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The benefits of physical activity for cognitive functioning in a student population

Researchers and practitioners within higher education have long been fascinated with the prediction and explanation of undergraduate student success. This is because of the practical importance of understanding the factors that contribute to engagement, retention and performance. Not only are there likely to be financial and psychological costs to failing or dropping out, but there are also likely to be consequences to students who underperform. Students can feel disheartened and demotivated, and this can have a knock-on effect on peers and even on those who teach them.

Underperformance is often linked to students' difficulties in organising, planning, and attending to their course work (Ferrett, 2000), all of which depend upon underlying cognitive functioning (i.e., mental processes such as memory, attention and executive functioning; Tomporowski, Davis, Miller, & Naglieri, 2008). Research into the predictors of cognitive functioning has attracted considerable attention and a growing body of evidence now exists on the importance of physical activity with children and clinical populations (See reviews by Best, 2010; Etnier, Salazar, Landers, Petruzzello, Han, & Nowell, 1997; Tomporowski et al., 2008). The purpose of the present study was to extend this body of literature and examine the role of physical activity on cognitive functioning in the student population.

Review of the literature

In a review of the literature on the effects of exercise on children's intelligence, cognition, and academic achievement, Tomporowski et al., (2008) have found that exercise is an important method of enhancing aspects of children's mental functioning central to cognitive development. Similarly, Best (2010) found that exercise improved children's executive function and that certain types of exercise had greater effects such as cognitively engaging activities. Ratey and Loehr (2011) reported similar findings in their review of the research on the positive impact of physical activity on cognition during adulthood. Within the adult population, a meta-analysis of one hundred and thirty-four studies examining the influence of fitness and exercise on cognitive function found that exercise improves cognitive function by a significant amount (Etnier et al., 1997).

The majority of studies carried out thus far on physical activity and cognitive functioning typically follow an experimental design that measure cognitive functioning pre- and post- a physical intervention. However, what is less certain is the extent to which this influence exists through the natural maintenance of an active lifestyle. Following this rationale, one would propose that individuals who engage in regular physical activity would perform better on tests of cognitive functioning than individuals who lead an inactive lifestyle (Richards, Hardy, & Wadsworth, 2003). To address this gap in the literature, Kamijo & Takeda (2009) studied a group of 40 young adults split into two groups, active or sedentary, on the basis of their regular physical activity level and found that those engaged in regular physical activity scored significantly higher on a spatial priming task. Similar findings were reported in a subsequent study by the same researchers (Kamijo & Takeda, 2010). The current study is set to expand upon such findings and examine whether students who engage in regular physical activity perform better on tasks of cognitive functioning in comparison to students who participate in little or no physical activities. Based on previous literature, it is hypothesised that students who engage in regular physical activity will perform better on tests of cognitive functioning, including measures of executive functioning, memory, and attention.

Method

Participants

The participants consisted of students (Male = 21, Female = 23) (mean age = 20.64 years, SD = 1.77) from a large University in the UK, selected randomly via an opportunistic sample. The participants were assigned to either the high physical activity group, medium physical activity group or low physical activity group, depending on their physical activity levels calculated from the physical activity questionnaire. Participants were divided into three non-overlapping groups based on the mean number of minutes of activity undertaken during the month prior to interview. The groups were defined as follows: Low exercise group < 740 minutes activity per month (n= 17: M = 6, F = 11); medium exercise group between 815 and 1380 minutes activity per month (n=15: M=7, F=8); high activity group > 1440 minutes activity per month (n=12: M=8, F=4).

Materials and Procedure

The Physical Activity Questionnaire (Thirlaway & Benton, 1992) was used to collect details of the physical activity participants undertook over the previous four weeks, in terms of type, regularity and duration of activity. The total duration of physical activity, per month, was calculated to the nearest minute.

The Stroop Test (Stroop, 1935) was used to assess response inhibition, concentration and selective attention. *The Digit Span Test* (DS: Wechsler, 1981) was used to measure short-term auditory memory and required participant to repeat an increasing sequence of numbers in the same order as they have been read to them. *The Mathematical Equation Addition Test* (Geary & Wiley, 1991) was used to measure reaction time, otherwise known as speed of processing. *The Trail Making Test* (Partington & Leiter, 1949) was used to measure attention, as well as visual search and visuospatial sequencing, psychomotor speed, complex motor skills, abstract and reasoning abilities, and cognitive flexibility.

Results

A perusal of the mean scores reveals that the low exercise group were slower in their performance than the other two groups on the Stroop test, the Addition test and the Trail Making test (see Table 1 below). Furthermore, for the Addition test and Trail Making test the fastest performance was by the high exercisers, followed by the medium exercisers and then the low exercisers.

A one-way between-groups MANOVA, incorporating all four cognitive measures with physical activity group as factors was conducted. Results revealed a significant main effect of group for: Addition (F = 13.63, df = 2,42, p < .001) and Trails (F= 9.84, df = 2,34, p < .001); with a small

Table 1. Performance on the Cognitive tests by the three exercise groups.

	Exercise Group			F Value
	Low (n=17)	Medium (n=15)	High (n=12)	
Stroop *Time taken to complete the test*	8.52	6.26	6.58	*F* = 3.46, *p =.041*
Digit Span *Maximum digit spans recorded*	5.58	5.86	5.91	*F=.195, p =.94*
Addition *Time taken to complete the test*	113.05	60.13	59.58	*F=13.6, p <.001*
Trail making *Time taken to complete the test*	182.17	110.33	97.58	*F=9.84, p < .001*

Note: Time was measured in seconds

effect for Stroop (F = 3.46, df = 2.14, p = .04). Thus, students in the high and medium activity groups performed significantly better than the low activity groups on tests of executive functioning and attention. No effect was observed for the digit span test ($p > .05$) suggesting that there were not significant differences in performance between the high, medium, and low activity groups.

To investigate further the relationship between cognitive test performance and activity levels, the mean number of minutes of activity for all participants was correlated with cognitive test performance using Pearson's *r*. Performance on the Addition test was found to be negatively associated with activity levels (r= -.35, n=44, p = .01) with no other associations being significant. However, results must be interpreted with caution due to the small sample size and possible confounding variables.

Discussion

The purpose of the present study was to examine whether students who regularly engage in physical activities score higher on tests of cognitive functioning than students who do not engage in physical activities. Findings indicated that the high exercise group demonstrated superior performance on three of the four cognitive tests, indicating superior speed of mental processing, attention, and executive functioning. No group difference was observed on the digit span test, indicating a lack of evidence for memory superiority for the high exercise group. These findings are supportive of previous research (Colombe & Kramer, 2003; Kamijo & Takeda, 2009; 2010).

This study is not without limitations and further research is needed in order to develop a greater understanding of the intricate relationship between physical activity and cognitive functioning in the student population. To begin with, it is important to consider that these findings do not imply a causal relationship between physical activity and cognitive functioning. Direction of causality is problematic as possible activity directly promotes cognitive growth and maintenance; however those with high cognitive abilities are also likely to engage in such activities (McAuley, Mullen, Szabo, White, Wojcicki, Mailey et al., 2011). To address this limitation future research would benefit from a longitudinal study. Another possible limitation is method bias. The data were collected via self-reports, and it is possible that the findings were influenced by this restriction in data-collection method. Although this is not an uncommon method of investigation, there are other methods of physical activity that should be considered. Examples include daily tasks such as shopping, cleaning, gardening etc. Moderate level everyday activities have been found to have improvements on health (Biddle, Fox & Boutcher, 2000), and sharpen the mind as well as the body producing improvements in cognitive functioning (Biddle & Mutrie, 2005). Finally, this study was conducted in a single setting and with a relatively small sample of participants. Future research in different Higher Education Institutions should be carried out in order to examine the extent to which these findings can be generalised.

Theoretical and practical implications

Despite the study limitations, these findings have important theoretical and practical implications. From a theoretical perspective, it adds to the increasing body of literature on physical activity and cognitive functioning amongst the student population. From a practical perspective, it provides evidence that should inform policies with regards to resource allocation in higher education. The overall health benefits of structured physical activity are probably much more important than possible academic gains. Indeed, engaging in physical activity has many beneficial effects, and individuals who are not physically active are at greater risk of obesity, hypertension, diabetes, and mental health problems than those who are (e.g., Biddle & Mutrie, 2005). Despite this knowledge, the problem of resource allocation often means that programmes aimed at promoting student well-being mainly focus on psycho-social and academic initiatives, with only little recognition of the importance of physical activity. However, a proven relationship between physical fitness and cognitive functioning could be used as an argument to support, retain, and perhaps even improve physical fitness programmes in higher education.

In summary, the results from the present study indicate that higher levels of physical activity are associated with increased levels of attention, reaction time and executive functioning amongst students. Further research is needed within the student population in order to gain a more comprehensive understanding of the topic that can then inform policies.

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