having 3, 4, and 5 MetS components and total weekly minutes of moderate to vigorous physical activity, average daily step count, fruit and vegetable intake, vegetable only intake, FFQM total score, overall health rating, mental health, perceived stress, family and friends' social support for physical activity participation, and family and friends' social support encouragement for healthy eating.

We used a series of separate linear regression models, both unadjusted and adjusted for age, education, and financial strain (MetS severity scores already taken into account for sex and race/ethnicity), to evaluate relationships between health behavior, health perception, and psychosocial outcomes. It was hypothesized that lower MetS severity scores would be associated to healthier behaviors, perceptions, and improved psychosocial outcomes.

Results

Demographics and outcome descriptive statistics for the 3, 4, and 5 component groups can be found in [Table 1](#). Overall, 55% ($n = 339$) of the participants met 3 MetS components, 33% ($n = 202$) of the participants met 4 MetS components, and 12% ($n = 77$) of the participants met 5 MetS components. Each group was predominantly in their mid-50s, white, college-educated, and did not struggle to pay for their basic needs. The sample, on average, was physically inactive (based on the Physical Activity Guidelines for Americans³⁵), met guidelines for fruit and vegetable servings (based on the Dietary Guidelines for Americans³⁶), moderately mindful, with good health perception ratings, perceived moderate amount of stress and social support for physical activity and diet. The number of MetS components had a significant graded relationship with the MetSSS (ie, as number of components increased so did MetSSS). A full summary of the sample's ($N = 618$) demographic information can be found in the baseline and design paper.²⁵ Eight participants were excluded from adjusted models because they refused to disclose their level of financial strain.

Table 1 Baseline Characteristics of Study Sample

	MetS 3 (n = 339)	MetS 4 (n = 202)	MetS 5 (n = 77)	Total (n = 618)
Age	55.15 (11.35)	55.12 (11.00)	56.53 (8.58)	55.50 (11.00)
Male N (%)	79 (23)	50 (25)	21 (27)	150 (24)
Race N (%)				
Black	77 (23)	23 (11)	6 (8)	106 (17)
White	226 (67)	162 (80)	68 (88)	456 (74)
Other	36 (11)	17 (8)	3 (4)	56 (9)
Education, < College, N (%)	135 (40)	83 (41)	32 (42)	250 (41)
No financial Strain N (%)	278 (82%)	178 (88%)	64 (83%)	520 (84%)
MVPA Sum (min/wk)	108.40 (103.58)	100.64 (85.75)	100.58 (100.05)	104.89 (97.58)
Average Daily Steps (steps/day)	4319.90 (2311.67)	4533.77 (2149.38)	4101.44 (2043.53)	4362.59 (2228.43)
Fruit and Vegetable Intake (servings/day)	4.80 (2.91)	4.66 (2.72)	4.96 (3.25)	4.77 (2.89)
Vegetable Only Intake (servings/day)	3.05 (2.32)	2.80 (1.86)	3.20 (2.39)	2.99 (2.19)
FFMQ Total Score	144.12 (16.84)	141.31 (17.27)	144.00 (14.44)	143.19 (16.73)
Overall Health Rating	2.94 (0.82)	2.94 (0.80)	2.96 (0.79)	2.94 (0.80)
Mental Health Score	79.40 (12.57)	79.85 (12.69)	81.75 (9.52)	79.84 (12.28)
Perceived Stress Score	19.88 (6.48)	20.01 (7.41)	19.79 (5.78)	19.91 (6.71)
Family SS for PA	23.79 (10.06)	23.30 (9.83)	21.43 (9.19)	23.33 (9.90)
Friends SS for PA	20.07 (9.89)	20.18 (9.36)	18.43 (7.78)	19.90 (9.48)
Family SS for Healthy Eating (Encourage)	13.76 (6.04)	13.27 (5.88)	11.96 (4.95)	13.38 (5.89)
Friends SS for Healthy Eating (Encourage)	10.28 (4.87)	10.09 (4.55)	9.91 (4.37)	10.17 (4.70)
Met Severity Score	-0.48 (0.93)	0.39 (1.02)	1.12 (0.90)	0.0 (1.12)

Notes: The ranges of scorable items include: FFMQ Total Score (19–195); Overall Health Rating (1–5); Mental Health Score (0–100); Perceived Stress Score (0–56); Family SS for PA (10–50); Friends SS for PA (10–50); Family SS for Healthy Eating (encourage) (0–25); Friend SS for Healthy Eating (encourage) (0–25). The MetS components were based on how many of the following MetS components were met: high blood pressure; central obesity; elevated triglycerides; elevated fasting glucose, and low high-density lipoprotein (HDL) cholesterol.

Abbreviations: MVPA, moderate to vigorous physical activity; FFMQ, Five Facet Mindfulness Questionnaire; SS, social support; PA, physical activity.

Correlates of Number of MetS Components

The study investigated lifestyle differences by number of MetS components. Table 2 summarizes the results of the unadjusted and adjusted models for each outcome. Overall, differences among the groups for physical activity, diet, and mindfulness were not significant. Table 3 summarizes the results of the unadjusted and adjusted models for those outcomes. Differences among the groups on overall health rating and mental health perception were not significant. Table 4 summarizes the coefficients, standard errors, and p-values for unadjusted and adjusted models for each perceived stress, social support for diet and exercise, and MetS severity scores. In an unadjusted model, people with 3 MetS components reported to be receiving significantly higher family social support for healthy eating (encouragement) (mean = 13.76, $p = 0.0307$) compared to people with 5 MetS components' family social support for health eating (encouragement) scores (mean = 11.96, $p = 0.0307$). However, differences in the adjusted model for people with 3 components' family social support for health eating (encouragement) (mean = 14.33) compared to people

Table 2 Unadjusted and Adjusted Models for Health Behaviors and # MetS Components

Outcome	Predictor	Unadjusted Model		^a Adjusted Model	
		Coef (S.E.)	P-value	Coef (S.E.)	P-value
MVPA Sum (min/wk)	MetS 3	0.06 (0.14)	0.681	0.05 (0.13)	0.716
	MetS 4	0.02 (0.14)	0.871	-0.01 (0.14)	0.952
	MetS 5	Ref		Ref	
Average Daily Steps (steps/day)	MetS 3	218.46 (281.23)	0.438	236.62 (279.32)	0.397
	MetS 4	432.32 (298.37)	0.148	364.84 (292.58)	0.213
	MetS 5	Ref		Ref	

(Continued)

Table 2 (Continued).

Outcome	Predictor	Unadjusted Model		^a Adjusted Model	
		Coef (S.E.)	P-value	Coef (S.E.)	P-value
Fruit and Vegetable Intake (servings/day)	MetS 3	-0.01 (0.08)	0.890	-0.01 (0.08)	0.897
	MetS 4	-0.03 (0.08)	0.750	-0.03 (0.08)	0.711
	MetS 5	Ref		Ref	
Vegetable only Intake (servings/day)	MetS 3	-0.03 (0.06)	0.594	-0.02 (0.07)	0.736
	MetS 4	-0.07 (0.06)	0.283	-0.07 (0.07)	0.288
	MetS 5	Ref		Ref	
FFMQ Total Score	MetS 3	0.12 (2.11)	0.954	-1.03 (2.11)	0.626
	MetS 4	-2.69 (2.24)	0.230	-3.36 (2.21)	0.130
	MetS 5	Ref		Ref	

Notes: ^aModel Adjusted for age, race, education achieved, and financial strain. 8 participants were excluded from the adjusted analysis (refused to answer financial strain item). The range of the FFMQ includes: 19–195. Total moderate and vigorous physical activity, total fruit and vegetable servings, and total vegetable only servings were log transformed to address non-normal distributions. The MetS components were based on how many of the following MetS components were met: high blood pressure; central obesity; elevated triglycerides; elevated fasting glucose, and low high-density lipoprotein (HDL) cholesterol.

Abbreviations: Coef, coefficient; MVPA, moderate to vigorous physical activity; FFQM, Five Facet Mindfulness Questionnaire; ref, reference group.

Table 3 Unadjusted and Adjusted Models for Health Perceptions and # MetS Components

Outcome	Predictor	Unadjusted Model		^a Adjusted Model	
		Coef (S.E.)	P-value	Coef (S.E.)	P-value
Overall Health Rating	MetS 3	-0.03 (0.10)	0.799	0.07 (0.10)	0.481
	MetS 4	-0.02 (0.11)	0.850	0.01 (0.10)	0.937
	MetS 5	Ref		Ref	
Mental Health Score	MetS 3	-2.38 (1.55)	0.129	-2.59 (1.49)	0.082
	MetS 4	-1.90 (1.64)	0.248	-2.13 (1.56)	0.173
	MetS 5	ref		ref	

Notes: ^aModel Adjusted for age, race, education achieved, and financial strain. 8 participants were excluded from the adjusted analysis (refused to answer financial strain item). The ranges of Overall Health Rating and Mental Health Score include 1–5 and 0–100, respectively. The # MetS components were based on how many of the following MetS components were met: high blood pressure; central obesity; elevated triglycerides; elevated fasting glucose, and low high-density lipoprotein (HDL) cholesterol.

Abbreviations: Coef, coefficient; MVPA, moderate to vigorous physical activity; FFQM, Five Facet Mindfulness Questionnaire; ref, reference group.

Table 4 Unadjusted and Adjusted Models for Psychosocial Outcomes and # MetS Components

Outcome	Predictor	Unadjusted Model		^a Adjusted Model	
		Coef (S.E.)	P-value	Coef (S.E.)	P-value
Perceived Stress Score	MetS 3	0.09 (0.85)	0.919	0.38 (0.83)	0.651
	MetS 4	0.22 (0.90)	0.809	0.52 (0.87)	0.551
	MetS 5	Ref		Ref	
Family SS for PA	MetS 3	2.46 (1.25)	0.059	1.54 (1.28)	0.228
	MetS 4	1.87 (1.32)	0.159	1.24 (1.34)	0.353
	MetS 5	Ref		Ref	

(Continued)

Table 4 (Continued).

Outcome	Predictor	Unadjusted Model		^a Adjusted Model	
		Coef (S.E.)	P-value	Coef (S.E.)	P-value
Friends SS for PA	MetS 3	1.64 (1.20)	0.171	0.78 (1.22)	0.524
	MetS 4	1.75 (1.27)	0.169	1.11 (1.27)	0.383
	MetS 5	Ref		Ref	
Family SS for Healthy Eating (Encourage)	MetS 3	1.80 (0.74)	0.015	1.16 (0.75)	0.119
	MetS 4	1.31 (0.79)	0.097	0.88 (0.79)	0.261
	MetS 5	ref		ref	
Friend SS for Healthy Eating (Encourage)	MetS 3	0.37 (0.59)	0.529	-0.30 (0.59)	0.611
	MetS 4	0.19 (0.63)	0.769	-0.17 (0.62)	0.781
	MetS 5	Ref		Ref	

Notes: ^aModel Adjusted for age, race, education achieved, and financial strain. 8 participants were excluded from the adjusted analysis (refused to answer financial strain item). Also, the MetS severity score model was only adjusted for education achieved, and financial strain as the score already adjusts for sex and race. The ranges of scorable items include: Perceived Stress Score (0–56); Family SS for PA (10–50); Friends SS for PA (10–50); Family SS for Healthy Eating (encourage) (0–25); Friend SS for Healthy Eating (encourage) (0–25). The MetS components were based on how many of the following MetS components were met: high blood pressure; central obesity; elevated triglycerides; elevated fasting glucose, and low high-density lipoprotein (HDL) cholesterol.

Abbreviations: Coef, coefficient; MVPA, moderate to vigorous physical activity; FFQM, Five Facet Mindfulness Questionnaire; SS, social support; PA, physical activity; ref, reference group.

with 5 components' family social support for health eating (encouragement) (mean = 13.17, $p = 0.119$) were not significant. No other differences were significant across groups for the psychosocial measures.

Correlates of MetSSS

We examined associations between the MetSSS and lifestyle outcomes. Table 5 summarizes the unadjusted and adjusted relationships between MetS severity score and all outcomes. Unadjusted MetSSS was significantly and inversely associated with average daily steps ($p = 0.002$), overall health rating ($p = 0.006$), friend social support for physical

Table 5 Unadjusted and Adjusted Models for Lifestyle Factors and MetS Severity

Outcome	Unadjusted Model		^a Adjusted Model	
	Coef (SE)	P-value	Coef (SE)	P-value
MVPA Sum (min/wk)	-0.09 (0.09)	0.322	-0.06 (0.09)	0.062
Average Daily Steps	-524.09 (170.54)	0.002*	-631.69 (170.65)	<0.001*
Fruit and Vegetable Intake	-0.09 (0.05)	0.064	-0.07 (0.05)	0.143
Vegetable only	-0.02 (0.04)	0.564	-0.01 (0.04)	0.737
FFMQ Total Score	0.70 (1.29)	0.587	0.87 (1.29)	0.499
Overall Health Rating	-0.17 (0.06)	0.006*	-0.14 (0.06)	0.014*
Mental Health Score	0.56 (0.95)	0.559	0.89 (0.91)	0.324
Perceived Stress	0.63 (0.52)	0.226	0.38 (0.50)	0.457
Family SS for PA Participation	-0.14 (0.36)	0.702	-0.24 (0.37)	0.511
Friends SS for PA	-0.92 (0.34)	0.007*	-0.89 (0.35)	0.011*
Family SS for Healthy Eating (Encourage)	-0.26 (0.21)	0.222	-0.36 (0.21)	0.092
Friend SS for Healthy Eating (Encourage)	-0.40 (0.17)	0.018*	-0.42 (0.17)	0.015*

Notes: ^aModel Adjusted for education achieved and financial strain. * $p < 0.05$. MetS Severity Score already accounts for sex and race. The ranges of scorable items include: FFMQ Total Score (19–195); Overall Health Rating (1–5); Mental Health Score (0–100); Perceived Stress Score (0–56); Family SS for PA (10–50); Friends SS for PA (10–50); Family SS for Healthy Eating (encourage) (0–25); Friend SS for Healthy Eating (encourage) (0–25). Total moderate and vigorous physical activity, total fruit and vegetable servings, and total vegetable only servings were log transformed to address non-normal distributions. Bolded values indicate a statistically significant relationship between MetS severity scores and the respective lifestyle outcome.

Abbreviations: Coef, coefficient; MVPA, moderate to vigorous physical activity; FFQM, Five Facet Mindfulness Questionnaire.

activity ($p = 0.007$), and friend social support for healthy eating (encouragement) ($p = 0.018$). After adjusting for education achieved, and financial strain, average daily steps ($p < 0.001$), overall health rating ($p = 0.01$), friend social support for physical activity ($p = 0.011$) and friend social support for healthy eating (encouragement) ($p = 0.015$) remained significantly associated with MetS severity.

Discussion

Previous studies have demonstrated that physical inactivity,³⁷ poor dietary habits,²¹ and stress¹⁹ are critical risk factors for developing MetS. Less research has been done on investigating how MetS severity relates to lifestyle after a MetS diagnosis. To our knowledge, no research has investigated the association of current lifestyle behaviors, health perceptions, and psychosocial outcomes with MetS severity. Lifestyle behaviors, health perceptions, and psychosocial outcomes were not related to the number of MetS components. People with 5 MetS components showed similar physical activity, diet, and mindfulness outcomes as people with 3 components. Despite a MetS diagnosis and being at a higher risk for cardiovascular disease⁶ and diabetes⁷ and all-cause mortality,⁸ participants, regardless of number of components, on average, perceived their overall health as “good” and reported good mental health. Psychosocial outcomes were also similar across the number of MetS components. One review paper reported that MetS development is a composite of the interaction between environmental, lifestyle, and genetic factors.³⁸ The homogenous sample of older, college educated, white women demonstrates similar environmental and lifestyle factors. Genetic factors may play a role in developing more MetS components once diagnosed with MetS. Future studies could continue to investigate these relationships with a more diverse sample. Also, scientists could continue to investigate the role genetics plays in the development of more MetS components. Moreover, the number of MetS components as a severity measure shows to be less sensitive to modifiable lifestyle outcomes compared to the MetSSS.

Previous studies have demonstrated associations between MetSSS and physical activity.^{23,24} Our study used objective measurements of physical activity using accelerometers, compared to self-reported measures in the other studies. We showed average daily steps were significantly related to MetSSS. Average daily steps are less biased than self-reported physical activity measures that often overestimate physical activity performed.³⁹ More studies could continue to investigate the relationship between objectively measured physical activity and MetSSS to confirm these findings and understand these relationships long-term. The current study demonstrated that eating fruits and vegetables was not significantly related to the MetSSS. This finding is similar to a previous cross-sectional study.²³ However, a prospective analysis showed, after one year, that decreasing MetS severity scores was associated with a high intake of fruit and vegetables.²⁴ These studies also use a more in-depth food log for looking at dietary variable. Future studies can consider long-term relationships between MetSSS and diet quality factors and investigate if these relationships are causal. Overall, MetSSS scores show to be more sensitive to lifestyle behaviors than the number of MetS components.

As a notable strength of our study, this was the first to investigate the MetSSS relationships with health perceptions and psychosocial outcomes. MetSSS was significantly related to better overall perceived health, higher friend social support for physical activity and higher friend social support for healthy eating (encouragement) in both unadjusted and adjusted models. The MetSSS is related to overall health perceptions, while number of components is not. This finding points to the increased sensitivity of MetSSS to an important health outcome compared the number of components. Also, friends' social support is more important for performing physical activity and healthy eating for people with a MetS diagnosis. Getting additional support from peers may be critical to reducing MetS severity. For example, a systematic review by Chen et al, (2021) suggested that peer support was associated with weight loss and lower body mass indexes in people who were overweight and obese.⁴⁰ This is different from research supporting that social support is not related to MetS.^{41,42} These studies looked at general social support but not social support for specific behaviors. Berthold et al (2021) did use a MetSSS, but the score was developed specifically for Asian populations as their study focused on Cambodian Americans. More research could help understand the relationship between MetS severity score and friend social support for physical activity and healthy eating to further see if the relationship is causal.

Overall, the study's findings are limited by a cross-sectional design and self-reported measures. The cross-sectional design limits the findings to associations and not causal relationships. Many measures were self-reported measurements prone to different biases.⁴³ However, the study did use objective measures when feasible, including objectively measured

physical activity using accelerometers. The limited sample psychosocial demography tempers the generalization of the findings to any sample other than mainly white, college-educated women in their mid-50s who do not struggle to pay for their basic needs, had MetS, and were highly motivated to join a lifestyle intervention. Future studies must continue to clarify these results with a more diverse sample and with equal representation of the number of MetS components. Longitudinal studies are encouraged to better understand the relationships between MetS severity scores and lifestyle behaviors, health perceptions, and psychological factors.

Conclusion

The current study demonstrated that MetS components were not related to modifiable lifestyle correlates. MetSSS is shown to be more sensitive to the impact of physical activity (including average daily steps), dieting, overall health perception, and friend social support for physical activity and healthy eating for individuals. This sensitivity to modifiable health behaviors, health perceptions, and psychosocial outcomes shows the importance of using the MetSSS score in lifestyle interventions to help identify and reduce MetS severity and, ultimately, achieve MetS remission after receiving a MetS diagnosis.

Data Sharing Statement

Access to the data and data dictionary generated through this project may be granted through request to the corresponding author. Data sharing will conform to any restrictions specified by regulatory bodies. A brief request form summarizing the intended use of the data and/or a Data Use Agreement may be required depending on the nature of the data requested. No data that could potentially identify individual research subjects will be shared.

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Disclosure

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