



The Impact of Lateral Dominance and Gender on Fine Motor Skill Performance: An Analysis Based on Ipsilateralness and Contralateralness

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Abstract

Aim: This study aimed to investigate the impact of lateral dominance (ipsilateralness vs. contralateralness) and gender on fine motor skill performance in adolescents.

Materials and Methods: This experimental study was conducted on a sample of 383 adolescents aged 16 to 18 during the academic year 2021-2022 in Shiraz. Participants were purposefully and conveniently selected based on the conditions of the COVID-19 pandemic. The Edinburgh Handedness Questionnaire was used to determine hand dominance, the Hole-in-the-Card test was employed to identify the dominant eye, and the Grooved Pegboard test was utilized to assess fine motor skill performance.

Results: The results of the analysis of variance indicated that in the ipsilateral group (dominant eye = dominant hand), there was no significant difference in performance based on gender ($p > 0.05$). However, in the contralateral group (dominant eye \neq dominant hand), females demonstrated better performance across all variables ($p < 0.05$), with significant differences observed in right-hand time ($p = 0.001$), left-hand time ($p = 0.028$), and overall score ($p = 0.003$).

Conclusion: The findings of this study indicate that gender and lateral dominance significantly affect fine motor skill performance. These results can be utilized in designing educational and training programs aimed at improving motor skills in adolescents based on lateral dominance.

Keywords: Adolescents, Grooved Pegboard Test, COVID-19, Motor Performance, Individual Differences, Coronavirus

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1. Introduction

Adolescence as a critical transition phase from childhood to adulthood has attracted considerable attention from researchers (1). This period is characterized not only by physical changes, but also by emotional and social changes that can influence the way adolescents interact with their environment. During this stage, the development of motor and emotional skills serves as a foundation for the acquisition of future athletic skills and daily activities (2).

One of the most important motor skills during puberty is fine motor skills. Fine motor skills include activities such as writing, drawing, and tasks involving the hands and fingers that require precision and a high degree of coordination and are applicable in many aspects of daily life. According to Newell, experiences and learning within constraints can significantly improve individual learning performance during this time. These constraints can include physical, social, cultural, and psychological factors that play a critical role in shaping individual behavior and motivation, especially during adolescence (3).

In fact, mastering fine motor skills in youth not only improves motor competence and increases athletic participation, but also contributes to better performance later in life and an active lifestyle. Research literature shows that the hormonal and physical changes resulting from sexual maturation and rapid body growth, which typically occur between the ages of 10 and 19, have a profound impact on a person's motor

skills. In addition, adolescents are constantly comparing themselves to their peers during this time, which can lead to positive or negative feelings about their motor skills. Research shows that around 30% of adolescents have mental health problems due to deficits in fine motor skills, which can have a negative impact on their social and personal lives (5). Neglecting the development of these skills can therefore have serious consequences for adolescents, such as reduced self-esteem, increased anxiety and difficulties in social interactions. Understanding and promoting fine motor skills can therefore not only improve motor performance and establish positive movement patterns in adolescents (6), but also positively influence their mental and social well-being, contributing to an improved quality of life and future success (4).

However, there are various factors that can influence the performance of fine motor skills. One of these is lateral dominance (7). Lateral dominance is a fascinating concept of functional, anatomical and structural asymmetry in the human brain and body that involves the dominance of the hands, feet, eyes and ears. The interplay of these factors leads to the emergence of two types of lateral dominance: ipsilaterality and contralaterality. Ipsilaterality refers to the condition in which the dominant limbs are on the same side of the body, e.g. when the right hand and right foot are dominant. In this case, the dominant limbs function in a coordinated and symmetrical manner. Conversely,

contralaterality refers to when the dominant limbs are on opposite sides of the body, e.g. when the right hand is dominant while the left foot is dominant. In this scenario, the dominant limbs function independently and asymmetrically. This evolutionary process of lateral dominance is indicative of the profound effects that these dominances have on an individual's motor performance (2, 8).

Moreover, the importance of lateral dominance is so great that psychologists consider hand dominance to be an indirect indicator of hemispheric or lateralization dominance (9), which can also be influenced by cultural factors (9, 10) or biological factors (11). However, studies suggest that while the human body and brain hemispheres generally appear symmetrical, the paired motor (hands and feet) and sensory (eyes and ears) organs operate asymmetrically (12). The lack of lateral dominance can lead to problems with motor balance and coordination, including disorders of fine motor skills and, in particular, hand-eye coordination (13). By understanding these concepts, we can better understand how lateral dominance can affect motor skills and subsequently an individual's social and psychological performance.

Furthermore, the difference between ipsilateral and contralateral (lateral dominance) is clearly observable in the world of sports, especially in activities that require precision and coordination. For example, in sports such as basketball and volleyball, the ability to perform delicate and coordinated movements with high accuracy can

significantly affect the final outcome of a game (14). It is estimated that 70-90% of athletes are ipsilaterally dominated, while 10-30% are contralaterally dominated. Athletes with contralateral dominance are highly represented in sports such as golf, soccer and tennis. In contrast, in target sports such as pistol shooting and archery, most athletes are ipsilateral due to the higher concentration on advanced performance levels (15). Systematic reviews have shown that understanding lateral dominance can help identify talent and optimize training programs, ultimately leading to improved athletic performance (15). However, cultural factors (16), age and gender (17, 18) as well as differences in ability (19) can influence this lateral dominance.

The ultimate goal of this research is to examine the impact of gender on the performance of fine motor skills based on ipsilateral/contralateral behavior. Fostering fine motor skills early in life can not only facilitate the development of social and cognitive skills, but also plays an important role in various future fields, including the arts, sports, and related professions. Therefore, investing in the training of these skills can directly improve the quality of life of individuals at all later stages of life and contribute to the formation of balanced and successful individuals. Given the importance of this research topic, we also hope that the results of this study can serve as a theoretical foundation for future research in the area of motor skills and lateral dominance (ipsilateral/contralateral), thus

assisting policy makers, educators, and athletic coaches in developing better educational and support programs to improve the quality of life, education, and training of youth and to identify talent. The recognition and measurement of lateral dominance alone, as well as the performance of fine motor skills associated with ipsilaterality and contralaterality during adolescence, therefore, continues to be overlooked by many researchers. Addressing this issue may represent a turning point in improving the theoretical underpinnings and research findings related to the importance of lateral dominance.

2. Materials and Methods

In this study, 383 adolescents (323 boys and 60 girls) aged 16 to 18 years from Shiraz were selected to participate in the Grooved Pegboard Test during the 2021-2022 school year. Participants were recruited from local schools and sports centers. Informed consent was obtained from all participants to take part in the test.

Inclusion criteria for the study included: no motor or neurological disorders, willingness to participate in the test, and age between 16 and 18 years (born between the second half of 2002 and the first half of 2006). These criteria were self-reported by the participants.

Exclusion criteria included: participation in special motor training related to the test, incomplete completion of the test, withdrawal from participation, history of motor system-

related diseases and not attending secondary school. These criteria were also confirmed by the researchers through the participants' self-report.

2.1. Instrument

2.1.1. Tools

In the present study, a form developed by the researchers was used to record the anthropometric factors and general information of the participants. The MI Body Composition Scale 2 was used to determine the participants' weight, a tape measure was used to measure height, a digital caliper model 1108 was used to measure the anthropometric dimensions of the fingers, the Hole-in-Card test (Helen test) was used to determine the dominant eye, and the Edinburgh Handedness Inventory was used to determine hand dominance. This questionnaire is recognized as a valid instrument for determining hand dominance due to its high reliability and validity in previous studies (26). In addition, the Grooved Pegboard Test (version 32025) was used to assess fine motor skills. This test was selected for its unique characteristics, including ease of use, high precision and sensitivity of measurement, standard criteria for the assessment of fine motor skills, versatility in assessing different aspects (functional and cognitive) and portability. In addition, the Grooved Pegboard Test has been used as a standard instrument for assessing fine motor skills in related research and its validity and

norms for assessing fine motor performance in Iran have been demonstrated (27, 28).

2.1.2. Methodology

This study was conducted under the supervision of the Department of Sports Sciences at the Faculty of Educational Sciences and Psychology, Shiraz University, and was approved in accordance with the principles of the Helsinki Declaration. Initially, informed consent was obtained from the participants, followed by the use of a researcher-developed form to collect demographic information. The collected data were coded anonymously.

The data collection team (composed of experienced and trained individuals) examined and recorded anthropometric factors, hand dominance, and eye dominance. Based on the obtained data, participants were divided into two groups: aligned and cross-dominant for each gender.

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The data collection team (consisting of experienced and trained individuals) examined and recorded anthropometric factors, hand

dominance and eye dominance. Based on the data obtained, participants were categorised into two groups: equidirectional and cross-dominant for each gender.

In the next phase, face-to-face interviews were conducted and the procedure for conducting the Grooved Pegboard Test (GPT) was explained to all participants. This test was used to measure fine motor movements under standardised conditions. The time taken for the right and left hand was recorded as a measure of fine motor performance. The results were documented on score sheets and used for statistical analysis.

2.1.3. Execution of the Grooved Pegboard Test

In the grooved pegboard test, participants were instructed to start with their dominant hand and insert the pegs one by one into the holes of the pegboard (with the right hand from left to right and with the left hand from right to left). The test began when the examiner gave the "start command" at a point common to all participants, and it ended when the participant inserted the last pin into the pegboard (20). However, if a participant did not complete the task within five minutes, the test was terminated. After completion of the first phase, the test was continued with the non-dominant hand. Finally, the time taken to place all the pins in the five rows was recorded as each participant's score on the data collection sheet (29).

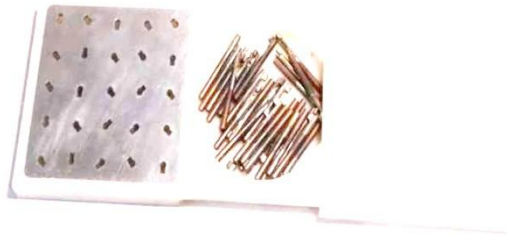


Figure 1. Test with grooved pegboards (version 32025)

2.1.4. Statistical Analysis

All collected data was analyzed using the statistical software SPSS, version 24. Descriptive statistics were used to determine frequency, mean, standard deviation, minimum and maximum values. Inferential statistics were used to compare the performance of fine motor skills, with a significance level (α) of 0.05. Analysis of variance (ANOVA) was performed for each dependent variable (right hand time, left hand time and total score) between groups, subdivided by gender and dominance/cross-dominance. Post hoc tests were performed to compare the groups and effect size was calculated using Eta squared.

3. Results

The results of the analysis of variance (ANOVA) showed a significant difference in the performance of the right hand depending on gender ($p=0.001$). The Bonferroni post hoc test revealed that this difference existed only between the cross-dominant groups of males and females, with a Δ of -7.412 seconds in favor of the female group ($\text{sig}=0.30$, $\eta^2=0.30$).

When examining the performance of the left hand, a significant difference was only observed for the factor dominance and cross-dominance ($p=0.039$). The Bonferroni post hoc test showed a significant difference only between the male and female cross-dominant groups, with a Δ of -5.435 seconds in favor of the female group ($\text{sig}=0.41$, $\eta^2=0.011$).

Finally, ANOVA showed a significant difference between the genders ($p=0.010$) when assessing the overall outcome (combined time for right and left hand performance). The Bonferroni post hoc test revealed that this difference was only present in the cross-dominant groups of males and females, with a Δ of -12.847 seconds in favor of the female group ($\text{sig}=0.005$, $\eta^2=0.017$).

Table 1. Analysis of variance between groups for the execution time of the grooved pegboard test for the right and left hand and the total score based on gender and lateral dominance

Variable	Effect	Gender	N	Mean Time (s)	Std. Deviation (M)	p-value
Right Hand Time	Same Dominant & Hand-Dominant	Male	232	67.8306	10.75220	P < .001
		Female	33	64.7936	10.23201	
	Different Eye-Dominant & Hand-Dominant	Male	91	69.2733	10.83242	
		Female	27	61.8611	7.98452	
Left Hand Time	Same Dominant & Hand-Dominant	Male	232	73.9077	12.42044	P < .039
		Female	33	74.4985	12.90030	
	Different Eye-	Male	91	73.3212	11.63980	

Total Score (Right & Left Hand)	Dominant & Hand-Dominant	Female	27	67.8859	9.04565	P < .010
	Same Eye-Dominant & Hand-Dominant	Male	232	141.7383	21.17805	
		Female	33	139.2921	20.91765	
	Different Eye-Dominant & Hand-Dominant	Male	91	142.5945	20.08726	
Female		27	129.7470	16.39424		

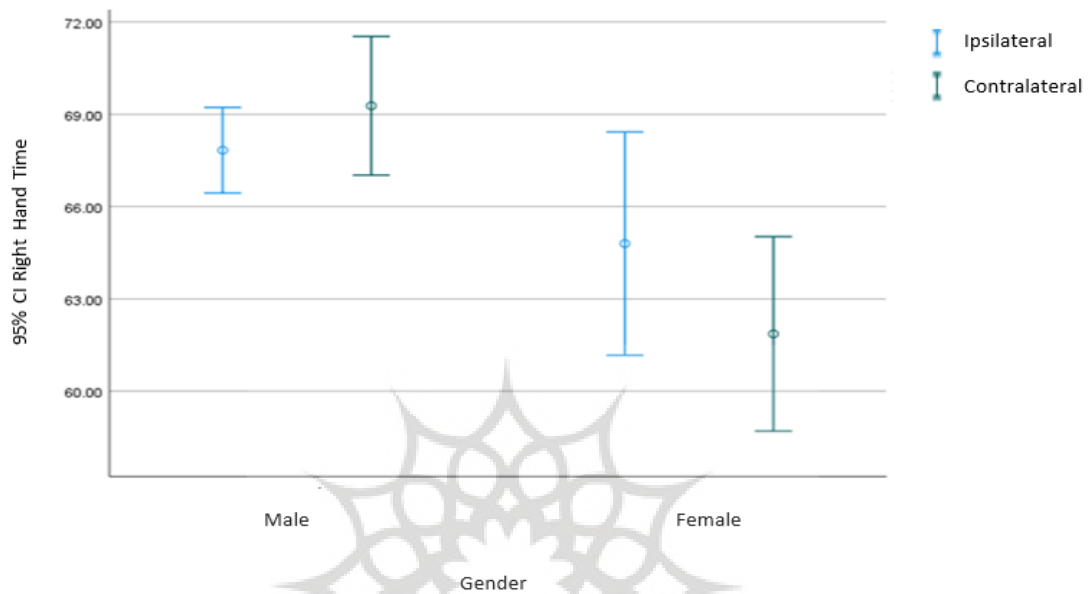


Figure 2. Execution time of the right hand in the grooved pegboard test as a function of gender and lateral dominance factors

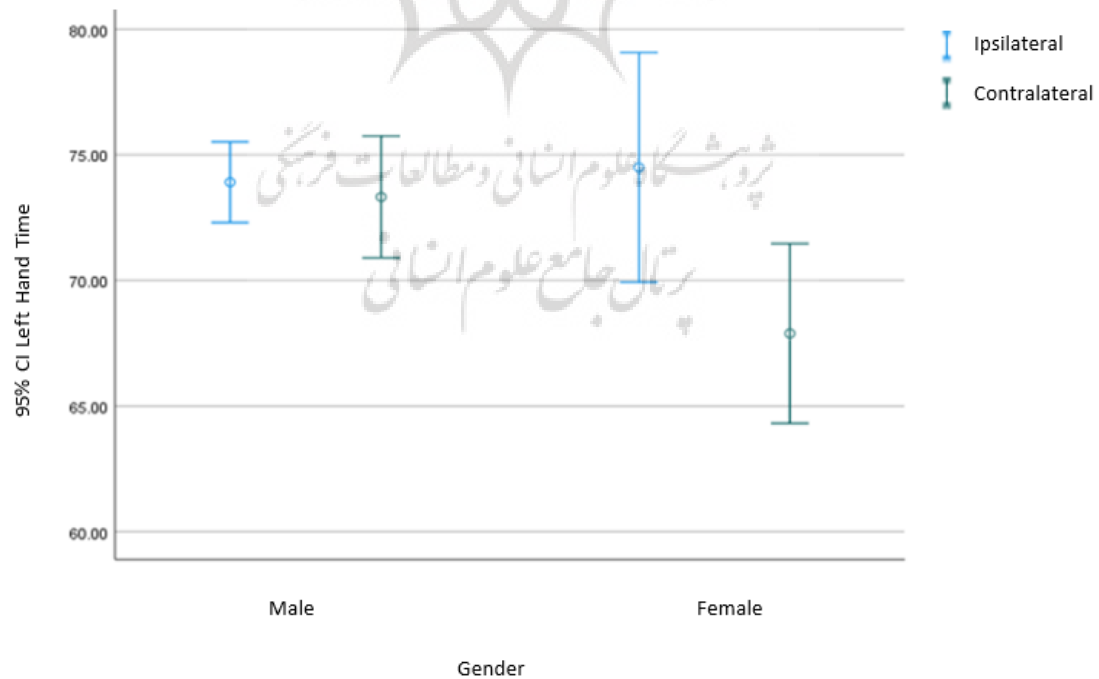


Figure 3. The execution time of the left hand in the grooved pegboard test as a function of gender and lateral dominance factors.

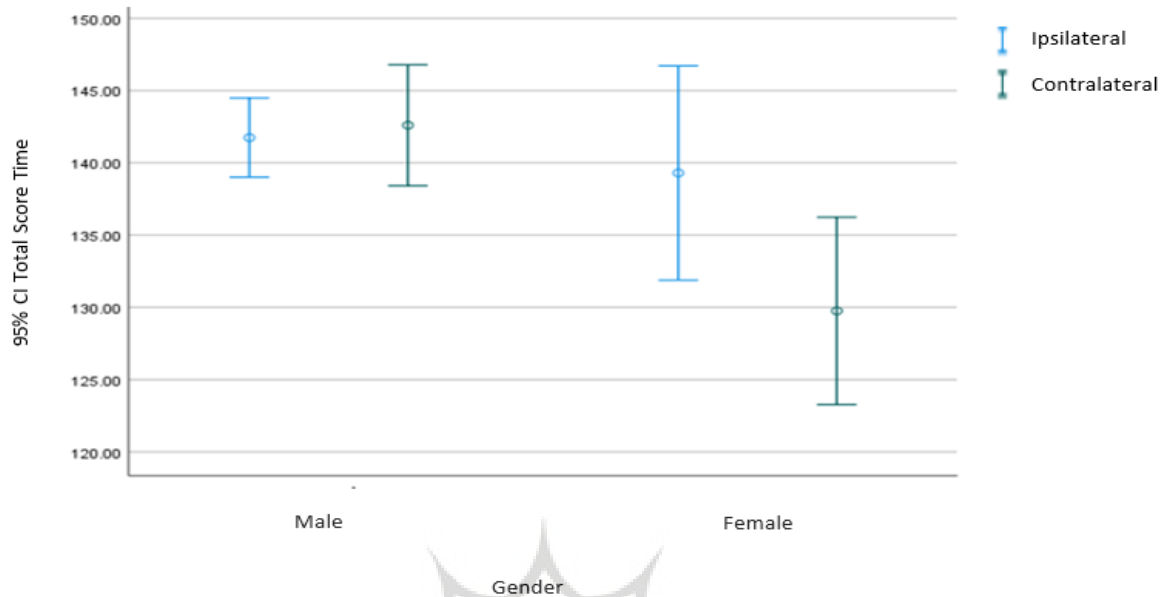


Figure 4. Total score (sum of the time for the right and left hand) in the Grooved Pegboard Test as a function of gender and lateral dominance factors.

4. Discussion and Conclusion

In today's world, education is considered one of the fundamental pillars of social and economic development. In this context, it is particularly important to examine and analyze the different age groups and their specific challenges. In particular, adolescents and young adults, who are in a critical phase of growth and identity change, require greater attention and research. Due to their unique psychological and social characteristics, this age group faces numerous challenges that require serious study. The aim of the present study was to investigate the effects of gender and handedness (dominance/cross-dominance) on fine motor skill performance in adolescents. Fine motor skills refer to activities

that require precision and coordination between hand and eye movements and play an important role in daily life, education and sports. These skills include activities such as writing, drawing, using small tools and performing fine tasks with the hand (30).

The results of this study show that gender-specific differences have a significant influence on motor performance. In particular, girls performed better in the right hand movements and in the overall results (combined time for the right and left hand). These results are consistent with previous research indicating a superiority of girls in fine motor activities (31, 32). Biological (33) and social (34) differences may help to explain these results. Studies have shown that girls tend to engage in fine motor activities

at an earlier age, which may improve their skills (35). In addition, in many cultures, girls are encouraged to engage in artistic and craft activities, which further strengthens their fine motor skills. For example, girls generally excel in activities such as writing, drawing and working with small tools, which may be due to different social and educational experiences (36). Conversely, boys tend to be more inclined towards gross motor activities such as team sports, which can lead to the development of gross motor skills (36).

The theory of compulsion can also help to understand these results. This theory states that motor performance is influenced by three types of constraints: individual constraints, environmental constraints, and task-related constraints (25). In this study, individual constraints included gender and type of handedness, which can affect adolescents' motor skills. For example, girls tend to engage in fine motor activities at an earlier age, which can improve their social and academic experiences and ultimately their skills. Environmental conditions, such as access to educational facilities and motor activities, can also influence or hinder the development of motor skills. In addition, social, cultural and physical constraints can have a negative impact on young people's ability to develop motor skills. Task limitations are specific characteristics of motor tasks. For example, the type of motor activity and its demands can affect a person's performance. To

improve motor skills, it is important to develop activities that take these limitations into account. The differences between handedness and cross-dominance in motor performance highlight the importance of considering the type of handedness when designing educational and training programs. In this study, adolescents with cross-dominance performed better in fine motor skills than adolescents with constant handedness. These results provide interesting insights into handedness and contradict the handedness theory, which states that the left hemisphere of the brain is primarily responsible for controlling right hand movements, while the right hemisphere is responsible for left hand movements (37). Furthermore, these findings contradict previous research indicating the positive effects of consistent handedness on motor performance (15). For example, one study found that adolescents with consistent handedness performed better on fine motor tasks (38). This discrepancy could be due to individual, cultural and social differences that influence the development of motor skills. It also suggests that a more detailed understanding of the structure and mechanisms of the brain in the performance of motor skills, taking into account handedness and the nature of the skills, could clarify this issue.

This study also had its limitations. For example, the sample was limited to a specific geographical area and the conditions of the COVID-19 pandemic, which may have influenced the results. Therefore, it is suggested

that future studies be conducted with larger and more diverse samples to improve the generalizability of the results. Considering the differences in handedness found in this study, it is also recommended that future studies should comprehensively and thoroughly investigate the structural mechanisms of the brain and the factors that influence the functional differences between individuals with equal and cross-dominant handedness in fine motor skills. This study also had its limitations. For example, the sample was limited to a specific geographical area and the conditions of the COVID-19 pandemic, which may have influenced the results. Therefore, it is suggested that future studies be conducted with larger and more diverse samples to improve the generalizability of the results. Considering the differences in handedness found in this study, it is also recommended that future studies should comprehensively and thoroughly investigate the structural mechanisms of the brain and the factors that influence the functional differences between individuals with equal and cross-dominant handedness in fine motor skills.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Acknowledgment

All the volunteers and participants are greatly appreciated for their participation in the implementation of this research.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of Department of Physical Education, Faculty of Educational Sciences and Psychology Shiraz university (protocol code SPE/IR.US.PSYEDU.REC.14033.48.1834 and date 2024-07-17 of approval).

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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