



Original Article

## Effects of taekwondo intervention on cognitive function and academic self-efficacy in children

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**Abstract.** [Purpose] The purpose of this study was to investigate the effects of taekwondo training on cognitive function and academic self-efficacy in children. [Subjects and Methods] Thirty-five children participated in the study. Seventeen children were randomly selected to undergo taekwondo training for 16 weeks (5 times per week). As controls, 18 children received no training. Cognitive function and academic self-efficacy were measured using the Stroop Color and Word Test (Word, Color, and Color-Word) and academic self-efficacy scale (Self-confidence, Self-regulatory Efficacy, and Task Difficulty Preference), respectively. [Results] In the taekwondo group, the Color-Word and Self-confidence scores increased significantly after intervention as compared to those before intervention. [Conclusion] It is suggested that regular taekwondo training may be effective for enhancing cognitive function and academic self-efficacy in growing children.

**Key words:** Taekwondo, Cognition, Academic self-efficacy

(This article was submitted Dec. 8, 2016, and was accepted Jan. 10, 2017)

### INTRODUCTION

It has been reported that childhood participation in physical activity, including regular exercise, could not only promote physical development<sup>1)</sup>, but could also prevent various diseases, such as metabolic syndrome, by improving body composition and enhancing health-related physical fitness<sup>2)</sup>. In addition, there are recent reports that childhood participation in physical activity might have a positive effect on cognitive function, on various academic achievements, including academic score, and on psychosocial function<sup>3, 4)</sup>. Specifically, Lees and Hopkins reported that aerobic physical activity had a positive correlation with cognition, academic achievement, behavior, and psychosocial functioning outcomes. Similarly, based on their finding that children with high aerobic capacity scored higher than average in mathematics, Desai et al. suggested that proper participation in physical activity at school might have potential benefits for academic achievement, although the mechanism of this impact was not clear.

On the other hand, taekwondo (TKD), a globally popular sport, is practiced by about 70 million people in 204 countries, and 380 thousand children apply for a Taekwondo belt test every year<sup>5)</sup>. Preceding studies have reported that regular TKD training had a positive effect on the improvement of physical fitness and on physical growth and development in children<sup>5)</sup>; and that childhood TKD training was effective in facilitating physical, cognitive, emotional, and social development—for example, by reducing anxiety, encouraging independence and leadership, and controlling aggression<sup>6, 7)</sup>. A recent study by Kim et al. using functional MRI verified the positive effect of TKD training on brain development in children. The results showed improvement in brain connectivity from the cerebellum to the parietal and frontal cortex. This suggests that TKD training may be effective in improving cognitive function and academic capability in children.

However, there has been very limited research to verify the effect of TKD training on academic capability and the development of cognitive function in growing children. Accordingly, the present study was conducted on children in elementary grades 4–6, aiming to verify the effect of TKD training on their cognitive function and academic self-efficacy.

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## SUBJECTS AND METHODS

Thirty-five healthy children aged 10 to 12 years volunteered as subjects for this study. Eighteen children (10 boys and 8 girls, mean age:  $11.4 \pm 0.7$  years, mean height:  $149.2 \pm 6.7$  cm, mean weight:  $45.8 \pm 6.7$  kg, mean BMI:  $20.5 \pm 2.0$  kg/m<sup>2</sup>) received no intervention and served as the control group. Seventeen children (11 boys and 6 girls, mean age:  $11.2 \pm 0.8$  years, mean height:  $148.8 \pm 7.7$  cm, mean weight:  $46.9 \pm 8.6$  kg, mean BMI:  $21.2 \pm 3.9$  kg/m<sup>2</sup>) received TKD training intervention for 16 weeks (TKD group). The study protocol was approved by an institutional ethics review board of the Youngsan University. All subjects and their parents were informed about the research procedure and possible risks involved, and both parents and subjects signed a written consent form.

TKD training was conducted 5 times per week, for 16 weeks, each time for 70 minutes, at an exercise intensity of 50–80% of HRmax. Specifically, each TKD training session involved 5 minutes of warm-up stretching, 10 minutes of basic physical fitness training, 40 minutes of main exercise (consisting of basic TKD movements, Poomsae, kicks, and Taekwon gymnastics), and 5 minutes of cool-down stretching.

For measuring cognitive function, the Stroop Color and Word Test was performed twice, before and after intervention, as previously described<sup>8</sup>). The tests comprise Word Reading, Color Reading, and Color-Word Reading parts. Each part contains 100 items arranged in 5 columns and 20 rows. Academic self-efficacy was measured using the scale developed by Kim and Park, which consists of 3 subordinate factors: Self-confidence, Self-regulatory Efficacy, and Task Difficulty Preference.

Statistical analyses were performed using SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA). Data have been presented as the mean  $\pm$  standard deviation, unless stated otherwise. For identifying differences in normally distributed results, the two-way repeated analysis of variance (ANOVA) was employed. When significant group by time interactions occurred, simple main effects were assessed using the independent and paired t-tests. The level of significance was set at 0.05 for all the tests.

## RESULTS

A comparison of anthropometric characteristics, Stroop Color and Word Test scores, and academic self-efficacy scores for the two groups before and after intervention has been presented in Table 1. In the TKD group, the Color-Word scores and Self-confidence scores increased significantly after intervention as compared to those before intervention ( $p < 0.05$ ). However, there were no significant differences in height; weight; BMI; and scores on the Word, Color, Self-regulatory Efficacy, and Task Difficulty Preference tests ( $p > 0.05$ ).

## DISCUSSION

The advancement of life science has brought about the development of new technologies that enable the morphometric analysis of the brain—such as image analysis technology. Accordingly, many preceding studies have reported the brain health improvement effect of exercise. For example, regular exercise has been reported to exert a positive effect on functional changes in the brain, by not only improving brain volume but by also inducing angiogenesis and neurogenesis<sup>10, 11</sup>). The present study employed the Stroop Color and Word Test to verify the effect of TKD training on cognitive function in children. The result showed that the TKD group achieved significantly higher Color-Word scores after the 16-week TKD training, suggesting that TKD training may be effective in improving cognitive function. This supports the findings of preceding research that reported significant increase in Stroop Color and Word Test scores following regular TKD training<sup>12</sup>). The Stroop Color

**Table 1.** A comparison of anthropometric characteristics, Stroop Color and Word Test scores, and academic self-efficacy scores for two groups before and after intervention

| Variables                          | Control group (n=18) |                 | TKD group (n=17) |                  |
|------------------------------------|----------------------|-----------------|------------------|------------------|
|                                    | Before               | After           | Before           | After            |
| Height (cm)                        | $149.2 \pm 6.7$      | $150.1 \pm 6.6$ | $148.8 \pm 7.7$  | $150.2 \pm 7.3$  |
| Weight (kg)                        | $45.8 \pm 6.7$       | $46.9 \pm 6.9$  | $46.9 \pm 8.6$   | $47.3 \pm 7.7$   |
| BMI (kg/m <sup>2</sup> )           | $20.5 \pm 2.0$       | $20.7 \pm 1.9$  | $21.2 \pm 3.9$   | $21.0 \pm 3.6$   |
| Word test (score)                  | $71.2 \pm 8.8$       | $72.2 \pm 7.7$  | $71.6 \pm 10.2$  | $73.7 \pm 9.1$   |
| Color test (score)                 | $51.2 \pm 6.7$       | $51.9 \pm 6.6$  | $52.1 \pm 6.7$   | $53.9 \pm 5.9$   |
| Color-Word test (score)            | $35.2 \pm 4.5$       | $35.6 \pm 5.0$  | $35.4 \pm 4.9$   | $36.8 \pm 4.3^*$ |
| Self-confidence (score)            | $3.5 \pm 0.8$        | $3.7 \pm 0.7$   | $3.4 \pm 0.7$    | $4.1 \pm 0.7^*$  |
| Self-regulatory efficacy (score)   | $3.4 \pm 0.6$        | $3.4 \pm 0.6$   | $3.4 \pm 0.7$    | $3.8 \pm 0.7$    |
| Task difficulty preference (score) | $3.1 \pm 0.9$        | $3.3 \pm 0.7$   | $3.1 \pm 0.8$    | $3.5 \pm 0.7$    |

Data are presented as mean  $\pm$  standard deviation. TKD: taekwondo; \* $p < 0.05$  vs. Before

and Word Test reflects cognitive function<sup>9</sup>). Using this test, Kim reported a significant increase in Color and Word scores after an 8-week TKD training at exercise intensities of RPE 11–15. In addition, a study conducted by Lakes et al.<sup>13</sup>, which involved 60 students in grades 7–8 and the practice of TKD for 9 months during physical education classes, showed that taekwondo was effective not only in enhancing physical fitness but also in improving cognitive function. Based on this result, TKD was suggested to be an appropriate exercise program for physical education at school.

Academic self-efficacy refers to learner's self-assessment on the ability to confidently organize and execute an action plan for carrying out an academic task, and it consists of 3 subordinate factors: Self-confidence, Self-Regulatory Efficacy, and Task Difficulty Preference<sup>9</sup>). The present study showed that TKD training resulted in a significantly high Self-confidence score (which indicates students' confidence or conviction in their own academic capability). According to preceding research, there is a direct and indirect correlation between academic self-efficacy and academic achievement, as the learners with higher academic self-efficacy tend to choose more challenging tasks, invest more efforts in successfully carrying out tasks, and use more effective learning strategies<sup>9, 14, 15</sup>). Taken together, these results suggest that TKD training may also be effective for enhancing academic capability in growing children. It has also been reported that the increased expression of neurotrophic factors that occurs with regular exercise plays an important role in the mechanism of brain function improvement<sup>16, 17</sup>). Therefore, in order to elucidate the mechanism through which TKD training aids the improvement of cognitive function and academic self-efficacy, follow-up research would need to include the analysis of neurotrophic factors. In addition, this study has the limitation that it could not exclude the effect of regular exercise because there was no other exercise group that can be compared with TKD group. In future studies, it is necessary to compare TKD training with other types of exercise programs.

In conclusion, it is suggested that regular TKD training may be effective for enhancing cognitive function and academic self-efficacy in growing children.

## ACKNOWLEDGEMENT

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2015S1A5B5A02015262).

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