Original Article

Physical Fitness and Academic Achievement of Elementary School Students: a cross-sectional survey in Southern Taiwan

KUO-MING, WANG ¹, PENG-SHENG, WANG ², YI-CHING, HUANG³
¹Department of Exercise and Health Science, National Taipei University of Nursing and Health Sciences, Taipei, TAIWAN
²Kaohsiung Municipal Jhuang Jing Elementary School, Kaohsiung, TAIWAN
³Department of Exercise and Health Science, National Taipei University of Nursing and Health Sciences, Taipei, TAIWAN

Published online: September 21, 2012
(Accepted for publication September 11, 2012)

DOI:10.7752/jpes.2012.03045; http://dx.doi.org/10.7752/jpes.2012.03045

Abstract
Problem statement: Schools sacrificed students’ health by abandoning physical education (PE) courses in order to improve overall academic achievement. The same situation was found in Taiwan.
Approach: This study used a cross-sectional survey and purposeful sampling design. It investigated the associations between the physical fitness (BMI, flexibility, strength, endurance and cardio-respiratory fitness) and the academic achievement of elementary school students, and was intended to be used as a reference for physical education in the future.
Results: The findings indicated that physical fitness and academic achievement of elementary school students in Taiwan were positively correlated.
Conclusions: While academic credentialism has overwhelmed Taiwan, it is hoped that schools, teachers and parents can realize that academic achievement and physical activity are complementary to each other, and adequate physical activity can not only just promote the mental and physical health of students but can improve their learning ability as well.
Keywords: school health, physical education, learning ability, healthy policy

Introduction
Physical fitness (PF) is associated with various health benefits. Lack of physical activity is a risk factor for global death and disability. A sedentary lifestyle can increase the death rate and cause obesity, diabetes and cardiovascular diseases (Healthy People, 2010). Empirical studies on students’ health have proved that the lack of physical activity and physical fitness not only affects mental development (Kantomaa, Tammelin, Ebeling & Taanila, 2008; Koivukangas et al., 2010; Roick et al., 2007), but also triggers chronic diseases like obesity and cardiovascular diseases due to insufficient activity (Andersen et al., 2006; Biddle, Gorely & Stensel, 2004). Sallis (2010), Roberts et al. (2009) and Van Dusen et al. (2011) pointed out that many schools sacrificed students’ health by abandoning physical education (PE) courses in order to improve overall academic achievement. The same situation was found in Taiwan. In order to clarify the associations between physical fitness and academic achievement, researchers have aggressively investigated the relationship between physical fitness and students’ academic achievement.

Despite different assessment methods and tools, their findings indicated that students’ physical fitness and academic achievement were positively correlated, and thus pushed the society to pay more attention to the importance of students’ physical activity (Coe et al., 2006; Kim et al., 2003; Roberts et al., 2009; Sallis et al., 1999; Sigfusdottir, Kristjansson & Allegranre, 2007). In a study on 7,961 Australian children aged at 7-15, Dwyer et al. (2001) classified them into different groups by age, gender and physical activity test. The results showed that the academic achievement of students who exercised usually was positively correlated. Similar findings were found in a study conducted by Chomitz et al. (2009) on lifestyle and academic achievement of 3,900 fourth to eighth graders in the UK. Fox et al. (2010) studied on the effect of physical activity and sports involvement on academic achievement of 4,746 junior and senior high school students found that the more physical activity and regular exercise, the better the academic achievement.

As there had been very few studies investigating the associations between physical fitness and academic achievement in Taiwan, we investigated this issue on students of different grades and gender from a public elementary school in southern Taiwan, with an aim to find out if cultural differences played a part in students’
physical fitness and academic achievement by comparing the research findings of worldwide studies on the same topic and thereby to urge the relevant authorities of Taiwan to pay more attention to promoting students’ physical fitness.

Methods
Participants

Containing total of 1,339 fourth to sixth graders of a public elementary school in southern Taiwan were selected for the study, including 676 boys and 663 girls. After eliminating those who were physically ill, who were children with special needs, and those whose parents did not consent to their participation, the exact number was 1,335. All questionnaires distributed were recovered and 1,065 copies (79.8%) (528 from boys and 537 from girls) were valid.

Research Instruments

Basic Student Information

Information on gender, age, grade, health condition, body height and weight were collected.

Physical Fitness Test

The physical fitness test items were based on the Physical Fitness Test (PFT) specified in the Health and Physical Education Syllabus for the Grade 1-9 Curriculum Guidelines announced by the Taiwan Ministry of Education. The test-retest validity (.60 to .75) and reliability (.62 to .90) coefficients were established for the assessment used in the study. These items included (1) body mass index (BMI): students were instructed to remove their shoes for the measurement. Data for weight and height were recorded in kilograms (mass) and meters (height); (2) flexibility (sit and reach test): students sat with shoes removed and legs extended with feet shoulder-width apart, against a specially constructed box. Students were instructed to reach along the measuring line as far as possible with hands on top of each other, palms down, and legs held flat. Participants completed three trials. Data from the third measurement were recorded in the nearest centimeter; (3) strength (standing long jump): students placed their feet over the edge of the starting line, crouched down and, using the arms and legs, jumped horizontally as far as possible, with both feet landing on the ground. The assistant measured and recorded the distance from the edge of the ground to the nearest impression made by the student. The assistant used the longest recorded distance to assess the performance. Participants completed three trials. Data from the third measurement were recorded to the centimeter; (4) endurance (1-minute bent knee sit-up): Students began the test in a supine position with knees bent and arms straight, parallel to the trunk. Students were instructed to keep their arms extended and slide their fingertips along the mat until reaching the specified marker using the abdominal muscles. Another student was responsible for counting the number of sit up performed and (5) cardio-respiratory fitness (800m run): the 800m run was to cover 800m in the shortest time possible. Students were encouraged to run throughout the test and to take walking breaks only as needed. Students were reminded to avoid starting too fast to avoid premature fatigue. Data were recorded in seconds to complete 800m.

Academic Survey

Academic achievement was assessed by the weighted academic score of Chinese Language, Mathematics and Science.

Design and procedure

A cross-sectional, purposive sampling design was used. After consent was obtained from the school, students’ parents and class teachers of all grades at the semester began, students were asked to complete the health screening questionnaire and basic data under the supervision of their parents to facilitate the physical fitness. Academic achievement was assessed by the weighted academic score in the 3rd month.

Physical Fitness Test

All testing equipment was calibrated prior to the test to ensure accurate results and the testing results were measured according to the standard operating procedures. All values were expressed in either centimeter (cm), meters (m) or kilograms (kg) rounded up to the second decimal place. Students were given full instructions of the test, including demonstration and front bending warm-up exercise. In order to find out the physical fitness effect on students’ academic achievement, we classified the participants into 3 groups in physical fitness by performance, including the Low group (approx. 30%), the Medium group (approx. 40%), and the High group (approx. 30%).

Academic Achievement Survey

The average grades for each subject was taken from the mean scores of the 1st and 2nd monthly examinations in each grade, and exclude normal performance, scores from quizzes and final term grades to prevent variation in grading by different subject and grade teachers. The final mean score for each test subject was obtained by dividing the mean subject grades with the total number of students in a grade level. Each
subject’s mean score was then multiplied by the total number of instruction hours in a grade level, and the final weighted academic score was the average value of the sum of scores from all subjects.

Data Analysis
After collecting the physical fitness test and academic achievement results of the participants, they were coded and compiled for analysis with statistical techniques. Data collected from the basic student information, physical fitness and academic achievement were presented in mean values plus standard deviation. Statistical analysis was performed with methods such as independent t-test, one-way ANOVA, and Scheffe’s post hoc analysis. p<0.05 is deemed statistically significant.

Ethical considerations
The study was approved by the Human Research Ethics Committee, National Taipei University of Nursing and Health Sciences. Participants were given detailed information of study procedures and parental consent form was obtained. All participation in this study was voluntary and participants were allowed to withdraw from the project during the period of the study without penalty. The experiments reported in the article were undertaken in compliance with the current laws of the country in which the experiments were performed.

Results
Differences of Physical Fitness and Academic Achievement by Gender and Grade
Of all questionnaires recovered, 1,065 copies (79.8%) were valid, including 528 copies from boys (179 fourth graders, 148 fifth graders and 201 sixth graders) and 537 copies from girls (160 fourth graders, 161 fifth graders and 216 sixth graders). The present status and differences of participants’ physical fitness and academic achievement was shown in Table 1.

Fourth Graders- In physical fitness, boys showed significantly better performance in strength (t(1327)=4.29, p<.001) and endurance (t(1377)=2.76, p<.01) than girls. The BMI measurement was higher in girls than boys (t(1337)=3.48, p<.01). In the flexibility, girls had significantly better performance than boys (t(1337)=6.43, p<.001). In academic achievement, there were no significantly differences between genders (p>.05).

Fifth Graders- In physical fitness, boys showed significantly better performance in strength than girls (t(1307)=5.50, p<.001). The BMI measurement was higher in girls than boys (t(1307)=2.18, p<.05). The flexibility, girls had significantly better performance than boys (t(1307)=3.23, p<.01). In academic achievement, there were no significantly differences between genders (p>.05).

Sixth Graders- In physical fitness, boys had significantly better performance in strength (t(1415)=7.16, p<.001), endurance (t(1415)=3.99, p<.001) and cardio-respiratory fitness (t(1415)=6.36, p<.001) than girls. The flexibility, girls had significantly better performance than boys (t(1415)=4.38, p<.001). In BMI measurement and academic achievement, there were no significantly differences between genders (p>.05). (Table 1)

The Effects of Physical Fitness on Academic Achievement of Genders
The boys’ physical fitness and academic achievement scores integrated showed that BMI, flexibility and endurance had no significant influence, as shown in Table 2. In strength (F(2,525)=1.69, p<.05) and cardio-respiratory fitness (F(2,525)=5.52, p<.01), all the results showed that the associations between physical fitness and the academic achievement in weighted score were statistically significant. Post hoc test showed that the high score group was significantly better in academic achievement than the low score group. (the high score in 800m run was lower second count).

The girls’ physical fitness and academic achievement scores integrated showed that BMI had no significant influence, as shown in Table 3. In flexibility (F(2,534)=4.99, p<.01), strength (F(2,534)=3.17, p<.01), endurance (F(2,534)=1.80, p<.05), and cardio-respiratory fitness (F(2,534)=8.50, p<.001), all the results showed that the associations between physical fitness and the academic achievement in weighted score were statistically significant. Post hoc test showed that the high score group was significantly better in academic achievement than the low score group (the high score in 800m run was lower second count). (Table 2,3)

Discussions
Differences of Physical Fitness and Academic Achievement by Gender and Grade
Although girls have better performance than boys in all grades in flexibility (sit and reach test), it is the opposite in strength (standing long jump), endurance (1-minute sit-up) and cardio-respiratory fitness (800m run). These results are similar to past studies in Taiwan (Chang, 2006). Ross et al. (1985) studied on adolescents aged 10-18, pointed out that boys could do many more sit-ups in one minute than girls. Riddoch and Boreham (1991) studied on adolescents aged 11-18 in North Ireland, found that girls were much more flexible than boys, whereas boys have much better strength or explosive power. With reference to the related studies, it is conclusive that the difference in physical fitness performance between boy and girl elementary school students...
was significant, where girls had better performance in flexibility and boys in explosive power, strength and endurance.

In academic achievement, the results of our study showed that there were no statistically insignificant between genders. These results were opposite to the research findings of Chomitz et al. (2009), who claimed that the difference in English tests between boys and girls was statistically significant, whereas the difference in Mathematics was insignificant. Akpinar et al. (2009) studied on 658 sixth to eighth graders in Turkish, indicated that girls had better performance in subjects requiring memorization than boys, but there was no difference between boys and girls in comprehension and applied science. We hypothesized that the reason for the discrepancies observed in our results, when compared with those of other researchers may be due to the different definitions of academic achievement and the tools used to collect data. In our study, we used the weighted academic scores from the first and second monthly examinations, and excluded grading from normal performance, quizzes and end of semester grades, in order to prevent deviation in scores by different class rooms and grade instructors. The differences in grading and collection, coupled with cultural diversity, could have contributed to the discrepancy between our results and those of the foreign investigators.

The Associations of Physical Fitness on Academic Achievement of Genders

In our study, boy students with better physical fitness (including strength and cardio-pulmonary fitness) and girl students with better physical fitness (including flexibility, strength, endurance and cardio-pulmonary fitness) had better academic achievement. Empirical studies have shown that exercise helps students enhance self-esteem, confidence and learning efficiency and improves academic achievement (Dwyer et al., 2001; Fox et al., 2010; Shephard, 1996). After applying the Woodcock-Johnson Test of Concentration to the two to fourth graders, Caterino and Polak (1999) found that students significantly increased their concentration after 15 minutes of vigorous aerobic exercise and 15 minutes of stretching exercise. Keays and Allison (1995) also pointed out that the more physical activities (moderate and vigorous) students participated in, the better their performance in memory, observation, problem-solving and decision-making when compared with ordinary students. It has been proven that the associations between physical fitness or physical activity and academic achievement have both physiological and psychological influence, whether it is the vitalization of cerebral neurons (Cotman & Berchtold, 2002) or the promotion of cerebral cortex blood circulation (Herholz et al., 1987), and can even improve self-esteem and confidence (Tremblay et al., 2001). The findings of our study were supported by the above studies. That was to say, suitable exercise and good physical strength will bring positive and significant influence to students’ academic achievement.

We also found that the type of physical fitness affected the academic achievement of girls more strongly than boys (4 items were statistically significant for girls; while only 2 were in boys). The results were similar to empirical studies (Akpinar et al., 2009; Chomitz et al., 2009; Kwak et al., 2009). Van Dusen et al. (2011) conducted 254,743 students grade 3-11 collected by 13 Texas school districts, also pointed the same findings. Van Dusen et al. (2011) assumed that the reason was girls who paid more time in reading than boys. However, why physical fitness had a greater influence on girls than boys should be investigated and clarified by future studies.

Limitations of the study

Potential limitations of our study are as follows. First, because of budget and workforce limitations, the participants in our study were selected from an elementary school in Southern Taiwan, which might not be representative of Taiwanese pupils throughout the nation. Also, the results might vary in other countries because of cultural differences. Second, because of the privacy considerations, we can not collect the socio-economic backgrounds of subjects in this study. Hence, the results can not totally exclude the effect of family’s socio-economic background influencing the academic performance. Lastly, this study was only a quantitative cross-sectional survey method, so the results may not reflect cause-effect relationships.

Conclusion

On the whole, our study showed that students with better physical fitness had better academic achievement than other groups. This finding is similar to the empirical studies conducted by foreign scholars, suggesting that physical fitness has absolutely positive associations on improving the learning ability of students regardless of cultural background. Among all subjects, the academic achievement in weighted score (including Chinese Language, Mathematics and Sciences) is strongly associations with physical fitness. We also found that girls were influenced by physical fitness more strongly than boys, which was worthy of further study.

Based on the positive effects of physical fitness on academic achievement found in our study and the fact that no current research indicates that increase of physical education (PE) courses at school has a negative effect on academic achievement, it is apparent that physical education (PE) course at school and adequate and regular exercise not only improve physical strength but also bring positive and significant influence toward
academic achievement. While academic credentialism has overwhelmed Taiwan, it is hoped that schools, teachers and parents can realize that academic achievement and physical activity are complementary to each other, and adequate physical activity can not only just promote the mental and physical health of students but can improve their learning ability as well.

References


### Table 1
Differences between Physical Fitness and Academic Achievement in genders and grades

<table>
<thead>
<tr>
<th>Items</th>
<th>Fourth grade</th>
<th>Fifth grade</th>
<th>Sixth grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>♀(n=160)</td>
<td>♂(n=179)</td>
<td>♀(n=161)</td>
</tr>
<tr>
<td>Age</td>
<td>10.05±  0.28</td>
<td>10.04±0.30</td>
<td>11.08±  0.30</td>
</tr>
<tr>
<td>Flexibility (cm)</td>
<td>31.36±  7.60</td>
<td>26.01±  7.69</td>
<td>6.43***</td>
</tr>
<tr>
<td>Strength (cm)</td>
<td>126.93±20.30</td>
<td>137.13±23.15</td>
<td>-4.29***</td>
</tr>
<tr>
<td>Endurance (min⁻¹)</td>
<td>24.97±  8.73</td>
<td>27.77±  9.81</td>
<td>-2.76*</td>
</tr>
<tr>
<td>Cardio-respiratory fitness (s⁻¹)</td>
<td>327.56±53.45</td>
<td>326.22±68.82</td>
<td>0.20</td>
</tr>
<tr>
<td>BMI(kg·m⁻²)</td>
<td>18.90±  3.58</td>
<td>17.67±  2.86</td>
<td>3.48***</td>
</tr>
<tr>
<td>Weighted score</td>
<td>90.32±  7.88</td>
<td>88.70±  8.91</td>
<td>1.77</td>
</tr>
</tbody>
</table>

*p<.05; **p<.01; ***p<.001

### Table 2
Comparison the Physical Fitness and Academic Achievement of boys

<table>
<thead>
<tr>
<th>Items</th>
<th>Low (n=250)</th>
<th>Medium (n=209)</th>
<th>High (n=69)</th>
<th>Intergroup difference</th>
<th>Low (n=164)</th>
<th>Medium (n=197)</th>
<th>High (n=67)</th>
<th>Intergroup difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI(kg·m⁻²)</td>
<td>M±SD</td>
<td>M±SD</td>
<td>M±SD</td>
<td></td>
<td>M±SD</td>
<td>M±SD</td>
<td>M±SD</td>
<td></td>
</tr>
<tr>
<td>Weighted score</td>
<td>85.66±10.60</td>
<td>86.89±10.20</td>
<td>87.05±10.02</td>
<td>0.99</td>
<td>85.66±8.73</td>
<td>86.65±11.76</td>
<td>86.70±10.14</td>
<td>0.61</td>
</tr>
<tr>
<td>Strength (cm)</td>
<td>M±SD</td>
<td>M±SD</td>
<td>M±SD</td>
<td></td>
<td>M±SD</td>
<td>M±SD</td>
<td>M±SD</td>
<td></td>
</tr>
<tr>
<td>Weighted score</td>
<td>85.13±11.24</td>
<td>86.42±10.14</td>
<td>87.15± 9.76</td>
<td>1.69*</td>
<td>H=L</td>
<td>86.01± 9.75</td>
<td>86.02±10.97</td>
<td>0.42</td>
</tr>
<tr>
<td>Cardio-respiratory fitness (s⁻¹)</td>
<td>M±SD</td>
<td>M±SD</td>
<td>M±SD</td>
<td></td>
<td>M±SD</td>
<td>M±SD</td>
<td>M±SD</td>
<td></td>
</tr>
<tr>
<td>Weighted score</td>
<td>84.69±11.64</td>
<td>85.90±11.02</td>
<td>88.43± 7.50</td>
<td>5.52**</td>
<td>H=L</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05; **p<.01

Values in difference were compared with one-way ANOVA. Inter-group difference was tested by Scheffe’s post hoc test. H: high group; L: Low group

Corresponding Author: YI-CHING, HUANG, Email: yiching@ntunhs.edu.tw
Table 3
Comparison the Physical Fitness and Academic Achievement of girls

<table>
<thead>
<tr>
<th>Items</th>
<th>BM1(kg·m⁻²)</th>
<th>Flexibility (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=298)</td>
<td>Medium (n=193)</td>
</tr>
<tr>
<td></td>
<td>M±SD</td>
<td>M±SD</td>
</tr>
<tr>
<td>Weighted score</td>
<td>85.87±10.43</td>
<td>87.71±10.60</td>
</tr>
<tr>
<td><strong>Intergroup difference</strong></td>
<td>H&gt;L</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items</th>
<th>Strength (cm)</th>
<th>Endurance (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=175)</td>
<td>Medium (n=193)</td>
</tr>
<tr>
<td></td>
<td>M±SD</td>
<td>M±SD</td>
</tr>
<tr>
<td>Weighted score</td>
<td>85.72±12.15</td>
<td>87.10±8.85</td>
</tr>
<tr>
<td><strong>Intergroup difference</strong></td>
<td>H&gt;L</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items</th>
<th>Cardio-respiratory fitness ( s⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=165)</td>
</tr>
<tr>
<td></td>
<td>M±SD</td>
</tr>
<tr>
<td>Weighted score</td>
<td>84.67±13.17</td>
</tr>
</tbody>
</table>

* p<.05 ; ** p<.01; *** p<.001;
Values in difference were compared with one-way ANOVA.
Inter-group difference was tested by Scheffe’s post hoc test.
H: high group; L: Low group