The Relationship between Physical Activity and Academic Achievement of University Students

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Abstract: Physical education belongs to the compulsory courses at many universities around the world. While many studies focused on the benefits of physical activity among elementary school pupils or high school students, the literature has been more silent on its effects in higher education. In this paper, we aim to determine what is the relationship between physical activity and academic achievement of university students. The research is based on a sample of 159 students at Master degree level studying at the Faculty of Business Administration, University of Economics, Prague. The results suggest that aerobic exercise has a positive effect on study results, but only among female students. No effects of anaerobic exercise have been found. Study achievement is also negatively influenced by the students' age. The results are in line with prior studies which, however, focused predominantly on pupils and high school students.

Keywords: Physical activity, academic achievement, study performance, universities, Czech Republic

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Introduction

A healthy lifestyle and sport activities are widely supported in the current society. Physical education has become a standard part of elementary and high school curricula, but also of universities' study plans. However, in some countries, the number of hours devoted to physical education is declining (Carlson et al.., 2008) and in many countries, physical training does not belong to the study plans of higher years of university studies.

Due to the importance of physical activity for the development of human body and brain, many authors tried to find out whether physical activity positively affects learning outcomes. The positive effect of physical activity on psychical well-being is undebatable; however, it is also reasonable to assume that the time devoted to leisure will negatively affect the number of hours spent learning, and hence, negatively affect the overall academic achievement.

The vast majority of past studies focused on the academic achievement of pupils and students in high schools. At the same time, physical education has become a compulsory part of university study plans. The aim of this paper is to determine if the physical activity positively affects the study results of university students.

The remainder of this paper is organized as follows. The first part summarizes the existing state-of-the-art. Subsequently, we present the methods and data used in the study. Then, the discussion and concluding remarks are presented.

Theoretical Background

Physical activity is closely related to human development. It is one of the factors affecting the process of growth and development of mental skills and physical abilities. The importance of physical activity has also been a subject of interest of the European Union working group entitled

"Sport & Health" (EU, 2008). According to their report, physical activity, health and life quality are closely related; in order to function properly and to prevent diseases, the human body needs to exert regular physical activity.

The positive impact of physical activity on the development of human brain can be considered to be empirically proven. The authors mention its positive effects on self-confidence and feeling of security, reduction of anxiety or mood improvement (Mutrie et al., 2010), or reduction of the risk of depression (Paluska & Schwenk, 2000). As a result, many authors also agree on the fact that the physical fitness positively affects study performance, both in the case of young children and older pupils (Etnier et al., 2006; Stevens et al., 2008; Chomitz et al., 2009). Sallis et al. (1999) found that children who are more physically active and enjoy a better physical condition may become better pupils. Similarly, Fox et al. (2010) found that students who were active in sport teams had better study results than their non-active counterparts. According to Rajic et al. (1997), regular physical activity carried out at least three times a week improves the activity of pupils in the classroom.

Consequently, physical activity positively affects not only organizational abilities and time management, but also reduces the level of stress (Rajic, 1997) and teaches the students discipline and perseverance, which may become useful when performing study-related tasks.

Sport activity is often divided into aerobic and anaerobic. Aerobic activity (aerobic fitness) is based on long-term exercise with middle intensity, typically accompanied by a high stroke frequency. On the other hand, anaerobic activities (muscular fitness) are focused on high performance in a short period of time. According to the existing studies, the two types of physical activity may have different effects on study performance.

In a sample of preadolescents in Illinois, Castelli et al. (2007) found that the aerobic capacity and body mass index (BMI) were closely

related to the success in reading and mathematics, while muscle fitness had no significant effects. Positive effects of aerobic fitness on academic achievement have also been reported by Fedew and Ahn (2011) and So (2012). However, So (2012) points out that when psychical activity is carried out too often, academic achievement may deteriorate as too much time is devoted to sport at the expense of study obligations.

As to anaerobic activity, the positive effects on academic achievement are at least debatable. In a large survey among teenagers, So (2012) found that anaerobic activity had no effect on academic achievement. Similar findings have also been presented by Castelli et al. (2007).

Carlson et al. (2008) found that physically active girls performed significantly better in mathematics and reading than non-active girls; however, no effects have been found in the sample of boys. The fact that gender significantly affects the results of comparative analyses was acknowledged by multiple other authors (e.g, Jago et al., 2009; Salvy et al., 2009). Based on the Carlson et al.'s (2008) study, we expect that gender will have moderating effects on the relationship between physical activity and academic achievement.

To sum up, most of the existing studies agreed on the fact that sport and physical activity have positive effects on study achievement, while a significant effect has been mostly observed in the case of aerobic activity. Moreover, the literature suggests that the effect of physical activity on academic achievement may depend on gender. At the same time, to the best of our knowledge, little attention has been devoted to the relationship between physical activity and academic outcomes of university students. Considering the above arguments, then, we hypothesize that:

- H1: Aerobic activity has positive effects on the academic achievement of university students.
- H2: Anaerobic activity has no effects on the academic achievement of university students.

- H3. There is a moderating effect of gender on the relationship between physical activity and academic achievement.

Methods and Data

Participants

The research sample consisted of the students enrolled in a Master degree at the Faculty of Business Administration (FBA), University of Economics, Prague, in the Czech Republic. To select respondents, we used a list of students of Management and Arts Management enrolled in the 2017 summer semester. We asked 403 students to fill the questionnaire using an e-mail request; 162 questionnaires were returned, which corresponds to the response rate of approximately 40.2%. Subsequently, three respondents were removed from the sample due to inconsistencies in answers (incorrect degree of studies), thus the final sample contained 159 respondents.

By using the CAWI method, we guaranteed the anonymity of respondents and reduced the time effort required, as the respondents were provided a direct link to their Study Information System together with instructions where to find relevant information about their studies.

Materials

To test our hypotheses, we employed linear regression analysis. Following most past studies (Keays & Allison, 1995), we used academic achievement as an outcome measure. Following e.g. Sallis et al. (1999), we used teacher-assigned grades as a measure of study achievement. Every participant reported their *average grade*, calculated as the mean grade of all completed courses (grades range from 1 = "Excellent" to 3 = "Good"). Although the grades on individual courses are of ordinal nature, the average grade is a continuous response variable, leading us to the use of the linear regression model. The non-response bias was

reduced as every participant was able to find this value in their university account profile (and was given the instructions how to find it). Using the average grade instead of focusing on individual courses grades also reduces the individual teachers' subjective evaluation.

Following the literature review, we included two key variables in the model; the weekly number of hours devoted to *anaerobic activities* and to *aerobic activities*. To reduce the response bias due to the non-understanding of the question, the participants were given the explanation of these two terms.

In the analysis, we also controlled for *gender*, since it is also known to affect study achievement. As a result, we employed a binary variable taking the value of one if the respondent was a woman, or zero otherwise. To test for moderating effects of gender, we also included interaction terms in the model.

Another factor which we controlled for in the analysis was the *age,* since it also enters into the relationship between physical activity and study results (Castelli et al., 2007). For instance, in a sample of Bocconi university students, Pellizzari and Billari (2012) found that younger students performed better than older students, while emphasizing that in samples of elementary school pupils, the observed effect had been the opposite; better academic results have been achieved by older pupils.

Results

Table 1 presents the descriptive statistics. There were 36% of women in the sample. The mean age was 24.15 years; most respondents were 23-27 years old, however, there were also two older students of 29 and 30 years. The maximum values of the number of hours devoted to aerobic and anaerobic activities on a weekly basis suggested that there were several professional sportsmen in the sample; specifically, five respondents carried out more than six hours of aerobic activities per

week, and four respondents carried out more than six hours of anaerobic activities on a weekly basis. Since these data are not due to measurement error, we did not remove the cases from the analysis.

Table 1 Descriptive statistics

	Minimum	Maximum	Mean	Std. Deviation
Average grade	1.000	2.900	1.830	0.377
Anaerobic	0	18	1.400	2.586
Aerobic	0	10	1.690	2.066
Gender	0	1	0.360	0.483
Age	22	30	24.150	1.213

Table 2 presents the bivariate Pearson correlations among the model variables. The average grade is significantly and negatively correlated with aerobic activities (suggesting that aerobic activities improve the study achievement), while it is significantly and positively correlated with anaerobic activities (suggesting that anaerobic activities reduce the study achievement). There is also a significant and negative correlation between aerobic and anaerobic activities, which suggests that there is a trade-off relationship between the two types of sport activities. Also, older students tend to prefer aerobic activities.

Table 2 Correlation Matrix

	Average grade	Anaerobic	Aerobic	Gender	Age
Average grade	1				
Anaerobic	0.194*	1			
Aerobic	–0.250**	–0.445**	1		
Gender	–0.137	–0.098	0.141	1	
Age	0.129	–0.137	0.193*	0.100	1

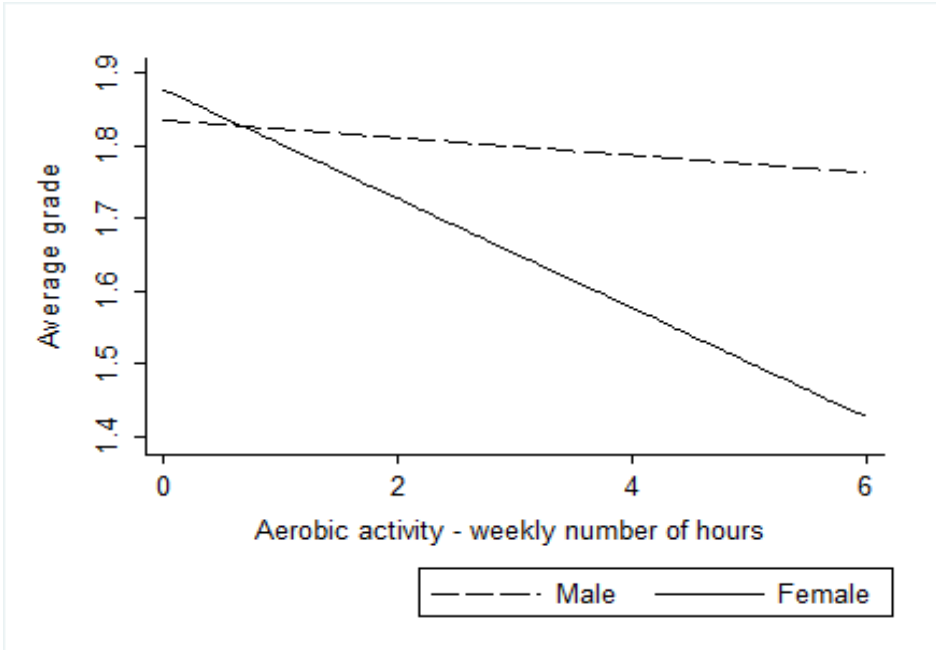
Note: ** $p < 0.01$, $p < 0.05$

Table 3 presents the estimated parameters of two models. First, we tested the main effects, and in the second step, we included the interaction terms. In the first step, we found a statistically significant

and negative effect of aerobic activities on the average grade; in other words, the results suggest that aerobic physical activities improve the study achievement.

However, the test for moderating effects revealed that the above findings applies only in the subsample of women; in the case of men, aerobic activity has no significant effects on study achievement. *Figure 1* displays the interaction plot for gender, illustrating that the positive effects of aerobic activity on academic achievement is significantly higher in the subsample of female students.

Figure 1 Interaction plot for gender



Regarding anaerobic physical activities, neither a statistically significant main effect on academic achievement nor a significant moderating effect have been found. Moreover, we found that age increased the

average grade, thus reducing the academic achievement; gender has no direct effect on academic achievement.

Table 3 Estimation of the model parameters

	Model 1			Model 2		
Variable	Coefficient	p value	VIF	Coefficient	p value	VIF
Intercept	0.419	0.470	-	0.292	0.620	-
Anaerobic	0.016	0.194	1.253	0.021	0.134	1.588
Aerobic	–0.041**	0.010	1.288	–0.12	0.567	2.344
Gender	–0.089	0.138	1.027	0.032	0.750	2.983
Age	0.050**	0.031	1.048	0.065***	0.008	1.078
Gender × Aerobic				–0.061*	0.055	3.681
Gender × Anaerobic				-0.010	0.759	2.031
R2	0.119			0.142		
F statistic	5.177***			4.202***		

Note: *** $p < 0.01$, ** $p < 0.05$,* $p < 0.1$.

To evaluate the presence of multicollinearity, we calculated the variance inflation factors (VIF), which are displayed in *Table 3*. Since no VIF exceeds the value of 5, we can conclude that there were no severe multicollinearity issues in our data (Hair et al., 2010). We also verified the other pre-requisites of the Gauss-Markov theorem: zero mean, normality and autocorrelation of residuals; no severe violations of the regression assumptions have been found.

To verify our linearity assumption, we performed additional tests of non-linearity. Specifically, we included the squared terms for aerobic and anaerobic activities to test for the existence of quadratic relationships. However, neither the squared term for aerobic activities ($\beta = 0.001$, $p = 0.396$) nor the squared term for anaerobic activities ($\beta = 0.001$, $p = 0.917$) were statistically significant.

As anticipated earlier, there are several observations that differ substantially from other cases. Specifically, five respondents carried out more than six hours of aerobic activities per week, and four

respondents carried out more than six hours of anaerobic activities weekly. Professional sportsmen or enthusiastic amateurs may represent potentially influential observations. However, when having removed these cases from the analysis, our conclusions remained unchanged.

Discussion

The results suggest that academic achievement of female university students is positively affected by the number of hours spent doing aerobic physical activity; however, this finding does not apply to male students. Moreover, we observed no significant effect of the anaerobic physical activity on the average grade. Besides, age seems to affect academic achievement negatively; older students perform worse, probably because they are often employed and do not focus on achieving good grades.

Our findings in the female students' subsample are consistent with studies performed in other countries (e.g. Castelli et al., 2007). Aerobic physical activity leads to changes in cognitive functions (Hillman et al., 2005) and to changes in the brain tissue. Individuals who regularly carry out aerobic activities are supposed to enjoy better reaction skills and a better ability to concentrate. Moreover, physical activity seems to positively affect the overall physical well-being (Mutrie et al., 2010). As a result, individuals who are active in aerobic sports may improve their abilities to manage their duties and organize their time; also, they enjoy better perseverance and lower levels of stress (Rajic, 1997). To further elaborate on the explanation of the benefits of physical activity on the academic achievement, we may refer to the meta-analysis of Colcombe and Kramer (2003) who summarized the results of 18 studies. According to the authors, physical activity had the most positive effect on the executive functions, which may be understood as cognitive processes allowing for staying focused and resolving new and unexpected situations. Specifically, executive functions involve self-

control, selective attention, working memory, creative thinking, the ability to incorporate different perspectives and to adapt to new circumstances (Diamond, 2013). The beneficial effect of the aerobic exercise on the executive functions is probably the main reason for a better ability to learn. In the experimental study of Kramer et al. (1999), the adult participants who undertook a training in the aerobic exercises were better able to solve tasks which required the executive functions.

However, according to our results, the above effects are significantly pronounced in the case of female students only. This finding is consistent with Carlson et al. (2008) who argue that gender differences in the effects of physical activity on the overall fitness are due to lower baseline levels of fitness in the case of females. As a result, the physical activity of male students may not produce the same physiological and psychological effects, which we observed in the subsample of female students.

Conclusion

In this study, we found that unlike anaerobic activity, aerobic activity has positive effects on study achievement of female university students. The study complements previous studies and suggests that aerobic activities support the development of executive functions of female students, as well as their organizational skills and the overall wellbeing. Together, these effects may contribute to a better ability to learn. However, we did not find significant evidence on a positive relationship between physical activity and academic achievement among male students.

This study is not free of limitations. One of them is the research sample size. Second, our sample was based on students of a business school. While this may represent a possible source of bias, we cannot be sure that the effect size in the population depends on the field of study. Third, academic achievement may also be influenced by other factors

not included in our model, such as the intelligence or the social, economic or family status of university students.

Our results may be used when designing study plans of universities. If the long-term sport activity with a middle intensity of exercise improves the study predispositions, policymakers may consider increasing the offer of courses focused on aerobic activities. In study plans with no physical education, such courses may even become compulsory study courses. Moreover, according to our results, courses focused on anaerobic activities will not improve the academic achievement. Our findings may also be used by the individual students; we argue that it is worthy to devote several hours per week to aerobic exercise, not only to improve own grades, but especially to improve own overall physical and psychical condition.

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