METHODOLOGY

The Effect of a Sport Stacking Intervention on Handwriting With Second Grade Students

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Abstract

The present study examined the impact a 14-week sport stacking (cup stacking) exercise intervention would have on children's handwriting quality and speed. Eighty-three second graders were randomly assigned to either an experimental or a control group. The experimental group (n = 42) participated in a 15-min session of sport stacking activities every school day for 14 weeks, and the control group (n = 41) experienced other supervised physical activities using the same time interval and duration. The dependent variables, handwriting speed and accuracy, were measured pre- and postintervention. Results showed a significant test effect, F(1, 81) = 19.1, p = .001, with all students in both groups increasing handwriting speed posttest. Moreover, a marginal interaction between group and test emerged, F(1, 81) = 3.1, p = .08, suggesting a tendency that the experimental group had a greater improvement

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in writing speed than the control group. No difference was found in handwriting accuracy. The results were not conclusive, and further investigations are recommended to test the potential effect of sport stacking activities on enhancement of perceptual-motor function, specifically handwriting skill for school children.

Penmanship is a lost art in our digital world of text messages, tweets, e-mail, and other electronic communication methods. Beyond learning the basics of printing letters in pre-kindergarten through the early elementary school grades, little emphasis is currently placed on the correct formation of letters and numbers. Typically standardized tests do not assess handwriting; thus precious instructional time is reserved for math and reading, which are the standard content areas assessed. Poor handwriting is typically more pronounced for children just learning how to write. Moreover, difficulty mastering transcription skills, such as handwriting, can constrain future learning (Graham, 1999). Developmentally appropriate exercise programs promoting perceptual-motor connections may lead to positive influence on handwriting skills of school children, which is crucial to learning and academic achievement (Fuentes, Mostofsky, & Bestian, 2009; Son & Meisels, 2006).

Handwriting involves fine motor control components and visual-motor integration (Weil & Amundson, 1994). One study found that children's handwriting performance is specifically correlated with in-hand manipulation, visual-motor control, upper limb speed, dexterity, and steadiness (Feder, Majnemer, Bourbonnais, Blayney, & Morin, 2007). Using regression analysis, Volman, Van Schendel, and Jongmans (2006) showed that visual-motor integration was the only significant predictor for quality of handwriting in the group of children with handwriting skill problems. This study also revealed that fine motor coordination (i.e., unimanual dexterity) was the only significant predictor with age-matched normal subjects, and other measured variables of visual perception and cognitive planning abilities were not significant. Maeland (1992) used various perceptual-motor tests, and only visual-motor integration was significant in predicting accuracy of handwriting performance for the sample of 59 participants consisting of clumsy, dysgraphic, and normal children. Moreover, Tseng and Chow (2000) tested perceptual-motor function of school-aged children with slow handwriting speed and found that age, visual sequential memory, and visual-motor integration were the three significant predictors of

handwriting speed. Apparently, handwriting is one of a host of more complex activities that children develop after they master basic manipulative skills with visual- and perceptual-motor abilities being indispensable. Therefore, this coordination between manual skills and perceptual exploration/experience is fundamental to improving children's handwriting skills.

Sport stacking, also known as cup stacking, involves the stacking and unstacking of commercially manufactured polymer cups in a sequential fashion to form various pyramids, as quickly as possible. This specialized manipulative activity has increased in popularity with many physical education (PE) programs across the United States. Recently, potential benefits of perceptual-motor skill development through sport stacking intervention for school children have been reported. Udermann, Murray, Mayer, and Sagendorf (2004) first demonstrated that hand–eye coordination and reaction time (RT) performances were improved in second graders of an elementary school following a 5-week sport stacking program. In the study, the soda pop test was used to evaluate hand–eye coordination and the yardstick test was used to evaluate changes of RT. Rhea, Ludwig, and Mokha (2007) further supported such a claim by demonstrating a positive influence on the development of bilateral coordination using a star tracer test after a 5-week intervention of sport stacking in sixth grade students. A recent study (Li, Coleman, Ransdell, Coleman, & Irwin, 2011) found that second grade students who had a 12-week sport stacking intervention showed a greater improvement in choice RT test than control subjects who experienced no intervention. Thus, sport stacking activities appear to influence the development of central processing, especially involving visual-motor integration for school children.

Another investigation used a randomized cross-over design to compare the differences between sport stacking exercise and an art activity in third grade school children (Mortimer, Krysztofiak, Custard, & McKune, 2011). The authors reported that a 3-week sport stacking activity program enhanced auditory and visual attention, measured on the integrated visual and auditory continuous performance test. However, no statistical significant changes were observed in the arts group postintervention.

Cognitive involvement of sport stacking has also been investigated using electroencephalogram (EEG) recording with adult participants (Hart & Bixby, 2005). Data from this study show that sport stacking activities use both sides of the brain, which may

promote bilateral proficiency through stimulating neural pathways in both hemispheres during exercise. These findings suggest that sport stacking may offer a unique benefit in promoting perceptual-motor development; however, several previous studies failed to reveal similar results when using short intervention durations (i.e., 3 to 5 weeks; Baumgarten, 2004; Hart, Smith, & DeChant, 2005; Hart, Smith, & DeChant-Bruennig, 2006). Therefore, the purpose of the present study was to explore whether an extended period of intervention, a 14-week sport stacking intervention, in a school setting would influence second graders' handwriting quality and speed. The hypothesis was that sport stacking would have a positive effect on children's handwriting skill, particularly with speed and quality. Previous research evidence suggests PE teachers and professionals in elementary programs across the United States will find it valuable to justify including sport stacking activities in their curriculum. Furthermore, these activities may enhance academic achievement for all school-aged children, specifically children who lack proficient hand–eye coordination or experience difficulties with school tasks such as writing, drawing, and self-help activities (Graham, 1999; Naido & Salkind, 1990).

Method

Subjects

Eighty-three second grade students, both boys and girls ($M = 7.5$ years, $SD = .54$), in five classes from a local public elementary school were recruited for this study. Since the majority of hand manipulation skills have been developed by the age of about 5- to 6-years-old, the participants in this study were at the age of perfecting their current fine motor skills (Exner, 1990). Institution Research Board approval was obtained, which included active consent. A parent or legal guardian of each child was asked to sign a consent form prior to the study. Parents were also asked not to purchase commercially available sport stacking kits for use at home.

Equipment and Materials

Sixty sets of stacking cups and 36 time pads (made by Speed Stacks, Inc.) were used throughout the 14-week intervention program. In addition, six stop watches, paper, and pencils were used for a handwriting test for both the pre- and postintervention.

Design and Procedure

All participants were randomly assigned into either an experimental group or a control group based on their student ID number (i.e., odd or even). Specifically, half of the students in each of the five classrooms were assigned to the experimental group and the other half to the control group. In this way, we expected to achieve a higher level of external validity to help eliminate the classroom effect that might contaminate the test results due to the special age of the students involved in the study. The students in the experimental group (n = 42; boys = 25, girls = 17) participated in a 14-week sport stacking program that consisted of 5 days a week for 15-min each day, either in the morning or in the early afternoon based on class schedule. The control group (n = 41; boy = 22, girls = 19) did not participate in sport stacking activities, but instead took part in supervised traditional physical activities, which included jumping rope and different small-sided games on the school playground or in the gym based on weather conditions. All students in both groups were tested on writing skills pre- and postintervention to assess the effects of sport stacking intervention program on children's handwriting skills.

The 14-week sport stacking intervention was organized and conducted by the school PE teacher, who had more than 20 years of teaching experience at that school and had attended sport stacking training sessions at district-wide in-services and state conferences. The PE teacher was assisted by the regular classroom teachers. Basic sport stacking hand position and format were introduced and practiced during Weeks 1 and 2 on the classroom tables; the method and sequence of three-cup stacks were learned and then practiced as quickly as possible. Specifically, the students learned to use both hands to make a pyramid with three cups ("up stacking") and then returning the cups into stacks ("down stacking") in predetermined sequences (Hart et al., 2005; Speed Stacks, 2010). In Weeks 3 to 5, students gradually progressed from one set of three-cup pyramid to two and three sets of three-cup pyramids in a row, focusing on the correct hand position and sequences with no time pressure. In Weeks 6 to 8, timing pads were introduced during practice to provide students with time feedback. Students were instructed to complete the task at hand as fast as possible. They were also encouraged to compete with their partner. In Weeks 9 to 14, students learned a new and more difficult six-cup pyramid stacking activity without the

timing pad at first. Once students could complete the task accurately, they were instructed to do it as fast as possible while using the timing pad.

Test and Measurement

Students were tested on handwriting skill in their regular classroom. University faculty members who are handwriting experts and trained graduate research assistants conducted these pre- and posttest and were blinded to student group assignment. At the beginning of the pretest, all students were given a hard copy of a paragraph and asked to print onto primary-style lined paper, which they used in the classroom daily. The three-sentence passage containing at least one instance of all 26 Arabic letters was targeted for the second grade level using the Flesch-Kincaid assessment to not exceed a 2.4 reading level (Tomplins, 2011). Thus, the children were copying sentences that they could likely read and comprehend. The handwriting passage for the test contained the following three sentences: "One day 20 boys and girls went to the zoo. They watched the animals jump and play in the water. Did you see the vet quickly feed them extra food?"

Students were given the instructions to copy the passage verbatim as accurately and as quickly as possible. The final time to complete copying the passage for each individual was recorded as soon as the student placed his or her pencil on the table. The same handwriting test was repeated at the end of the intervention.

The same instructions were presented to each class in the same manner. Students were instructed to copy the sentences using their best handwriting and to lay their pencils down when finished. The text given to the students was in the font that most closely matched that with which they were familiar. Students were accustomed to tasks having similar instructions.

Students' handwritten compositions were evaluated individually according to the children's ability to reproduce the familiar Zaner-Bloser®-style letters. One handwriting expert rated all of the students' papers using the same chart of Zaner-Bloser®-style letters. A wall chart containing the same letter formation was used in the classrooms and available for students to easily see. Students used the same primary-style lined paper with which they were familiar and their own pencils.

The total number of correct letter formation based on the specific guidelines the classroom teacher used to teach manuscript writing was then recorded for each student. For example, did the letter sit on the bottom line and reach to the middle line only (e.g., letters *a*, *c*, and *m*); did the letter sit on the bottom line and reach halfway between the middle line and the top line and have its crossbar at the middle line (letter *t*); did the letter sit on the bottom line and reach the top line (e.g., *T*, *b*, or *l*)? Additionally, did the line touch the circle correctly forming the letters *d* or *p*; were the letters *s* or *z* written correctly or backward?

Data Analysis

Descriptive statistics were calculated on all dependent variables for group means and standard deviations. Because no gender effect had been reported in the previous findings with this particular age group (Li et al., 2011; Mortimer et al., 2011; Udermann et al., 2004), a 2 (Group: Intervention vs. Control) x 2 (Test: pre vs. post) ANOVA with repeated measures on the second factor was conducted on handwriting speed and the correct number of letter formation, to examine the influences of the sport stacking intervention on handwriting performances.

Results

Means and standard deviations of test performances in handwriting speed and number of correctly formed letters for the experimental and control groups are presented in Table 1. The analysis on the writing speed revealed a significant test effect, $F(1, 81) = 19.1$, $p = .001$, ES = .54, indicating that all students regardless of the group assignment completed the sentences significantly faster in the posttest. Moreover, a marginal interaction between the group and test, $F(1, 81) = 3.1$, $p = .08$, suggested a marginal improvement in handwriting speed with the experimental group (decreased time an average of 84 s) as compared to the control group (decreased time an average of 36 s). The ES is .32 between the two groups for the posttest (Figure 1), which according to Cohen (1988) is indicative of a low to medium effect. As to the letter formation accuracy, no significant difference was found, which suggests that the quality of handwriting did not show any noteworthy differences between the two groups and between the two tests.

Table 1

Means and Standard Deviations of Handwriting Test Scores for Experimental and Control Groups

Test Variables		Experimental Group		Control Group	
		Pre	Post	Pre	Post
Handwriting Speed (S)*	*M*	262.2	178.7	249.3	213.7
	SD	101.2	55.7	120.0	161.9
# of Correct Letter Formation	*M*	13.9	13.7	13.1	10.4
	SD	8.0	9.2	8.2	8.3

*A marginal effect between the pre- and posttest, p =.08, ES = .32.

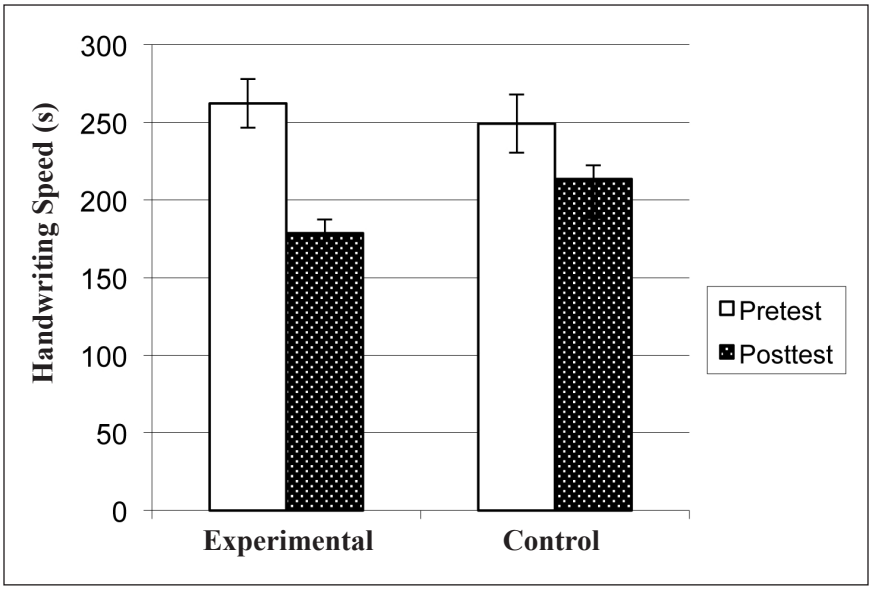

Figure 1. Handwriting speed in pre- and posttest performances for experimental and control groups.

Discussion

Research evidence indicates that participating in physical activity can produce a positive influence on child development including neurologic, somatic, cognitive, and social development (Son & Meisels, 2006). Although sport stacking is increasing in popularity in PE programs, as well as in competitions across the United States, lack of adequate empirical data supports the claims of

various anecdotal reports (Speed Stacks, 2010). The present study was designed to test whether the positive effects observed from previous studies (Li et al., 2011; Udermann et al., 2004) could be extended to classroom learning, such as handwriting skills, which involves visual-motor integration and fine motor control (Weil & Amundson, 1994). Specifically, the related literature suggested the short intervention duration was one of the drawbacks of previous research; therefore, we examined whether daily sport stacking activities for 14 weeks would influence the handwriting skills of second grade students. Additionally, a double-blind, randomized trial was conducted with an equitable control group, which experienced a similar treatment using the same time and duration limits as the experimental group.

As expected, all participants improved their handwriting speed significantly in the postintervention most likely due to natural maturity and learning effect. However, no significant group effects were found from the analysis on either writing speed or correct letter formation. We noticed a marginal interaction ($p = .08$) between group and test for handwriting speed, suggesting there was a tendency that led to improvement in handwriting speed for the experimental group compared to the control group. Again, the difference did not reach the statistical significance level.

The overall results failed to support the hypothesis that the 14-week sport stacking intervention might enhance children's handwriting skills. Given that the students involved in the study were young children who were in the developmental stage for fine motor skills, substantial performance variability in the testing was observed. Another possible reason for the nonsignificant findings may be related to the particular handwriting test procedure used in the current study. While it demonstrated the test feasibility and encouraged writing speed, the measurement also showed shortcomings. During the handwriting test, all students were instructed to write as neatly and as quickly as possible. Most students followed the directions well, but a few students appeared to concentrate more on writing quality and used much longer time than others. Therefore, students did not complete the test at the same time. Methods used by Tseng and Murray (1994) may be more appropriate to address the issue. In their study, students in Grades 3 to 5 were instructed to copy a sentence completely and repeatedly until 10 min had passed. This method uses a controlled total time and allows students to focus on the writing task during the test without unnecessary distractions

because all students finished the test together. In the present study, students who completed the writing task early were instructed to sit quietly until all students had finished and the completion of the test was announced. We recommend using a controlled total writing time in future studies.

Piaget (1952) advocated that sensory-motor skills play a central role in children's early cognitive development. Advances in neuropsychology also provide information about the relationship between motor skills and cognition based on brain activity and structure (Son & Meisels, 2006). The writing systems are constructed from cognitive capabilities, such as the visual, phonological, and semantic systems. Based on literature review, Rosenbaum, Carlson, and Gilmore (2001) concluded that intellectual and perceptual-motor skills are acquired in fundamentally similar ways. It is believed that motor and cognitive systems develop dynamically by interacting with each other. Developing meaningful and effective physical activity programs in PE settings is necessary and important in promoting children's positive development in motor and cognitive domains.

Based on our knowledge, the present investigation was the first study to examine the effects of a sport stacking intervention on handwriting, which is one of the important skills required to be developed during early stage to enhance children's ability to communicate and improve overall learning abilities. A recent developmental study reported that movement time in handwriting decreased with age (Bidet-Ildei & Orliaguet, 2008). These findings confirm that writing speed is age-related and developmentally sensitive. Our data support the claim by showing that the students in both groups increased their writing speed significantly 14 weeks later. They also reveal a tendency that writing speed may be enhanced through the sport stacking intervention, but not the quality of letter formation. However, further testing of this speculation is required before a strong conclusion can be made. Knowing that sport stacking involves the use of visual perceptual cues, action planning, visual–hand coordination, and rapid hand movement abilities and that handwriting also requires visual perception (Feder et al., 2007), fine motor coordination (Case-Smith, 2002; Rogers & Case-Smith, 2002) and visual-motor integration (Maeland, 1992; Volman et al., 2006), the line of research investigating the potential benefits on perceptual-motor competencies gained through a sport stacking intervention is meaningful and has valuable practical applications.

Due to academic achievement demands placed on schools today, educational professionals are constantly searching for ideas and solutions that can positively impact learning. Research has linked high-quality handwriting to academic success (Son & Meisels, 2006). Connecting activities such as sport stacking to success in school can unlock learning for every child, which is the mission for every school district. Allowing PE to be the venue for these activities to occur will boost the profession's reputation and heighten the need for more PE across the United States.

Although not significant, the current study found a potential influence of a 14-week sport stacking intervention with second grade students on handwriting, a skill strongly linked to learning. Because sport stacking involves visual-motor integrated movements, the activity helps to develop fine motor control components and visual-motor skill, which are key elements of handwriting. Studies involving development of perceptual-motor skills and their effect on learning are requisite. Future studies using sport stacking to possibly affect other variables connected to learning process will be also needed to aid our schools to more effectively promote learning for all elementary students.

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