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REGULAR ARTICLE

Personality Traits, Coping, Health-related Behaviors, and Cumulative Physiological Health in a National Sample: 10 Year Prospective Effects of Conscientiousness via Perceptions of Activity on Allostatic Load

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Abstract

Background Personality traits, coping styles, and health-related behaviors show associations with various aspects of health. However, integrative life-course investigations of pathways by which these factors might affect later cumulative physiological health risk remain sparse.

Purpose To investigate prospective associations of personality traits via coping styles and health-related behaviors on allostatic load in a national sample.

Methods Using data from the Midlife in the United States study (MIDUS; N = 1,054), path analyses were used to test direct and indirect associations (via coping styles, smoking, frequency of alcohol consumption, leisure-time physical activity, and perceptions of activity) of personality traits on a latent measurement model of allostatic load informed by 10 biomarkers associated with cardiovascular, inflammation, glucose, and lipid subsystems.

Results Direct 10 year associations of greater conscientiousness on healthier allostatic load and greater extraversion on less healthy allostatic load were observed. Consistent with hypothesized behavioral pathways, relationships between conscientiousness and extraversion on allostatic load were prospectively mediated by greater perceptions of activity. Physical activity and more frequent alcohol use were associated with healthier allostatic load but did not act as prospective mediators.

Conclusions The results provide further evidence of conscientiousness' standing as a marker of health via cumulative physiological health. Moreover, a greater perception of activity was identified as a pathway through which conscientious individuals experienced healthier physiological profiles over time. Examining a more detailed picture of the psychosocial mechanisms leading to development of health risk, as was found with perceptions of activity, remains an important area for future research.

Keywords: Personality · Conscientiousness · Coping · Activity · Allostatic load

Despite improved evidence to support the linkages among personality traits, health-related behaviors, and coping styles [1–7], temporally relevant integrations of these influences on physiological markers of health remain sparse [8]. An integrative life course risk chain model [9], which posits personality as a primary (premorbid) antecedent of health-related factors leading to physiological risk represents a viable framework for testing these pathways. This approach consolidates a number of epidemiological risk chains and depicts not only who is at greater risk for health decline but also how individuals experience different health outcomes over time. The links in this integrated life course risk chain model include social and behavioral factors (e.g., activity, diet, and interpersonal conflict) that can influence later pathology (e.g., hypertension, hypothalamic-pituitary-adrenal axis dysregulation, and systemic inflammation), which, over time, can result in disease and/or disability (e.g., cardiovascular diseases, physical function deficits, and cancer), ultimately informing who is at greatest risk for premature death.

This framework posits several potential avenues through which health status can be affected by personality. Guided by this framework, the broad aim of the

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present work was to test a prospective model of cognitive and behavioral pathways related to coping. The model aimed to identify the coping-related pathways through which personality traits might be associated with markers of physiological health risk. Specifically, the present research examined how personality traits were prospectively linked to coping strategies and related health behaviors, as well as a latent measurement model of physiological health risk—allostatic load. Allostatic load reflects a cumulative measurement of stress-related biomarkers that act in a "temporal cascade of multisystemic physiological dysregulation" [2, 10]. Identifying these biomarkers within their systems (e.g., neuroendocrine or immune) allows for the operationalization and measurement of maladaptive stress response patterns and can help identify disease trajectories over time. Using this latent construct, the present work also investigated the extent to which coping styles and coping-related health behaviors acted as prospective mediators of relations between personality traits and allostatic load. Investigating the mechanisms by which personality traits influence health is a necessary step for identifying candidate targets for intervention among those individuals who are at greatest risk. The following sections review the existing research linking personality traits, coping-related health-related behaviors, coping styles, and markers of physiological health risk

Personality Traits, Health-related Behaviors, and Coping Styles

Personality traits are associated with health-related behaviors, including smoking [11], excessive alcohol consumption [12], and inactivity [13], which, in turn, have been shown to be part of coping responses to stressors [2, 14–17]. Specifically, conscientious and emotionally stable individuals tend to be nonsmokers [18, 19]; conscientious, emotionally stable, and agreeable individuals consume less alcohol [12]; and conscientious, emotionally stable, extraverted, and open individuals are more likely to be active [20]. These behaviors, in part, reflect individual differences in coping patterns but also are contingent upon environmental and societal factors that affect the likelihood of individuals engaging in these behaviors.

Aside from links to health-related behaviors, research has shown associations between personality traits and coping styles—including primary and secondary control strategies—that are posited to play a role in health risk and resilience [21]. Primary control strategies include the active manipulation of the environment through brainstorming, planning, and implementation of solutions to address stressors [21]. Secondary control strategies include reappraisals of stressors designed to produce a positive outlook about a difficult situation, including the identification of benefits arising from the situation, as well as an acceptance of the aspects of the stressor that cannot be altered or addressed [22]. Primary (vs. secondary) control strategies may have greater putative adaptive value by allowing an individual to create a context in which needs can be met and, over time, facilitate developmental potential [23].

In meta-analytic work [21], the primary control strategy of problem solving has shown positive associations with conscientiousness and openness to experience and a negative association with neuroticism. Extraversion has shown positive associations with both primary problem solving and the use of direct social support [21]. Extraversion, agreeableness, openness, and conscientiousness have been linked to the secondary control strategy of cognitive restructuring, whereby an individual reframes how a "bad" situation is construed, favoring a "bright side" approach or identifying benefits derived from a stressor [21]. Neuroticism has been shown to be positively associated with withdrawal, wishful thinking, and disengagement such that a neurotic individual would be more likely to withdraw from a stressor [21].

Personality and Allostatic Load

Previous work examining associations between personality traits and physical health and mortality has produced reliable evidence for conscientiousness. Specifically, the Terman Life Cycle Study found that childhood conscientiousness significantly predicted lower mortality risk across a 65 year period [24]. Similarly, in the Hawaii Personality and Health Longitudinal Study, conscientiousness (in Grades 1, 2, 5, or 6) predicted less physiological dysfunction at age 45 [25]. In addition to findings for conscientiousness, an integrative data analysis across 15 international data sets consistently found greater neuroticism, lower conscientiousness, lower extraversion, and lower agreeableness to be associated with greater risk of mortality [26]. Other research investigating scales related to the Big Five personality traits found cynicism (disagreeableness) to be associated with greater all-cause and cancer mortality over a 45 year period [27]. Taken together, these findings suggest healthier outcomes for those individuals who are conscientious, agreeable, and extraverted and less healthy outcomes for highly neurotic individuals. Despite these links, it is less clear whether personality traits' links to morbidity and mortality are maintained, in part, by relations to surrogate markers of disease risk, such as allostatic load.

Allostatic load is a construct of physiological functioning intended to assess cumulative health risk as defined by a single or a few biomarkers ascribed to bodily systems involved in direct and indirect responses to stressors [28]. Allostatic load has been characterized as a chain of mediated psychophysiological processes that starts with the body's initial adaptation to stress and includes primary biochemical mediators (e.g., insulin, glucose, total cholesterol, high-density lipoprotein (HDL) cholesterol, and triglycerides) that act within biological systems (e.g. metabolic, cardiovascular, and immune), which are referred to as secondary outcome systems [10].

In terms of outcomes measured via allostatic load, most prior research investigating personality correlates have focused on a single indicator or only a few biomarkers [29–34]. For example, lower conscientiousness and extraversion and greater neuroticism have shown associations with greater interleukin 6 (IL-6), a proinflammatory cytokine [7, 35, 36]. Other research has shown conscientious-related traits to be associated with healthier diurnal cortisol secretion via perceptions of activity [37], as well as lower IL-6 levels via lower rates of smoking and lower weight [7]. Taken together, these findings for individual biomarkers of allostatic load suggest that personality traits may be linked to greater physiological dysregulation in response to cumulative stressors and related coping responses, including health behaviors. One recent study demonstrated personality traits' effects using a more comprehensive suite of biomarkers [38], showing greater conscientiousness and openness in both men and women, and agreeableness in men were concurrently associated with lower composite summary scores of allostatic load, while extraversion was positively associated with higher allostatic load in men. Finally, when looking at personality trait change over time, higher allostatic load has been found to be related to greater neuroticism, lower extraversion, lower conscientiousness, and declines in extraversion, conscientiousness, and agreeableness [39].

While research on associations between traits and allostatic load is emerging, an integration of traits, coping styles, and coping-related health behaviors with allostatic load using a temporally informed design is wanting. Such a process-oriented approach would allow for the identification of pathways contributing to cumulative physiological health

Coping Strategies and Allostatic Load

Despite coping strategies' putative functions as relatively stable response patterns to stressors and, thus, markers of the stress process, few studies have investigated associations between primary and secondary cognitive coping styles and allostatic load. In relation to self-reported health, some research has shown the use of primary control strategies to be associated with perceived health in younger individuals [40]. Cross-sectional evidence has found associations between coping and higher allostatic load for women who used disengagement coping [41]. Similar to the existing research on personality and allostatic load, as well as coping-related health behaviors and allostatic load, the dearth of research investigating coping strategies and allostatic load warrants a more comprehensive examination of the effects of personality traits, coping styles, and health behaviors on cumulative physiological health risk vis a vis allostatic load.

Health Behaviors and Allostatic Load

In addition to cognitive stress response strategies, behavioral mediators may also play a role in understanding personality traits' influence on physiological health. Varying perceptions of engagement in activities of day-to-day living, physical exercise, smoking, and alcohol consumption can be components of response patterns for individuals when faced with stressors [2, 14–17]. While these coping-related health behaviors have been shown to be associated with several health outcomes, the relationships between these behaviors and allostatic load remain largely untested. Previous work has typically focused on individual mediators/markers of allostatic load and specific health behaviors. Smoking tends to be associated with increased variability of systolic and diastolic blood pressure [42]. Physical activity levels have been shown to influence hypothalamic-pituitary-adrenal activity and decrease insulin resistance [43, 44]. Research on a composite index of allostatic load has found greater alcohol consumption and less physical activity to be associated with greater allostatic load [45–47]. In addition to physical activity, perceptions of activity have been found to be directly related to healthier patterns of diurnal cortisol secretion [37]. While no studies to date have assessed the influence of perceptions of activity on allostatic load, existing findings suggest that an active lifestyle (outside of what is formally considered leisure-time physical activity) may contribute to healthier aging and greater subjective well-being. Specifically, within activity, the domain of social activities has shown the most robust set of associations with well-being, health, or survival [48]. Taken together, the evidence to date suggests that the inclusion of perceptions of being active outside of leisure-time physical activity represents a potentially informative mediator. In sum, the literature suggests a likely influence of coping-related health behaviors on allostatic load. The present work tested this prediction by examining the prospective associations of smoking,

alcohol use, leisure-time physical activity, and perceptions of activity on a comprehensive set of biomarkers related to allostatic load.

The Present Study

Personality traits influence coping strategies and related responses to stress, including perceptions of activity, smoking, alcohol consumption, and physical activity, all of which may affect physiological risk for illness and disease. Using a prospective mediation design with three time points of data from the Midlife in the United States study (MIDUS), the primary aim of the present study was to test direct and indirect effects of personality traits on a latent measurement model of allostatic load through primary and secondary coping strategies and smoking, alcohol use, physical activity, and perceptions of activity. Typically, tests of age-related mediation utilize a cross-sectional approach, which can produce biased estimates of parameters [49]. In contrast, the present work benefitted from a prospective design allowing for the minimization of the risk for bias produced from time-related mean-level differences in cross-sectional methodologies [50]. The present work was, therefore, well suited to evaluate the aging-related causal hypotheses that were investigated.

In addition, the existing literature on allostatic load relies upon idiosyncratic assessments of single biomarkers and/or the use of summary scores. The present work leveraged recent applications of structural equation modeling in the construction of allostatic load [51]. Biomarkers were partitioned first to reflect several physiological subsystems. Subsequently, these systems informed latent standing on allostatic load. Compared to a summary composite score, this approach retained the information value of individual biomarkers as they may differentially inform the construct of health risk [51].

Initial conceptualizations of allostatic load [7] suggested that biomarkers fall into three categories: metabolic, cardiovascular, and immune. Recent research has shown three related factors to demonstrate the largest contributions to a common allostatic load factor (inflammation, glucose, and lipid; [51]). As a result, the present work used these and related findings to construct a hierarchical measurement model of allostatic load, wherein individual biomarkers reflected the three latent primary subsystems, which, in turn, informed latent standing on allostatic load. Pulse rate was included as an additional manifest biomarker for allostatic load based on prior research that showed resting heart rate to be an independent risk factor for cardiovascular disease and cardiovascular mortality risk [52–54]. The use of a hierarchical approach provides a more parsimonious model for future work on allostatic load by utilizing those biomarkers that are theoretically and empirically informative of the construct while partitioning error variance.

Greater conscientiousness, extraversion, openness, agreeableness, and lower neuroticism were hypothesized to be prospectively associated with lower allostatic load over 10 years (Fig. 1). Among the coping strategies, greater overall sense of control was hypothesized to be associated with lower allostatic load. The primary control strategy of persistence in goal striving and the secondary control strategy of positive reappraisals were hypothesized to be associated with lower allostatic load. The secondary control strategy of lowering aspirations was hypothesized to be associated with greater allostatic load. Finally, the behaviors of smoking and alcohol consumption were expected to be associated with greater allostatic load, while both leisure-time physical activity and perceptions of activity were expected to be associated

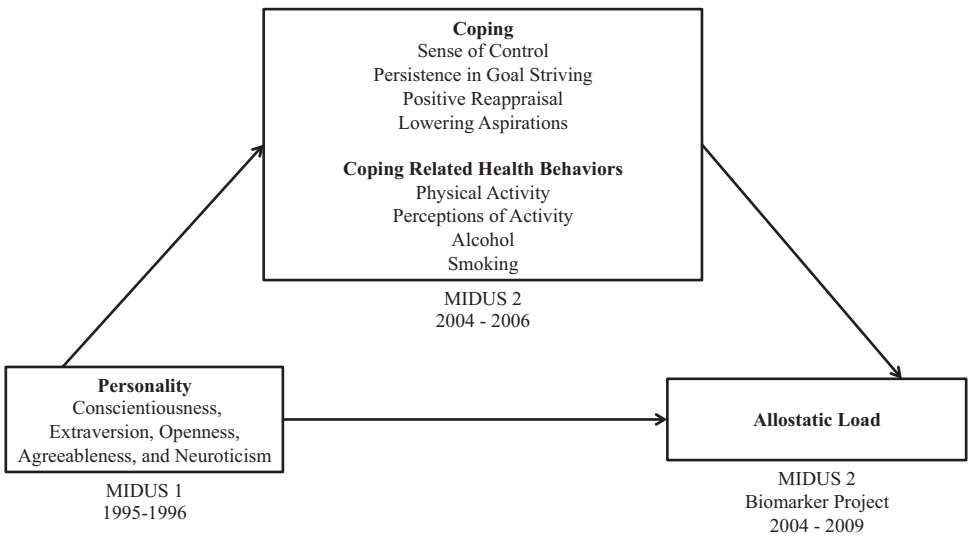

Fig. 1. Expected direct and indirect trait relations to allostatic load via coping strategies and coping-related health behaviors.

with lower allostatic load. Further, the prospective effects of greater conscientiousness and extraversion on lower allostatic load were expected to be mediated, in part, by primary control strategies and greater involvement in physical activity and greater perceptions of activity. The prospective effect of neuroticism on allostatic load was expected to be mediated, in part, by greater use of lowering aspirations and greater frequency of smoking and alcohol consumption. Finally, the prospective effect of openness on allostatic load was expected to be mediated by positive reappraisals and greater physical activity. Figure 1 depicts the hypothesized pathways from personality traits to allostatic load via coping strategies and coping-related health behaviors.

Method

The data for the present study were drawn from three data collection projects from the MIDUS study, an ongoing longitudinal study of health and aging. The original MIDUS I sample was acquired in 1995–1996 by the MacArthur Foundation Research Network on successful Midlife Development and consisted of adults aged 25–74 (N = 7,108). The first follow-up project, MIDUS II (N = 4,963), was completed during 2004–2006. From MIDUS II, a subsample (n = 1,255) participated in the Biomarker Project, which collected data from 2004 to 2009 and included comprehensive biomarker assessments. After the exclusion of individuals who, by design, did not have data at all three waves of data collection, a final sample of 1,054 participants was retained for the current study. Additional information regarding the procedures of data collection can be found on the MIDUS Web site: http://midus.wisc.edu/midus1/samples.php. Descriptive statistics for the study variables can be found in Table 1.

Measures

The personality traits of neuroticism, extraversion, openness, agreeableness, and conscientiousness were measured during MIDUS I with a measure of personality dimensions [55] comprised of 30 self-descriptive adjectives from previous inventories of the Big Five [56]. Participants were asked to respond on a scale from 1 (a lot) to 4 (not at all) and items were recoded so that greater scores reflected greater standing on a personality dimension. In the present study, reliability alphas were as follows: neuroticism ("moody," "worrying," "nervous," "calm" (r) α = .75), extraversion ("outgoing," "friendly," "lively," "talkative" α = .77), openness ("creative," "imaginative," "intelligent," "curious," "broad-minded," "sophisticated," "adventurous" α = .76), agreeableness ("helpful," "warm," "caring," "softhearted," "sympathetic" α = .80), and conscientiousness ("organized," "responsible," "hardworking," "careless" (r) α = .58). It should be noted that the adjective "active" was removed from the extraversion scale due to overlapping content with the mediator variable assessing perceptions of activity (described below).

Lower Socioeconomic status has been found to relate to higher allostatic load [57]. Therefore, the present work took into consideration the effect of socioeconomic standing at Time 1 on allostatic load. Socioeconomic status was controlled for in the final model using education as a general indicator of socioeconomic status. Education was measured in MIDUS I as part of the telephone interview. Participants reported their highest level of educational attainment. Response options ranged from "no school/some grade school" (1) to "PhD, MD, JD, or other professional degree" (12).

During MIDUS II, health behaviors were assessed. Respondents were asked if they had ever smoked at least one cigarette. If participants responded "yes", they were asked a follow-up question asking if they have ever smoked regularly. Smoking behavior was dichotomized into those who reported no lifetime history of smoking and those who reported any lifetime history of smoking (by combining previously smoked regularly but does not currently smoke and current daily smoking). Frequency of alcohol use was also assessed at MIDUS II by asking participants to indicate how often they had at least one drink during the past month. Seven response options included: every day, 5 or 6 days a week, 3 or 4 days a week, 1 or 2 days a week, less than one day a week, never, or do not know/not sure. Physical activity was measured using parallel sets of questions asking about two levels of physical activity (vigorous and moderate) during the summer and winter. Reports for both moderate and vigorous leisure-time physical activity were first summed within season and then averaged across seasons to provide mean summer/winter scores of moderate/vigorous leisure-time physical activity. Perceptions of activity were assessed with one question that asked participants "During the past 30 days, how much of the time did you feel ACTIVE?" Possible answers included: all the time, most of the time, some of the time, a little of the time, or none of the time.

Coping styles were assessed at MIDUS II through a series of questions from the Midlife Development Inventory (MIDI) Personality Scales [58] designed to assess perceived control and control strategies. Overall sense of control was measured using a 12-item scale, which included four "personal mastery" items and eight "perceived constraints" items. Items reflecting "personal mastery" included statements such as "I can do just about anything I really set my mind to" and perceived constraints included statements such as "I often

Table 1. Descriptive statistics for study variables

	N = 1,054
	Mean (*SD*) or %
Age	46.19 (11.81)
Gender (% female)	54.70%
Race/ethnicity	
White/Caucasian	90.60%
Black/African American	2.80%
Native American or Aleutian Islander/Eskimo	0.50%
Asian or Pacific Islander	0.20%
Other	1.80%
Multiracial	0.70%
Unknown	3.50%
Education level	
Eighth grade/junior high school	0.60%
Some high school	3.00%
General Education Development	1.20%
Graduated high school	22.60%
1–2 years of college, no degree	16.10%
≥3 years of college, no degree	5.40%
Associates degree/2 year degree	7.00%
Bachelor's degree/4 year degree	23.70%
Some graduate school	4.20%
Master's degree	11.70%
Professional degree	4.50%
Personality traits	
Conscientiousness	3.46 (0.42)
Extraversion	3.19 (0.58)
Neuroticism	2.20 (0.66)
Openness to experience	3.06 (0.49)
Agreeableness	3.47 (0.47)
Coping styles	
Sense of control	5.64 (0.96)
Persistence in goal striving	3.20 (0.54)
Positive reappraisal	3.08 (0.61)
Lowering aspirations	2.22 (0.53)
Coping-related health behaviors	
Lifetime smoking	.43 (0.50)
Alcohol	1.37 (1.49)
Physical activity	5.68 (3.25)
Perceptions of activity	3.70 (0.92)
Biomarkers	
Pulse	70.65 (11.09)
CRP	2.70 (4.28)
IL-6	2.79 (2.79)
Fibrinogen	340.94 (83.18)
Glucose	100.42 (24.78)
Glycated hemoglobin	5.99 (0.92)
Insulin resistance	3.33 (3.65)
Waist-to-hip ratio	0.89 (0.10)
HDL	54.63 (17.51)
Triglycerides	135.53 (139.75)

All biomarker scores are reported in their original (untransformed) metrics.

CRP C-reactive protein; *HDL* high-density lipoprotein; *IL-6* interleukin 6.

feel helpless in dealing with the problems of life." Items reflecting personal mastery were reverse-coded so that higher scores represented higher levels of control. The combined scales reflect the participant's overall perceived control (α = .87). Primary and secondary control strategies were assessed using a three-factor model [21]. Respondents used a four-point scale to indicate how well each of 14 items described them. Primary control was assessed using a persistence in goal striving scale (α = .77). Items included statements such as, "When faced with a bad situation, I do what I can do to change it for the better." Secondary control was assessed using two measures: positive reappraisals (α = .78) and lowering aspirations (α = .60). Positive reappraisals included items such as "I find I usually learn something meaningful from a difficult situation." Lowering aspirations included items such as "When my expectations are not being met, I lower my expectations." Items were recoded so that high scores reflected higher standing in each dimension.

The Biomarker Project follow-up to MIDUS II included collection of the following samples for biomarker assay: fasting blood samples, 12 hr (overnight) urine samples, and saliva samples. In line with previous operationalizations of allostatic load [7, 51], a total of 10 biomarkers were retained to inform cumulative health risk. These included: pulse rate, IL-6, C-reactive protein (CRP), fibrinogen, fasting glucose, glycosylated hemoglobin, insulin resistance (HOMA-IR), waist-to-hip ratio (WHR), HDL, and triglycerides. In line with previous work on allostatic load, log transformations were applied to CRP, IL-6, glycated hemoglobin, fasting glucose, HOMA-IR, and triglycerides. Outliers were addressed by winsorizing the lower and upper 0.5%. Mean substitution was used to account for any remaining missing data to meet assumptions for bootstrapping. Both primary mediators and secondary outcomes of allostatic load were represented in the measurement model to represent the interplay of the different systems involved and various acute or long-term effects [59]. Based on significant bivariate correlations, age and sex were included as covariates in the measurement model.

Biomarkers were subsequently parceled to reflect their functioning within the following systems: inflammation, glucose, and lipids. The organization of biomarkers within their respective systems in the present study corresponds to results from previous work on allostatic load [7, 51] (please see the Supplementary Material for complete details for the measurement model). Measurement model fit was assessed using the root mean square error of approximation (RMSEA) and the comparative fit index (CFI). The measurement model was deemed to have a good fit with an RMSEA approaching 0 (RMSEA = .055) and CFI above .90 (CFI = .968).

Analyses

Correlational analyses were used to assess the magnitude and direction of effects among the study variables. Path models were constructed using structural equation modeling in SPSS AMOS 25.0.0 software and analyzed using the organization of relationships described above and depicted in Fig. 1, with the additional criterion of showing a statistically significant ($p < .05$) bivariate relationship in the correlational analyses. Education was used as an indicator of socioeconomic status and was included in the structural model. Indirect prospective effects of traits on the latent variable of allostatic load were tested by examining whether the bootstrapped (k = 10,000) 95% confidence intervals (CIs) around the estimates of indirect effects included 0 [60–62]. The Supplementary Material provides additional details pertaining to the specified measurement model of allostatic load.

Results

The correlational results showed multiple significant bivariate relationships between personality traits and coping styles and health behaviors, as well as associations among personality traits, coping styles, coping-related health behaviors, and individual markers of allostatic load (see Table 2). The initial structural model showed adequate fit (RMSEA = .069; CFI = .830) but included several nonsignificant pathways. As a result, for clarity, several paths were excluded from the final structural model depicted in Fig. 2. Pathways chosen for removal were based solely upon nonsignificant pathways (i.e., modification indices were not used in the consideration of path removal). Pathways from conscientiousness to alcohol and physical activity were removed. Paths from extraversion to physical activity and neuroticism to alcohol consumption were removed. The path from smoking to allostatic load was nonsignificant and was removed from the model. All coping style pathways (sense of control, persistence in goal striving, positive reappraisals, and lowering aspirations) did not show significant direct effects on allostatic load and were, therefore, removed from the final structural model (RMSEA = .067; CFI = .823).

Direct Effects of Personality Traits on Coping Styles, Health Behaviors, and Allostatic Load

In the prospective structural model, conscientiousness showed significant direct effects on greater sense of control, greater persistence in goal striving, greater perceptions of activity, and a lower likelihood of lifetime smoking (see Fig. 2). Extraversion demonstrated significant associations with greater overall sense of control, persistence in goal striving, and greater perceptions of activity. Openness to experience was significantly associated with the use of positive reappraisal strategies and greater physical activity. Neuroticism was significantly associated with lower sense of overall control, the use of lowering aspirations as a coping strategy, and greater smoking. Greater conscientiousness were directly associated with lower (healthier) allostatic load more than 10 years later. Contrary to expectations, greater levels of extraversion were directly associated with greater allostatic load, and agreeableness did not show a significant direct association with allostatic load (see Fig. 2).

Direct Effects of Coping Styles and Health Behaviors on Allostatic Load

In the prospective structural model (see Fig. 2), broad coping styles were not significantly linked to allostatic load 2 years later. Consistent with expectations, greater perceptions of activity and greater physical activity were significantly associated with lower (healthier) allostatic load. Contrary to expectations, greater typical weekly frequency of alcohol consumption was significantly associated with lower subsequent allostatic load.

Indirect Effects of Personality Traits on Allostatic Load via Candidate Mediators

The hypothesized structural model posited indirect associations of personality traits on cumulative health risk via coping styles and coping-related health behaviors pathways. Given the patterns of effects described above, tests of indirect effects were only possible for conscientiousness and extraversion via leisure-time physical activity and perceptions of day-to-day activity. Bootstrapping procedures showed indirect effects on allostatic load via perceptions of activity for both conscientiousness (β = −.052; 95% CI [−.077, −.031]) and extraversion (β = −.047, 95% CI [−.071, −.026]). The

Table 2. Correlations among study variables

Variable		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Demographics																											
	1. Age	–																									
	2. Sex	−.06	–																								
	3. Education	.00	.09**	–																							
Wave 1																											
	4. Conscientiousness	.01	.15**	0.08*	–																						
	5. Extraversion	.09**	.08*	−.06*	.16**	–																					
	6. Neuroticism	−.22**	.09**	−.10**	−.20	−.12**	–																				
	7. Openness	.05	−.04	.18**	.23**	.45**	−.19**	–																			
	8. Agreeableness	.07*	.22**	−.11**	.27**	.51**	−.03	.37**	–																		
Wave 2																											
	9. Sense of Control	.05	−.06	.16**	.23**	.21**	−.29**	.26**	.10**	–																	
	10. Persistence	.08**	.08*	.03	.34**	.29**	−.15**	.33**	.28**	.41**	–																
	11. Positive Reappraisal	.04	.13**	.01	.19**	.28**	−.23**	.30**	.25**	.40**	.57**	–															
	12. Lowering Aspirations	.07*	.19**	−.11**	−.11**	−.08**	.18**	−.13**	.01	−.34**	−.08**	.00	–														
	13. Lifetime Smoking	.09**	−.12**	−.17**	−.11**	.06	.09**	.10**	.03	.01	.00	.03	.01	–													
	14. Alcohol	.06	−.15**	.14**	−.03	.00	.05	.07*	−.06*	.09**	.01	−.03	−.04	.17**	–												
	15. Physical Activity	−.19**	−.07*	.19**	.03	−.02	.00	.07*	−.04	.15**	.06	.04	−.14**	−.03	.15**	–											
	16. Perceptions of Activity	.19**	−.03	.07*	.21**	.20**	−.23**	.16**	.17**	.41**	.33**	.28**	−.14**	−.09**	.09**	.23**	–										
Wave 3																											
	17. Pulse	.01	.12**	−.07*	−.06	.08*	.06	.03	.04	−.04	.00	.04	.04	.09**	−.08**	−.11**	−.12**	–									
Inflam.	18. CRP	.04	.15**	−.12**	−.02	.10**	.04	.00	0.07*	−.01	.01	.03	.02	.04	−.07*	−.16**	−.13**	.26**	–								
	19. IL-6	.22**	.03	−.07*	−.074*	0.06*	−.07*	.00	.02	−.05	−.04	.00	−.01	.10**	−.05	−.20**	−.15**	.20**	.49**	–							
	20. Fibrinogen	.14**	.14**	−.10**	−.03	.05	−.05	−.02	.01	−.03	−.01	.04	.06*	.02	−.09**	−.12**	−.05	.15**	.51**	.41**	–						
Gluc.	21. Glucose	.10**	−.19**	−.06*	−.12**	.09**	−.03	.04	.02	.02	−.05	−.03	−.03	.02	−.02	−.11**	−.08**	.12**	.12**	.12**	.06*	–					
	22. Hemoglobin	.23**	−.05	−.04	−.04	.12**	−.06*	.06*	.07*	.01	.00	.02	.01	.02	−.12**	−.14**	−.06	.16**	.17**	.18**	.17**	.65**	–				
	23. Insulin Resistance	−.01	−.17**	−.11**	−.11**	.07*	.02	.00	.01	−.02	−.05	−.04	-.06	.03	−.11**	−.13**	−.18**	.17**	.30**	.27**	.19**	.56**	.37**	–			
Lipids	24. Waist-to-hip Ratio	.16**	−.66**	−.05	−.18**	−.01	−.06*	.05	−.10**	−.01	−.07*	−.08**	−.09**	.17**	.09**	−.04	−.07*	.07*	.10**	.18**	.03	.31**	.22**	.41**	–		
	25. HDL	.05	.41**	.07*	.14**	.04	−.04	−.02	.07*	.08**	.05	.07*	.08**	−.04	.18**	.07*	.16**	−.12**	−.16**	−.18**	−.01	−.21**	−.15**	−.42**	−.46**	–	
	26. Triglycerides	−.01	−.22**	−.13**	−.10**	.04	.07*	.04	−.02	−.08*	−.04	−.04	−.02	.04	−.05	−.08**	.16**	.15**	.23**	.18**	.05	.29**	.17**	.51	.37**	−.53**	–

N = 1,054; Persistence = persistence in goal striving.

Gluc. glucose; *HDL* high-density lipoprotein; *Inflam.* inflammation; *IL-6* interleukin 6.
*$p < .05$, **$p < .01$.

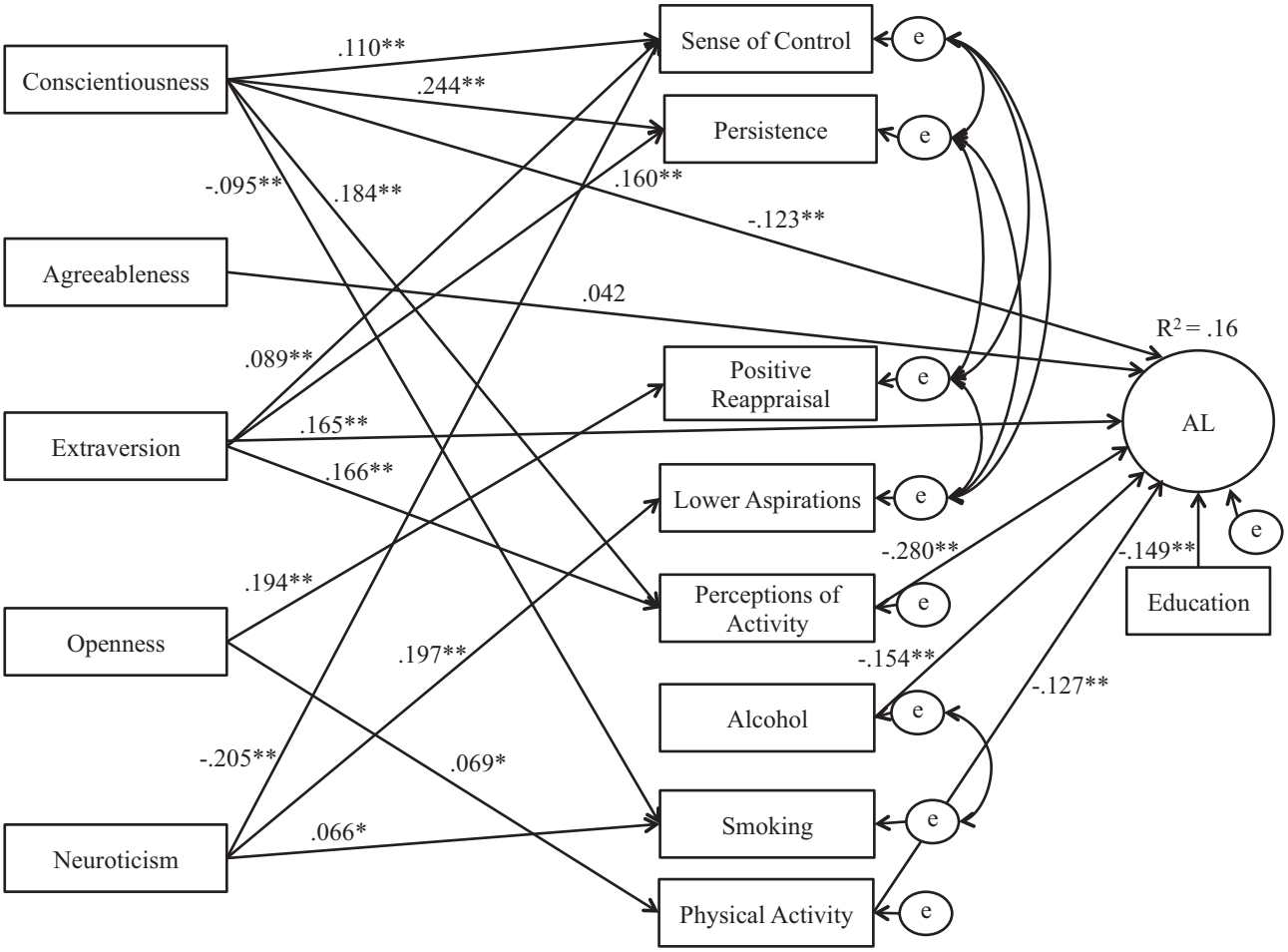

Fig. 2. Structural model of personality trait effects on allostatic load via coping strategies and coping-related health behaviors. All path weights depict standardized loadings. Complete details for the specified measurement model of allostatic load are provided in the Supplementary Material. *$p < .05$, **$p < .01$.

total effects of conscientiousness on allostatic load were significant ($\beta = -.175$; 95% CI [−.259, −.095]). The total effects of extraversion were also significant ($\beta = .119$; 95% CI [.026, .205]), albeit in the opposite direction as the indirect effects via perceptions of activity. Finally, an indirect effect for openness to experience on allostatic load via physical activity was observed ($\beta = -.009$; 95% CI [−.020, −.001]). It is notable that the standardized effect for this effect is very small and the CI approaches 0, warranting caution in its interpretation.

Discussion

The goal of the present study was to test coping style and health behavioral pathways through which personality traits affect physiological health using a large national sample with a prospective design and an integrative modeling approach for the biomarkers ascribed to allostatic load. The results showed that conscientious individuals had significantly lower cumulative physiological health risk more than 10 years later. Moreover, consistent with the hypotheses and prior research [37], conscientiousness was associated with subsequent lower physiological health risk via greater perceptions of being active. In addition to the indirect relationship of conscientiousness on allostatic load via perceptions of activity, extraversion also showed a significant indirect prospective effect on allostatic load via greater perceptions of activity. The indirect effects for perceptions of activity suggest a possible protective health effect of greater perceived day-to-day activity in conscientious and extraverted middle-aged individuals over the course of a decade.

These findings support a life course risk chain model [9], whereby personality traits act as an antecedent influence for subsequent pathways to health status. In the present work, the results suggest that the perception of day-to-day activity outside of leisure-time physical activity may be a protective health factor for individuals who are conscientious and extraverted. The health outcomes associated with individuals who perceive greater day-to-day activity

illustrates one social/behavioral route related to conscientiousness and extraversion that informs the linkages leading to health resilience. The identification of perceptions of activity as a link provides an opportunity for future research to examine the direct effects of specific types of day-to-day activities on health. Specifying the types of activity may be useful in identifying circumstances where the antecedent cause (i.e., personality traits) of the causal chain is not easily manipulated. In other words, changing (increasing) one's level of conscientiousness may not be readily achieved; however, identifying the trait links to certain activities offers the potential for a more health-proximal point for a personality-informed intervention. Future research is necessary to specify the types of activity that are suitable for intervention.

Individuals who have greater engagement in day-to-day activities may have more opportunities for social, cognitive, and/or physical stimulation due to lifestyle goals and choices. Scheduling and participating in activities in one's life may forestall the development of negative health outcomes associated with less active lifestyle choices and habits [48]. The potential buffering effect of perceptions of activity may be a result of multidimensional influences and the diversity of activities in one's life or may be derived from one area of day-to-day activities, such as social involvement or vocational investment. Future research should attempt to specify the components of perceptions of engagement in day-to-day activities that can be protective against cumulative physiological health risk.

In addition to the significant indirect effects, the results showed significant prospective 2 year direct effects of greater leisure-time physical activity and weekly frequency of alcohol consumption on lower allostatic load, as well as significant prospective 10 year direct effects of personality traits on coping styles and coping-related health behaviors. While the direct findings for personality traits on coping styles, as well as for physical activity on allostatic load, were in line with hypotheses, the finding for alcohol consumption on allostatic load was not. There is the potential that the measurement of alcohol frequency, but not quantity, obscured the possible effects of excessive drinking on health outcomes. It is possible that negligible-to-small amounts of alcohol (potentially consumed in social situations) are beneficial for one's health. Given the assessment limitations, it is not possible to draw conclusions from the present work regarding the relationship between alcohol consumption and allostatic load. It is also notable that none of the coping styles showed a significant effect on allostatic load. Rather than coping styles per se contributing to physiological health risk, the perception of control and predictability in the context of specific perceived stressors might be more informative of allostatic load compared to generalized context-independent self-ratings of coping approaches. That is, general tendencies for coping styles may be less informative for physiology than the in vivo implementation of coping styles and strategies during the experience of perceived stressors.

When considering the lack of findings for mediating pathways from conscientiousness to health outcomes via coping styles, it is useful to consider work that suggests conscientiousness may be more consequential in some contexts than in others [63]. Similar to coping strategies, it should be considered that conscientiousness' effect on health might depend on interactions with other personal characteristics. For example, the Life Course of Personality Model [63] posits that the health-related benefits of conscientiousness might vary across contexts and across different configurations of personality traits. Such a model may also help to explain differential findings associated with extraversion on health outcomes. It is important to consider both the processes specific to phases of the life course (such as those that occur in childhood vs. adulthood) and also the continuous processes that are in play over time (such as cumulative economic disadvantage or educational or social investment). These factors may work synergistically with the health-promoting behaviors associated with personality traits. Research examining these interactions involving conscientiousness, and especially extraversion, with social context and other personality traits is uncommon. This future work will necessitate a large, diverse sample to meet requirements for synergistic hypotheses that are dependent upon a heterogeneity of environmental and contextual experiences.

While the present study found significant effects for broad measures of conscientiousness and extraversion, future research should assess the effects of trait aspects or facets in the expression of allostatic load. For conscientiousness, it may be the case that industriousness, that is, being persistent and goal oriented, may be more informative of allostatic load than general tendencies for being responsible and organized. The mediated effect of extraversion by perceptions of activity suggests the possibility that the sociability aspect of extraversion [64], that is, the preference for social activities and being with others rather than being alone, may be a more informative component of extraversion that affords greater specificity in the prediction of cumulative physiological health. The results of the present study showed opposing effects for extraversion, whereby it directly contributed to greater risk unless it was associated with greater perceptions of activity, when it then contributed to greater health resilience. Other research has shown similar effects for the association between neuroticism and health risk such that, when adjusting for age and sex, a global measure of neuroticism seems to indicate poorer mental and physical health and higher mortality risk. However, when factor (facet) levels of neuroticism were considered,

those neurotics characterized by worry or vulnerability showed opposing effects, indicating lower mortality risk [65, 66]. These findings are preliminary but highlight the need for more narrow, facet-level examinations of personality trait effects on health, especially for extraversion, neuroticism, and conscientiousness and their relations to allostatic load.

Finally, the measurement model of allostatic load in the present study was designed to produce a more thorough operationalization based on prior theorizing and empirical work [7, 51]. However, to date, the extant literature on allostatic load does not offer a consensus view of standardized procedures for assessing, measuring, and scoring allostatic load. In addition to standardizing the type, number, and organization of biomarkers, clarifying the predictive utility of allostatic load on various forms of morbidity is a useful next step in related research. Allostatic load is posited to be a surrogate outcome that acts as an indicator of future long-term health and longevity. It should be noted that allostatic load, like many limited-time measurements of health (immune markers, cortisol levels, etc.), is not isomorphic with disease diagnosis, progression, or death [67]. In order to make stronger claims about points of intervention and prevention, future work should further address the predictive validity of allostatic load through standardized (i.e., reproducible) measurement using the biomarkers that are most informative of putatively related forms of disease and illness (e.g., cardiovascular diseases and Type 2 diabetes). As the sample population of the MIDUS data set ages, longitudinal tests for these outcomes will allow for a better understanding of how biomarkers predict long-term health outcomes.

Given the assessment goals of the original study, the MIDI Personality Scales were designed to provide the fewest items needed to reliably measure personality. Due to the brevity of the assessment, validities of the scales have been rightfully scrutinized. Conclusions from this study should take into consideration the shortcomings of the measurement of personality traits in MIDUS [68], as well as the moderate-sized correlations among some of the putatively orthogonal traits reported in Table 2. Correlations among extraversion and openness ($r = .45$, $p < .01$) and extraversion and agreeableness ($r = .51$, $p < .01$) raise questions related to the construct (e.g., discriminant) validity of the scales. Aside from the use of trait aspects or facets and construct measurement and assessment pertaining to the Big Five and allostatic load, additional limitations of the present work include the relatively homogeneous sample, as well as the absence of a baseline assessment of allostatic load per the design of MIDUS.

Despite the limitations, the present work contributes to an understanding of pathways through which personality traits "get under the skin" [8] by identifying a candidate route that ties long-term health risk to prior standing on personality traits. In addition to testing prospective mediation, the present study included a comprehensive assessment of cumulative physiological health via allostatic load. Consistent with prior work [37] and life course risk chain models of health [9], the results showed that perception of activity was a characteristic pathway through which conscientiousness and extraversion contributed to greater subsequent physiological resilience. Further discerning the content of such perceptions, and their role in the health process, would be consistent with recent calls for progress in developing personality-informed frameworks for interventions aimed at fostering healthy aging trajectories [69].

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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Compliance With Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards The authors declare that they have no conflict of interest.

Authors' Contributions E.M. (conceptualization, methodology, data curation, formal analysis, visualization, original draft [lead]), T.B. (conceptualization, methodology, formal analysis, writing – original draft).

Ethical Approval All procedures followed were in accordance with the American Psychological Association ethical standards and with the Helsinki Declaration.

Informed Consent All participants provided written informed consent.

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