2-1-2019

Association Between Perceived Physical Activity and Cognitive Function in Older Adults

Paul D. Loprinzi
University of Mississippi

Emily Frith
University of Mississippi

Recommended Citation

Loprinzi, P. D., & Frith, E. (2019). Association Between Perceived Physical Activity and Cognitive Function in Older Adults. Psychological Reports, 122(1), 108–116. https://doi.org/10.1177/0033294117750632

Article

Association Between Perceived Physical Activity and Cognitive Function in Older Adults

Psychological Reports
2019, Vol. 122(1) 108–116

DOI: 10.1177/0033294117750632
journals.sagepub.com/home/prx
SAGE

Paul D. Loprinzi and Emily Frith
Exercise Psychology Laboratory, Physical Activity
Epidemiology Laboratory, School of Applied Sciences,
Department of Health, Exercise Science and Recreation Management, The University of
Mississippi, Oxford, MS, USA

Abstract

There is irrefutable evidence that regular participation in physical activity is favorably associated with numerous positive health outcomes, including cognitive function. Emerging work suggests that perceived physical activity, independent of actual physical activity behavior, is inversely associated with mortality risk. In this study, we evaluate whether perceived physical activity, independent of actual physical activity, is associated with cognitive function, a robust indicator of mortality risk. Data from the cross-sectional 1999–2002 National Health and Nutrition Examination Survey were employed ($N = 2352$; 60+ years of age). Actual physical activity was assessed via a validated survey. Perceived physical activity was assessed using the following question: "Compared with others of the same age, would you say that you are: *more active*, *less active*, or *about the same*?" Cognitive function was assessed from the Digit Symbol Substitution Test. When examined in separate models, both actual and perceived physical activity were positively and statistically significantly associated with cognitive function. However, when considered in the same model, actual physical activity was no longer statistically significantly associated with cognitive function, but perceived physical activity was. Perceived physical activity, independent of actual physical activity, is independently associated with cognitive function. If these findings are replicated, future work should consider evaluating perceived physical activity when examining the effects of actual physical activity behavior on cognitive function.

Corresponding Author:
Paul D. Loprinzi, Exercise Psychology Laboratory, Physical Activity Epidemiology Laboratory, School of Applied Sciences, Department of Health, Exercise Science, and Recreation Management, The University of Mississippi, 229 Turner Center, University, Oxford, MS 38677, USA.
Email: pdloprin@olemiss.edu

Keywords
Epidemiology, cognitive impairment, exercise, older adults, perceptions, psychology

Introduction

Individual-level perceptions play an important role in shaping physical activity behavior, which is evident by prominent health behavior theories (e.g., social cognitive theory, theory of planned behavior, transtheoretical model) including a perception-based construct (e.g., attitudes, beliefs; Loprinzi, Cardinal, Si, Bennett, & Winters-Stone, 2012; Stolte, Hopman-Rock, Aartsen, Van Tilburg, & Chorus, 2017; Young, Plotnikoff, Collins, Callister, & Morgan, 2014). Not only does physical activity play a critical role in improving various positive health outcomes (e.g., cognition; Loprinzi, Herod, Cardinal, & Noakes, 2013; Warburton, Nicol, & Bredin, 2006), along with behavioral perceptions influencing behavioral engagement, but emerging work suggests that behavioral perceptions may influence health outcomes independent of behavioral engagement (Zahrt & Crum, 2017). For example, Zahrt and Crum (2017) demonstrated that perceived levels of physical activity were inversely associated with mortality risk, independent of actual physical activity behavior. Zahrt and Crum proposed three mechanisms to explain this observation, specifically that perceptions can affect motivation for future behavior change (Koponen, Simonsen, & Suominen, 2017), perceptions can influence affective states such as stress and depression (Ghorbani, Krauss, Watson, & Lebreton, 2008), and last, perceptions can elicit physiological responses directly (e.g., altered telomere biology; Schutte & Malouff, 2016).

The purpose of this brief report was to evaluate if perceptions of physical activity, independent of actual physical activity behavior, are associated with cognitive function, a strong indicator of early mortality in the older adult population (Frith, Addoh, Mann, Windham, & Loprinzi, 2017; Loprinzi, Crush, & Joyner, 2017). This potential observation is plausible given the recent work by Zahrt and Crum (2017) as well as the body of literature linking perceived cognition with actual cognitive function (Allen & Roberts, 2016; Cahen & Tacca, 2013; Tacca, 2011). For example, when perceptual and cognitive deficits co-occur, cognitive skills may be further compromised (Allen & Roberts, 2016). Of course, this latter point differs from this study as we are interested in whether perceptions of a behavior (as opposed to perceptions of cognition) influence cognition independent of behavioral engagement. Providing support for our hypothesis, similar brain networks (e.g., prefrontal cortex) are activated for executive function tasks and when making social comparisons (Kedia, Mussweiler, & Linden, 2014). Further, research demonstrates that physical activity influences self-perceived health status (Kaleta, Makowiec-Dabrowska, Dziankowska-Zaborszczyk, & Jegier, 2006), and perceived health status is associated with better cognitive function (Machon, Vergara, Dorronsoro, Vrotsou, & Larranaga, 2016).

Methods

Design and participants

Participant data from the cross-sectional 1999–2002 National Health and Nutrition Examination Survey (NHANES) were used for this study. This study was approved by the National Center for Health Statistics ethics review board. In addition, informed consent was obtained prior to the commencement of any data collection. Details regarding the NHANES study methodology can be found elsewhere (http://www.cdc.gov/nchs/nhanes.htm). Only adults 60+ years of age were eligible for the 1999–2002 NHANES cognition assessment. The sample included 2352 older-adult participants who provided cognitive function assessment.

Cognitive function

The Digit Symbol Substitution Test (DSST) is a parameter of the Wechsler Adult Intelligence Test (Wechsler, 1958), which has been used in various epidemiological and clinical studies (Bienias, Beckett, Bennett, Wilson, & Evans, 2003; Plassman et al., 2007; Proust-Lima, Amieva, Dartigues, & Jacqmin-Gadda, 2007) and has demonstrated evidence of validity and reliability (Hinton-Bayre & Geffen, 2005; Joy, Kaplan, & Fein, 2003). The DSST involves cognitive parameters such as processing speed, sustained attention, and working memory, and is frequently used as an index of frontal lobe executive function (Parkin & Java, 1999; Vilkki & Holst, 1991). The DSST was employed using a paper-and-pencil format. At the top of the paper was a key containing nine numbers paired with symbols. Participants had two minutes to copy the corresponding symbols in 133 boxes that adjoin the numbers. A score was provided for each correct match; the maximum score was 133.

Perceived physical activity

As described in the literature (Zahrt & Crum, 2017), perceived physical activity was assessed using the following question, "Compared with others of the same age, would you say that you are: *more active*, *less active*, or *about the same*?" This question has demonstrated evidence of predictive validity (Zahrt & Crum, 2017).

Actual physical activity

As explained elsewhere (Loprinzi, 2015a, 2016), participants were asked questions regarding their participation in leisure-time physical activity over the past 30 days. Metabolic equivalent of task (MET)-min-month was ascertained by multiplying the number of days, by the mean duration, and by the respective

MET level of each reported physical activity. Those >2000 MET-min-month (equivalent to 150 minutes/week) were categorized as meeting moderate-to-vigorous physical activity (MVPA) guidelines. This physical activity measure has been shown to significantly associate with objectively measured physical activity (accelerometry; Loprinzi, 2015a).

Covariates

Based on previous research demonstrating an association with physical activity and cognition (Biessels & Reagan, 2015; Gates, Fiatarone Singh, Sachdev, & Valenzuela, 2013; Koekkoek, Kappelle, Van Den Berg, Rutten, & Biessels, 2015; Loprinzi et al., 2013; Loprinzi & Ramulu, 2013; Morrato, Hill, Wyatt, Ghushchyan, & Sullivan, 2007), covariates included: *age*, *gender*, *race–ethnicity* (Mexican American, other Hispanic, non-Hispanic White, non-Hispanic Black, other), self-reported *smoking* (yes/no), *energy intake* (kilocalories; continuous), physician-diagnosed *hypertension* (yes/no), *weight status* (overweight/obese, measured body mass index 25 kg/m^2 or higher, vs. normal weight), *education* (high school or less vs. some college or more), and glycated A1C (%; continuous).

Analysis

All statistical analyses, computed in Stata (v. 12), accounted for the complex survey design employed in NHANES. A weighted adjusted linear regression model was used to examine the association of physical activity and cognitive function (outcome variable). All assumptions of linear regression were checked and confirmed not to be violated. Three models were computed. Model 1 included all covariates plus actual MVPA; Model 2 included all covariates plus perceived physical activity; and Model 3 included all covariates plus the actual MVPA and perceived physical activity. Statistical significance was established as $\alpha \leq .05$.

Results

Characteristics of the study variables are shown in Table 1. Participants, on average, were 69 years; 37% of the sample met physical activity guidelines, and the mean DSST was 47.8.

The mean (*SE*) actual MVPA (MET-min-month) for those who perceived their physical activity to be more active than others, less active than others, and about the same, respectively, was 4977 (421), 660 (127), and 2534 (240). The proportion meeting MVPA guidelines for those who perceived their physical activity to be more active than others, less active than others, and about the same, respectively, was 47.7%, 13.4%, and 29.8%.

Table 1. Weighted characteristics of the study variables, 1999–2002 NHANES ($N = 2352$).

Variable	Point estimate	*SE*
DSST (mean)	47.8	0.6
Age (mean years)	69.9	0.2
Energy intake (mean kcals)	1801.8	20.5
A1C (mean%)	5.8	0.02
Body mass index (mean kg/m^2)	28.2	0.1
% Overweight/obese	70.3	
Gender, female (%)	55.3	
Race–Ethnicity (%)		
Mexican American	2.9	
Non-Hispanic White	83.8	
Non-Hispanic Black	6.4	
Other/Multiracial	6.9	
Education, college or more (%)	71.7	
Current smoker (%)	12.4	
Hypertensive (%)	49.4	
MVPA MET-min-month, mean	3597.1	291
Meeting MVPA guidelines (%)	37.2	
Perceived physical activity (%)		
More active than others	52.6	
Less active than others	11.8	
About the same as others	35.6	

DSST: digit symbol substitution test; MET: metabolic equivalent of task; MVPA: moderate-to-vigorous physical activity; NHANES: National Health and Nutrition Examination Survey; *SE*: standard error.

Table 2 displays the multivariable linear regression results. When examined in separate models (i.e., Models 1 and 2), both actual and perceived physical activity were positively and statistically significantly associated with cognitive function. However, when considered in the same model (i.e., Model 3), actual physical activity was no longer statistically significantly associated with cognitive function, but perceived physical activity was. That is, those who perceived themselves as more active than others (compared with about the same activity as others), had a greater cognitive function score ($\beta = 2.34$; 95% confidence interval, CI = 0.62, 4.07; $p = .009$). Those who perceived themselves as less active than others (compared with about the same activity as others), had a lower cognitive function ($\beta = -2.40$; 95% CI = −4.81, 0.01; $p = .05$). Notably, there

Table 2. Weighted multivariable regression analyses examining the association between perceived and actual physical activity on cognition, 1999–2002 NHANES ($N = 2352$).

Variables	β	95% CI	p
Model 1			
Actual MVPA, 2000+ MET-min-month increase	0.23	0.02, 0.46	0.03
Model 2			
More active than others versus about the same as others	2.52	0.74, 4.31	0.007
Less active than others versus about the same as others	−2.54	−4.85, −0.22	0.03
Model 3			
Actual MVPA, 2000+ MET-min-month increase	0.16	−0.06, 0.38	0.14
More active than others versus about the same as others	2.34	0.62, 4.07	0.009
Less active than others versus about the same as others	−2.40	−4.81, 0.01	0.05

Note: Model 1 included all covariates plus actual MVPA. Model 2 included all covariates plus perceived physical activity. Model 3 included all covariates plus actual MVPA and perceived physical activity. CI: confidence interval; MET: metabolic equivalent of task; MVPA: moderate-to-vigorous physical activity; NHANES: National Health and Nutrition Examination Survey.

was no multiplicative interaction effect of perceived and actual physical activity on cognition ($p = .46$). There was also no evidence of multicollinearity in Model 3 (highest VIF, 2.07).

Discussion

The purpose of this brief report was to evaluate whether perceived physical activity is associated with better cognition, independent of actual physical activity behavior. The motivation of this article stemmed from the recent work by Zahrt and Crum (2017), who showed that perceived physical activity predicted mortality risk, independent of actual physical activity. Our observation aligns with that of Zahrt and Crum by showing that, independent of actual physical activity behavior, those with higher levels of perceived physical activity had higher cognitive function, which has been shown to be a strong indicator of mortality risk (Loprinzi et al., 2017).

It is challenging to provide a straightforward explanation for our observed findings, as it is not intuitive as to how the perception of a behavior could influence an objective measure of a cognitive parameter. As stated previously, one potential explanation is that self-perceived health status may mediate the relationship between perceived physical activity and cognition (Kaleta et al., 2006; Machon et al., 2016) via, perhaps, modulation of perceived stress (Ghorbani et al., 2008). At face level, our observations suggest that perceived physical activity may play a unique role in influencing health, including cognition and mortality. Of course, accurate perceptions (Loprinzi, 2015b) of perceived physical activity would be critical, as, for example, if an individual was inactive, but perceived themselves as active, this potential reduced perceived stress may not fully counteract the detrimental effects of physical inactivity. Notably, and as demonstrated in the Results section, we observed congruence between perceived and actual physical activity.

In conclusion, the findings from this brief report suggest that, independent of actual physical activity behavior, perceived physical activity was positively associated with cognitive function. If these findings are replicated, future work should consider evaluating perceived physical activity when examining the effects of actual physical activity behavior on cognitive function. We also encourage future work to overcome the limitations of our study, which includes the cross-sectional study design and self-reported assessment of physical activity. Notably, however, our findings suggest that self-report may also be considered a strength, and may be necessary as a preliminary approach to lay the groundwork for subsequent perceptual intervention trials examining these mechanisms through objective mechanisms. Thus, additional work would benefit by evaluating if, indeed, perceived stress, perceived heath status, and physiological health profile mediate the relationship between perceived physical activity and cognitive function, independent of actual physical activity behavior.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Allen, H. A., & Roberts, K. L. (2016). Editorial: Perception and cognition: Interactions in the aging brain. *Frontiers in Aging Neuroscience*, *8*, 130. doi: 10.3389/fnagi.2016.00130

Bienias, J. L., Beckett, L. A., Bennett, D. A., Wilson, R. S., & Evans, D. A. (2003). Design of the Chicago health and aging project (CHAP). *Journal of the Alzheimer's Disease*, *5*(5), 349–355.

Biessels, G. J., & Reagan, L. P. (2015). Hippocampal insulin resistance and cognitive dysfunction. *Nature Reviews Neuroscience*, *16*(11), 660–671. doi: 10.1038/nrn4019

Cahen, A., & Tacca, M. C. (2013). Linking perception and cognition. *Frontiers in Psychology*, *4*, 144. doi: 10.3389/fpsyg.2013.00144

Frith, E., Addoh, O., Mann, J. R., Windham, B. G., & Loprinzi, P. D. (2017). Individual and combined associations of cognitive and mobility limitations on mortality risk in older adults. *Mayo Clinic Proceedings*, *92*(10), 1494–1501. doi: 10.1016/j.mayocp.2017.06.019

Gates, N., Fiatarone Singh, M. A., Sachdev, P. S., & Valenzuela, M. (2013). The effect of exercise training on cognitive function in older adults with mild cognitive impairment: A meta-analysis of randomized controlled trials. *The American Journal of Geriatric Psychiatry*, *21*(11), 1086–1097. doi: 10.1016/j.jagp.2013.02.018

Ghorbani, N., Krauss, S. W., Watson, P. J., & Lebreton, D. (2008). Relationship of perceived stress with depression: Complete mediation by perceived control and anxiety in Iran and the United States. *International Journal of Psychology*, *43*(6), 958–968. doi: 10.1080/00207590701295264

Hinton-Bayre, A., & Geffen, G. (2005). Comparability, reliability, and practice effects on alternate forms of the Digit Symbol Substitution and Symbol Digit Modalities tests. *Psychological Assessment*, *17*(2), 237–241. doi: 10.1037/1040-3590.17.2.237

Joy, S., Kaplan, E., & Fein, D. (2003). Digit symbol-incidental learning in the WAIS-III: Construct validity and clinical significance. *Clinical Neuropsychology*, *17*(2), 182–194. doi: 10.1076/clin.17.2.182.16495

Kaleta, D., Makowiec-Dabrowska, T., Dziankowska-Zaborszczyk, E., & Jegier, A. (2006). Physical activity and self-perceived health status. *International Journal of Occupational Medicine and Environmental Health*, *19*(1), 61–69.

Kedia, G., Mussweiler, T., & Linden, D. E. (2014). Brain mechanisms of social comparison and their influence on the reward system. *Neuroreport*, *25*(16), 1255–1265. doi: 10.1097/WNR.0000000000000255

Koekkoek, P. S., Kappelle, L. J., van den Berg, E., Rutten, G. E., & Biessels, G. J. (2015). Cognitive function in patients with diabetes mellitus: Guidance for daily care. *Lancet Neurology*, *14*(3), 329–340. doi: 10.1016/S1474-4422(14)70249-2

Koponen, A. M., Simonsen, N., & Suominen, S. (2017). Determinants of physical activity among patients with type 2 diabetes: The role of perceived autonomy support, autonomous motivation and self-care competence. *Psychology, Health, and Medicine*, *22*(3), 332–344. doi: 10.1080/13548506.2016.1154179

Loprinzi, P. D. (2015a). Dose-response association of moderate-to-vigorous physical activity with cardiovascular biomarkers and all-cause mortality: Considerations by individual sports, exercise and recreational physical activities. *Preventive Medicine*, *81*, 73–77. doi: 10.1016/j.ypmed.2015.08.014

Loprinzi, P. D. (2015b). Factors influencing the disconnect between self-perceived health status and actual health profile: Implications for improving self-awareness of health status. *Preventive Medicine*, *73*, 37–39. doi: 10.1016/j.ypmed.2015.01.002

Loprinzi, P. D. (2016). Multimorbidity, cognitive function, and physical activity. *Age (Dordr)*, *38*(1), 8. doi: 10.1007/s11357-016-9874-5

Loprinzi, P. D., & Ramulu, P. Y. (2013). Objectively measured physical activity and inflammatory markers among US adults with diabetes: implications for attenuating disease progression. *Mayo Clinic Proceedings*, *88*(9), 942–951. doi: 10.1016/j.mayocp.2013.05.015

Loprinzi, P. D., Crush, E., & Joyner, C. (2017). Cardiovascular disease biomarkers on cognitive function in older adults: Joint effects of cardiovascular disease biomarkers and cognitive function on mortality risk. *Preventive Medicine*, *94*, 27–30. doi: 10.1016/j.ypmed.2016.11.011

Loprinzi, P. D., Herod, S. M., Cardinal, B. J., & Noakes, T. D. (2013). Physical activity and the brain: A review of this dynamic, bi-directional relationship. *Brain Research*, *1539*, 95–104. doi: 10.1016/j.brainres.2013.10.004

Loprinzi, P. D., Cardinal, B. J., Si, Q., Bennett, J. A., & Winters-Stone, K. M. (2012). Theory-based predictors of follow-up exercise behavior after a supervised exercise

intervention in older breast cancer survivors. *Support Care Cancer*, *20*(10), 2511–2521. doi: 10.1007/s00520-011-1360-0
Machon, M., Vergara, I., Dorronsoro, M., Vrotsou, K., & Larranaga, I. (2016). Self-perceived health in functionally independent older people: Associated factors. *BMC Geriatrics*, *16*, 66. doi: 10.1186/s12877-016-0239-9
Morrato, E. H., Hill, J. O., Wyatt, H. R., Ghushchyan, V., & Sullivan, P. W. (2007). Physical activity in U.S. adults with diabetes and at risk for developing diabetes, 2003. *Diabetes Care*, *30*(2), 203–209. doi: 10.2337/dc06-1128
Parkin, A. J., & Java, R. I. (1999). Deterioration of frontal lobe function in normal aging: Influences of fluid intelligence versus perceptual speed. *Neuropsychology*, *13*(4), 539–545.
Plassman, B. L., Langa, K. M., Fisher, G. G., Heeringa, S. G., Weir, D. R., Ofstedal, M. B., ... Wallace, R. B. (2007). Prevalence of dementia in the United States: The aging, demographics, and memory study. *Neuroepidemiology*, *29*(1–2), 125–132. doi: 10.1159/000109998
Proust-Lima, C., Amieva, H., Dartigues, J. F., & Jacqmin-Gadda, H. (2007). Sensitivity of four psychometric tests to measure cognitive changes in brain aging-population-based studies. *American Journal of Epidemiology*, *165*(3), 344–350. doi: 10.1093/aje/kwk017
Schutte, N. S., & Malouff, J. M. (2016). The relationship between perceived stress and telomere length: A meta-analysis. *Stress Health*, *32*(4), 313–319. doi: 10.1002/smi.2607
Stolte, E., Hopman-Rock, M., Aartsen, M. J., van Tilburg, T. G., & Chorus, A. (2017). The theory of planned behavior and physical activity change: outcomes of the aging well and healthily intervention program for older adults. *Journal of Aging and Physical Activity*, *25*(3), 438–445. doi: 10.1123/japa.2016-0182
Tacca, M. C. (2011). Commonalities between perception and cognition. *Frontiers in Psychology*, *2*, 358. doi: 10.3389/fpsyg.2011.00358
Vilkki, J., & Holst, P. (1991). Mental programming after frontal lobe lesions: Results on digit symbol performance with self-selected goals. *Cortex*, *27*(2), 203–211.
Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: The evidence. *CMAJ*, *174*(6), 801–809. doi: 10.1503/cmaj.051351
Wechsler, D. (1958). The measurement and appraisal of adult intelligence. *Academic Medicine*, *33*(9), 1–297.
Young, M. D., Plotnikoff, R. C., Collins, C. E., Callister, R., & Morgan, P. J. (2014). Social cognitive theory and physical activity: A systematic review and meta-analysis. *Obesity Reviews*, *15*(12), 983–995. doi: 10.1111/obr.12225
Zahrt, O. H., & Crum, A. J. (2017). Perceived physical activity and mortality: Evidence from three nationally representative U.S. samples. *Health Psychology* doi: 10.1037/hea0000531.

Author Biographies

Paul D. Loprinzi, PhD, is an associate professor in the Department of Health, Exercise Science and Recreation Management at the University of Mississippi.

Emily Frith, is a PhD student in the Department of Health, Exercise Science and Recreation Management at the University of Mississippi.