Fine Motor Skills, Writing Skills and Physical Education Based Assistive Intervention Program in Children at Grade 1

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Abstract
The purpose of this study is to investigate the effect of physical education based intervention program, aiming to help the development of writing skills of primary school children, on fine motor skill precision and fine motor skill integration. A total of 104 primary school children at grade 1 with at least 2 years of preschool education participated in the study. Children in the experimental group, together with the curriculum studies, did adapted ball control drills three times a week, each 40 minutes, for 10 weeks. Fine motor skill levels of the children were examined with tests of Manual dexterity, Upper limb coordination, Fine motor skill precision and Fine motor skill integration sub-dimensions in the complete form of the Bruininks-Oseretsky test of Motor Proficiency Second Edition (BOT-2). The first measurement was made in the first week of school education, and the last measurements were made after a 10-week intervention period. Data were evaluated by repeated measures analysis of variance and simple effect test. At the end of the intervention, dexterity, upper extremity coordination, fine motor skill sensitivity and fine motor skill integration values improved in the experimental group compared to the control group. This difference between two groups was determined to be statistically significant. As a result, it can be said that physical education based intervention programs for small muscle groups positively affect children’s fine motor skills development and thus their interest in writing and schooling.

Keywords: Fine motor skill, Fine motor integration, Fine motor precision, Handwriting, Manual dexterity, Physical education program, Primary school, Upper limb coordination, Bruininks-Oseretsky motor proficiency test-2.


History: Received: 9 July 2019
Revised: 16 August 2019
Accepted: 28 September 2019
Published: 31 October 2019

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Publisher: Asian Online Journal Publishing Group

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**Contribution of this paper to the literature**

This study contributes to existing literature by investigating the effect of physical education based intervention program, aiming to help the development of writing skills of primary school children, on fine motor skill precision and fine motor skill integration.

1. **Introduction**

Developmentally, a preschool child sharpens the visual perceptual and fine motor skills necessary to perform activities that require visual-motor integration, such as handwriting (Beery, 1997). Fine motor skills also play an important role in supporting people's daily lives (Linde et al., 2013). Fine motor skill competence is an essential component of daily living activities. Poor fine motor skills can cause increased anxiety, distress in academic achievement and poor self-esteem (Gaul and Issartel, 2016).

The majority of the daily life of school-age children is spent at school and 30–60% of this time is spent performing fine motor tasks (McHale and Cermak, 1992). Almost 85% of the time spent on fine motor tasks consists of paper and pencil-based activities, which are perhaps about the most important skills for academic achievement (Marr et al., 2003). It was found that children with strong fine motor skills showed earlier development in reading skills and higher academic achievement (Cameron et al., 2012).

Due to the development of technology, the amount of time children are exposed to technology products decreases day by day (Lauricella et al., 2015), which limits the movement experiences necessary for children to continue their daily lives (Maitland et al., 2013). However, some studies have suggested that fine motor skills are not adversely affected because fine motor skills are required to use technological products (Adams et al., 2012). Nevertheless, these skills are forced to a different orbit, which leads to the loss of fine motor skills that an individual needs in daily life (Coll, 2015). Considering that an individual has to master the motor skills by the age of 10 (Gallahue et al., 2012) many fine skills may be considered at risk. It is stated that children with such motor impairment as Developmental Coordination Disorder (DCD) have difficulty in tying shoelaces, buttoning shirt button, opening and closing the zipper, brushing teeth and using cutlery (Wang et al., 2009; Magalhaes et al., 2011).

Unfortunately, if intervention is not performed at the right time, these difficulties may continue throughout life and ultimately affect their quality of life (Gaul and Issartel, 2016).

Fine motor skills are the types of skills performed using small groups of muscles necessary to move objects (Gallahue et al., 2012). In addition, fine motor skills include graphomotor skills (GS) including the control and strength of the muscles (Levine, 1987). Fine Motor Skill represents a set of skills connected to a set of similar structures, such as hand-eye coordination, transformation of a visually perceived object into motor output, skills involved in writing, and even handwriting (Bart et al., 2007). However, in some studies, the definition of Fine Motor Skill has been expressed as “small muscle movements requiring close hand-eye coordination” (Suggate et al., 2019).

Good motor skills can serve as a buffer for normative difficulties experienced by children in transition to school whereas poor motor skills emerge as a weakness in transition to primary school education (Bart et al., 2007).

The majority of school-age children display poor drawings and handwriting (Bingham and Snapp-Childs, 2019). Difficulties in handwriting skills among children of primary school age have been shown as one of the most common reasons for directing children to pediatric occupational therapy services worldwide (Feder et al., 2006). Weak fine motor control, lack of coordination in muscle contraction, irregularity in impact rate and strength can lead to distorted and illegible handwriting, and therefore, evaluation of fine motor control in handwriting movement is important in the comprehensive assessment of handwriting dysfunction. Clinical observations and performance tests are traditionally part of the handwriting evaluation (Rosenblum et al., 2005; Di Brina et al., 2008; Lam et al., 2011). Handwriting incompetency may be caused by inappropriate external factors such as biomechanical or environmental components, or internal factors such as poor performance in perceptual and motor skills.

Monitoring and drawing tasks are the prominent tools for evaluating various aspects of motor control. Therefore, many exemplary models designed to study motor control included them as part of their assessment (Smits et al., 2018). Factors such as visual perception show little correlation with handwriting, whereas tactile kinaesthetic and motor planning are more closely related to handwriting (Tseng and Cermak, 1993). As well as handwriting, visual-motor coordination abilities, motor planning, cognitive and perceptual skills, a mix of tactile and kinaesthetic sensitivities are complex perceptual-motor skills (Maeland, 1992). Furthermore, handwriting appears as a perceptual motor skill acquired through repetitive practice (Feder and Majnemer, 2007) and is often presented as an example of motor skill acquired through procedural learning processes (Wilhelm et al., 2012).

Handwriting is actually a very complex skill. A proper handwriting requires fine motor skills, visual perception, cognition integration and maturation (Volman et al., 2006; Shams and Kim, 2010). Therefore, fine motor skills are important because correctly formed letters can only be produced with force control and proper timing of coordinated finger, hand and arm movements (Alston and Taylor, 1987). There are many basic skill components that will interfere with handwriting performance. Before starting the handwriting process, children need to develop preparation skills to form letters, such as development of large and small muscles, visual perception, fine motor skills, and hand manipulation skills (Lamme, 1979). When copying letters and words, children need not only keeping the task in mind, attention, visual and manual coordination, but also control of fine movements and enough power of the finger and the hand (Stevenson and Just, 2014). It is seen that motor competence measures related to handwriting production have an indirect effect on handwriting in school age children (Berninger, 2009).

Acquiring handwriting skills at the beginning of education is the basis of future academic success (Cahill, 2009). It is seen that handwriting errors in the first grade of primary school are related to academic achievement up to 6th grade (Moore and Rust, 1989).

Therefore, it is essential to develop intervention methods to facilitate the development of graphomotor and skills fine motor of 1st grade children in primary school. In this context, the studies which are already presented intensively in line with the teaching programs in schools may affect their opinions about school due to not taking their developmental level and maturation into account.
In this study, it is aimed to investigate the effects of physical education based intervention program, which was prepared out of writing activities of children, on fine motor integration, fine motor precision, manual dexterity and upper limb coordination level and indirectly on writing activities of primary school 1st grade children.

2. Material and Method

2.1. Research Model

Quantitative research model was used in the study. Data for the motor development of the participants were obtained by experimental method in the form of pre-test/post-test.

2.2. Research Group

A total of 123 1st grade students of a private school with at least 2 years preschool education were included in the study for the sake of implementing the same curriculum in Kütahya province. The classes were randomly assigned to the study and control groups. However, 104 participants (59 experimental group, 45 control group) were evaluated in the experimental dimension of the study according to the attendance record of the children. The mean age of the participants in the experimental group was 6,08±0,281 while the mean age of the control group was found to be 6,13±0,344. 53 of the participants were male and 51 were female.

2.3. Data Gathering Tools

The participants' upper limb coordination, manual dexterity, fine motor skill integration and fine motor skill precision levels were analysed using the complete form of The Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2). Shape Filling-Circle, Shape Filling-Star, Drawing a Line-Crooked, Drawing a Line-Curved, Connecting Dots, Paper Folding and Cutting a Circle were applied to determine fine motor skill precision. Circle Copy, Square Copy, Overlapped Circle Copy, Curved Line Copy, Triangle Copy, Diamond Copy, Star Copy, Overlapped Pencils Copy were applied for fine motor skill integration. In order to determine the manual dexterity, the participants were made to put dots in a circle, transfer coins, arrange plastic nails, classify cards and rope blocks. In order to determine the upper limb coordination, ball-release and two-handed catch, two-handed ball-throw, catch, release and one-handed catch, the preferred hand ball-catch, the preferred hand ball-bounce, ball-bounce with two-hand sequence and the preferred hand ball-throw to a target were applied. The evaluation of the tests was made by 3 referees and the middle value was taken into consideration omitting the highest and the lowest values. The raw values obtained were converted to point scores and the total values of each sub-dimension were determined.

2.4. Ethical Considerations

The families of the participants were informed about the current motor development level of the participants and the intervention program and informed consent was obtained.

2.5. Application Protocol

Students were divided into specific groups of 20 subjects and were placed in 10 stations, each with 2 students. Considering the age and attention span of the students, each student performed the specified movement for 2 min. at each station. Each station used a different size ball randomly (basketball, volleyball, handball, soccer ball, tennis ball, etc.). Every two minutes, students changed the station in pairs. These 10 stations were carried out 2 rounds. A sample protocol is shown in details in Table 1.

Table 1. Sample course plan.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Acquisition</th>
<th>Training program</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>- One-handed and two-handed ball control without contacting the palm</td>
<td>1. Can control an approaching object with one hand and two hands.</td>
<td>Station 1: Balls are thrown into the air with two hands and caught.</td>
<td></td>
</tr>
<tr>
<td>- Controlling moving ball/objects with hands and fingers</td>
<td>2. Can move the object with right and left hand where it is or on a specified route.</td>
<td>Station 2: Balls are thrown into the air with one hand in turn and captured.</td>
<td></td>
</tr>
<tr>
<td>- Ball orientation with fingers</td>
<td>3. Can move objects along specified path using only fingers.</td>
<td>Station 3: The ball is bounced and caught with one hand and two hands.</td>
<td></td>
</tr>
<tr>
<td>- Moving the ball along the specified route</td>
<td>4. Can apply pressure to objects at different rates.</td>
<td>Station 4: The ball is turned around the head without contacting the palm.</td>
<td></td>
</tr>
<tr>
<td>- Applying force to the ball with different pressures</td>
<td>5. Can repeat the movement s/he sees.</td>
<td>Station 5: The ball is turned around the waist without contacting the palm.</td>
<td></td>
</tr>
<tr>
<td>- Following the ball with the eye and moving it in the same orbit</td>
<td>Learning by doing and experience, expression, demonstration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Developed from the data in “https://www.breakthroughbasketball.com/fundamentals/ballhandling.html”
2.6. Statistics

The quantitative data were evaluated by repeated measure Anova and simple effect test in SPSS 24.0.

3. Findings

![Figure 1: Fine motor precision comparison](image1)

Repeated measure Anova, p<0.05.

In **Figure 1**, according to the results of the repeated measurements Anova test, when the change in the group time interaction dimension between the post-test and pre-test of the experimental group and the change between the post-test and pre-test of the control group were compared, the former was found to be higher than the latter. This difference was statistically significant (F(1, 102) = 6.093; p<0.05).

![Table 2](image2)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Measurement (I)</th>
<th>Measurement (J)</th>
<th>Mean difference (I-J)</th>
<th>Std. error</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>Post test</td>
<td>Pre test</td>
<td>1.778</td>
<td>0.869</td>
<td>4.181</td>
<td>0.043</td>
</tr>
<tr>
<td>Experimental group</td>
<td>Post test</td>
<td>Pre test</td>
<td>4.627</td>
<td>0.759</td>
<td>37.136</td>
<td>0.000</td>
</tr>
</tbody>
</table>

In **Table 2**, according to the results of the simple effect test, both the change occurring between the post-test and pre-test of the experimental group (F(1, 102) = 37.136; p<0.05) and the change between the post-test and pre-test of the control group (F(1, 102) = 4.181; p<0.05) were found to be statistically significant.

![Figure 2: Fine motor integration comparison](image3)

Repeated measure Anova, p<0.05.

In **Figure 2**, according to the results of the data analysis, when the change between the post and pre-test values of the experimental group and that of the control were compared, the change in the experimental group was higher than the control group. This difference between two groups was determined to statistically significant. (F(1, 102) = 18.460; p<0.05).
Table 3. Comparison of fine motor integration measurements in simple effect test.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Measurement (I)</th>
<th>Measurement (J)</th>
<th>Mean difference (I-J)</th>
<th>Std. error</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>Post test</td>
<td>Pre test</td>
<td>1.822</td>
<td>0.792</td>
<td>5.296</td>
<td>0.023</td>
</tr>
<tr>
<td>Experimental group</td>
<td>Post test</td>
<td>Pre test</td>
<td>6.339</td>
<td>0.692</td>
<td>84.029</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Simple effect test, p<0.05.

In Table 3, when the results of simple effect test were examined, it was seen that there was a significant difference between the measurements when the change between the post-test and pre-test of the control group was compared ($F_{1,102}$=5.296; p<0.05). Similarly, when the change between the post-test and pre-test of the experimental group was compared, a statistically significant difference was found between the measurements ($F_{1,102}$=84.029; p<0.05).

In Figure 3, data analysis results showed that when the change between the pre and post-test values of the experimental group and that of the control were compared, the change was found to be higher in the experimental group than the control group. The differences between the measurements were statistically significant when compared in group dimension ($F_{1,102}$=17.739; p<0.05).

Table 4. Comparison of manual dexterity measurements in simple effect test.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Measurement (I)</th>
<th>Measurement (J)</th>
<th>Mean difference (I-J)</th>
<th>Std. error</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>Post test</td>
<td>Pre test</td>
<td>2.533</td>
<td>0.553</td>
<td>20.966</td>
<td>0.000</td>
</tr>
<tr>
<td>Experimental group</td>
<td>Post test</td>
<td>Pre test</td>
<td>5.627</td>
<td>0.483</td>
<td>135.628</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Simple effect test, p<0.05.

In Table 4, when the results of simple effect test were examined, it was seen that there was a significant difference between the measurements when the change between the post-test and pre-test of the control group was compared ($F_{1,102}$=20.966; p<0.05). Similarly, when the change between the post-test and pre-test of the experimental group was compared, a statistically significant difference was determined between the measurements ($F_{1,102}$=135.628; p<0.05).

In Figure 4, according to the results of the data analysis, when the improvement between the post and pre-test values of the experimental group and that of the control were compared, the improvement was found to be higher in the experimental group than the control group. This difference between two groups was determined to statistically significant ($F_{1,102}$=19.494; p<0.05).
In Table 5, according to the results of the simple effect test, both the change occurring between the post-test and pre-test of the experimental group (F1,1002=135.620; p<0.05) and the change between the post-test and pre-test of the control group (F1,1002=10.620; p<0.05) were found to be statistically significant.

4. Discussion

It was determined that the manual dexterity level of the children who started primary school grade 1 at an early age was behind that of the older grade 1 students (Kildan and Ahi, 2014). In some studies, visual motor integration came to the fore in individuals who had problems in writing skills, while manual dexterity and upper limb coordination came into prominence in normal writing skills (Tseng and Chow, 2000; Volman et al., 2006). Children with higher scores at standardized visual motor integration tests were shown to produce faster (Tseng and Chow, 2000) and more legible handwriting than those with lower scores (Cornhill and Case-Smith, 1996). In another study, it was found that children with handwriting problems showed a lack of fine motor control (Smiths-Engelsman et al., 2001). In addition, studies on brain function using fMRI revealed a close relationship between visual and motor systems related to handwriting (James, 2010). In addition, a statistically significant relationship between object control skills and visual motor integration was revealed in a study by Du Plessis et al. (2015) investigating the relationship between Grade 1 learners' visual motor integration, visual perception, motor coordination and object control skills. A study examining the effect of fine motor skills on handwriting legibility in preschool age children showed a high level of relationship between fine motor skills and handwriting legibility. The study revealed that the accuracy of hand manipulation skills is factors that influence handwriting legibility (Seo, 2018). While Tseng and Chow (2000) found a high correlation both between writing speed and upper limb coordination and manual dexterity values of normal writing individuals and between writing speed and visual motor integration values in slow writing individuals (Tseng and Chow, 2000), Kaiser et al. (2009) investigated the relationship between visual motor integration, eye-hand coordination and handwriting quality and concluded that the relationship between visual-motor integration and hand-eye coordination can be used to predict the quality of handwriting.

The findings of our study showed that the group who received physical education based intervention program had more improvement in fine motor integration, fine motor precision, manual dexterity and upper limb coordination skills compared to control group. Kambas et al. (2002) investigated the effect of a motor intervention program emphasizing space and time in children aged 4-5 years. The graphomotor skills of the participants were evaluated with the following BOTMP-CF articles. A significant difference was found between the control and experimental groups after the intervention process. In addition, Spanaki et al. (2008) examined the effect of motor development intervention program on graphomotor, gross and fine skills of children from preschools and primary schools. At the end of the process, regardless of motor competence, the improvements in graphomotor, gross and fine skills were important for all participants. In another study on the effects of intervention program on the development of fine motor and visual motor integration skills in preschool students, the participants in the intervention group showed a statistically significant increase in fine motor and visual motor skills, while the control group showed a slight decrease in both areas (Ohi et al., 2013). The effect of structured handwriting reading program applied to children included in the Head Start program on fine motor skills was examined and the data showed a positive effect on the development of manual skills and fine motor integration in preschool children (Winslow, 2011). In another study, upper limb coordination, manual dexterity, fine motor precision and fine motor integration values were compared in Fine Motor and Early Writing Pre-K Curriculum (FM EW) program applied-experimental group and Handwriting Without Tears - Get Set For School Curriculum (HWT) program applied-experimental group and control group participants. In the study, the participants in the FMEW group achieved the highest score in the sub-tests of fine motor precision, manual dexterity and upper limb coordination (Lear, 2012). In another study on the relationship between handwriting skills and visual motor integration of preschool children, the students who were able to copy the first nine VMI forms correctly in both versions of the modified SCRIPT (Daly et al., 2000). In a study by Ratzon et al. (2007) participants in the study group achieved significant gains compared to the control group both in graphomotor test and in the Bruininks-Oseretsky Motor Efficiency Test Long + Form. The study on the effects of short-term graphomotor program aimed at improving writing preparation skills of 1st grade students revealed that motor skill development levels were higher in the intervention group. Jongmans et al. (2005) found that neuromotor task studies gave positive results on handwriting development. Likewise, some studies have shown that visual motor and fine motor intervention programs of occupational treatment are effective in preschool and primary school (Bazyk et al., 2009). In a study investigating the effects of developmental coordination disorder (DCD) motor skills program, significant improvements were observed in hand skills, ball skills and handwriting skills after the training period (Farhat et al., 2016). All these studies support our hypotheses within the scope of our research.

5. Conclusion

Many studies have revealed a relationship between fine motor skills and handwriting of children. However, as a result of the pressure exerted on teachers and children who are still in play age due to the academic achievement criteria of the parents, children are subjected to intensive writing education with transition from preschool education to primary school. In fact, this pressure causes children to forget to play during this period and their

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<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group</td>
<td>Post test</td>
<td>Pre test</td>
<td>2.622</td>
<td>0.805</td>
<td>10.620</td>
<td>0.002</td>
</tr>
<tr>
<td>Experimental group</td>
<td>Post test</td>
<td>Pre test</td>
<td>7.339</td>
<td>0.703</td>
<td>135.620</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Simple effect test: p<0.005.
attitudes towards school in the preschool period are negatively affected. Drawing line and similar studies aiming to improve children's writing skills in line with the curriculum can put excessive burden on children depending on their maturation and readiness levels. This may have a negative impact on the future perspective of education of children who will be in education for long periods of time according to the education system of the country in which they live. In informal interviews with 1st grade students and their parents, they stated that children liked kindergarten more than primary school and they got very tired during writing drills. On the other hand, it was determined that the students in the intervention program group had no negative thoughts about the school. It can be thought that this may be due to transferring the children's concentration away from play on writing skills.

For this reason, it can be stated that intervention programs developed based on physical education can positively affect children's fine motor skills development and indirectly writing skills. In this regard, physical education intervention programs for fine motor skills development can be added to the primary school grade one curriculum. In addition, it is important to conduct a qualitative research in order to reveal the reasons of the negative thoughts that the children have developed against school and to eliminate these negative factors.

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