ORIGINAL ARTICLE

Assessment of manual dexterity using the grooved pegboard test in secondary school students aged 11–12 years

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Abstract

Background and Study Aim	Understanding and addressing potential variations in hand dexterity among children is essential for educational strategies and interventions aimed at enhancing fine motor skills development in this age group. The study's objective was to assess hand dexterity levels among 11-12 years old secondary school students, considering variables such as gender, grade, and hand preference.
Material and Methods	Ninety-three students (41 females and 52 males) in grades 5 and 6 of the secondary school. The Grooved Pegboard Test (GPT) (Lafayette Model 32025) was used as a data collection tool to determine the students' performance in hand dexterity (fine motor skills). The Mann-Whitney U-test was used to test for differences between gender, grade, and hand preference in the mean GPT scores.
Results	Results showed that both female and male 6th graders had better GPT performance in both dominant and non-dominant hands than 5th graders. On the other hand, there were no significant grade differences in GPT performance between dominant and non-dominant hands (p>0.05). There was no difference in GPT performance between 5th and 6th grade (p>0.05). There were no statistical differences between females and males in GPT performance in either the dominant or non-dominant hand (p>0.05).
Conclusions	Results highlight the importance of considering age-related changes in fine motor skills when developing educational strategies and interventions for children in the 11-12 year age group. Further research may be needed to explore the underlying factors contributing to these variations in hand dexterity.
Keywords:	fine motor skill, eye-hand coordination, motor control, manipulative dexterity, visual motor coordination

Introduction

Fine motor skills represent a set of skills associated with a set of similar structures, such as hand-eye coordination, the transformation of a visually perceived object into a motor output, skills involved in writing, and even handwriting [1]. In some studies, the definition of fine motor skills has been expressed as 'small muscle movements requiring close hand-eye coordination [2].

Fine motor skills are also defined as the coordination of small muscle movements and eye-hand coordination, and commonly include tasks that require visual, cognitive, and manual dexterity, such as picking up objects with tweezers, handwriting, or drawing a picture with a pencil [3]. Suggate et al. [4] suggested that the broad description of fine motor skills could be divided into three categories: general fine motor skills (e.g. dressing a doll), graphomotor skills (e.g. the ability to hold a pencil and draw but not write), and handwriting.

Hand-eye coordination; the creation of appropriate motor responses to the visual stimuli received in the mind and body. The harmony of all the movements made as a result of the perception of the eye and the transmission of the stimulus to the brain via sensory nerves. The transmission to the necessary muscles via sensory nerves for the implementation of the plan decided to be made. The ability to integrate the use of eyes and hands by making predictions in following and stopping/catching the object [5, 6].

There are many validated tests to measure fine motor skills and hand dexterity in people with impaired hand function. One of these is the Grooved Pegboard Test (GPT), a standardised test that measures manual dexterity, hand-eye coordination, rapid visual-motor coordination and psychomotor speed [7, 8, 9].

Examining research on the Perdue Pegboard Test reveals several notable studies. Wilcox and Nordstokke [10] studied performance in individuals aged 6-14 years, while Kanj et al. [11] investigated factors associated with motor dexterity on the grooved pegboard test. Fuelscher et al. [12] focused on manual dexterity in both the dominant and non-dominant hand. Clark et al. [13] assessed fine motor skills in 4- and 5-year-old children, and Skogan et al. [9] and Van Wijk and Meintjes [14] conducted studies on age, gender, and education. Wilhelm et al.

[15] and Bryden and Roy [16] explored performance differences in dominant and non-dominant hands, while Scharoun and Bryden [17] investigated hand preference, performance, and hand choice in children. Additionally, Schmidt et al. [18] delved into the influence of handedness and gender.

The literature review shows that there are a number of studies that have examined the performance of school children in hand-eye coordination, a fine motor skill. Concerns have been raised about how well normative data collected four to five decades ago reflect motor performance in today's child and adolescent populations, particularly as measured by the GPT. Comparisons of normative data across age, gender and time have the potential to provide new insights [9]. Skogan et al. [9] also reported that a recurring problem in this area of research is the lack of normative GPT data for children and adolescents under the age of 16. In this respect, the research is considered valuable and could contribute to the literature.

Purpose of the Study. The study aimed to assess hand dexterity among secondary school students in grades 5 and 6 and to examine performance differences on the Grooved Pegboard Test based on gender, grade, and hand preference variables. In this context, answers to the following questions were sought 'What are the students' hand-eye coordination ability scores and do the performance scores differ according to gender, grade and hand preference variables?'

Materials and Methods

Participants

One school in Istanbul agreed to participate in the study by providing access to de-identified data. Ninety-three (21 females and 26 males from 5th grade and 20 females and 26 males from 6th grade) students (11-12 years old) from the secondary school in Istanbul participated in this study, with two classes completing the Grooved Pegboard Test. Thirty-seven of the participants were right-handed and five were left-handed. Class, gender and self-reported handedness were recorded for each participant. The study was conducted in November 2022.

Research Design

This quantitative study was organised according to the comparative relational survey model. The study protocol was approved by the Ethics Committee of Marmara University. All participants gave their informed consent and no incentive was given for their participation.

The Grooved Pegboard Test (Lafayette Model 32025) was used as a data collection tool to determine the students' performance in hand dexterity (fine motor skills). The Grooved Pegboard Test (Lafayette Model 32025) is a rectangular board with a tray for the 25 pegs and a stopwatch to calculate the time taken to place the pegs in the holes. The stopwatch begins when a subject picks the first peg and ends when the last peg is placed in the hole, at which point the performance time is calculated. Subjects completed two trials, the first with their dominant hand and the second with their non-dominant hand. Hand preference was assessed by declaring their preferred hand for writing. Subjects were instructed to pick up only one pencil at a time, and if a pencil was dropped, to pick up a new one from the pile. Each participant was asked to use their dominant hand to place the pegs in the designated locations. The participant placed the 25 pegs in their correct designated holes in sequential order for each run. The first peg was to be placed in the first left hole in the first row of holes, while the last peg was to be placed in the last right hole in the fifth row of holes. In contrast, for the non-dominant hand, the first pin should be placed in the first right hole in the first hole line and the last pin in the left hole in the last hole line [7].

Statistical Analysis

Initially, the Grooved Pegboard Test data was entered into Microsoft Excel, meticulously checking for any missing data and inconsistencies to ensure data quality. The data were then coded and analysed using SPSS 22. Normality of the data was assessed using the Shapiro-Wilks test with α set at 0.05. The Mann-Whitney U-test was used to test for differences between gender, grade, and hand preference in the mean GPT scores.

Results

The results of this study are presented in the following four tables. In Table 1, no statistical difference was observed in the preferred hand for the Grooved Pegboard Test performance between the sexes in grade 5 and grade 6.

No statistical difference was observed between

Table 1. Preferred hand performance across grades

Variable	Grade	Gender	N	Mean (SD)	U	z	p
Preferred Hand	5	Female	21	76.80 (15.38)	219.500	-1.146	.252
		Male	26	80.07 (13.89)			
The Grooved Pegboard Test (second/s)	6	Female	20	70.45 (9.08)	204.000	-1.243	.214
		Male	26	75.76 (12.40)			

*p<0.05

Table 2. Non-preferred hand performance across grades

Variable	Grade	Gender	N	Mean (SD)	U	z	p
Non-preferred Hand	5	Female	21	90.00 (35.15)	266.500	-.139	.889
		Male	26	86.53 (17.31)			
The Grooved Pegboard Test (second/s)	6	Female	20	86.65 (19.98)	211.000	-1.087	.277
		Male	26	82.65 (18.33)			

*p<0.05

Table 4. Non-preferred hand performance across gender

Variable	Gender	Grade	N	Mean (SD)	U	z	p
Non-preferred Hand	Female	5	6	90.00 (35.15)	209.000	-.026	.979
		6	10	86.65 (19.98)			
The Grooved Pegboard Test (second/s)	Male	5	12	86.53 (17.31)	271.000	-1.227	.220
		6	14	82.65 (18.33)			

*p<0.05

Table 3. Preferred hand performance across gender

Variable	Gender	Grade	N	Mean (SD)	U	z	p
Preferred Hand	Female	5	6	76.80 (15.38)	158.500	-1.345	.179
		6	10	70.45 (9.08)			
The Grooved Pegboard Test (second/s)	Male	5	12	80.07 (13.89)	271.500	-1.218	.223
		6	14	75.76 (12.40)			

*p<0.05

the sexes in terms of non-preferred hand Grooved Pegboard Test (GPT) execution time for both 5th and 6th-grade students (Table 2).

In Table 3, there were no statistically significant differences observed between grades in preferred hand Grooved Pegboard Test (GPT) execution time for both females and males (p>0.05).

There was no statistical difference in the non-preferred hand Grooved Pegboard Test execution time between the grades in females (p>0.05) and males (p>0.05).

Discussion

The aim of this study was to determine the performance levels of hand-eye coordination (hand dexterity), which is a fine motor skill, in 5th and 6th grade secondary school students, and also to investigate whether there is a difference in these performance levels in terms of gender, grade/class and hand preference variables.

Several studies have shown that GPT performance also depends on socio-demographic variables such as age, gender, handedness and education [10, 12, 17, 19, 20, 21]. Our results showed that both female and male 6th grade students had better GPT performance in both dominant, and non-dominant hands than 5th grade students. On the other hand, there were no significant grade differences in GPT performance between dominant, and non-dominant hands (p>0.05). According to Wilcox and Nordstokke

[10], performance improved across age groups (6-14) for both males and females, Kanj et al. [11] showed that speed of completion of the GPT improved with age. The work of Fuelscher et al. [12] shows age-related improvements in manual dexterity for both the dominant and non-dominant hand. İri et al. [5] reported that there was no statistically significant difference between the sexes in hand-eye coordination in children aged 11-14 years. Ferrett et al. [19] reported that age has a significant effect on GPT performance and is one of the most important factors contributing to completion time. Strauss et al. [21] found that improvement on the Grooved Pegboard Test continues up to the age of 14-15 years.

Our results showed that there was no difference in GPT performance between grade 5 and grade 6. However, females and males in grade 6 had better GPT performance than those in grade 5. As in other studies, our study consistently showed that age has a significant effect on GPT completion time performance and that GPT performance also improves with increasing age.

Previous literature has also shown that fine motor skills are a strong predictor of academic performance [22, 23, 24]. Our findings may also be related to academic achievement as well as age. Skogan et al. [9] noted that studies of children and adolescents reporting gender-specific GPT scores of typically developing children and adolescents

are scarce. Studies have also failed to provide clear evidence of gender differences in manual dexterity performance [3, 21, 25]. Skogan et al. [9] found that males were faster than females with both dominant hands at the age of 10-12 years; Rosselli et al. [25] found that boys were faster than girls (6-11 years) at tapping in manual dexterity tests.

According to our study results, there were no statistical differences between the sexes in GPT performance in both dominant, and non-dominant hands. However, females in grades 5 and 6 performed better on the GPT than males in grades 5 and 6. Our results for GPT performance do not confirm the findings of the above studies.

From a neurobiological perspective, improved manual dexterity in childhood is often attributed to maturation of the corticospinal tract (CST), the sensorimotor white matter pathway responsible for voluntary movements [26]. Fuelscher et al. [12] reported that in children aged 9-13 years, greater manual dexterity of the dominant hand was associated with increased fibre cross-section in the CST. They suggest that greater manual dexterity of the dominant hand in late childhood may be associated with enlargement of the contralateral CST during this period. Thompson et al. [27] reported that the interhand-percentage-difference score for individuals was calculated as preferred hand - non-preferred hand ÷ preferred hand. Clark, Shelley & Cwikla [13] found that the fine motor skills of 4- and 5-year-old children, as measured by the Grooved Pegboard Test, were 243.18 seconds with the dominant hand and 271.82 seconds with the non-dominant hand. The intra-manual percentage difference was 11.8% in favour of the dominant hand. According to Wilhelm et al. [15], the mean time for the Grooved Pegboard test in males (age: 26.9±1.6 years) showed a significant difference between the performance of the dominant and non-dominant hand. The results were 61.04±1.67 s for the right hand and 68.15±1.58 s for the left hand. The intra-manual percentage difference was 10.4% in favour of the dominant hand. The work of Fuelscher et al. [12] shows age-related improvements in manual dexterity for both the dominant and non-dominant hand. Skogan et al. [9] also reported that from the age of 10, girls tended to be faster (dominant hand) than boys in GPT performance. At the age of 11-12 years, boys were faster than girls with the non-dominant hand on finger tapping speed (tap count).

In our sample, the typical percentage score differences between the dominant and non-dominant hand were about %8 (6.46 sec) for males in 5th grade, %9 (6.89 sec) for males in 6th grade, and also %13 (13.20 sec) for females in 5th grade, %16 (16.20 sec) for males in 6th grade on GPT performance in favour of the dominant hand. In the results of our study, there were no statistical differences between females and males in GPT performance in both the dominant and non-dominant hand. On the other hand, although females in grades 5 and 6 had better GPT performance in the dominant hand than males, males in grades 5 and 6 had better GPT performance in the non-dominant hand than females. In this respect, our results were consistent with the study by Skogan et al. [9].

The current study supports that there is no statistically significant difference in age, gender and hand preference on fine motor skills between 5th and 6th grade boys and girls.

The study findings also show that GPT performance improves with increasing age, females had better performance than males, and females had better in dominant hand than males, in non-dominant hand, males had better than females.

Conclusions

The results of the present study provide valuable insights into the fine motor skills of 11-12-year-old children and their potential variations based on grade, gender, and hand preference. However, it's important to acknowledge several limitations that should be considered when interpreting these findings.

Firstly, the study's sample size was relatively small, which may limit the generalizability of the results. This small sample size could give the study the character of a pilot study on fine motor skills in children. Future research endeavors should aim to address this limitation by analyzing larger samples and including a broader range of age groups. This would allow for a more comprehensive understanding of the development of fine motor skills across childhood and adolescence.

Additionally, while this study focused on specific variables such as grade, gender, and hand preference, there may be other factors influencing fine motor skills that were not considered in this research. Future studies could explore a wider range of variables to provide a more holistic understanding of the factors contributing to fine motor skill development in children.

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgement

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