Original Article

Gender Differences in Academic Performance of High School Students: The Relationship with Cardiorespiratory Fitness, Muscle Endurance, and Test Anxiety

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Abstract

Background: The purpose of this study was to investigate the relationship between cardiorespiratory fitness, muscle endurance, and test anxiety levels with academic performance in both genders of high school students. **Methods:** A total of 545 grade nine students (mean age: 14.1 ± 0.4 years old) participated in this study. Final grades in language, mathematics, and science and the overall mean average of all courses were used to assess academic performance. Cardiorespiratory fitness levels were estimated using the 20 meter shuttle run test and muscle endurance was measured using push-up and curl-up tests. Participants also completed a questionnaire for the assessment of test anxiety. Independent *t*-tests, correlations, and linear regression analysis were performed. **Results:** Results show that female students (n = 292) had significantly higher grades in language and science as well as a higher overall mean average than male students ($P < 0.001$). Moreover, we observed that female students had significant greater correlation coefficient values than male students for cardiorespiratory fitness levels and muscle endurance with academic performance ($P < 0.05$). Finally, linear regression analysis showed multiple differences between male and female students regarding independent predictors of academic performance ($P < 0.01$). **Conclusions:** Results of the present study indicate that the academic performances of male and female students are different in high school and that these distinct academic performances appear to be explained by different variables.

Keywords: *Academic achievement, adolescent, estimated VO_2 max, language, mathematics and science, sex differences, stress*

Introduction

There is evidence to suggest that academic performances of male and female students are different in elementary and high school.[1-7] For example, in the United States, Duckworth and Seligman[4] studied differences between genders in academic performance in two cohorts of respectively 137 and 167 grade eight students. The authors compared the academic performance of male and female students in mathematics, social studies, and language (English) courses as well as the overall grade point average (GPA) using school records. In both cohorts, female students outperformed male students, with an effect size (d) of up to 0.8 in mathematics ($P < 0.05$), 0.7 in language ($P < 0.001$), 0.6 in social studies ($P < 0.01$), and up to 0.7 for the overall GPA ($P < 0.001$). Britner[2] also showed that female students had significantly better grades in science than male students (d = 0.3, $P < 0.05$) in a cohort of 502 students from grades nine to 12 in an American high school. Another group of researchers from Germany investigated gender differences in academic performance in 1380 students from grades five to 10.[5] The authors used grades in language (German) and mathematics to compare academic performance in both genders. Results showed that female students had better grades than male students in language, with a small d = 0.3 ($P < 0.01$), whereas male students presented slightly better grades in mathematics than female students (d = 0.1, $P < 0.05$). In contrast, Chen and Pajares[8] reported that there were no significant gender differences in science between 508 grade six students in an American middle school.

Improving the academic performance of high school students is a fundamental

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objective for any high school. By improving their academic performance, students could increase their probability of being accepted to university, obtain a bursary or an award, as well as develop a greater self-satisfaction. Thus, the ability to predict the academic performance of a high school student has important implications for all high schools and society.

Cardiorespiratory fitness levels, muscle endurance and test anxiety are three factors that seem to influence academic performance.[6,9-22] Indeed, cardiorespiratory fitness levels appear to be positively associated with academic performance in elementary and high school students.[9-12,17,18,21-23] For example, Raine *et al*.[9] followed 52 American adolescents from grade six through grade eight. Their results suggest that changes in aerobic fitness were positively related with changes in mathematics achievement ($r = 0.28$, $P < 0.05$). This relationship seems to be stronger in female students than in male students.[10,11,16] In contrast, another study showed that the relationship between cardiorespiratory fitness and academic performance was stronger in male students than in female students.[24] However, Castelli *et al*.[18] noted no differences between genders regarding the relationship between cardiorespiratory fitness and academic performance.

Muscle endurance (curl-ups and push-ups) has also been shown to be positively related to academic performance.[17,18,25] For example, push-up and curl-up tests have been found to be positively correlated with mathematic, reading, and general academic performance.[18] However, the authors did not analyze their results regarding gender differences. Moreover, in the United States, Van Dusen *et al*.[25] reported positives associations between push-up and curl-up tests with standardized mathematics and reading tests in a sample of 254 743 grade three to 11 students. The authors observed that these relationships were stronger in female students only for reading. In another study conducted in 838 American middle school students, the relationship between muscle endurance tests and academic performance (mathematics and reading) was stronger in male students (odds ratio between 2.21 and 3.15).[17]

There is also evidence to suggest that elementary and high school students with a lower level of test anxiety appear to present a better academic performance than students with a higher level of test anxiety.[13-15,20] For example, Carey *et al*.[20] observed in 903 seventh and eighth grades British students that test anxiety was negatively related to reading ($r = -0.14$, $P < 0.05$) and mathematic ($r = -0.26$, $P < 0.05$) performances. Furthermore, findings in regard to the relationship between test anxiety and academic performance appear to be gender dependent.[6,13,26,27] More specifically, female students seem to present higher levels of test anxiety than male students.[6,15,26,27] However, the differences in the influence of test anxiety on academic performance between male and female students remain unclear. For example, a meta-analysis concluded that there was no difference in the relationship between test anxiety and academic performance in both genders.[15] In contrast, there is evidence to suggest that the relationship between academic performance and test anxiety is more pronounced in male students compared to female students, despite a higher level of test anxiety in female students.[26,27] In another study, Rahafar *et al*.[6] observed that test anxiety was a predictor of academic performance in only female high school students.

Taken together, it appears that gender differences in academic performance as well as the factors that could explain those differences remain contradictory. That is, the relationship between cardiorespiratory fitness, muscle endurance, and test anxiety with academic performance may vary according to the student's gender. Furthermore, existing research on these relationships was for the most part performed on children in elementary and middle schools.[1,28] Interestingly, gender differences in academic performance seem to be greater at the high school level than at the elementary and middle school level.[28] Thus, investigating these differences in a population of adolescent students in high school becomes more relevant. Also, the majority of research that examined academic performance with cardiorespiratory fitness levels, muscle endurance, and test anxiety has been conducted in the United States[1,28,29] with, to our knowledge, no studies in Canada. Therefore, to further contribute to the literature and to untangle the discrepancies in the results concerning the gender differences in academic performance, the purpose of this study was to investigate the relationship between cardiorespiratory fitness, muscle endurance, and test anxiety with academic performance in both genders of adolescent students in high school. We hypothesized that academic performance would be different between genders and that cardiorespiratory fitness, muscle endurance, and test anxiety levels would explain academic performance in both genders differently. The present study could initiate some changes in high school policies and practices leading high school educators to consider planning interventions that are gender specific, which could lead to improving academic performance in both genders more efficiently.

Methods

Overview

This study relied on data from an internal project of a single French–Canadian public high school located in Montreal (Canada). The project was an initiative of the high school, which collected data on academic performance, physical fitness, and test anxiety from all of its grade nine students. It should be noted that this high school follows a specific educational program called the International

Baccalaureate, which corresponds to an elite program in the province of Quebec. All students enrolled into this high school had excellent grades in elementary school and had to achieve an entrance exam prior to their admission. Participants and their parents/guardians were informed about the study and they had the choice to refuse to participate and/or to withdraw at any time without penalty. All procedures were approved by the school administration, by its Governing board, by the school board, and by the Ethics Committee of the Faculty of Science at the Université du Québec à Montréal.

Participants

The study sample consisted of 545 grade nine students (mean age: 14.1 ± 0.4 years old) from the selected high school. Three entire cohorts of grade nine students participated in this study between 2012 and 2015. Inclusion criteria were 1) to be enrolled in the targeted school and 2) to be in grade nine.

Academic performance

Using the school's final report card, grades for language (French), mathematics, science as well as the mean average of each student, in percentage, were used to assess academic performance. The mean average is an overall weighted average calculated by the school using the final grades, in percentage, of all courses taken by a student during the school year. That is, the weighted value of each course used for the mean average was as follows: first language (22%), second language (8%), third language (8%), mathematics (17%), science (17%), history (11%), ethics and religious culture (6%), visual arts (6%), and physical education (6%). It should be noted that all students from the same cohort performed their language, mathematics, and science exams at the exact same time during the school year.

Cardiorespiratory fitness

The validated multistage 20 meter shuttle run test was used to estimate maximal oxygen consumption (VO_2 max). As previously described,[30] participants ran back and forth on a 20 meter course and had to touch the 20 meter line before a sound signal was emitted from a pre-recorded tape. The frequency of the sound signals was increased by 0.5 km/h each minute with an initial speed of 8.5 km/h. When the participant could no longer follow the pace of the signal, the last stage number that was accomplished was used to determine VO_2 max using the speed corresponding to that stage (speed = 8 km/h + 0.5 km/h x stage number). The estimated VO_2 max was calculated using the following validated prediction equation: VO_2 max (ml/kg/min) =31.025 + 3.238*S - 3.248*A + 0.1536*A*S, where S = speed (km/h) and A = Age (years).[30] Test–retest reliability coefficient of the multistage 20 meter shuttle run test was 0.89 for children aged between 6 and 16 years old.[30]

Muscle endurance

Muscle endurance was assessed using push-up and curl-up tests.[31] For the push-up test, participants had to put their hands and toes on the floor with the body in the plank position and had to complete as many push-ups as possible at a steady pace without taking a break. For each of the push-ups achieved, participants had to bend their elbows at 90°. The body had to be straight during the execution of the movement. The push-up test has been shown to be highly reliable (r = 0.95).[32] For the curl-up test, participants had to lie on a mat on the floor, on their back, with their knees bent 90°, hands on thighs and arms outstretched, and had to perform a maximum of curl-ups in a 60 s period. Test–retest reliability coefficient for the 60 s curl-up test was 0.98.[33]

It should be noted that the VO_2 max and muscle endurance tests were performed during regularly scheduled physical education classes and administered by the same trained physical education teacher for all three cohorts. Both tests were performed on separate days. Furthermore, students were already familiarized with both of these tests as they had to perform them since grade seven.

Test anxiety

Test anxiety was assessed by the special education technician of the school using the revised 27-item version of the Cognitive Test Anxiety Scale,[34] a 27-item measure which used a four-point rating scale. Scores were calculated on a total of 108, with higher scores reflecting greater test anxiety. The revised 27-item version of the cognitive test anxiety scale has been shown to have good reliability (α = 0.91) and construct validity (r = 0.78).[34]

Statistical analysis

The data are expressed as the mean ± standard deviation (SD). Participants were divided into two groups based on their gender (male: n = 253; female: n = 292). We first verified the normality of the distribution of variables in both groups with the skewness and the kurtosis tests and found that not all variables were normally distributed. Therefore, Spearman rank correlations were performed to examine the relationship between academic performance measures with cardiorespiratory fitness, muscle endurance, and test anxiety in both groups. Then, a comparison between correlation coefficient values of both genders was performed using the Fisher's Z-transformation.[35] An independent t-test was used for the mean comparison between both groups. We also calculated the effect size (d: mean difference between groups [Male-Female]/SD pooled) for all variables that were significantly different between groups. Finally, a stepwise linear regression analysis was performed to identify predictors of academic performance in both genders. Based on significant differences between groups, independent variables considered in the final model for academic performance

measures were estimated VO_2 max, number of curl-ups, number of push-ups, and test anxiety. Statistical analysis was performed using SPSS 25 for Windows (Chicago, IL, USA). Significance was defined at $P < 0.05$.

Results

Comparisons of physical characteristics, test anxiety, and academic performance measures between genders are presented in Table 1. Both genders were comparable for age and grades in mathematics. Estimated VO_2 max ($P < 0.01$; $d = 1.5$), number of curl-ups ($P < 0.01$; $d = 0.8$), and number of push-ups ($P < 0.01$; $d = 1.6$) were significantly higher in male students compared to female students. However, female students had significantly greater test anxiety levels ($P < 0.01$; $d = -0.5$) as well as higher grades in language ($P < 0.01$; $d = -0.5$), science ($P < 0.01$; $d = -0.4$), and overall mean average ($P < 0.01$; $d = -0.6$) than male students.

Correlations between physical characteristics and test anxiety levels with academic performance measures in both genders are shown in Table 2. In female students, we observed significant positive correlations between estimated VO_2 max, number of curl-ups, and number of push-ups with all measures of academic performance and significant negative correlations between test anxiety with all measures of academic performance. In male students, significant negative relationships between test anxiety and all measures of academic performance were also noted. However, no significant or weaker positive correlations were found between estimated VO_2 max, number of curl-ups, and number of push-ups with academic performance measures in male students. Moreover, we observed that female students had significant greater correlation coefficient values than male students for the following correlations: estimated VO_2 max with overall mean average, mathematics and science; number of curl-ups with overall mean average; number of push-ups with overall mean average, mathematics, and science. No significant differences between genders were noted in correlation coefficient values for grades in language and test anxiety.

We performed stepwise regression analysis to examine the independent predictors of academic performance in both genders. Table 3 illustrates the summary of the models. Our results showed multiple differences between male and female students regarding independent predictors of academic performance. In summary, the best predictor of academic performance is test anxiety for male students ($P < 0.01$; between 5 and 9%) and estimated VO_2 max for female students ($P < 0.01$; between 9 and 21%).

Discussion

We hypothesized that academic performance would be different between genders and that cardiorespiratory fitness, muscle endurance, and test anxiety levels would explain academic performance in both genders differently. Results from the present study support our hypotheses. That is, female students had significantly higher grades in language and science as well as overall mean average than male students. This finding is consistent with the results of several other studies in children and adolescents that also found female students outperforming male students.[1,2,4,5,7] Interestingly, Duckworth and Seligman[4] suggested that

Table 1: Physical characteristics, test anxiety, and academic performance measures between genders

Variables	Females students *n*=292	Male students *n*=253	*P*
Age (years)	14.1±0.4	14.1±0.4	0.859
Estimated VO_2 max (ml/kg/min)	42.4±4.3	49.6±5.0	**< 0.001**
Curl-ups (number)	46.4±13.1	57.1±13.4	**< 0.001**
Push-ups (number)	14.1±9.0	33.8±15.1	**< 0.001**
Test anxiety (/108)	63.0±14.0	56.5±14.1	**< 0.001**
Mean average (%)	83.9±5.1	80.3±6.2	**< 0.001**
Language (%)	83.2±6.9	79.2±7.8	**< 0.001**
Mathematics (%)	83.2±9.2	81.9±10.7	0.146
Sciences (%)	79.0±7.4	76.1±8.2	**< 0.001**

Values are mean±standard deviation (SD). Variables in bold represent significant differences between groups

Table 2: Correlations between physical characteristics and test anxiety with academic performance measures in both genders

	Female students				Male students			
	Estimated VO_2 max	Curl-ups	Push-ups	Test anxiety	Estimated VO_2 max	Curl-ups	Push-ups	Test anxiety
Mean average	0.45**	0.37**	0.41**	−0.34**	0.18**†	0.19**†	0.16*†	-0.27**
Language	0.27**	0.25**	0.26**	−0.31**	0.15*	0.16**	0.14*	-0.24**
Mathematics	0.32**	0.22**	0.32**	−0.27**	0.06†	0.06	0.07†	-0.33**
Sciences	0.34**	0.23**	0.30**	−0.27**	0.03†	0.10	0.03†	-0.26**

*P<0.05. **P<0.01. †Significant differences in correlation coefficient values between both genders (P<0.05)

Table 3: Stepwise regression analysis regarding independent predictors of academic performance (AP) in both genders

Dependent variable	Step	Independent variable	Partial r^2	r^2 cumulative	*P*
AP: Mean average					
Female students	1	Estimated VO_2 max	0.208	0.208	<0.001
	2	Test anxiety	0.071	0.279	<0.001
	3	Curl-ups	0.019	0.298	0.014
	4	Push-ups	0.013	0.311	0.019
Male students	1	Test anxiety	0.068	0.068	<0.001
	2	Estimated VO_2 max	0.038	0.106	0.001
AP: Language					
Female students	1	Estimated VO_2 max	0.093	0.093	<0.001
	2	Test anxiety	0.036	0.129	0.001
Male students	1	Test anxiety	0.049	0.049	<0.001
	2	Estimated VO_2 max	0.028	0.077	0.007
AP: Mathematics					
Female students	1	Estimated VO_2 max	0.109	0.109	<0.001
	2	Test anxiety	0.054	0.163	<0.001
Male students	1	Test anxiety	0.089	0.089	<0.001
AP: Sciences					
Female students	1	Estimated VO_2 max	0.118	0.118	<0.001
	2	Test anxiety	0.045	0.163	<0.001
Male students	1	Test anxiety	0.066	0.066	<0.001

Independent predictors included in the model were the same for all dependent variables: Estimated VO_2 max, number of curl-ups, number of push-ups and test anxiety

female students outperform male students partly because they are more self-disciplined, whereas Pomerantz *et al*.[7] concluded that female students are more concerned with pleasing adults and they also put more emphasis in the preparation of their academic evaluations than male students.

In addition, the present study showed that correlation coefficient values of cardiorespiratory fitness, muscle endurance, and test anxiety with academic performance measures presented several variations in both genders. However, few similarities were also observed in our cohort. For example, we reported significant relationships with cardiorespiratory fitness and muscle endurance (curl-ups and push-ups) with all four academic performance measures in female students, whereas only two significant correlations were observed with cardiorespiratory fitness and muscle endurance (curl-ups and push-ups) with academic performance (i.e. overall mean average and language) in male students. Moreover, we found that female students had significant stronger correlation coefficient values than male students for the following correlations: estimated VO_2 max with overall mean average, mathematics and science; number of curl-ups with overall mean average; number of push-ups with overall mean average, mathematics, and science. These results are in line with the results of other studies which also showed that the relationship between cardiorespiratory fitness and academic performance is stronger in female students than male students.[10,11,16] Our findings also partially confirm prior results reporting a positive and stronger relationship between muscle endurance and academic performance in female students.[25] Furthermore, no differences in correlation coefficient values were observed for test anxiety and academic performance measures between genders. These results are in line with Hembree[15] meta-analysis, which concluded that there was no difference in the relationship between test anxiety and academic performance in both genders, despite higher level of test anxiety in female students. Finally, our results showed that test anxiety was the primary independent predictor for all the academic performance measures in male students, explaining 5–9% of the variance and cardiorespiratory fitness was the primary predictor for all the academic performance measures in female students, explaining 9–21% of the variance. This suggests that predictors of academic performance differ in both genders. However, the mechanisms that could explain these differences between both genders are presently unknown.

There are limitations in the present study. Our findings are limited to a population of grade nine students from a single French–Canadian public high school in Montreal, Canada. Furthermore, we used a cross-sectional approach, which does not allow us to conclude to any causal associations between cardiorespiratory fitness, muscle endurance, and test anxiety with academic performance in our cohort. Nonetheless, our results are strengthened by studying a homogenous population in a large sample size. Future studies may want to investigate the relationship between cardiorespiratory fitness, muscle endurance, and test anxiety with academic performance in longitudinal and intervention studies in different countries, ethnicities, socioeconomic

status, and levels of education (elementary, high school, and University).

Conclusions

In conclusion, results of the present study indicate that female high school students outperform male students academically and that these distinct academic performances appear to be explained by different variables (cardiorespiratory fitness for females and test anxiety for males). Furthermore, this study may give a better understanding of the interrelationship between academic performance with cardiorespiratory fitness, muscle endurance, and test anxiety to high school educators that could help guide them in the development of effective intervention programs, which may lead to better grades. That is, high school educators could consider planning a great variety of free intervention programs to promote the importance of improving cardiorespiratory levels and reducing test anxiety to students in the classrooms (e.g., organized sport activities and workshops on adopting a healthy lifestyle).

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Conflicts of interest

There are no conflicts of interest.

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