Physical Activity Mediates the Association Between Personality and Biomarkers of Health

Eileen K. Graham^{1,2}
Emily D. Bastarache¹
Elizabeth Milad²
Nicholas A. Turiano³
Kelly A. Cotter⁴
Daniel K. Mroczek^{1,2}

¹Northwestern University, Department of Psychology, Weinberg College of Arts & Sciences, Evanston, IL

²Northwestern University, Department of Medical Social Sciences, Feinberg School of Medicine, Chicago, IL

³West Virginia University, Department of Psychology, Morgantown, WV

⁴California State University-Stanislaus, Department of Psychology, Turlock, CA

Address Correspondence to:

Eileen K. Graham

Northwestern University

Department of Medical Social Sciences

Feinberg School of Medicine

633 N. St. Clair, 19th Floor

Chicago, IL 60611

Eileen.graham@northwestern.edu

(913) 530-6580

Abstract

The current study investigated whether personality traits and facets predicted levels of Interleukin-6, C-reactive protein, and Fibrinogen and whether physical activity mediated the relationship between personality and these biomarkers of health. High harm avoidance and low neuroticism were associated with elevated IL-6, while high social potency, high control, and low achievement were associated with elevated FGN. Mediation models suggested that physical activity mediated the association between higher levels of achievement and lower IL-6. Physical activity is an important factor in the health behavior model, and explains some of the associations between personality and downstream inflammation.

Key Words: Inflammatory markers, personality traits, personality facets, physical activity, health behavior model

1. Introduction

There is a well-established literature regarding the associations between personality and inflammation (Luchetti, Barkley, Stephan, Terracciano, & Sutin, 2014; Sutin et al., 2010; Turiano, Mroczek, Moynihan, & Chapman, 2013), between personality and physical activity (Cotter & Lachman, 2010; De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; Wilson, Das, Evans, & Dishman, 2015), and between physical activity and chronic inflammation (Ertek & Cicero, 2012; Kasapis & Thompson, 2005; Woods, Vieira, & Keylock, 2009; Woods, Wilund, Martin, & Kistler, 2012). However, none have examined possible interlinking pathways between the three constructs. While personality and physical activity have been independently associated with inflammation (Armon, Melamed, Shirom, Berliner, & Shapira, 2013), prior research has not considered the extent to which physical activity might serve as a health behavior linking the pathways between personality and inflammation. The current study bridges these gaps by examining whether physical activity mediates the associations between personality and inflammation in the national Midlife Development in the U.S. study (MIDUS).

Serum Interleukin-6 (IL-6) is a pro-inflammatory cytokine and a marker of inflammation (Kritchevsky, Cesari, & Pahor, 2005). When infection occurs in the body, cells of the immune system release IL-6 to promote inflammation and notify the body that an inflammatory response is taking place (Scheller, Ohnesorge, & Rose-John, 2006). C-reactive protein (CRP) is released from the liver when it senses the presence of IL-6. CRP goes to the site of inflammation and helps destroy pathogens and return the body to homeostasis (Ansar & Ghosh, 2013). Fibrinogen (FGN) is also a marker of inflammation, as it is the protein responsible for blood clot formation. In an isolated scenario, Fibrinogen, IL-6 and CRP are part of a critical response to battling

pathogen invasion (Kritchevsky et al., 2005). Most importantly, individuals who experience extensive amounts of these responses over time often develop chronic inflammation, which is associated with a myriad of negative health outcomes (Collaboration, 2012).

We used the Health Behavior Model (HBM) (Friedman, 2000; Mroczek, Spiro, & Turiano, 2009; Smith, 2006; Turiano, Chapman, Gruenewald, & Mroczek, 2015) as our theoretical framework for the current study. This theory posits that certain personality characteristics are associated with either beneficial or detrimental behaviors that are directly related to their health. There is a growing body of literature on various aspects of health in multiple samples supporting this theory (Bogg & Roberts, 2004). The current study adds to this body of literature by testing the effects of personality on markers of inflammation via the physical activity.

1.1 Personality and Inflammation

Inflammatory markers have emerged as key factors in understanding adult health (Ansar & Ghosh, 2013; Collaboration, 2012; Davalos & Akassoglou, 2012; Kritchevsky et al., 2005). Studies have suggested that personality may play a role such that higher neuroticism, lower conscientiousness, lower extraversion, and lower openness are related to elevated fibrinogen, IL-6, and CRP (Armon et al., 2013; Luchetti et al., 2014; Mottus, Luciano, Starr, Pollard, & Deary, 2013; Sutin et al., 2010; Turiano et al., 2013). Interactions of these personality traits have indicated that high conscientiousness and high neuroticism together predicted lower IL-6 (Turiano et al., 2013).

While previous studies have explored these questions using trait personality, little work has explored personality facets, or the lower-order characteristics that underlie higher-order trait factors. Facet-level analysis of personality is essential because it helps deepen our understanding

of the underlying characteristics, and thus may help explain the patterns of association between personality traits and various outcomes (Graham, 2011; Graham & Lachman, 2014). Some work has linked facets with inflammatory markers. For example, depressive symptoms, and hostility have been linked to higher levels of serum IL-6 and serum CRP in multiple studies (Brummett et al., 2010; Mwendwa et al., 2013). High impulsivity and excitement seeking have been linked to inflammation (via white blood cell count) and lymphocyte counts (Sutin et al., 2012). Additional work by Sutin and colleagues (2010) found that higher neuroticism facets (hostility, impulsivity, and vulnerability) and lower conscientiousness facets (order, dutifulness, achievement, and discipline) were correlated with serum IL-6, and predicted greater odds of clinically high serum IL-6. Activity (a facet of extraversion) was a protective factor against clinically high serum IL-6. Others have supported these findings, suggesting that higher conscientiousness and higher levels of self-directedness were associated with lower IL-6 (Chapman et al., 2011) and lower CRP (Henningsson et al., 2008). This is further evidence for the importance of examining facet-level personality, as it can be the case that associations are not detected at the trait level, but only emerge when examining these lower-order characteristics. Thus, this gives us more precise findings regarding how personality may be linked to inflammation.

1.2 Physical activity and inflammation

There is a breadth of literature examining links between physical activity and inflammation (Andersson et al., 2010; Ertek & Cicero, 2012; Gleeson et al., 2011; Kasapis & Thompson, 2005; Woods et al., 2009). While some have focused on athletes, there are also studies that have focused on average activity in healthy adults. A meta-analysis examined studies that linked levels of activity and exercise training to inflammatory markers (Kasapis & Thompson, 2005). They established a clear pattern of protection against inflammation among

exercisers. While exercise produced a short-term inflammatory response, regular training over time produced a long-term anti-inflammatory effect. Thus, results support of the notion that regular physical activity can help prevent chronic inflammation (Kasapis & Thompson, 2005). Other work has found converging evidence. For example, Andersson and colleagues (2010) found that during a two-week period of heavy physical activity, CRP levels increased, but during a 3-week recovery period levels decreased significantly. The authors argue that this decrease in the inflammatory response as a result of physical activity may be a key to explaining links between physical activity and reduced cardiovascular disease risk.

1.3 Personality and Physical Activity

While associations between personality and health outcomes are well established, there is a diverse and growing body of literature examining specific health behaviors in association with personality (Friedman, 2000; Hampson, Goldberg, Vogt, & Dubanoski, 2007; Munafo, Zetteler, & Clark, 2007; Raynor & Levine, 2009; Terracciano, Lockenhoff, Crum, Bienvendu, & Costa, 2008), as these factors may be a pathway through which personality influences health. That is, personality traits have a direct impact on health, but personality traits are also related to other factors (such as health behaviors), which in turn are the stronger influence on health. Physical activity is one such behavior that may play a role, as shown by a growing body of literature connecting it to personality (Allen & Laborde, 2014). Wilson and colleagues (2015) found that, among undergraduate women, higher extraversion was associated with higher self-reported physical activity, and higher neuroticism was associated with lower physical activity. Some studies have also examined the impact of personality and *lack* of physical activity, via leisure sitting-time. Ebstrup and colleagues (2013) found that individuals reporting lower conscientiousness, lower extraversion, lower openness, and higher neuroticism tend to report

more inactivity. Other studies have examined whether personality factors differ across self-identified “exercisers” and “non-exercisers”. They found that in a large population-based sample, people identifying as regular exercisers (defined as exercising at least 60 minutes per week at moderate intensity) were more extraverted, less anxious, and less neurotic compared to those who were non-exercisers (De Moor et al., 2006).

Two meta-analyses have been published, reviewing literature on personality and physical activity. Rhodes & Smith (2006) found that, across 33 studies of adults (aged 18+), extraversion and conscientiousness were associated with higher levels of physical activity, while neuroticism was associated with lower levels. Wilson and colleagues’ (2015) brought this literature up to date. They found, across 64 studies using a wide age-range, that extraversion, openness, and conscientiousness was consistently associated with more physical activity (both objective and self-report), and neuroticism was associated with less physical activity.

All told, these findings paint a clear picture of personality traits and physical activity. However, relatively few studies have examined personality facets or nuances (McCrae, 2015) to gain a finer-grained glimpse into what may be driving these associations. The term “facet” refers to a narrower trait that reflects more specific psychosocial or behavioral features than do broad trait dimensions like the Big Five. That is, what is it about conscientiousness and extraversion that makes people more likely to be physically active, and why do individuals high in neuroticism exercise less? Facet-level analyses are relatively rare in this area, but a few studies have been conducted. For example, Hoyt and colleagues (2009) found that among university students, NEO facets predict exercise behavior. Specifically, activity (extraversion) and self-discipline (conscientiousness) were direct predictors of exercise behavior, while anxiety (neuroticism) moderated the association between exercise-intention and exercise-behavior. The

interaction results revealed low anxiety paired with high levels of exercise-intention is associated with the greatest likelihood of engaging in exercise behavior. The current study sought to bring these areas of inquiry together, using the theoretical framework of the health behavior model, and examined the associations between personality (traits and facets) and inflammatory biomarkers, via physical activity.

1.4 Hypotheses

1.4.1. Personality and inflammation. In the Multi-Dimensional Personality Questionnaire (MPQ), the negative emotionality dimension and sub-scales most closely reflect dimensions of neuroticism in the Big-5 (Costa & McCrae, 1992), while the constraint dimension and subscales mostly closely align with the construct of conscientiousness. While other studies have typically used a single biomarker (most commonly IL-6), we used multiple indicators of inflammation. Interleukin-6, C-Reactive Protein, and Fibrinogen each represent a distinct part of the immune process. For predictive validity of personality traits, we tested multiple outcomes to determine if parallel effects would be found. With this and previous work described above in mind, in the current study we hypothesized that stress reactivity, aggression, and alienation would be positively associated with IL-6, CRP, and fibrinogen, while control, traditionalism, and harm avoidance would be negatively associated with the three inflammatory markers. Previous studies suggest that negative dispositional traits such as depression, anxiety, and hostility are positively associated with IL-6 (Suarez, Lewis, Krishnan, & Young, 2004). Therefore, in this current study, we expected that high stress reactivity, aggression, and alienation would lead to higher levels of all three inflammatory markers. In contrast, we expected higher levels on control, traditionalism, and harm avoidance to result in lower levels of the three inflammatory markers. Since inflammatory markers are found to be related to dispositional states (Marsland, Prather, Petersen,

Cohen, & Manuck, 2008), we expected that higher levels of well-being would result in lower biomarker levels. In previous studies, extraversion was negatively associated with IL-6. While not identical to the extraversion construct, social potency in the MPQ is certainly related. Therefore, we also hypothesized that social potency would be negatively related, such that higher social potency would be associated with lower levels of the biomarkers. We hypothesized that achievement would also be negatively associated with levels of the three biomarkers. Lastly, in accordance with research on quality of social connections (Lubben & Gironde, 2003) as a predictor of psychological well-being and other health benefits, we hypothesized that higher Social Closeness would be associated with lower levels of the three inflammatory markers.

1.4.2 Personality and Physical Activity. Given the clear literature on the associations between personality and physical activity (Wilson et al., 2015; Wilson & Dishman, 2015) we expected to find similar patterns in the current study. Specifically, we expected to find that higher levels of extraversion, conscientiousness, and openness and lower levels of neuroticism would be associated with more physical activity. We did not utilize the same facets as those previously reported, but those that have been linked (activity and self-discipline) are considered to be facets of extraversion and conscientiousness. As such, we predicted that comparable facets in the MPQ scale would also be linked to higher physical activity, specifically behavioral control, achievement, social closeness, and social potency.

1.4.3 Mediation Hypotheses. We expected to find a relationship between personality and inflammatory markers via physical activity. Traditionally, mediation is established when the effect of an independent variable on a dependent variable is reduced (partial mediation) or eliminated (full mediation) by a mediating variable (Baron & Kenny, 1986). However, current methodological models of mediation (e.g., MacKinnon, (2008)), holds that mediation can be

present when there is no direct pathway between predictor and outcome. This suggests that the predictor is indeed related to the outcome, but *only* through a mediator. Given the evidence in the literature that neuroticism, extraversion, conscientiousness, openness, activity, and self-discipline have all been linked to physical activity, and that physical activity is associated with lower inflammation, we expected to find that these personality traits and similar facets would all be associated with inflammation via physical activity. See Figure 1 for a theoretical model.

2. Methods

2.1 *Sample.*

Data for this study were taken from the Mid-Life Development in the United States (MIDUS) study (Brim, Ryff, & Kessler, 2004), a national sample of 7,108 participants recruited by random-digit-dialing who completed data collection (mail questionnaires and phone interviews) in 1994-1995. A second wave of data collection occurred in 2004-2005, and consisted of a total sample of 4,963 participants from the original sample (a full analysis of sample attrition can be found in Radler & Ryff (2010)). A subset of time 2 respondents were recruited for participation in the biomarkers study (2004-2009). Participants were required to travel to a General Clinical Research Center to complete this portion of the study. There, participants (N = 1,255) provided blood, urine, and saliva specimens for an intensive study of HPA-axis, autonomic, immune, cardiovascular, musculoskeletal, and metabolic function. Trained medical staff collected these data in addition to vital signs, a physical exam, and a medical history. A final sample of 961 participants had psychosocial and biological data for the current study.

2.2 *Measures.*

2.2.1 Personality Traits. Traits were assessed at Time 2 using the MIDI personality scales (Goldberg, 1992; Lachman & Weaver, 1997). Participants rated the extent to which 26 adjectives described them on a 1-4 scale (1=not at all, 4= a lot). The adjectives measured the Big Five: Neuroticism (moody, worrying, nervous, calm [reverse], $\alpha=.74$); Extraversion (outgoing, friendly, lively, active, talkative, $\alpha=.76$); Openness to Experience (creative, imaginative, intelligent, curious, broad-minded, sophisticated, adventurous, $\alpha=.77$); Conscientiousness (organized, responsible, hardworking, thorough, careless [reverse], $\alpha=.68$); and Agreeableness (helpful, warm, caring, softhearted, sympathetic, $\alpha=.80$).

2.2.2 Personality Facets. Facets were assessed at Time 2 using the Multi-Dimensional Personality Questionnaire (Patrick, Curtin, & Tellegen, 2002; Tellegen, 1985), based on the Tellegen 3-factor model (positive emotionality, negative emotionality, behavioral constraint) assessing 10 sub-facets of personality (well-being [$\alpha=.73$], social potency [$\alpha=.71$], achievement [$\alpha=.67$], social closeness [$\alpha=.69$], stress reactivity [$\alpha=.74$], aggression [$\alpha=.66$], alienation [$\alpha=.61$], behavioral control [$\alpha=.61$], traditionalism [$\alpha=.59$], and harm avoidance [$\alpha=.57$]). Participants rated the extent that statements described them (1=true, 2=somewhat true, 3=somewhat false, 4=false) (e.g. “I usually find ways to liven up my day” and “when I get angry, I am often ready to hit someone”). For harm-avoidance, in addition to two statements, participants were also given two sets of scenarios and asked to select the scenario they would dislike more (riding a long stretch of rapids in a canoe, or waiting for someone who’s late).

2.2.3 Physical Activity. Physical activity was assessed at Time 2 via 12 items that asked about the frequency of moderate and vigorous physical activity that the respondent engaged in (0=never – 5=several times a week). Frequency of moderate/vigorous activity was asked about separately by domain (leisure, work, or home), and by season (winter or summer). Items were

combined per Cotter & Lachman's (2010) scoring procedure ($\alpha = .92$). Season scores (winter versus summer) were first averaged within each domain for moderate and vigorous activity, then the domain with the highest score (leisure, work, or home) was used as the moderate or vigorous activity score. Finally, moderate and vigorous activity scores were averaged together, resulting in the final total physical activity score.

2.2.4 Inflammatory Markers. Three key inflammatory markers were assessed for this study: Interleukin-6 (IL-6), C-Reactive Protein (CRP), and Fibrinogen (FGN). They were assessed between 2005-2009 as part of the MIDUS Bio-markers Subproject (Project 4), whose primary aim was to identify biological pathways associated with health outcomes. Investigators randomly selected 1,255 individuals from the overall MIDUS sample to participate. Consenting participants then travelled to one of three data collection sites (UCLA, University of Wisconsin, and Georgetown University). The testing protocol included blood samples, morphology, functional capacities, bone densitometry, medication use, and a physical exam, all conducted by clinicians or trained staff. For full details on the project 4 data collection see Ryff, Seeman, & Weinstein (2013). As these markers also tend to be affected by a series of medications, all models controlled for the use of blood thinners, statins, steroids, chronic condition comorbidity, and time between the measurement of personality and the biomarker measurement (Turiano et al., 2013).

3. Results

3.1 Data Analysis.

Preliminary analyses were conducted using hierarchical linear regression. We tested personality traits and facets separately, and tested each of the three inflammatory markers separately as well (IL-6, CRP, FGN), so there were six models testing the effects of personality

on inflammatory markers. We tested the effects of both traits and facets to establish the associations between personality and inflammation both at the broader trait-level, and at the narrow bandwidth facet-level. We kept the models for the MPQ and Big Five scales separate, as the two scales tend to be highly and could over-saturate the models if combined. All models controlled for age, gender, education, race, self-rated health, depression, body composition, medications, comorbidities, and time.

Regression models also tested the associations between personality and physical activity, in order to decipher the factors that were candidates for mediation. Mediation models were computed in Mplus version 7.2 (Muthen & Muthen, 1998- 2012), within the structural equation modeling framework. These models allowed for the testing of the main effect of personality on physical activity (a-path), of physical activity on inflammation (b-path), and of personality on inflammation (c-path) (Baron & Kenny, 1986; MacKinnon & Fairchild, 2009). To test mediation formally in these models, the products of the a and b pathways were computed, providing an estimate of the indirect (mediating) effect of personality on inflammation *through* physical activity (Figure 1).

[INSERT FIGURE 1 HERE]

3.2 Main Effects

3.2.1 Personality Facets and Inflammatory Markers. Baseline models revealed effects of harm avoidance on IL-6 (Table 1) [INSERT HERE], CRP (Table 2) [INSERT HERE] and FGN (Table 3) [INSERT HERE] ($p < .01$), of alienation on CRP and FGN, and of achievement and control on FGN. However, once the models controlled for the necessary covariates, most of these effects no longer held. The full adjusted models showed that harm avoidance was associated with elevated IL-6 ($B = .06$, $SE = .024$), while social potency ($B = .025$, $SE = .01$), behavioral control

($B=.02$, $SE=.008$), and low achievement ($B=-.032$, $SE=.01$) predicted FGN. None of the facets predicted CRP.

3.2.2 Personality Traits and Inflammatory Markers. Baseline models revealed positive effects of agreeableness on serum IL-6 (Table 4) [INSERT HERE] and CRP (Table 5) [INSERT HERE], negative effects of neuroticism, and conscientiousness on serum IL-6, and negative effects of openness on serum FGN (Table 6) [INSERT HERE]. Once the models were fully adjusted for covariates, most of these effects were reduced as well, leaving few remaining main effects for the traits. Specifically, the fully adjusted models showed that low neuroticism ($B=-.061$, $SE=.024$) predicted higher serum IL-6. We also found marginal effects of openness on serum CRP ($B=-.079$, $SE=.045$) and neuroticism ($B=-.017$, $SE=.009$) on serum FGN, such that higher levels of openness predicted lower serum levels of CRP and higher levels of neuroticism predicted higher serum FGN.

3.2.3 Physical Activity on Inflammatory Markers. In order to test physical activity as a mediator, we first needed to establish associations between physical activity and the inflammatory markers (the b-pathway of a mediation model). Our preliminary linear regressions revealed that, net of all covariates, higher physical activity predicted lower levels of IL-6 ($B=-.09$, $SE=.03$) and CRP ($B=-.10$, $SE=.04$), which is consistent with prior literature and our hypotheses.

3.2.4 Personality Traits/Facets on Physical Activity. Regression models revealed associations for agreeableness ($B=-.12$, $SE=.06$), extraversion ($B=.13$, $SE=.06$), and achievement ($B=.17$, $SE=.06$), indicating that individuals with high extraversion and achievement, and low agreeableness tended to report higher levels of physical activity.

All told, we determined that three factors of personality predicted physical activity, and that physical activity predicted IL-6 and CRP. Based on these results, we proceeded to build six mediation models: extraversion on IL-6 and CRP; agreeableness on IL-6 and CRP, and achievement on IL-6 and CRP (all via physical activity).

3.3 Mediation Effects.

The fully adjusted mediation models controlled for the same covariates as the preliminary analyses. A summary of the results for all six mediation models can be found in Table 7 [INSERT HERE]. Consistent with the preliminary regressions, physical activity predicted both serum levels of IL-6 ($B = -.07$, $SE = .02$) and serum levels of CRP ($B = -.06$, $SE = .02$). Also consistent with preliminary results, higher extraversion ($B = .13$, $SE = .06$) and achievement ($B = .17$, $SE = .06$), and lower agreeableness ($B = -.12$, $SE = .06$) predicted higher levels of physical activity. For extraversion and agreeableness, the mediating effects of physical activity were not significant for either inflammatory marker, although we observed trends in the expected direction for extraversion on IL-6 and CRP, and agreeableness on serum IL-6 via physical activity suggesting that higher extraversion and lower agreeableness predicts more physical activity, and thus lower levels of inflammatory markers. Lastly, the indirect effect for achievement was significant for serum IL-6 and but not for serum CRP (although the pattern was in the expected direction). This effect suggests that individuals who are higher in achievement report greater levels of physical activity and in turn have lower levels of these inflammatory markers.

4. Discussion.

The current study found evidence for the relationship between personality and inflammatory markers at both the trait and facet levels. We found some associations for traits,

and most strongly in relation to serum Interleukin-6. Specifically, higher neuroticism, higher conscientiousness, and lower agreeableness were associated with lower serum IL-6, although this association remained only for neuroticism once the models were fully adjusted. All three of these traits also exhibited trends towards more physical activity, although this association was only statistically significant for agreeableness. The general trend suggests that individuals with higher neuroticism, higher conscientiousness, and/or lower agreeableness tend to have healthier levels of inflammation, which can be explained by their engagement in healthier lifestyle physical activity behaviors.

On the facet level, we found that higher harm avoidance was associated with higher serum IL-6, and that higher social potency, higher behavioral control, and lower achievement were associated with higher serum FGN. The fact that control and harm avoidance were both positively associated with inflammation is consistent with the negative association between neuroticism and inflammation. What emerges from these findings suggests that individuals who are more emotionally stable, level-headed, and cautious, less impulsive and anxious, and prefer to avoid potentially harmful situations, tend to have higher levels of inflammation. This certainly seems counterintuitive, as one would expect that more anxiety, and less level-headedness would be associated with elevated inflammation. A recent paper by Turiano and colleagues (2013) found that this negative effect of neuroticism was conditional upon conscientiousness. Specifically, higher neuroticism was associated with lower serum IL-6 under the circumstances upon which conscientiousness was also high, suggesting that high conscientiousness served as a buffer for the maladaptive effects of neuroticism. We reproduced this interaction for neuroticism in the present study, and also found a consistent interaction for harm avoidance, but not for control. This suggests that individuals high in harm avoidance and also conscientiousness have

lower serum IL-6 levels. Future studies need to further explore these associations to a) establish whether these findings replicate across multiple data sets, and b) what mechanisms might explain these associations.

As for the tests of mediation, the overall patterns of effects support our hypotheses. For agreeableness, individuals low on this trait were more likely to exercise more, and had lower levels of inflammatory markers. This is consistent with the direct effects of agreeableness and serum IL-6, and suggests that physical activity may partially explain this association.

Additionally, we found individuals high in extraversion were more likely to engage in physical activity (as expected), and had lower inflammation. While we did not find a direct effect of extraversion on inflammation, this trend in the expected direction suggests that physical activity may explain this association as well. Finally, individuals with high achievement were more likely to engage in physical activity and had lower inflammation. Again, while we did not observe a direct relationship between achievement and inflammation (for CRP and IL-6), the fact that we did find mediation that achieved traditional statistical significance suggests that the associations between achievement and inflammation are mediated by physical activity (MacKinnon, 2008; MacKinnon & Fairchild, 2009), and is consistent with our expectations.

The current study has shown that the health behaviors model (Smith, 2006) is one way of explaining the associations between personality and inflammation. However, there are other potential pathways that were not explored in this study that would also not be accounted for with the health behaviors model. For example, social support, major life events, and social roles may be more important than health behaviors in contributing to serum levels of inflammatory markers, particularly when mediating pathways from some personality traits/facets. This may be why we only found associations between personality and physical activity for some traits/facets

and not all. Future studies should explore additional pathways that could explain the associations of other aspects of personality to health outcomes.

Personality gets “outside the skin” via several potential processes, such as reactive processes (moderation), or self-regulative processes (mediation) (Hampson, 2012). In this study, we tested the self-regulative process of personality via mediation on health, specifically inflammation. Additional work with more long-term longitudinal data will give us further insight into the effects that the models tested here have on objective long-term health outcomes, such as disease onset and mortality.

While we did measure personality prior to the measurements of inflammatory markers, one limitation to this study is that we did not have baseline levels of serum inflammatory markers to control for. As such, we do not know whether personality is related to subsequent change in inflammation, and future studies with additional follow-up data of these inflammatory markers are needed. Additionally, the temporal structure for testing mediation was not ideal, as physical activity and personality facets were assessed in the same measurement occasion.

All told, the structure of our findings suggests a promising avenue of research. Broad generalizations however, should not be made, as these pathways and models need to be replicated in other data sets, and reproduced in MIDUS with additional measurement occasions. However, limitations aside, there are clinical implications of these findings. Physical activity is one mechanism by which personality gets under the skin, and may help future researchers and practitioners understand how’s and why’s of the associations between personality, inflammation, and downstream health.

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Table 1. The associations between personality facets and Interleukin-6 (N=959)

	Model 1			Model 2			Model 3			Model 4		
	B	SE	<i>p</i>	B	SE	<i>P</i>	B	SE	<i>P</i>	B	SE	<i>P</i>
Facets												
Well-Being	.037	.030	.222	.021	.029	.475	.011	.029	.689	.008	.028	.779
Social Potency	-.013	.029	.648	-.002	.028	.931	-.009	.028	.749	-.016	.027	.561
Achievement	-.037	.030	.223	-.029	.029	.314	-.011	.029	.708	-.005	.028	.867
Closeness	-.004	.025	.869	.008	.024	.734	-.003	.024	.911	-.006	.023	.810
Reactivity	-.054	.029	.063	-.038	.029	.187	-.061	.028	.032	-.052	.028	.065
Aggression	.050	.030	.098	.037	.029	.207	.039	.028	.172	.040	.028	.156
Alienation	.045	.028	.113	.045	.028	.101	.041	.027	.131	.026	.027	.332
Control	-.002	.024	.929	.000	.024	.989	.000	.023	.989	-.002	.023	.914
Traditionalism	.039	.023	.092	.026	.023	.271	.037	.023	.101	.036	.022	.113
H. Avoidance	.098	.025	.000	.057	.025	.024	.054	.025	.030	.055	.024	.026
Age				.155	.024	.000	.119	.026	.000	.103	.026	.000
Gender				.029	.048	.547	.002	.049	.975	.177	.064	.006
Education				-.002	.025	.932	-.018	.025	.458	-.006	.024	.808
SRH				.133	.026	.000	.095	.027	.000	.067	.027	.015
Race				-.007	.025	.766	.008	.024	.734	.012	.024	.618
Blood Thinner							.101	.026	.000	.071	.027	.010
Statin							.019	.024	.420	.004	.024	.874
Steroid							-.006	.023	.788	-.009	.022	.691
Depression							.085	.022	.000	.073	.022	.001
Time							.073	.017	.000	.070	.017	.000
WHR										.138	.031	.000
Comorbidity										.040	.030	.191
Adj R ²	.024			.092			.139			.156		
F	3.40			7.44			8.72			9.08		

Note: WHR= Waist to Hip Ratio; SRH= Self-Rated Health

Coefficients in Bold are significant (p<.05)

Table 2. The associations between personality facets and CRP (N=956)

	Model 1			Model 2			Model 3			Model 4		
	B	SE	p	B	SE	P	B	SE	P	B	SE	P
Facets												
Well-Being	.026	.047	.587	.033	.047	.480	.034	.047	.471	.027	.046	.557
Social Potency	.052	.045	.258	.081	.045	.071	.078	.045	.080	.062	.044	.155
Achievement	-.089	.048	.062	-.089	.047	.058	-.083	.047	.074	-.073	.046	.113
Closeness	.043	.039	.274	.027	.039	.492	.027	.038	.487	.020	.038	.605
Reactivity	-.037	.046	.424	-.066	.046	.151	-.087	.046	.059	-.072	.045	.114
Aggression	.027	.047	.571	.037	.047	.426	.050	.046	.277	.053	.045	.240
Alienation	.103	.044	.021	.067	.044	.130	.075	.044	.087	.043	.043	.318
Control	.009	.039	.814	.041	.038	.284	.042	.038	.265	.039	.037	.290
Traditionalism	.000	.037	.991	-.017	.037	.641	-.006	.037	.866	-.010	.036	.788
H. Avoidance	.132	.039	.001	.070	.040	.084	.065	.040	.105	.069	.039	.079
Age				.015	.039	.706	-.013	.042	.760	-.054	.042	.207
Gender				.317	.077	.000	.236	.080	.003	.583	.103	.000
Education				-.071	.040	.077	-.072	.040	.072	-.046	.039	.245
SRH				.228	.042	.000	.187	.043	.000	.122	.044	.006
Race				-.041	.039	.295	-.037	.039	.338	-.029	.038	.441
Blood Thinner							.095	.041	.022	.022	.044	.622
Statin							-.052	.039	.175	-.029	.039	.020
Steroid							.081	.037	.027	.073	.036	.043
Depression							.117	.035	.001	.087	.035	.014
Time							-.030	.028	.283	-.036	.027	.184
WHR										.278	.050	.000
Comorbidity										.119	.049	.015
Adj R ²	.016			.064			.083			.116		
F	2.59			5.33			5.32			6.72		

Note: WHR= Waist to Hip Ratio; SRH= Self-Rated Health

Coefficients in Bold are significant (p<.05)

Table 3. The associations between personality facets and Fibrinogen (N=956)

	Model 1			Model 2			Model 3			Model 4		
	B	SE	p	B	SE	P	B	SE	P	B	SE	P
Facets												
Well-Being	.011	.011	.318	.003	.011	.742	.002	.010	.873	.001	.010	.920
Social Potency	.018	.010	.073	.027	.010	.008	.026	.010	.008	.025	.010	.013
Achievement	-.042	.011	.000	-.038	.011	.000	-.033	.010	.002	-.032	.010	.002
Closeness	.004	.009	.634	.002	.009	.844	-.002	.009	.834	-.002	.009	.771
Reactivity	-.017	.010	.108	-.014	.010	.186	-.016	.010	.116	-.015	.010	.151
Aggression	.006	.011	.557	.007	.011	.508	.005	.010	.616	.005	.010	.596
Alienation	.021	.010	.039	.017	.010	.087	.013	.010	.172	.010	.010	.293
Control	.018	.009	.034	.021	.009	.013	.020	.008	.016	.020	.008	.017
Traditionalism	.006	.008	.490	.000	.008	.977	.001	.008	.889	.001	.008	.920
H. Avoidance	.021	.009	.019	.002	.009	.840	.004	.009	.673	.004	.009	.639
Age				.036	.009	.000	.038	.009	.000	.034	.010	.000
Gender				.078	.017	.000	.084	.018	.000	.116	.024	.000
Education				-.014	.009	.113	-.021	.009	.019	-.019	.009	.039
SRH				.027	.010	.005	.026	.010	.007	.020	.010	.049
Race				.014	.009	.115	.020	.009	.025	.020	.009	.020
Blood Thinner							-.002	.009	.865	-.009	.010	.380
Statin							.007	.009	.385	.003	.009	.697
Steroid							-.027	.008	.001	-.027	.008	.001
Depression							.017	.008	.037	.014	.008	.090
Time							.033	.006	.000	.032	.006	.000
WHR										.026	.011	.023
Comorbidity										.012	.011	.270
Adj R ²	.026			.072			.109			.113		
F	3.50			5.94			6.82			6.52		

Note: WHR= Waist to Hip Ratio; SRH= Self-Rated Health

Coefficients in Bold are significant (p<.05)

Table 4. The Associations Between Personality Traits and Interleukin-6 (N=961)

Traits	Model 1			Model 2			Model 3			Model 4		
	B	SE	P	B	SE	P	B	SE	P	B	SE	p
Agree	.059	.027	.030	.030	.027	.279	.017	.027	.528	.008	.027	.766
Extra	.008	.030	.781	.011	.029	.712	.008	.028	.772	.010	.028	.735
Neuro	-.061	.025	.014	-.051	.025	.041	-.070	.024	.004	-.061	.024	.012
Consc	-.081	.026	.002	-.050	.025	.045	-.046	.024	.061	-.032	.024	.195
Open	-.053	.029	.063	-.040	.029	.161	-.035	.028	.216	-.044	.028	.114
Age				.153	.023	.000	.118	.025	.000	.106	.025	.000
Gender				.054	.048	.254	.034	.048	.486	.210	.064	.001
Education				-.021	.024	.391	-.040	.024	.093	-.024	.024	.303
SRH				.140	.027	.000	.101	.027	.000	.073	.028	.008
Race				.003	.024	.890	.016	.024	.491	.019	.024	.411
Blood Thinner							.104	.025	.000	.075	.027	.006
Statin							.020	.024	.401	.003	.024	.889
Steroid							-.008	.022	.715	-.011	.022	.627
Depression							.086	.022	.000	.074	.022	.001
Time							.071	.017	.000	.067	.017	.000
WHR										.139	.031	.000
Comorbidity										.038	.030	.203
Adj R ²	.017			.093			.141			.159		
F	4.37			10.81			11.51			11.64		

Note: WHR= Waist to Hip Ratio; SRH=Self-Rated Health

Coefficients in Bold are significant (p<.05)

Table 5. The Associations Between Personality Traits and CRP (N=958)

	Model 1			Model 2			Model 3			Model 4		
	B	SE	P	B	SE	P	B	SE	P	B	SE	p
Traits												
Agree	.154	.043	.000	.085	.044	.051	.074	.043	.090	.056	.043	.193
Extra	.019	.047	.692	.037	.046	.429	.046	.046	.318	.048	.045	.285
Neuro	.012	.039	.756	-.047	.040	.243	-.066	.040	.100	-.050	.040	.204
Consc	-.075	.040	.064	-.050	.040	.212	-.050	.040	.210	-.019	.039	.632
Open	-.082	.045	.070	-.045	.046	.320	-.056	.045	.215	-.079	.045	.077
Age				.011	.037	.775	-.021	.040	.603	-.055	.041	.181
Gender				.300	.076	.000	.224	.079	.004	.579	.103	.000
Education				-.070	.039	.070	-.074	.039	.056	-.041	.038	.285
SRH				.235	.043	.000	.194	.044	.000	.129	.045	.004
Race				-.024	.039	.540	-.020	.039	.609	-.013	.038	.734
Blood Thinner							.098	.041	.017	.024	.044	.591
Statin							-.044	.038	.252	-.087	.039	.026
Steroid							.085	.037	.021	.077	.036	.032
Depression							.116	.036	.001	.087	.035	.014
Time							-.027	.027	.321	-.035	.027	.195
WHR										.286	.050	.000
Comorbidity										.121	.049	.014
Adj R ²	.015			.063			.083			.118		
F	3.962			7.463			6.768			8.504		

Note: WHR= Waist to Hip Ratio; SRH= Self-Rated Health
Coefficients in Bold are significant (p<.05)

Table 6. The Associations Between Personality Traits and Fibrinogen (N=958)

	Model 1			Model 2			Model 3			Model 4		
	B	SE	P	B	SE	P	B	SE	P	B	SE	p
Traits												
Agree	.010	.010	.306	-.008	.010	.429	-.011	.010	.265	-.013	.010	.186
Extra	.010	.011	.334	.009	.011	.407	.007	.010	.509	.007	.010	.489
Neuro	-.012	.009	.173	-.015	.009	.106	-.019	.009	.039	-.017	.009	.063
Consc	-.009	.009	.339	-.006	.009	.483	-.003	.009	.697	0.00	.009	.996
Open	-.025	.010	.016	-.015	.010	.145	-.012	.010	.232	-.015	.010	.151
Age				.035	.008	.000	.038	.009	.000	.034	.009	.000
Gender				.081	.017	.000	.088	.018	.000	.128	.023	.000
Education				-.015	.009	.082	-.022	.009	.009	-.019	.009	.031
SRH				.027	.010	.005	.026	.010	.008	.019	.010	.060
Race				.020	.009	.024	.025	.009	.004	.026	.009	.003
Blood Thinner							-.001	.009	.880	-.009	.010	.350
Statin							.010	.009	.232	.006	.009	.526
Steroid							-.026	.008	.001	-.027	.008	.001
Depression							.019	.008	.016	.016	.008	.047
Time							.033	.006	.000	.032	.006	.000
WHR										.032	.011	.005
Comorbidity										.012	.011	.268
Adj R ²	.004			.060			.100			.107		
F	1.86			7.10			8.10			7.74		

Note: WHR= Waist to Hip Ratio; SRH= Self-Rated Health

Coefficients in Bold are significant (p<.05)

Table 7. Summary of Mediation Models

	Agreeableness						Extraversion						Achievement					
	CRP			IL-6			CRP			IL-6			CRP			IL-6		
	B	SE	p	B	SE	p	B	SE	p	B	SE	p	B	SE	p	B	SE	p
A-Path	-.12	.06	.042	-.12	.06	.039	.13	.06	.029	.13	.06	.028	.17	.06	.004	.17	.06	.004
B-Path	-.07	.02	.007	-.06	.02	.000	-.07	.02	.005	-.06	.02	.000	-.07	.03	.008	-.06	.02	.000
Mediated Effect	.01	.01	.105	.01	.004	.068	-.01	.01	.084	-.01	.004	.055	-.01	.01	.052	-.01	.01	.021
AIC	8861.05			7953.33			8882.43			7974.27			8750.27			7842.01		

Note: A-path=the effect of personality physical activity; B-path=the effect of physical activity on inflammatory marker

All models are adjusted for age, sex, education, self-rated health, race, blood, statin, steroids, depression, time, body composition, comorbidities, and other personality factors in the given scale.

Figure 1. Theoretical Mediation Model