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Clinical Study

Associations of Cardiorespiratory Fitness and Fatness with Metabolic Syndrome in Rural Women with Prehypertension

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Background. This study investigated the associations of fitness and fatness with metabolic syndrome in rural women, part of a recognized US health disparities group. *Methods*. Fitness, percentage body fat, BMI, and metabolic syndrome criteria were assessed at baseline in 289 rural women with prehypertension, ages 40–69, enrolled in a healthy eating and activity community-based clinical trial for reducing blood pressure. *Results*. Ninety (31%) women had metabolic syndrome, of which 70% were obese by BMI ($\geq 30\,\text{kg/m}^2$), 100% by percentage body fat ($\geq 30\%$), and 100% by revised BMI standards ($\geq 25\,\text{kg/m}^2$) cited in current literature. Hierarchical logistic regression models, adjusted for age, income, and education, revealed that higher percentage body fat ($P < 0.001$) was associated with greater prevalence of metabolic syndrome. Alone, higher fitness lowered the odds of metabolic syndrome by 7% ($P < 0.001$), but it did not lower the odds significantly beyond the effects of body fat. When dichotomized into "fit" and "unfit" groups, women categorized as "fat" had lower odds of metabolic syndrome if they were "fit" by 75% and 59%, for percentage body fat and revised BMI, respectively. *Conclusion*. Among rural women with prehypertension, obesity and fitness were associated with metabolic syndrome. Obesity defined as $\geq 25\,\text{kg/m}^2$ produced results more consistent with percentage body fat as compared to the $\geq 30\,\text{kg/m}^2$ definition.

1. Introduction

Although substantial progress has been made in the awareness, prevention, and treatment of cardiovascular disease in women in the United States (USA) over the past 10 years, women's lifetime risk of cardiovascular disease is high [1]. Adverse trends in cardiovascular disease risk factors are a growing concern, partly due to an ongoing increase in average body weight, with nearly two of every three women in the United States (USA) over 20 years of age now being classified as overweight or obese [2]. However, data from the National Health and Nutrition Survey (NHANES) collected from a series of cross-sectional national representative health surveys suggest that obesity prevalence among women in the USA has been stable for more than 10 years and that cardiovascular disease risk factors have been declining in the population, particularly among those with overweight or obesity [3, 4].

Yet, NHANES data also show that the prevalence of obesity and metabolic syndrome is markedly higher in rural women than urban residents [5, 6]. Metabolic syndrome is a designation given to individuals who have a cluster of risk factors characterized by abdominal obesity and disorders of lipid and carbohydrate metabolism that predispose individuals to cardiovascular disease and type II diabetes [7–9].

The prevalence of metabolic syndrome components varies between populations due to differences in genetic heterogeneity and variations in lifestyles [10]. Rural Midwestern women are recognized as part of a distinct group in the US population who have documented health disparities, with poorer self-reported health, higher rates of sedentary behavior and obesity, lower fitness, and higher risk of other cardiovascular risk disease factors, compared to their urban counterparts [5, 6, 10–13]. The reported findings related to the influence of rurality in terms of geographic locations and associated lifestyles with metabolic syndrome is inconsistent, reinforcing the need to understand the unique health risks for specific rural populations [11, 14, 15]. Identifying risk factors for and methods to improve metabolic health is an important public health issue, especially for this vulnerable rural population, as metabolic syndrome may be a stronger predictor for future risk of cardiovascular disease risk in women than in men [16]. Agencies within the US Department of Health and Human Services, such as the National Institutes of Health (NIH) and the Agency for Healthcare Quality and Safety have designated women in underserved rural communities as priority populations for targeted research to address health disparities, especially as related to cardiovascular disease risk prevention [17–19].

In addition to obesity, cross-sectional studies also show low cardiorespiratory fitness being a risk factor associated with metabolic syndrome; however, the relationship between fitness and fatness with metabolic syndrome is complex. Higher cardiorespiratory fitness is associated with more favorable metabolic health even among obese individuals, yet the relative importance of fitness regardless of body composition remains unclear [20–24]. A prospective longitudinal study of 3,148 healthy adults, ages 18 or older, by Lee and colleagues [25] found that maintaining or improving fitness from baseline to an average follow-up of 6.6 year, appeared to attenuate, but not eliminate, some of the negative effects of fat gain as related to the risk of developing metabolic syndrome, and that lowering body fat from baseline lowered the increased risk of developing metabolic syndrome associated with fitness loss.

Discrepancies among findings related to the relative combined contributions of cardiorespiratory fitness and fatness with metabolic syndrome could be due to the use of different methods for measuring fitness and fatness [25]. Studies frequently use self-reported physical activity which may be more prone to overestimation, particularly in sedentary populations such as rural women, rather than objective measures of cardiorespiratory fitness [26]. Fatness is most frequently defined as being above a certain measure of body mass index (BMI), because BMI is an easy to assess, low cost, and convenient measure. Recent literature suggests that as obesity management is becoming a larger public health priority, the detection of obesity may need to include measurement of percent body fat, as the NIH BMI-based classification ($\geq 30\,\text{kg/m}^2$) may significantly underestimate the prevalence of obesity when compared to percent body fat [27–30]. Blew and colleagues suggest that a lower cut-score of BMI ($\geq 25\,\text{kg/m}^2$), referred to as revised BMI in this paper, may be superior for diagnosing obesity in postmenopausal women [29]. Fitness and fatness as risk factors may vary in adult populations, in part due to differences in race/ethnicity or other factors [31].

We did not find studies that specifically examined objective measures of fitness and percent body fat or their associations in the targeted health disparities group of rural Midwestern US midlife and older women, especially women with prehypertension. Individuals with prehypertension, defined by the Joint National Committee on the Prevention, Detection, and Treatment of High Blood Pressure (JNC 7) as a systolic blood pressure of 120–139 mmHg and/or diastolic blood pressure of 80–89 mmHg, are at greater risk for developing hypertension [32]. Individuals having blood pressures in the upper half of the prehypertensive range (130–135/85–89 mmHg) have more than a 2-fold increase in relative risk from cardiovascular disease compared to those with normal blood pressure [32].

This study investigated the fitness, fatness, and metabolic syndrome in an understudied population of rural Midwestern US midlife and older women who were prehypertensive and enrolled in the *Wellness for Women: DASHing toward Health* community-based clinical trial. Specifically, the purposes of this cross-sectional study were to (1) describe estimated cardiorespiratory fitness, BMI, percent body fat, and metabolic syndrome in midlife and older rural women with prehypertension, and (2) investigate associations of fitness and/or fatness with the occurrence of metabolic syndrome. We anticipated that women enrolled in this *DASHing toward Health* clinical trial might have a high prevalence of metabolic syndrome, as all had documented blood pressures in the prehypertensive range and were not taking any antihypertensive medication.

2. Methods

2.1. Study Population. This study cohort included rural women with prehypertension, ages 40–69, who were enrolled in the *Wellness for Women: DASHing Towards Health* community-based randomized-controlled trial. Briefly, this community-based clinical trial compared the effectiveness of two theory-based tailored 12-month interventions for promoting healthy eating and activity using different delivery methods (Internet or mailed printed materials) to standard advice only, with the goal of facilitating a reduction in blood pressure among rural women with prehypertension who were not candidates for drug therapy. Data presented here were obtained at baseline of the trial.

Recruitment methods included advertisements for women to participate in free community-based blood pressure screenings and participation by having a booth at local health fairs, craft shows, and other social events. Women with blood pressure readings at screening sites that were from 10 mmHg below to 10 mmHg above the prehypertension systolic range or five mm Hg below to five mmHg above the prehypertension diastolic range were told briefly about the study. If interested, women were asked to provide their phone and address for mailing study information and for a follow-up screening interview to establish eligibility for the study. To confirm prehypertensive status for inclusion in the study, women attended two visits one week apart to assess blood pressure by research nurses at our local research office. Written informed consent was obtained from all subjects prior to participation. The

Institutional Review Board of the University of Nebraska Medical Center approved this study (approval no. 352-05-FB).

Other inclusion criteria included being able to walk one-mile without an assistive device or oxygen and answering "no" to all questions on the Physical Activity Readiness Questionnaire (PAR-Q) or obtaining medical clearance from their physician to participate [33]. Women with type II diabetes were permitted to participate unless they were insulin dependent. Women were excluded from the study if they were taking antihypertensive medication, including diuretics, or systemic glucocorticoids, or if they reported consuming more than 14 alcoholic drinks per week. Women were excluded if they were unable to walk one mile continuously without stopping to rest and/or presented with other physical or medical restrictions that would preclude following the JNC 7 recommendations for moderate physical activity and healthy eating. Smokers were permitted to enroll with smoking status noted.

A total of 289 rural women ages 57.8 ± 7.6 years participated. The women were primarily non-Hispanic white (97.2%), married (83%), employed outside of the home full- or part-time (79%), had some education beyond high school (82%), and lived in a household with $40,000 or more income (71.2%) (see Table 1). Only 16 (5.5%) of the participants had type II diabetes, of which nine of the 16 had metabolic syndrome.

2.2. Study Design. Cross-sectional baseline data was examined from women enrolled in the *Wellness for Women: DASHing toward Health* community-based clinical trial. Participants were scheduled for two visits scheduled one week apart at a centralized research office located within 70 miles of their homes. For the second visit, a minimum of 12 hours of fasting was required for blood samples.

2.3. Blood Pressure Assessment. Blood pressure was assessed following five minutes of quiet sitting. A calibrated mercury sphygmomanometer with an appropriate size cuff for each woman was used following standardized ausculatory methods [34]. At each visit, at least two blood pressure measurements were obtained, separated by at least 30 seconds. Systolic blood pressure was the appearance of the first Korotokoff sound. Diastolic blood pressure was the disappearance of Korotkoff sounds. At each visit, the blood pressure was the mean of the two measurements that were within 5 mmHg for both systolic and diastolic measures. The baseline blood pressure recorded was the mean of the two final blood pressure measurements across the 2 visits. Participants were asked to avoid caffeine, exercise, and smoking for at least 30 minutes prior to a measure.

2.4. Blood Analyses. Blood specimens were drawn after a 12-hour fast to determine high-density lipoprotein (HDL-C), triglycerides, and fasting glucose following a standardized protocol [35] to be used for calculating the presence of metabolic syndrome.

2.5. Anthropometry and Body Composition. The Tanita Model (TBF-215, Tanita Corporation of America, Inc., 2625 S. Clearbrook Dr., Arlington Heights, IL 60005-9824) was used in this field trial to measure height, weight, and percent body fat following the manufacturer's recommendations. Each woman was measured at least two times until two exact measures of height were obtained. BMI was calculated as weight in kilograms divided by height in meters squared. As the bioelectrical impedance analysis system methodology for determining percent body fat is sensitive to hydration status, women were asked to fast within 4 hours of the test, not exercise within 12 hours of the test, avoid alcohol or diuretics before testing, and to void the bladder within 30 minutes of the test [36]. Although the bioelectrical impedance method for estimating body fat percentage underestimates the percent body fat compared to the underwater weighing and dual X-ray absorptiometry (DXA) methods, this method nevertheless was appropriate for the overall community-based clinical trial because it is a safe, non-invasive, and reliable clinical method shown to detect similar changes in percent body fat during weight loss in obese women that were comparable to the magnitude of change as determined via DXA [36–40].

Waist circumference was measured by placing a tape in a horizontal plane around the abdomen at the level of the iliac crest. The tape was snug and parallel to the floor but was held without skin compression. The measurement was taken at the end of expiration, with the average of two trials recorded [41, 42].

2.6. Cardiorespiratory Fitness. Cardiorespiratory fitness was estimated using the submaximal 1-mile walk test, a safe and adaptable test for the women in this community-based trial, whereby each woman was asked to walk as fast as possible over a 1-mile indoor track. Estimated $\mathrm{VO_2max}$ was calculated using weight, age, gender, total walk time, and 15-second post-activity heart rate in the equation validated for older women [43]. All women were able to complete the 1-mile walk.

2.7. Metabolic Syndrome Classification. Metabolic syndrome was defined in this study according to the Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults, Adult Treatment Panel III (NCEP ATP III) [44] which includes three or more of the following: waist circumference >88 centimeters; systolic blood pressure of ≥130 mmHg or diastolic blood pressure of ≥85 mmHg; fasting plasma glucose ≥100 mg/dL or on medication for high blood glucose; HDL cholesterol <50 mg/dL; or triglycerides of ≥150 mg/dL. The NCEP ATP III guidelines include women on antihypertensive medication as a criterion; however, eligibility criteria for this study excluded women on any antihypertensive medication so this was not an issue.

2.8. Data Analysis. IBM SPSS Statistics, Version 19 for Windows (SPSS Inc, Chicago IL) was used to analyse the data. To address the first purpose of this paper, descriptive statistics were used to describe the sample, and a χ^2 test was used to compare women with and without metabolic syndrome with respect to demographic characteristics (e.g., education, employment), self-reported health, estimated cardiorespiratory fitness, BMI, percent body fat, and the five criteria comprising metabolic syndrome.

To address the second purpose of this paper, logistic regression was used to predict the occurrence of metabolic syndrome from percent body fat and cardiorespiratory fitness as continuous variables, alone and in combination. All models were adjusted for age, income, and education. Because the literature indicates that cardiorespiratory fitness may influence metabolic health regardless of fatness, we fit a hierarchical model with step 1 including percent body fat only, step 2 adding the estimated VO_2max, and at step 3 adding the product of percent body fat and estimated VO_2max in order to evaluate the possibility that the effect of one might depend on the level of the other (interaction).

We also used a second method to examine the combined effects of cardiorespiratory fitness and body composition to predict occurrence of metabolic syndrome from the fitness and fatness categories using logistic regression where women were grouped into four categories of (1) "fit and not fat", (2) "fit and fat," (3) "not fit and not fat", and (4) "not fit and fat," using literature cited cut-scores for "fit" and "fat." We repeated this analysis using both percent fat and BMI, as practitioners in the field are likely to find BMI a more easily implemented method of determining obesity in rural patients/clients than is the percent body fat.

Cardiorespiratory fitness was classified as "unfit" (≤25 mL/kg/min) or "fit" (>25 mL/kg/min), consistent with age-appropriate guidelines by the American College of Sports Medicine (ACSM) where the cut-score selected was closest to the mean age of our population [37]. Those women with a percent body fat ≥30% were considered "fat" and those with <30% were considered "not fat" consistent with the literature for midlife and older women [28]. For BMI, we used the revised cut-score of BMI $\geq 25\,\text{kg/m}^2$ to categorize women as "fat" and $<25\,\text{kg/m}^2$ to categorize women as "not fat" as recommended by Blew and colleagues, rather than the NIH BMI cut- score ($\geq 30\,\text{kg/m}^2$), as this lower cut-score is purported to better correlate with percent body fat to define obesity in postmenopausal women [29]. As none of the women in the "fit/not fat" and "unfit/not fat" had metabolic syndrome regardless of which measure of body composition was used to create the categories, we omitted these two categories from the logistic regression analyses to avoid the estimation problems that such structural zeros cause. All logistic regression models were adjusted for age, education, and household income. In all analyses, alpha of 0.05 was used.

3. Results

Of the 289 rural women, 31% ($n = 90$) of women met the criteria for metabolic syndrome, of which 70% were classified as obese by NIH BMI standards ($\geq 30\,\text{kg/m}^2$), and all were classified as obese using the revised BMI score ($\geq 25\,\text{kg/m}^2$) [29] and the percent body fat cut-score (≥30%), respectively. None of the 18.3% ($n = 53$) classified as normal weight by the revised BMI (20–$24.9\,\text{kg/m}^2$) or as having <30% body fat (26.6%; $n = 53$) met the definition of metabolic syndrome.

Table 1 highlights the characteristics of the total sample and women categorized with and without metabolic syndrome. Overall, 40.1% ($n = 116$) of women reported their general health as very poor to fair, with 51% ($n = 46$) of women with metabolic syndrome reporting very poor to fair general health. Differences were observed in estimated fitness categories, BMI, percent body fat, and all five criteria for metabolic syndrome between women categorized with and without metabolic syndrome, with women classified with metabolic syndrome having less desirable results. Rates of obesity in the total sample was 41.8% ($n = 127$), 81.7% ($n = 236$) and 94% ($n = 273$) as defined by NIH based BMI, the revised BMI, and percent body fat, respectively.

Table 2 presents the results of the logistic regression models, adjusted for age, income and education, predicting occurrence of metabolic syndrome from body percent body fat and fitness, alone and in combination. Higher body fat percentage (OR = 1.21, 95% CI = 1.14–1.29, $P < 0.001$) was significantly associated with metabolic syndrome (Model 1). Fitness category considered alone also was a significant predictor, with the odds of having metabolic syndrome 7% lower with higher fitness (OR = 0.93, 95% CI = 0.90–0.97, $P = 0.001$). With body fat percentage, addition of the estimated VO_2max and/or the interaction of percent body fat and fitness did not significantly improve the fit of the model.

Table 3 illustrates logistic regressions predicting metabolic syndrome by "unfit/fat" and "fit/fat" categories using the two body composition methods. When using body fat percentage, being in the "fit" group reduced the odds of metabolic syndrome by approximately 75% compared to being in the "unfit" group (OR = 0.25, 95% CI = 0.12–0.52, $P < 0.001$). A similar pattern was observed when the revised BMI obesity cut-score as appropriate for postmenopausal women, with a reduction in odds of metabolic syndrome by 59% (OR = 0.41, CI = 0.19–0.87, $P = 0.02$).

4. Discussion

This study explored the associations between fitness and fatness with the presence of metabolic syndrome in an understudied population of midlife and older rural US Midwestern women with prehypertension. Because the cohort consisted of women with documented prehypertension, we anticipated these women might have a high prevalence of metabolic syndrome. Though rural populations differ from each other, our findings that 31% of this cohort had metabolic syndrome was similar to the work of Vaughan and associates [15] who reported that 33% of rural Australian women ages 25–74 years were classified as having metabolic syndrome. However, our prevalence of metabolic syndrome (31%) was much less than the 40.2% reported for rural women across the USA from the 1999–2006 NHANES data [5], perhaps in part due to our inclusion/exclusion criteria which included women

Table 1: Characteristics of rural women with prehypertension according to the presence of metabolic syndrome.

Variable	Total sample $n = 289$		No metabolic syndrome $n = 199$		Metabolic syndrome $n = 90$		P
	n	(% yes)	n	(% yes)	n	(% yes)	
White	283	97.9%	197	99.0%	86	95.6%	NS
Rural residency							NS
On farm/ranch or in country	82	28.4%	56	28.1%	26	28.9%	
In town <2,500	38	13.1%	27	13.6%	11	12.2%	
In town 2,500–19,999	31	10.7%	23	11.6%	8	8.9%	
In town 20,000–49,999	114	39.4%	79	39.7%	35	38.9%	
In town ≥50,000	24	8.3%	14	7.0%	10	11.1%	
Education							NS
High school or lower	52	18.0%	29	14.6%	23	25.6%	
Some college	119	41.2%	87	43.7%	32	35.6%	
College grad or above	118	40.8%	83	41.7%	35	38.9%	
Employment							NS
Full time	175	60.6%	126	63.3%	49	54.4%	
Part time	53	18.3%	33	16.6%	20	22.2%	
Household income							NS
< $20,000	20	6.9%	12	6.0%	8	8.9%	
$20,000 to $39,999	62	21.5%	37	18.6%	25	27.8%	
$40,000 to $59,999	79	27.3%	55	27.6%	24	26.7%	
$60,000 or higher	127	43.9%	94	47.2%	33	36.7%	
Smoke cigarettes	16	5.5%	11	5.5%	5	5.6%	NS
General health categorized							0.037
Very good	41	14.2%	31	15.6%	10	11.1%	
Good	132	45.7%	98	49.2%	34	37.8%	
Very poor to fair	116	40.1%	70	35.2%	46	51.1%	
Estimated VO_2max (mL/kg/min)							<0.001
≤25	190	65.7%	112	56.3%	78	86.7%	
>25	99	34.3%	87	43.7%	12	13.3%	
NIH-based BMI category (kg/m^2)							<0.001
Normal (<25)	53	18.3%	53	26.6%	0	0.0%	
Overweight (25–29.9)	109	37.7%	82	41.2%	27	30.0%	
Obese (≥30)	127	43.9%	64	32.2%	63	70.0%	
Revised BMI category (kg/m^2)*							<0.001
Normal (<25)	53	18.3%	53	26.6%	0	0.0%	
Obese (≥25)	236	81.7%	146	73.5%	90	100.0%	
Body fat (%)							0.006
<30	16	5.5%	16	8.0%	0	0.0%	
≥30	273	94.5%	183	92.0%	90	100.0%	
Metabolic syndrome criteria							
Waist circumference (cm)							<0.001
≤88	67	23.2%	70	35.2%	1	1.1%	
>88	222	76.8%	129	64.8%	89	98.9%	
Triglyceride (mg/dL)							<0.001
<150	207	71.6%	181	91.0%	26	28.9%	
≥150	82	28.4%	18	9.0%	64	71.1%	
HDL (mg/dL)							<0.001
≥50	198	68.5%	177	88.9%	21	23.3%	
<50	91	31.5%	22	11.1%	69	76.7%	

Table 1: Continued.

Variable	Total sample $n = 289$		No metabolic syndrome $n = 199$		Metabolic syndrome $n = 90$		P
	n	(% yes)	n	(% yes)	n	(% yes)	
Blood pressure (mmHg)							<0.001
<130/85	163	56.4%	135	67.8%	28	31.1%	
≥130/85	126	43.6%	64	32.2%	62	68.9%	
Glucose (mg/dL)							<0.001
<100	251	86.9%	190	95.5%	61	67.8%	
≥100	38	13.1%	9	4.5%	29	32.2%	

P values are from χ^2 test. Significance level $P \leq 0.05$.
*Revised BMI categories are based upon the work of Blew and colleagues [29].

Table 2: Logistic regressions predicting the metabolic syndrome from percent body fat and estimated cardiorespiratory fitness.

	Model 1				Model 2				Model 3			
	b	OR	95% CI	P	b	OR	95% CI	P	b	OR	95% CI	P
% Body fat	0.19	1.21	1.14–1.29	<0.001	0.22	1.25	1.16–1.35	<0.001	0.12	1.13	0.92–1.37	NS
Fitness					0.04	1.04	0.98–1.10	NS	−0.18	0.84	0.57–1.23	NS
% Body fat × fitness									0.01	1.01	1.00–1.01	NS
Fitness	−0.7	0.93	0.90–0.97	0.001								

All models were adjusted for age, education, and household income.
Nagelkerke R squares were 0.25, 0.26, and 0.27 for % Body Fat Models 1, 2, and 3, respectively.
Nagelkerke R square was 0.09 for Fitness Model 1.

able to walk one-mile without assistance and excluded women with hypertension.

While the overall cohort had a high percentage (40.1%) who reported their quality of health being very poor to fair, the percentage of women with metabolic syndrome who rated their health as very poor to fair was much higher (51%). This is consistent with findings from other rural US Midwestern women [12]. Of those with metabolic syndrome, the finding of a high prevalence of both obesity and low estimated cardiorespiratory fitness are of concern, as the evidence demonstrates that obesity, particularly abdominal obesity, is a core component of metabolic syndrome [7] and that a minimal level of cardiorespiratory fitness is important for overall health [45].

Our results are consistent with the work of Shah and Braverman [27] who compared BMI to a direct determination of percent body fat using duel energy X-ray absorptiometry (DXA) with findings that NIH-based BMI standards for defining obesity significantly underestimated the prevalence of obesity, especially in women with advancing age. Although we used the bioelectrical impedance method for estimating percent body fat which has a large standard of error estimation of 3.5 to 5.0% and tends to underestimate the percent body fat compared to the gold standard of dual-X-ray absorptiometry (DXA), we felt that examining body composition using bioelectrical impedance analysis for percent body fat would further inform this study of rural women [37, 38]. We did attempt to reduce the risk of measurement error by having the participants follow pre-test control conditions that affect hydration levels.

As noted by Shah and Braverman [27], BMI may ignore the influence of sarcopenic obesity in aging women. For this reason, several groups of researchers have attempted to identify new cut-points for BMI that would better categorize individuals as obese, with studies suggesting obesity cut points for women should range from 24 to 25.5 kg/m^2 [27, 29, 30]. Our results also suggested the NIH BMI cut-score (≥30 kg/m^2) for obesity misclassified 50.5% of women who were defined as obese by percent body fat; however, the revised BMI cut-score resulted in a more similar percentage of women classified as obese (81.6%; $n = 236$) as those classified obese by body fat (94.5%; $n = 273$). Using a revised cut-score of ≥25 kg/m^2 to better categorize women as "fat" may explain why we found that "fit/fat" women (see Table 3) had lower odds of prevalent metabolic syndrome similar to that when using percent body fat in the analysis. Rural practitioners may want to consider using this revised BMI score to define obesity in midlife and older women.

While obesity is highly associated with a cluster of metabolic abnormalities, current studies suggest that 20–30% of obese individuals appear to maintain a favorable metabolic profile [8], perhaps due to having a higher cardiorespiratory fitness level. Aging has been associated with a decrease in lean mass and an increase in percent body fat, both which have been identified as contributing to the development of metabolic syndrome [7]. Hassinen et al. [23]

Table 3: Logistic regressions predicting metabolic syndrome by unfit/fat and fit/fat categories using two body composition methods.

	Cases	*b*	OR	95% CI	*P*
Model 1—fit/fat categories defining obesity by percent body fat					
Unfit/fat	78/188 (41.5%)		1		
Fit/fat	12/85 (14.1%)	−1.39	0.25	0.12–0.52	<0.001
Model 2—fit/fat categories defining obesity by revised BMI cut-score					
Unfit/fat	78/179 (43.6%)		1		
Fit/fat	12/57 (21.1%)	−0.90	0.41	0.19–0.87	0.02

"Fat" was defined as body fat cut-score ≥30% and as $\geq 25\,\text{kg/m}^2$ for revised BMI obesity cut-score.
"Fit" was >25 mL/kg/min. Both models were adjusted for age, education, and household income.
Both models excluded women classified as "Not-Fat" as there were no cases of Metabolic Syndrome in women classified as "Not-Fat".
Nagelkerke *R* square was 0.07 and 0.11 for Models 1 and 2, respectively.

studied women ages 57–79 with results that indicated low cardiorespiratory fitness could be considered a feature of metabolic syndrome. They used a more accurate measure of fitness, symptom-limited maximal exercise stress test on a cycle ergometer, in contrast to our 1-mile walk test which provided an estimate of cardiorespiratory fitness. Our findings were similar to Hassinen and colleagues [23] in that when examining the association of fitness alone with the presence of metabolic syndrome, women with higher fitness had 7% lower odds of having metabolic syndrome and fitness was associated with lower odds of metabolic syndrome when classified as "fit/fat" by either the percent body fat cut-score or the revised BMI cut-score. When we entered both % body fat and fitness as continuous variables, fitness was not significant. Our finding is also similar to Hassinen and associates [23] who found that abdominal obesity as measured by waist circumference markedly weakened the association between cardiorespiratory fitness and metabolic syndrome.

Our study is unique in that it included successful recruitment of a large sample of midlife and older rural women with prehypertension, an understudied population that is recognized for having health disparities. This study included complete data for all variables and included two body composition measures (percent body fat in addition to BMI) and an objective measure of estimated cardiorespiratory fitness.

Several limitations are noted. The cross-sectional design limited any interpretation of causality. Because recruitment used a convenience sample of female volunteers, the women in this study may not have been representative of, or generalizable to, the overall population of women of that region. There was potential for misclassification of both "fitness" and "fatness" due to the limitations of measurement methods selected for use in this community-based clinical trial (percent body fat via bioelectrical impedance and fitness via the 1-mile submaximal field test) as opposed to more direct, complex laboratory studies of DXA for percent body fat and a maximal, graded exercise test for fitness. Our women may not have been representative of the population-at-large as they were not hypertensive, able to walk at least one mile unassisted, and were volunteers seeking a lifestyle intervention to reduce blood pressure. In addition, we did not examine medications that might impact weight nor did we collect the proportion of women on statins or other lipid-lowering agents.

In conclusion, these rural women with prehypertension had a high prevalence of metabolic syndrome, placing them at high risk for cardiovascular disease. Metabolic syndrome was associated with a high prevalence of obesity, lower estimated cardiorespiratory fitness, and more self-reports of poor to fair health status. NIH BMI-based classifications appeared to underestimate obesity in this population whereas the revised BMI cut-score produced results that were similar to the percent fat cut-scores for defining obesity. Rural practitioners may find using a BMI cut-score of $\geq 25\,\text{kg/m}^2$ to be useful in defining obesity in this population.

Obesity and fitness, each alone, was associated with metabolic syndrome. There is an indication that fitness may be important to reducing the risk of metabolic syndrome, though the presence, and potentially the degree of fatness, may reduce this association.

Conflict of Interests

The authors declare no conflict of interests.

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