Psychological Well-Being and Metabolic Syndrome: Findings From the Midlife in the United States National Sample

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ABSTRACT

Objectives: Psychological well-being predicts favorable cardiovascular outcomes, but less evidence addresses biological mediators underlying these effects. Therefore, associations among well-being and metabolic syndrome (MetSyn) were examined in a national sample.

Methods: Survey of Midlife in the US participants (MIDUS; $n = 1205$) provided survey assessments of hedonic (positive affect, life satisfaction) and eudaimonic well-being (e.g., personal growth and purpose in life) at two waves 9 to 10 years apart. MetSyn components were measured during an overnight clinic visit at Time 2 only. Outcomes included the number of MetSyn risk factors and a binary outcome reflective of MetSyn status.

Results: The unadjusted prevalence of MetSyn was 36.6%. Life satisfaction (B [standard error {SE}] = −0.12 [0.04], $p = .005$), positive affect (B [SE] = −0.10 [0.04], $p = .009$), and personal growth (B [SE] = −0.10 [0.04], $p = .012$) predicted fewer MetSyn components and lower risk of meeting diagnostic criteria in fully adjusted models. Results were unchanged by adjustments for depressive symptoms, and were not moderated by age, sex, race, or socioeconomic status. Life satisfaction (B [SE] = −0.11 [0.05], $p = .023$) and a eudaimonic well-being composite (B [SE] = −0.11 [0.05], $p = .045$) also predicted fewer components and lower risk of meeting diagnostic criteria in longitudinal models.

Conclusions: Psychosocial resources, including positive affect, life satisfaction, and personal growth, predicted reduced risk for MetSyn both cross sectionally and longitudinally. Further work should examine consequences of these linkages for cardiovascular outcomes in intervention contexts.

Key words: hedonic well-being, eudaimonic well-being, metabolic syndrome.

INTRODUCTION

A growing body of research addresses the salubrious health effects of positive psychological functioning, which converges with the World Health Organization's view of health as a state of well-being and more than the absence of disease (1). Evidence supports independent health benefits of psychological well-being, which is more than the absence of negative psychological functioning, such as depression, anxiety, or anger (2). Indeed, well-being is a multidimensional domain that has been differentiated into related, but distinct, components. Hedonic well-being typically encompasses constructs such as positive affect, happiness, and life satisfaction. Eudaimonic well-being, in contrast, refers to evaluative judgments about people's lives, such as their sense of purpose and meaning and whether they perceive that personal talents and abilities are being realized (3,4). Major reviews have synthesized the wealth of evidence linking both hedonic and eudaimonic well-being to optimal health, including in the realm of cardiovascular risk, morbidity, and mortality (5,6). For example, purpose in life, a key component of eudaimonic well-being, has been found to prospectively predict both reduced risk of myocardial infarction (7) and reduced risk of stroke (8), independent of traditional cardiovascular risk factors. This work suggests that well-being predicts lower cardiovascular

GCRC = General Clinic Research Center, **HDL** = high-density lipoprotein, **MetSyn** = metabolic syndrome, **MIDUS** = Midlife in the United States, **RDD** = random digit dial

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Received for publication June 9, 2014; revision received February 9, 2015.

DOI: 10.1097/PSY.0000000000000192

morbidity and mortality in both healthy and patient populations, independent of health behaviors and traditional risk factors.

Identifying links between well-being and reduced cardiovascular morbidity and mortality invites inquiry into the biological processes mediating such associations. Hypothesized mediators include autonomic and neuroendocrine regulation (hypothalamic-pituitary-adrenal axis and sympathetic nervous system activation), inflammation, and cardiometabolic functioning (e.g., obesity, blood pressure, cholesterol, and glucose regulation). In the current report, we focus on cardiometabolic functioning, assessed via metabolic syndrome, using a large sample of adults across five decades of age. Metabolic syndrome is a constellation of central obesity, hypertension, dysregulated lipids, and insulin resistance or hyperglycemia. Individuals with metabolic syndrome have increased risk for cardiovascular disease, stroke, and Type 2 diabetes (9). Metabolic syndrome has a high prevalence rate (>30%) among US adults, with rates increasing in recent years (10). There are several definitions of metabolic syndrome in the literature, including the National Cholesterol Education Program's Adult Treatment Panel III, the World Health Organization, and the International Diabetes Foundation, which vary somewhat in the clinical cut points defining risk (9). In the current study, our primary outcome was based on Adult Treatment Panel III criteria given that this is the definition most commonly used for studies of psychological factors and metabolic syndrome (11).

Although no prior studies have examined links among hedonic or eudaimonic well-being with diagnostic metabolic syndrome, several have documented associations among well-being and individual components comprising metabolic syndrome. For example, high-density lipoprotein (HDL) cholesterol has been linked with greater optimism in the present sample (12) as well as with greater positive affect, personal growth, and purpose in life in a sample of older women (13). In the same sample of older women, positive affect further predicted lower levels of glycated hemoglobin over time (14). Positive emotions were associated with lower rates of hypertension in a sample of older Mexican Americans (15), and happiness was inversely related to ambulatory blood pressure in the Whitehall psychobiology study (16). A related positive psychological construct, perceived control, was cross sectionally associated with higher HDL cholesterol and lower glycated hemoglobin and waist circumference in a national sample of middle-aged and older Americans (17). Finally, life satisfaction was inversely associated with excess weight in a community sample of adolescents and young adults (18). In a recent review, emerging evidence supported associations among well-being and metabolic function, although limited evidence precluded drawing meaningful distinctions among different types of well-being (6). Findings were also less consistent regarding associations among eudaimonic well-being and glucose regulation and body composition. Few studies have incorporated both hedonic and eudaimonic well-being measures, which is essential to empirically test their comparative effects (cf Refs. (12,18–22)). Although hedonic and eudaimonic well-being measures are moderately correlated, they have previously demonstrated unique associations with central and peripheral health outcomes (4,6,13,23).

The aim of the current study was thus to examine associations between both hedonic and eudaimonic well-being with metabolic syndrome in a national sample of adults known as Midlife in the United States (MIDUS). In line with prior evidence, we hypothesized that both types of well-being, although capturing distinct components of positive psychological experience, would be associated with lower risk of metabolic syndrome. That is, both feeling good and being actively engaged in life may predict reduced risk for cardiometabolic factors implicated in multiple disease outcomes. Our initial analyses focused on cross-sectional associations, but we augment the analyses with longitudinal associations between a subset of well-being assessments, measured 9 to 10 years earlier, and currently assessed metabolic syndrome.

METHODS

Sample

Participants were from the MIDUS survey, which included more than 7000 noninstitutionalized adults in the first wave of data collection (1995–1996), recruited via random digit dialing (RDD) from the 48 contiguous states, siblings of the RDD sample, and a large sample of twins (24,25). MIDUS I data collection went from January 1995 to September 1996. Detailed information on the MIDUS I assessments and longitudinal retention is previously reported (22,23). The second wave (MIDUS II) began in 2004, with 75% of surviving respondents participating. Biological data were collected from a subset of MIDUS II respondents who agreed to travel to one of three General Clinical Research Centers (GCRCs) for an overnight visit. MIDUS II survey data collection ran from January 2004 to August 2005; biological data collection occurred between July 2004 and May 2009. There was a 43% response rate, reflective of the demanding protocol and extensive travel required for many participants (26). The biological subsample was comparable to the full MIDUS II sample on most demographic and health characteristics, but was better educated and less likely to smoke compared with nonparticipants. Detailed information on the biological sample, protocol, and available measures are previously reported (26). This study was approved by institutional review boards at Georgetown University; University of California, Los Angeles; and University of Wisconsin, Madison. All participants provided written informed consent. Descriptive statistics by metabolic syndrome status are provided in Table 1.

The biological sample included 1255 individuals. To examine race as a covariate, a small number of respondents were excluded ($n = 50$) who identified as a race other than white or black or African American; small cell sizes precluded investigating other racial or ethnic groups. Of the remaining

TABLE 1. Descriptive Statistics for Study Variables (n = 1205)

	No Metabolic Syndrome (n = 764)			Metabolic Syndrome (n = 441)		
Variable	M (SD)	%	Range	M (SD)	%	Range
Age, y	57.2 (11.8)		35–86	58.0 (11.2)		37–85
Sex, % female*		61.4			49.4	
Race, % black/African American		17.6			20.2	
Education*						
≤High school, %		26.1			31.4	
Some college, %		27.8			33.0	
≥College degree, %		46.1			35.7	
Marital status, % married		63.2			67.7	
Positive affect*	3.7 (0.8)		1–5	3.6 (0.7)		1–5
Life satisfaction*	7.8 (1.2)		2–10	7.6 (1.4)		2.75–10
M1 Life satisfaction (n = 982)*	7.9 (1.1)		2.5–10	7.7 (1.2)		3.33–9.75
Autonomy	37.2 (6.7)		17–49	37.6 (6.6)		14–49
Environmental mastery	38.6 (7.6)		11–49	38.0 (7.5)		12–49
Personal growth*	40.1 (6.6)		14–49	38.5 (6.8)		18–49
Positive relations with others	40.7 (7.3)		7–49	40.4 (7.0)		9–49
Purpose in life	39.8 (8.0)		15–49	39.0 (7.0)		10–49
Self-acceptance*	38.9 (8.0)		7–49	37.7 (8.5)		10–49
M1 Well-being composite (n = 981)*	0.06 (0.6)		−2.8–1.3	−0.07 (0.7)		−1.83–1.2
Waist circumference, cm*	91.5 (15.1)		60–187	107.9 (12.8)		75–170
Waist circumference criteria, % yes*		37.0			90.5	
Systolic blood pressure, mm Hg*	127.7 (18.1)		83–222	138.4 (16.0)		95–195
Diastolic blood pressure, mm Hg*	74.2 (10.8)		48–125	78.1 (10.1)		51–114
Blood pressure criteria, % yes*		41.6			77.1	
HDL cholesterol, mg/dl*	61.7 (17.3)		24–121	44.9 (13.9)		19–103
HDL cholesterol criteria, % yes*		10.5			61.0	
Triglycerides, mg/dl*	96.6 (43.9)		25–431	180.4 (95.3)		42–765
Triglycerides criteria, % yes*		8.5			58.5	
Glucose, mg/dl*	96.4 (25.6)		56–418	111.8 (29.9)		67–335
Glucose criteria, % yes*		19.7			71.8	
No. MetSyn symptoms*	1.2 (0.8)		0–2	3.6 (0.7)		3–5
Physical activity, min/wk*	384.9 (643.2)		0–5040	256.8 (495.0)		0–4080
Alcohol consumption, drinks/mo	14.5 (27.2)		0–278	13.4 (30.0)		0–405
Current smoking, % yes		14.8			14.7	
Cholesterol medication, % yes*		23.6			36.7	
Blood pressure–lowering medications, % yes*		30.6			47.4	
Glucose-lowering medications, % yes*		5.8			18.8	

M = mean; SD = standard deviation; M1 = Midlife in the United States I; HDL = high-density lipoprotein; MetSyn = metabolic syndrome.

* $p < .05$ when comparing individuals with and without metabolic syndrome by independent-samples t test or χ^2 tests.

respondents (n = 1205), 379 were twins (51.7% monozygotic) and 6 were siblings. The sample size for longitudinal analyses was reduced, given that the MIDUS II sample had been expanded to include a city-specific sample of African Americans (n = 201) (24). No prior well-being assessments were available for these respondents. Furthermore, 28 respondents did not provide well-being data at MIDUS I. Therefore, the sample size for longitudinal analyses was 981, including 368 twins (51.4% monozygotic) and 6 siblings.

Measures

Well-Being

All self-reported well-being scales were completed as part of the MIDUS I and II survey assessments. Eudaimonic well-being was based on Ryff's theoretical framework and included six scales: Autonomy, Environmental Mastery, Personal Growth, Positive Relations with Others, Purpose in Life, and Self-Acceptance (27,28). The original

scales each had 20 items, and other versions with 14 items per scale have been published (28–30). At MIDUS II, each scale had seven items, and internal consistency ranged from 0.66 to 0.84. Well-being was also measured at MIDUS I, but with limited scales (three items per scale), which had low internal consistency coefficients (0.36–0.59). Thus, for tests of longitudinal associations among well-being and metabolic syndrome, we used a composite measure of well-being from MIDUS I by summing all individual items (18 in total). Assessed this way, internal consistency was 0.80 for the total eudaimonic well-being measure from MIDUS I.

Hedonic well-being was assessed with positive affect and life satisfaction. Positive affect was assessed by an average rating of how much of the time respondents felt, "enthusiastic," "attentive," "proud," and "active" in the last 30 days on a four-point scale ($\alpha = .85$). These adjectives were derived from the Positive and Negative Affect Schedule (31). Assessed this way, positive affect was only measured at MIDUS II; the same measure was not available at MIDUS I. To assess life satisfaction, respondents were asked to rate five dimensions of their lives, including their life overall, work, health, relationship with their spouse/partner, and relationships with their children, on a scale from 0 (worst possible) to 10 (best possible). The scores for relationship with spouse/partner and relationship with children were averaged to create one "item." Our measure was calculated as the mean of this new item with the other three items, with higher scores reflecting greater overall life satisfaction (32). Life satisfaction was assessed identically at MIDUS I and MIDUS II, and internal consistency was 0.67 at both time points.

Metabolic Syndrome

Metabolic syndrome was assessed at MIDUS II only. Metabolic syndrome was defined by the National Cholesterol Education Program: Adult Treatment Panel III definition (33). Accordingly, participants were classified as meeting metabolic syndrome criteria when they had at least three of the following risk factors: central obesity (defined as waist circumference >102 cm for men or >88 cm for women), triglycerides ≥150 mg/dl, HDL cholesterol <40 mg/dl in men or <50 mg/dl in women, blood pressure ≥130 mm Hg systolic or ≥85 mm Hg diastolic, and fasting plasma glucose ≥100 mg/dl. Waist was measured at the narrowest point between the ribs and iliac crest by GCRC staff. Blood pressure was assessed in a seated position three times consecutively with a 30-second interval between each measurement, and the two most similar readings were averaged. Participants rested for 5 minutes before the first blood pressure assessment. The lipid panel and glucose were assessed from a fasting blood sample taken on the morning of the second day of the GCRC visit (Roche Diagnostics, Indianapolis, IN).

We used two outcome variables for metabolic syndrome. The first was a count of components described earlier, of which participants met the criteria, ranging from 0 to 5. The second outcome variable was dichotomous, reflective of whether participants met the definition of metabolic syndrome (34,35).

Covariates

Covariates were measured as part of the MIDUS II survey and biological assessments. Demographic variables included age, sex, educational attainment (12-response category variable ranging from no education to professional degree; used continuously), race (coded to reflect white or black/African American only), and marital status (married versus all other). Health behavior variables, collected at the GCRC visit, included current smoking status, alcohol consumption over the previous month, physical activity (self-reported minutes per week of moderate and vigorous activity), and medication usage, including blood pressure–lowering, cholesterol, or glucose-lowering medications.

Statistical Analyses

Hierarchical linear regression models were used to test cross-sectional associations among well-being and metabolic syndrome components, and associations between well-being and diagnostic metabolic syndrome status were examined in hierarchical logistic regression models. Model 1 included demographic variables, including age, sex, education, race, and marital status, entered in the first step. The well-being measures were added in the second step of the regression, with each scale entered in respective models (i.e., eight regressions total for the eight well-being indicators). Model 2 included demographic and health covariates on the first step, and well-being was added in the second step in separate regression models for each well-being scale.

Preliminary analyses revealed that the linkages between well-being and both metabolic syndrome outcomes were not moderated by age, sex, educational attainment, or race (p values > .10). All continuous variables were standardized as z scores. Thus, coefficients reflect the change in metabolic syndrome risk for an increase in well-being of 1 standard deviation. The α level was set to .05. Degrees of freedom varied slightly to reflect different degrees of missing data. No more than five individuals were missing data on any given variable other than race, and the sample size with complete data on all variables was 1193 for cross-sectional analyses. Because the MIDUS sample includes siblings and twins, assumptions regarding independent observations are violated. Thus, we conducted supplemental analyses using generalized estimating equation to adjust for biological dependencies in the data.

Identical models and covariates were used to test longitudinal associations among well-being (measured 9–10 years earlier at MIDUS I) and metabolic syndrome (measured at MIDUS II only). Appropriate measures of well-being from MIDUS II were included in the model. The sample size for the longitudinal analyses was reduced ($n = 981$), given missing data and that the MIDUS II sample had been expanded to include a city-specific sample of African Americans ($n = 201$) (26). No prior well-being assessments were available for these African American respondents.

RESULTS

Biological data to assess metabolic syndrome status were only available at Time 2. Respondents met the criteria for two components of metabolic syndrome, on average, and metabolic syndrome prevalence was 36.6%. Descriptive information for individuals with and without metabolic syndrome is presented in Table 1. Table 2 presents bivariate correlations for study variables. Lower educational attainment, male sex, less physical activity, less alcohol consumption, and usage of blood pressure, cholesterol, or glucose-lowering medication were associated with greater risk for metabolic syndrome in bivariate models. As would be expected, all individual components of the metabolic syndrome were correlated with metabolic syndrome status in the expected directions. MIDUS II positive affect and life satisfactions were moderately correlated with each other ($r = 0.48$) and with the eudaimonic well-being scales (r values = 0.20–0.54). Correlations among MIDUS II eudaimonic well-being scales ranged from 0.36 to 0.77. Of the metabolic syndrome components, well-being measures were consistently correlated with waist circumference, HDL cholesterol, and triglycerides, and less so with blood pressure and glucose.

Metabolic Syndrome Components

Hierarchical linear regression models were used to examine cross-sectional associations between well-being and

TABLE 2. Bivariate Correlations Among Study Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. MetSyn status	—											
2. No. MetSyn symptoms	0.84*	—										
3. Positive affect	−0.09*	−0.08*	—									
4. Life satisfaction	−0.11*	−0.09*	0.48*	—								
5. M1 Life satisfaction	−0.09*	−0.10*	0.35*	0.49*	—							
6. Autonomy	0.04	0.02	0.28*	0.20*	0.18*	—						
7. Environmental mastery	−0.04	−0.04	0.51*	0.53*	0.40*	0.49*	—					
8. Personal growth	−0.13*	−0.11*	0.41*	0.34*	0.21*	0.44*	0.57*	—				
9. Positive relations with others	−0.02	−0.02	0.41*	0.44*	0.35*	0.36*	0.63*	0.59*	—			
10. Purpose in life	−0.09*	−0.06*	0.47*	0.38*	0.29*	0.40*	0.63*	0.67*	0.60*	—		
11. Self-acceptance	−0.07*	−0.07*	0.54*	0.53*	0.35*	0.49*	0.77*	0.63*	0.67*	0.69*	—	
12. M1 Well-being composite	−0.08*	−0.10*	0.41*	0.39*	0.52*	0.39*	0.51*	0.48*	0.48*	0.51*	0.56*	—
13. Age	0.09*	0.04	0.17*	0.26*	0.22*	0.14*	0.24*	0.07*	0.21*	0.06*	0.18*	0.10*
14. Female sex	−0.14*	−0.12*	−0.01	−0.00	−0.01	−0.09*	−0.05	0.11*	0.13*	0.05	−0.01	−0.01
15. Black/AA race	0.05	0.03	0.07*	−0.21*	0.00	0.01	−0.15*	−0.09*	−0.17*	−0.04	−0.11*	−0.04
16. Education	−0.14*	−0.09*	0.04	0.12*	−0.04	0.07*	0.15*	0.22*	0.11*	0.14*	0.20*	0.12*
17. Married	0.01	0.05	0.01	0.22*	0.17*	−0.00	0.14*	0.07*	0.18*	0.14*	0.16*	0.17*
18. Waist circumference	0.61*	0.48*	−0.11*	−0.13*	−0.11*	0.08*	−0.04	−0.15*	−0.10*	−0.10*	−0.08*	−0.07*
19. Systolic blood pressure	0.42*	0.29*	0.05	0.02	0.04	0.03	0.07*	−0.04	0.07*	−0.01	0.01	0.04
20. Diastolic blood pressure	0.27*	0.17*	−0.03	−0.10*	−0.04	−0.03	−0.04	−0.07*	−0.05	−0.03	−0.06*	−0.00
21. HDL cholesterol	−0.52*	−0.45*	0.10*	0.06*	0.08*	−0.06*	0.07*	0.11*	0.07*	0.10*	0.07*	0.10*
22. Triglycerides	0.65*	0.55*	−0.12*	−0.12*	−0.11*	0.04	−0.09*	−0.11*	−0.05	−0.12*	−0.10*	−0.10*
23. Glucose	0.44*	0.36*	−0.00	−0.08*	−0.02	0.04	0.01	−0.02	−0.01	0.01	0.00	−0.01
24. Physical activity	−0.17*	−0.15*	0.09*	0.13*	0.09*	0.06*	0.13*	0.14*	0.08*	0.13*	0.12*	0.11*
25. Alcohol consumption	−0.08*	−0.06*	0.02	−0.03	0.02	0.01	−0.01	0.01	−0.07*	−0.00	−0.01	0.02
26. Current smoking	0.04	−0.00	−0.11*	−0.22*	−0.17*	−0.01	−0.16*	−0.12*	−0.17*	−0.16*	−0.19*	−0.14*
27. Cholesterol medication	0.16*	0.14*	0.07*	0.05	0.03	0.04	0.05	−0.03	0.04	0.02	0.04	−0.01
28. BP-lowering medications	0.22*	0.17*	0.00	−0.02	0.01	0.03	0.02	−0.03	0.06*	−0.00	−0.01	−0.01
29. Glucose-lowering medications	0.23*	0.21*	−0.02	−0.07*	−0.03	0.01	0.02	−0.04	−0.02	−0.02	0.01	−0.01

MetSyn = metabolic syndrome; M1 = Midlife in the United States I; AA = African American; HDL = high-density lipoprotein; BP = blood pressure. Triglycerides, glucose, physical activity, and alcohol consumption were all log transformed before calculating correlations to achieve normal distributions.
* $p \leq .05$.

metabolic syndrome components (Table 3). In Model 1, the first step of the regression included demographic variables only, including age (B [standard error {SE}] = 0.12 [0.04), $t(1193) = 3.04$, $p = .002$), female sex (B [SE] = −0.42 [0.08), $t(1193) = 5.17$, $p < .001$), black or African American race (B [SE] = 0.16 [0.11), $t(1193) = 1.42$, $p = .16$), educational attainment (B [SE] = −0.19 [0.04), $t(1193) = 4.75$, $p < .001$), and being married (B [SE] = 0.02 [0.09), $t(1193) = 0.20$, $p = .84$). Together, demographic variables accounted for 5.1% of the variance in metabolic syndrome components. Well-being measures were added in the next step, with each scale entered in respective models. Adjusting for demographic variables, higher levels of both dimensions of hedonic well-being (i.e., life satisfaction and positive affect) and three dimensions of eudaimonic well-being (i.e., personal growth, purpose in life, and self-acceptance) significantly predicted fewer metabolic syndrome components (Table 3, Model 1). In Model 2, demographic factors, health behaviors, and medication usage were added as covariates in the first step of regression models and well-being was added in the next step, with each scale entered in respective models. In fully adjusted models, greater life satisfaction ($t(1186) = 2.83$, $p = .005$), positive affect ($t(1183) = 2.62$, $p = .009$), and personal growth ($t(1181) = 2.52$, $p = .012$) remained significant

TABLE 3. Linear Regression Models With Well-Being Predicting Number of Metabolic Syndrome Components

	Model 1 Demographic				Model 2 Demographic + Health Covariates			
Variable	*B*	SE	*p*	ΔR^2	*B*	SE	*p*	ΔR^2
M2 Hedonic well-being								
Life satisfaction	−0.17	0.04	<.001	0.012	−0.12	0.04	.005	0.006
Positive affect	−0.14	0.04	<.001	0.010	−0.10	0.04	.009	0.005
M2 Eudaimonic well-being								
Autonomy	0.03	0.04	.44	0.000	0.05	0.04	.24	0.001
Environmental mastery	−0.06	0.04	.12	0.002	−0.04	0.04	.27	0.001
Personal growth	−0.13	0.04	.002	0.008	−0.10	0.04	.012	0.005
Positive relations	0.004	0.04	.92	0.000	0.01	0.04	.83	0.000
Purpose in life	−0.10	0.04	.016	0.005	−0.07	0.04	.063	0.003
Self-acceptance	−0.09	0.04	.024	0.004	−0.07	0.04	.069	0.002

SE = standard error; M2 = Midlife in the United States II.

All continuous variables were standardized as *z* scores, and coefficients reflect a change in metabolic syndrome risk for an increase in well-being of 1 standard deviation. Model 1 included age, race, sex, marital status, and education. Model 2 included Model 1 covariates plus smoking status, physical activity, alcohol consumption, and usage of cholesterol, blood pressure, and glucose-lowering medications. The ΔR^2 values reflect the amount of additional variance in metabolic syndrome components accounted for by well-being above and beyond the demographic factors (Model 1) and the demographic factors and health covariates together (Model 2), respectively.

predictors of fewer metabolic syndrome components, whereas purpose in life ($t(1181) = 1.86$, $p = .063$) and self-acceptance ($t(1181) = 1.82$, $p = .069$) were attenuated (Table 3, Model 2).

Metabolic Syndrome Status

Hierarchical logistic regression models were used to examine cross-sectional associations between well-being and diagnostic metabolic syndrome (Table 4). In Model 1, the first step of the regression included demographic variables only, including age (*B* [SE] = 0.07 [0.06], Wald = 1.21, $p = .27$), female sex (*B* [SE] = 0.49 [0.13], Wald = 15.39, $p < .001$), black or African American race (*B* [SE] = −0.20 [0.17], Wald = 1.28, $p = .26$), educational attainment (*B* [SE] = −0.20 [0.06], Wald = 10.15, $p = .001$), and being married (*B* [SE] = −0.19 [0.14], Wald = 1.80, $p = .18$). Together, demographic variables accounted for 3.6% of the variance in metabolic syndrome status. Well-being

TABLE 4. Logistic Regression Models With Well-Being Predicting Metabolic Syndrome Diagnosis

	Model 1 Demographic					Model 2 Demographic + Health Covariates				
Variable	*B*	SE	OR	95% CI	ΔR^2	*B*	SE	OR	95% CI	ΔR^2
M2 Hedonic well-being										
Life satisfaction	−0.21**	0.07	0.81	0.71–0.92	0.012	−0.16*	0.07	0.85	0.75–0.97	0.006
Positive affect	−0.19**	0.06	0.83	0.73–0.93	0.011	−0.15*	0.07	0.86	0.76–0.98	0.006
M2 Eudaimonic well-being										
Autonomy	0.04	0.06	1.04	0.92–1.17	0.001	0.07	0.07	1.07	0.94–1.21	0.001
Environmental mastery	−0.09	0.06	0.91	0.81–1.04	0.002	−0.07	0.07	0.93	0.82–1.07	0.001
Personal growth	−0.18**	0.06	0.83	0.74–0.94	0.009	−0.15*	0.07	0.86	0.76–0.98	0.006
Positive relations	−0.002	0.07	1.00	0.88–1.13	0.000	0.01	0.07	1.01	0.88–1.15	0.000
Purpose in life	−0.09	0.06	0.91	0.81–1.03	0.003	−0.07	0.07	0.93	0.82–1.06	0.001
Self-acceptance	−0.14*	0.06	0.87	0.77–0.98	0.006	−0.13†	0.07	0.88	0.77–1.00	0.004

SE = standard error; OR = odds ratio; CI = confidence interval; M2 = Midlife in the United States II.

All continuous variables were standardized as *z* scores, and coefficients reflect a change in metabolic syndrome risk for an increase in well-being of 1 standard deviation. Model 1 included age, race, sex, marital status, and education. Model 2 included Model 1 covariates plus smoking status, physical activity, alcohol consumption, and usage of cholesterol, blood pressure, and glucose-lowering medications. The ΔR^2 values reflect the change in Nagelkerke R^2 values between regression blocks with covariates only and blocks with covariates and well-being. This approximates the additional variance in metabolic syndrome status accounted for by well-being above and beyond the demographic factors (Model 1) and the demographic factors and health covariates together (Model 2), respectively.

* $p < .05$, ** $p < .01$, † $p < .10$.

measures were added in the next step, with each scale entered in respective models. In models adjusting for demographic factors, life satisfaction, positive affect, personal growth, and self-acceptance were significant predictors of lower risk of meeting metabolic syndrome criteria (Table 4, Model 1). In Model 2, demographic factors, health behaviors, and medication usage were added as covariates in the first step of regression models and well-being was added in the next step, with each scale entered in respective models. In fully adjusted models, the association between self-acceptance and metabolic syndrome was attenuated (Wald = 3.69, $p = .055$), whereas the associations between life satisfaction (Wald = 5.53, $p = .019$), positive affect (Wald = 5.33, $p = .021$), and personal growth (Wald = 5.38, $p = .020$) remained significant (Table 4, Model 2).

Role of Depressive Symptoms

To assess whether ill-being was affecting aforementioned results, depressive symptoms (assessed with the Center for Epidemiologic Studies Depression Scale (CES-D) (36) were added to models with well-being factors that were significant in fully adjusted models. CES-D scores in this sample ranged from 0 to 54 (mean [standard deviation] = 8.6 [8.2]). Bivariate correlations between well-being and depressive symptoms ranged from 0.24 to 0.53 (p values < .001). Life satisfaction and positive affect remained significant predictors of both outcomes with depressive symptoms included in fully adjusted models (components: positive affect: $t(1175) = 2.42$ [$p = .016$], life satisfaction: $t(1178) = 2.50$ [$p = .012$]; status: positive affect: Wald = 4.19 [$p = .041$], life satisfaction: Wald = 3.81 [$p = .051$]). Personal growth also remained a significant predictor of both outcomes (components: $t(1173) = 2.28$ [$p = .023$]; status: Wald = 3.84 [$p = .050$]).

Independence Among Well-Being Measures

To assess the relative independence among hedonic and eudaimonic well-being, additional models were run that controlled for the other variety of well-being. When a eudaimonic well-being composite was included in models with positive affect and life satisfaction, respectively, these hedonic measures remained significant predictors of metabolic syndrome. In fully adjusted models, positive affect significantly predicted metabolic syndrome components (B [SE] = −0.12 [0.05], $p = .012$) and status (odds ratio [OR] = 0.84, 95% confidence interval [CI] = 0.72–0.98, $p = .023$), as did life satisfaction (components: B [SE] = −0.13 [0.05], $p = .005$; status: OR = 0.84, 95% CI = 0.72–0.98, $p = .024$). Associations among personal growth and metabolic syndrome were attenuated when positive affect was included as an additional control (components: (B [SE] = −0.07 [0.04], $p = .13$; status: OR = 0.90, 95% CI = 0.78–1.04, $p = .16$).

Longitudinal Analyses

Table 5 presents longitudinal associations among well-being and both metabolic syndrome outcomes. Life satisfaction was assessed identically at MIDUS I and MIDUS II. Life satisfaction at MIDUS I correlated with life satisfaction at MIDUS II at $r = 0.50$ ($p < .001$). In line with the cross-sectional analyses, life satisfaction at MIDUS I significantly predicted both metabolic syndrome outcomes 9–10 years later controlling for MIDUS II life satisfaction, demographic, and health covariates. The eudaimonic well-being composite at Time 1 correlated with eudaimonic well-being composite at Time 2 at $r = 0.60$ ($p < .001$). The eudaimonic well-being composite from MIDUS I also significantly predicted number of metabolic syndrome components and metabolic syndrome status in fully adjusted models (controlling for MIDUS II eudaimonic well-being, demographic factors, and health covariates).[1]

Data Dependencies

Because the MIDUS sample includes a considerable number of siblings of the RDD sample and twins (37%), assumptions of independent observations are violated. To address these data dependencies, supplemental analyses used generalized estimating equations models with random intercepts for family clusters. The within-cluster covariance structure was specified as exchangeable. All conclusions drawn from reported results remained identical to those presented earlier, supporting that biological dependencies in the data did not bias results.

DISCUSSION

This was the first study to examine associations between both hedonic and eudaimonic well-being and metabolic syndrome in a national sample of adults. Previous research identified well-being as prospectively predictive of lower cardiovascular morbidity and mortality, but evidence linking well-being to intermediate biological processes has been limited in number and scope (6). Metabolic syndrome represents a potential biological mediator, and this study provided an important test of associations among multiple varieties of well-being with metabolic syndrome. Results from the current study demonstrated that several dimensions of well-being predicted lower risk of metabolic syndrome in cross-sectional and longitudinal models.

Specifically, after adjustments for sociodemographic factors, hedonic indicators of life satisfaction and positive affect, as well as eudaimonic indicators of purpose in life,

[1]To attenuate concerns of reverse causality in the lagged analyses (i.e., that healthier people rated higher well-being at Time 1), we additionally controlled for self reported number of chronic conditions at baseline. In these models, life satisfaction and eudaimonic well-being remained significant predictors of both metabolic syndrome outcomes.

TABLE 5. Longitudinal Models With Well-Being Predicting Metabolic Syndrome Outcomes

	DV: Metabolic Syndrome Components						DV: Metabolic Syndrome Status								
	Model 1 Demographic			Model 2 Demographic + Health Covariates			Model 1 Demographic					Model 2 Demographic + Health Covariates			
Variable	*B*	SE	*p*	*B*	SE	*p*	*B*	SE	OR	95% CI		*B*	SE	OR	95% CI
M1 Life satisfaction	−0.13	0.05	.015	−0.11	0.05	.023	−0.20*	0.08	0.82	0.70–0.96		−0.20*	0.08	0.82	0.69–0.97
M2 Life satisfaction	−0.11	0.06	.058	−0.04	0.06	.52	−0.14	0.09	0.87	0.73–1.04		−0.05	0.09	0.96	0.80. 1.15
M1 Eudaimonic composite	−0.12	0.06	.025	−0.11	0.05	.045	−0.26**	0.09	0.77	0.65–0.92		−0.26**	0.09	0.77	0.65–0.93
M2 Eudaimonic composite	0.01	0.06	.92	0.02	0.06	.71	0.06	0.09	1.06	0.88–1.27		0.08	0.10	1.09	0.90–1.32

DV = dependent variable; SE = standard error; OR = odds ratio; CI = confidence interval; M1 = Midlife in the United States I; M2 = Midlife in the United States II.

All continuous variables were standardized as *z* scores, and coefficients reflect a change in metabolic syndrome risk for an increase in well-being of 1 standard deviation. Model 1 included well-being at Midlife in the United States II, age, race, sex, marital status, and educational attainment. Model 2 added current smoking status, physical activity, alcohol consumption and usage of cholesterol, blood pressure, or glucose lowering medications.

* $p < .05$, ** $p < .01$.

personal growth, and self-acceptance, were all significant predictors of lower metabolic syndrome risk in cross-sectional models. Importantly, none of these sociodemographic factors functioned to moderate the associations among well-being and metabolic syndrome. Additional adjustments for health covariates, including health behaviors and medication usage, attenuated associations between self-acceptance and purpose in life, but all other aforementioned associations remained significant in fully adjusted models. Life satisfaction and the eudaimonic well-being composite also predicted lower risk of metabolic syndrome status in fully adjusted, longitudinal models. Of the metabolic syndrome components, associations were strongest among well-being and waist circumference, HDL cholesterol, and triglycerides. Thus, body composition and diet, as opposed to glucose metabolism directly, may be the most relevant targets of well-being interventions.

To examine the relative independence of these associations, additional models included depressive symptoms as well as both varieties of well-being included together. All associations with well-being and metabolic syndrome remained significant with depressive symptoms included in the model. These results coincide with considerable evidence supporting well-being and distress as separate dimensions and not simply two ends of the same continuum (4,37). Furthermore, both hedonic well-being measures remained significant predictors of metabolic syndrome with the eudaimonic composite in the model, supporting the distinctiveness among hedonic and eudaimonic well-being (3). However, associations among personal growth and metabolic syndrome were attenuated when positive affect was included as an additional control, suggesting that positive affect is implicated in the salubrious associations seen with personal growth. Personal growth reflects a sense of self-improvement, continued development, and realization of one's potential, which could lead to feelings of high positive affect. This observation calls for greater research on how various aspects of hedonic and eudaimonic well-being work together to contribute to better health outcomes. So doing will require studies that incorporate both types of assessment in the same investigation so as to investigate their individual and joint effects. This is one of a few studies that incorporate both hedonic and eudaimonic dimensions in the same article, which is critical to examine their relative contributions to health markers (cf Refs. (12,18–22)).

With regard to clinical implications, several promising interventions exist to improve well-being. Specifically, "well-being therapy" has been successful at reducing recurrence of major depression (38) and generalized anxiety disorder (39,40). Other interventions that increased hedonic well-being further showed reductions in visits to student health facilities (41). Early randomized controlled trials have been effective at increasing dimensions of eudaimonic well-being, specifically purpose in life, among patients

with cancer (42,43). Hedonic and eudaimonic well-being have been linked to healthier brain functioning, including prefrontal activation asymmetries (23), sustained activity in reward circuitry after positive stimuli (44), and faster recovery from negative emotional stimuli (45) as well as cortisol regulation (13,44), which likely constitute additional mechanisms underlying the health-promoting effects of well-being. Individuals with high well-being generally report lower rates of smoking, less abuse of alcohol, healthier diet, and more leisure time physical activity (6). These health behaviors are implicated in the pathogenesis of metabolic syndrome (46). In sum, well-being is modifiable, and such interventions may yield important physical health benefits.

Several study limitations warrant mention. Of primary concern is the lack of biological assessments at MIDUS I, precluding the testing of truly longitudinal relationships. Therefore, causality cannot be determined due to a lack of time-ordering among the predictor and outcome variables. We do, however, note stability in life satisfaction and the eudaimonic well-being composite over the 9- to 10-year interval. Furthermore, when self-reported chronic conditions at baseline were included as an additional control variable, both longitudinal well-being measures remained significant predictors of metabolic syndrome (data not shown), which attenuates but does not eliminate concerns that healthier individuals reported higher well-being at baseline, explaining the observed reduced risk of metabolic syndrome at follow-up. Second, there was limited representation of individuals from racial and ethnic minority groups, with the exception of city-specific sample of African Americans from Milwaukee, Wisconsin, in cross-sectional models. Thus, it is unknown whether these results generalize to a more representative sample of African Americans or to other racial and ethnic groups. Another limitation involved dissimilar assessments of well-being at MIDUS I and MIDUS II. A composite of eudaimonic well-being and life satisfaction were the only well-being measures with identical assessments at both time points, although we note that associations were largely similar in cross-sectional and longitudinal models. Internal consistency of the life satisfaction measure at MIDUS I and MIDUS II was relatively low ($\alpha = .67$), likely reflective of the multiple domains assessed with our measure (i.e., health, relationships, work, and life overall). Furthermore, the assessment of positive affect only tapped into high activation states, and thus, it is unknown whether the same associations with metabolic syndrome would emerge if low or medium activation states were assessed. Prospective analyses that can replicate and extend the current results represent an important avenue for future work. Finally, effect sizes were relatively small, with well-being accounting for 1% to 2% of the variance in metabolic syndrome outcomes. However, the magnitude of these associations is similar to that seen with age and educational attainment in this sample, which are both recognized as important risk factors for metabolic syndrome (9).

Despite these limitations, this research incorporated a comprehensive formulation of well-being, including its distinct hedonic and eudaimonic varieties. We also incorporated an objectively assessed outcome with important public health implications, namely, metabolic syndrome, and for the first time demonstrated that both hedonic and eudaimonic well-being contribute to this index of cardiometabolic risk. Finally, the study questions were investigated in a large sample of sociodemographically heterogeneous participants, including participants' ages spanning five decades. Findings supported the modest protective effects of well-being for metabolic syndrome in this sample, providing support for metabolic syndrome as a biological mediator of the links between well-being and cardiovascular morbidity and mortality.

Source of Funding and Conflicts of Interest: This work was supported by the National Institute on Aging at the National Institutes of Health (P01-AG020166) to conduct a longitudinal follow-up of the MIDUS investigation (Dr. Ryff). The original study was supported by the John D. and Catherine T. MacArthur Foundation Research Network on Successful Midlife Development. Support also came from the following grants: M01-RR023942 (Georgetown), M01-RR00865 (University of California, Los Angeles) from the General Clinical Research Centers Program, and 1UL1RR025011 (University of Wisconsin) from the Clinical and Translational Science Award program of the National Center for Research Resources, National Institutes of Health. J.M.B. is supported by a training grant from the National Heart, Lung, and Blood Institute (5T32HL007560-32). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute or the National Institutes of Health. Both authors declare no conflicts of interest.

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