

Interrelationships between Personality, Executive Function and Physical Activity

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Abstract

The purpose of this study was to examine the interrelationships between personality, executive function (EF) and physical activity. Personality (NEO-FFI) and physical activity (IPAQ) were assessed via self-report methodology, whereas executive function was assessed from a computer-based task (Go-No/Go). Multivariable regression analyses examined the association between personality, executive function, and physical activity. The personality trait agreeableness was positively associated with the percent of correct target detection for the Repeating Rule ($\beta = 0.57$; 95% CI: 0.09-1.04; $P=0.01$) and Stop Sign Rule ($\beta = 0.57$; 95% CI: 0.10-1.05; $P=0.01$). Mean reaction time for the Repeating Rule was inversely associated with moderate-to-vigorous physical activity (MVPA) ($\beta = -1.90$; 95% CI: -3.3, -0.4; $P=0.01$). The personality trait agreeableness was associated with greater EF, and greater EF, in turn, was associated with more MVPA.

Keywords: Executive function, MVPA, agreeableness

Öz

Kişilik, Yürütücü İşlev ve Fiziksel Aktivite Arasındaki Karşılıklı İlişkiler

Bu çalışmanın amacı, kişilik, yürütücü işlev (EF) ve fiziksel aktivite arasındaki karşılıklı ilişkileri incelemektir. Kişilik (NEO-FFI) ve fiziksel aktivite (IPAQ) kendi kendini raporlama yöntemi ile değerlendirilirken, yürütücü işlev bilgisayar tabanlı bir görevle değerlendirildi (Go-No/Go). Kişilik, yürütücü işlev ve fiziksel aktivite arasındaki ilişkiler, çok değişkenli regresyon analizleri ile incelenmiştir. Kişilik özelliğinin kabul edilebilirliği, Yineleme Kuralı ($\beta=0,57$; %95 CI: 0,09-1,04; $P=0,01$) ve Durma İşareti Kuralı ($\beta=0,57$; %95 CI: 0,10-1,05; $P=0,01$) için doğru hedef saptamanın yüzdesi ile doğru orantılıydı. Yinelenen Kural için ortalama tepki süresi, orta-şiddetli fiziksel aktivite (MVPA) ile ters orantılıydı ($\beta=-1,90$; %95 CI: -3,3, -0,4; $P=0,01$). Kişilik özelliklerinin kabul edilebilirliği daha büyük EF ile ilişkiliydi ve buna karşılık, daha büyük EF, daha fazla MVPA ile ilişkiliydi.

Anahtar Kelimeler: Yürütücü işlev, MVPA, kabul edilebilirlik

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INTRODUCTION

Previous research demonstrates a link between personality and physical activity (Rhodes & Smith, 2006). That is, personality traits *extraversion* (e.g., gregarious) and *conscientiousness* (e.g., self-disciplined) are positively associated with physical activity, whereas personality traits *neuroticism* (e.g., anxious), *openness to experience/intellect* (e.g., perceptive), and *agreeableness* (e.g., cooperative) are inversely associated with physical activity (Rhodes & Smith, 2006)

Executive functioning is defined as managing cognitive processes including working memory, cognitive flexibility, response selection, planning, and execution of tasks (Murdock, Oddi, & Bridgett, 2013). Executive function improvement is also linked with increased physical activity (Davis et al., 2011). Similarly, research demonstrates that executive function is also related to personality (Murdock et al., 2013). That is, in general, the personality trait *neuroticism* is inversely associated with executive function, whereas personality trait *openness to experience/intellect* is positively associated with executive function (Murdock et al., 2013). The traits *extraversion* and *conscientiousness* appear to be unrelated to executive function; however, this is not consistent across all studies (Fleming, Heintzelman, & Bartholow, 2016), underscoring the importance of further work on this under-investigated topic. Other work has also delineated the relationship between personality and various cognitive-related parameters. As an example, in a systematic review, Low et al. demonstrated that neuroticism is associated with increased dementia risk, whereas conscientiousness reduces this risk (Low, Harrison, & Lackersteen, 2013).

However, the concurrent interrelationships among these three parameters have not been systematically studied. Given the noted relationships identified in the above paragraph, it is plausible to suggest that, for example, *openness to experience/intellect* may be associated with increased executive function, which in turn, may be associated with increased physical activity. Similarly, it is plausible to suggest that *neuroticism* may be associated with lower executive function, which in turn, may be associated with reduced physical activity. For example, a person who is conscientious may be better able to self-regulate behavior, while a person with higher levels of neuroticism may be less able to self-regulate behavior due to a preponderance of emotional processing that disturbs cognitive control processing. Taken together, these assertions suggest that

executive function may mediate the relationship between personality traits and physical activity. To examine this possibility, the present study, written as a short communication, examines the interrelationships between personality, executive function and physical activity, with specific interest in examining whether executive function does indeed mediate the relationship between personality and physical activity. This is worthy of exploration as this may provide insight into the potential reasons through which personality may be related to health-enhancing behaviors, such as physical activity. We evaluate the interrelationships among these three parameters while also considering various other factors, such as weight status and dietary behavior, as these parameters are associated with personality, cognition and physical activity (Kitamura et al., 2016; Langenberg et al., 2015; Lehtisalo et al., 2016; Memel, Bourassa, Woolverton, & Sbarra, 2016).

METHODS

Design and Participants

Recruitment of individuals included 200 students (undergraduate or graduate), sampled via a convenience-based sampling approach. Data collection began in October of 2015 and continued through June of 2016. Participants completed an assessment of physical activity, EF and personality, with physical activity and personality assessed via questionnaire and EF assessed via a computerized test. Body mass index was also measured; thus, all assessments took place in person in our laboratory. Notably, among the 200 participants, there were no missing data. A random sample of 10% of the 200 participants completed the questionnaires again one-week later for test-retest reliability purposes. Additionally, these participants also wore a pedometer for one-week in an effort to assess the possible convergent validity of the self-reported physical activity assessment.

Measurement of Personality

In order to assess personality, the Neuroticism-Extraversion-Openness Five Factor Inventory (NEO-FFI) questionnaire was utilized. The NEO is a five factor inventory scale. The inventory consists of five 12-item scales that measure each domain of five factors (Neuroticism, Extroversion, Openness, Agreeableness, Conscientiousness). There are 60 statements that describe people in a general way. A sample item from the NEO questionnaire that assesses

Conscientiousness is *"I keep my belongings clean and neat;"* A sample item assessing Extroversion is *"I like to have a lot of people around me;"* A sample item assessing Openness is *"I am intrigued by the patterns I find in art and nature;"* A sample item assessing Neuroticism is *"When I'm under a great deal of stress, sometimes I feel like I'm going to pieces;"* and lastly, a sample item for Agreeableness is *"I would rather cooperate with others than compete with them."* Response options range from zero to four, with zero being strongly disagree and four being strongly agree. Response option two stands for neutral. The NEO-FFI provides a quick, reliable, and accurate measure of the five domains of adult (ages 17 years and older) personality. (Costa PT, 1992) Internal consistency of the present sample, as measured by Cronbach's alpha, was 0.85 (neuroticism), 0.75 (extroversion), 0.75 (openness), 0.76 (agreeableness), and 0.84 (conscientiousness). The test-retest reliability assessment (ICC) of the present sample was 0.92 (neuroticism), 0.95 (extroversion), 0.93 (openness), 0.98 (agreeableness), and 0.96 (conscientiousness).

Measurement of Physical Activity

Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). The IPAQ form asks participants about the time they spend being physically active in the last seven days. For example, a question on the form is *"How much time did you usually spend on one of those days doing vigorous physical activities in the garden or yard?"* Participants reported their answer in hours per day or minutes. Physical activity herein was expressed as the min/week of MVPA. Previous research shows the IPAQ to be reliable and valid. (Craig et al., 2003) Among the 10% random sample of the present study, the correlation between IPAQ-determined MVPA and pedometer-determined steps was, $r = 0.43$ ($P < 0.001$). The one-week test-retest reliability of the 10% random sample was, $ICC = 0.79$.

Measurement of Executive Function

The Parametric Go/No-Go (PGNG) computer task was used to measure individual differences in executive function (Langenecker, Zubieta, Young, Akil, & Nielson, 2007). This assessment takes approximately 30 minutes and requires individuals to actively regulate responses to presented stimuli and either initiate response quickly or inhibit their response. The executive function construct is multi-dimensional (Miyake et al., 2000), and PGNG measures predominantly tap one facet of executive function

that may be particularly pertinent to behavioral self-regulation: the ability to suspend prepotent responses to external cues. Functional imaging studies have documented associations between PGNG performance and activation in the prefrontal and anterior cingulate regions of the brain (Hester, Fassbender, & Garavan, 2004; Watanabe, Hikosaka, Sakagami, & Shirakawa, 2002); both structures have been implicated in behavioral self-regulation in humans (Heatherton, 2011). Detailed discussion of the factor structure and construct validity of the PGNG test is published elsewhere (Langenecker et al., 2007; Votruba & Langenecker, 2013).

Utilizing computerized software, participants are presented with a series of flashing letter targets (e.g., "r", "s", and "t") intermixed with other letters (e.g., "a", "c", etc.), with each presented letter occurring at a rate of 500 ms. There are 3 primary outcome parameters, including the Simple Rule, Repeating Rule and Stop Sign Rule. For the Simple Rule, participants are asked to press the space bar every time the target letter (e.g., "r", "s", or "t") appears, with our evaluated outcome of this rule being the percent of correct target detection and mean reaction time. For the Repeating Rule, participants are asked to press the space bar every time they see the target letter (e.g., "r", "s", or "t"), but only if the target letter is not repeating the previous target; our evaluated outcome for this rule was the percent of correct (non-repeating) target detection and mean reaction time. For example, if the following letter sequence occurred, they would not press the space bar for the second "r" (a, t, r, p, d, r), but they would press the space bar twice (at "r" and "s") during this sequence (a, t, r, p, d, s). Lastly, for the Stop Sign Rule, participants are asked to press the space bar when they see the target letter, but only if the target letter is not followed by a stop sign; our evaluated outcome for this rule was the percent of correct (non-stopped) target detection and mean reaction time. That is, if a large red stop sign symbol is presented after the target letter, they should not press the space bar for that target letter.

Covariates

Covariates included age, gender, race-ethnicity, educational level, perceived health status (excellent, very good, good, fair, or poor), measured body mass index, self-report of meeting sleep guidelines (7-9 hrs/night of sleep vs. not), self-reported smoking status (smoker vs. non-smoker), self-report of being a heavy alcohol drinker or not (30+ alcoholic drinks/month for women, 60+ month for

men), and self-report of dietary behavior (summed dietary index from the Starting the Conversation survey) (Paxton, Strycker, Toobert, Ammerman, & Glasgow, 2011). Notably, other covariates, such as anxiety, were considered, but their inclusion did not appreciably alter the present study's findings, and thus, were not included herein.

Statistical Analyses

All statistical analyses were computed in Stata (v. 12, College Station, TX). Multivariable linear regression analysis was used to examine the association between personality and executive function. In this model, each personality trait along with all of the above-listed covariates were included in the model, with models computed separately for Simple Rule, Repeating Rule, and Stop Sign Rule. Notably, there were no concerns with multicollinearity, as, for example, the highest correlation between any of the 5 personality traits was, $r = 0.45$ (agreeableness and extraversion). Then, multivariable linear regression models were computed examining the association between executive function and MVPA (outcome variable), with models computed separately for Simple Rule, Repeating

Rule, and Stop Sign Rule; similarly, all covariates were included in this model. A multivariable logistic regression model evaluated the association between personality and meeting MVPA guidelines (150 min/week of MVPA; outcome variable); similarly, all covariates were included in this model. In all models, statistical significance was established as $P < 0.05$.

RESULTS

Characteristics of the study variable are shown in Table 1. The mean age for the study population was 21.62, with a range of 18-33 years of age. The population had a mean BMI of 25.95 kg/m². Participants included 63% female students.

With regard to the association between personality and meeting MVPA guidelines, in an adjusted model, the only personality trait associated with MVPA was extraversion (OR=1.10; 95% CI: 1.02-1.19; $P=0.01$). In this model, the only significant covariates included gender and diet; females were less likely to meet MVPA guidelines

Table 1: Demographical characteristics in the study sample (N=200).

Variable	Point Estimate	Standard Deviation
Age, mean years	21.62	2.25
BMI, mean kg/m ²	25.95	6.93
Ethnicity, % non-hispanic white	69	
Education, % undergraduate student	86	
Health status		
% excellent	15.5	
% very good	46	
% good	32.5	
% fair	6	
Neuroticism, mean	30.82	8.11
Extraversion, mean	43.11	6.06
Openness, mean	38.97	6.73
Agreeableness, mean	45.54	6.12
Conscientiousness, mean	46.79	6.48
MVPA, mean min/week	375.59	324.00
% meeting MVPA guidelines ^a	75	
Target simple, percent correct	85.0	12.2
Target simple, mean reaction time milliseconds	393.68	32.86
Two target repeat, percent detection	73.43	17.83
Two target repeat, mean reaction time in milliseconds	406.79	29.54
Two target stop sign, percent detection	73.45	17.82
Two target stop sign, mean reaction time in milliseconds	614.96	2915.96
BMI body mass index		
MVPA, moderate/vigorous physical activity		
^a MVPA for at least 150 minutes/week		

(OR=0.23; 95% CI: 0.08-0.62; $P=0.004$), and for every 1 unit increase (higher scores indicative of better overall diet) in the diet score, participants had a 27% increased odds of meeting MVPA guidelines (OR=1.27; 95% CI: 1.07-1.50; $P=0.004$).

With regard to the association between personality and executive function, none of the five personality traits were associated with either mean reaction time or percent of correct target detection for the Simple Rule (data not shown). The personality trait agreeableness was positively associated with the percent of correct target detection for the Repeating Rule ($\beta = 0.57$; 95% CI: 0.09-1.04; $P=0.01$) and Stop Sign Rule ($\beta = 0.57$; 95% CI: 0.10-1.05; $P=0.01$). The only significant covariates in this model were ethnicity and age; non-whites (vs. whites) had a lower percent of correct target detection ($\beta = -6.1$; 95% CI: -11.9, -0.3; $P=0.003$), and for every 1 year increase in age, there was a corresponding 1.3% decrease in percent of correct target detection ($\beta = -1.37$; 95% CI: -2.7, -0.03; $P=0.04$).

With regard to the association between executive function and MVPA, mean reaction time for the Repeating Rule was inversely associated with MVPA ($\beta = -1.90$; 95% CI: -3.3, -0.4; $P=0.01$). That is, those with a longer (worse) reaction time engaged in less MVPA. Notably, no other associations (data not shown) between executive function and MVPA were significant (e.g., mean reaction time of Simple Rule/Stop Sign Rule; percent of correct detection for Simple/Repeating/Stop Sign Rule). The only significant covariates in this model were health status ($\beta = -64.7$; 95% CI: -124.6, -4.8; $P=0.03$) and dietary behavior ($\beta = 27.3$; 95% CI: 8.2-46.3; $P=0.005$), with worse perceived health status associated with lower levels of MVPA and better dietary behavior associated with higher levels of MVPA.

DISCUSSION

Physical activity reduces the risk of cognitive decline (Frederiksen et al., 2015), and some personality traits are associated with higher levels of MVPA (Rhodes & Smith, 2006). Further, executive function improvement is also linked with increased physical activity (Davis et al., 2011) and personality (Murdock et al., 2013). Previous research suggests that the personality trait neuroticism is associated with the response selection component of executive function, as well as poorer decision making in older adults

(Luu, Collins, & Tucker, 2000). Based on these interrelationships, we aimed to evaluate whether one potential reason through which personality may be associated with physical activity is through its influence on executive function. In this short communication, we did not observe convincing evidence that, indeed, executive function mediated the relationship between personality and physical activity. One notable finding, however, was that those with a greater agreeableness personality trait had greater executive function, and higher executive function, in turn, was associated with more MVPA engagement. Importantly, only the repeating and stopsign execution function tests were statistically significant. Unlike the simple rule task, these tasks have a greater working memory component, which supports other research demonstrating an association between exercise and personality on working memory (Sibley & Beilock, 2007; Smith, Persyn, & Butler, 2011). With regard to our covariate results, our findings are consistent with prior literature demonstrating that healthier dietary patterns, age and ethnicity, in particular, are associated with cognition (Cheung, Ho, Chan, Sea, & Woo, 2014; Mehta et al., 2004).

Williams et al. (2010) examined personality and executive function in elderly individuals. The authors noted that executive function was positively associated with neuroticism and negatively associated with openness and agreeableness (Williams, Suchy, & Kraybill, 2010); other studies have also confirmed these inverse associations between openness and agreeableness with cognitive performance (Ouanes et al., 2017). Unlike these observations, the present study demonstrated some evidence of a positive association between executive function and the personality trait agreeableness. The opposing findings may be due to the different populations evaluated, including elderly individuals versus college-aged young adults, as well as different measures used to assess cognitive function. Williams et al. suggest that a potential reason for the observed inverse association between executive function and the personality trait agreeableness may be due to age-induced frontal lobe dysfunction, which is a main center for executive function, exhibiting behavioral disinhibition and social inappropriateness (Williams et al., 2010). Our observed positive association between executive function and agreeableness in this younger sample is also plausible and may be due to high levels of agreeableness serving as a protective ability associated with a strong level of social support (Williams et al., 2010). Further, with strong social support, interpersonal conflicts and negative health

behaviors such as physical inactivity are more effectively avoided (Williams et al., 2010). Other work supports a strong association between the personality type openness and various cognitive functions (Soubelet & Salthouse, 2011).

The present study observed a positive relationship between executive function and MVPA. Many studies examine the relationship between physical activity and executive function, but less research has evaluated the extent to which executive function may be driving levels of MVPA. Of course, the cross-sectional nature of this study does not allow us to evaluate the direction of effect between executive function and MVPA (McAuley et al., 2011). As we have discussed elsewhere (Loprinzi, Herod, Cardinal, & Noakes, 2013), it is plausible that there is a bi-directional relationship between executive function and MVPA. If prospective studies confirm our present study's observations, then this would suggest that one potential reason through which personality may be associated with physical activity is through its association with executive function.

A limitation of this brief report is the limited generalizability to other non-young adult populations. Other limitations include the subjective assessment of physical activity and cross-sectional study design, rendering temporality not possible. An additional limitation is the use of a single measure of executive function. Thus, future work on this topic should employ a prospective or experimental design and include multiple measures of executive function. Strengths of this study include the study's novelty and employing a subsample for test-retest assessment.

CONCLUSION

The population studied includes college aged individuals, which is an important time to manage a healthy lifestyle and a high academic workload. Executive function is important for cognitive processing and planning and executing tasks (Williams et al., 2010). Thus, factors that influence and are influenced by executive function are important to examine. The present study aimed to evaluate whether personality was associated with executive function, and in turn, whether executive function was associated with greater engagement in physical activity. We did not observe convincing evidence for this hypothesis, but there was some evidence to suggest that the personality trait agreeableness was associated with greater executive function, and in turn, higher executive function was associated with

greater physical activity behavior. Further research should consider evaluating these associations across different lifespans to generalize findings to other populations, and when doing so, employ a prospective study design to ascertain temporality of the associations.

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