DOI: 10.7860/JCDR/2023/59208.17430

Gender Difference in Hand-eye Coordination in Young Adults- A Cross-sectional Study

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ABSTRACT

Introduction: The ability of the visual system to coordinate the information acquired from the eyes to control and guide the hands in completing a task is known as hand-eye coordination. The typical hand-eye coordination involves the synergistic function of numerous sensorimotor systems, including the visual system, vestibular system and proprioception, as well as the head, eye and arm control systems.

Aim: To investigate which gender is superior and efficient in learning hand-eye coordination using the mirror drawing task.

Materials and Methods: A cross-sectional study was conducted at a tertiary care hospital, Mangalore, Karnataka, India, from April 2020 to April 2021 involving a total of 90 young adults divided into two groups of 45 males (group A) and 45 females (group B). A mirror drawing task was given to each student with four trials and two minutes rest in between the trials. Subjects were expected to trace a shape, most typically a polygon while only seeing the upturned reflection of their hand in a mirror and staying within the confines of a double boundary using a mirror drawing test. The number of errors, time taken to complete the task, and efficiency index of each student was calculated manually using the efficiency index formula and compared between the two groups.

Results: Total 90 participants were included with a mean age of 21.2 and 21.8 years for group A and group B, respectively. Group A (males) showed a greater efficiency index (5.52±2.29) when compared to group B (females) (4.61±1.77) (p-value-0.039). The Spearman's ratio of mean error and mean time was 0.575 in males and 0.483 in females.

Conclusion: The males outperformed in efficiency index when compared to females in hand-eye coordination with repeated practice. The study concluded that males were having greater efficiency index and less number of errors and less time taken compared to females.

Keywords: Efficiency index, Mirror drawing task, Mirror-tracing, Sex difference, Visuomotor coordination

INTRODUCTION

Hand-eye coordination is one of the human abilities that is required and can influence various parts of daily life, such as school, daily activities and social interactions [1]. Eye movements have a role in skilled motor activity that is distinct from the action itself but is intricately linked to it [2]. Hand-eye coordination is the visual system's ability to synchronise the information received from the eyes to control, guide and steer the hands in completing a task [3].

The typical hand-eye coordination involves the synergistic function of numerous sensorimotor systems, including the visual system, vestibular system and proprioception, as well as the head, eye, and arm control systems, in addition as some components of cognition, such as memory and attention [4]. All three systems are constrained by the fourth system, the schema system, which defines the prevailing tasks and projects the overall chain of events [5].

Fixing gaze at task-relevant points in an integrated pattern which allows the brain to appraise the geometric relationships between the exterior world and the interior world through vision and proprioception over lengths of time [6]. Various investigations have been conducted on the meaning of visual-motor synchronisation in human behaviour. Before initiating the hand movement they showed that their gaze was fixed on an aimed object implying that the eyes convey information about the distance to the arms [7]. The ability to coordinate is one of the component of physical fitness that is related to one's skills, both hand and eye coordination [8].

The beginning of performance in motor skill learning activities allegedly reflects on regulated procedures such as trial and error and adaptation of performance solutions, which progress with age [9]. Desired muscle contractions are transformed due to the visual information that falls on the retina which is unified with other sensory information related to gaze direction, hand location and head orientation [10].

Generally, males outperform females in spatial tasks, working memory, mathematical and numerical abilities, while females have more precedence in verbal fluency, perceptual speed, accuracy, and fine motor skills [11,12]. Previous research has shown that the female advantage is distinct when it comes to generating items in a sequence, but not when it comes to ordering sequential objects. Furthermore, females continue to achieve movement sequences in the action of pursuing complex and compound skilled movements than the males do [13].

Since 1910, skill learning studies uses the mirror drawing task. In this task, students are required to trace a shape commonly, a polygon, e.g., a star, diamond, square, or a triangle and stay inside the boundaries of a double borderline, mean while only looking at the upturned reflection of their hand through a mirror. Mirror learning gives the information about the construction of new affiliations between pivoted vision by 180° and arm movement [9].

Earlier research indicated that the average male achievements in spatial tasks is superior to females recognised by biological and cultural information as inspected [14,15]. Physical practices improved eye-hand coordination in both male and female participants, according to researchers [16]. Hand-eye coordination and spatiotemporal skills play a vital role in everyday performance and learning skills [3]. However, there is inadequate knowledge about the gender difference in learning hand-eye coordination and the efficiency, speed, accuracy in learning tasks regarding hand-eye coordination [12]. Hence, the current study was aimed to investigate which gender is better and efficient in learning hand-eye coordination using the mirror drawing task. The objectives of the study were to assess the correlation between mean error, mean time and efficiency index in hand-eye coordination.

MATERIALS AND METHODS

The cross-sectional study was conducted on college students of the Institute of Physiotherapy, situated in Mangalore, Karnataka, India, between April 2020 to April 2021. The study protocol was approved by the Institutional Ethical Committee (NIPT/IEC/Min/23/2019-20) of a deemed to be University, Mangalore, Karnataka, India. The study was registered in clinical trial registry, India with registration number CTRI/2020/06/025905. Eligible students were given information about the procedure, after which students were given an informed consent form to be signed.

Inclusion criteria: Participants aged between 19-26 years and who were willing to participate in the study with written informed consent were included from the study.

Exclusion criteria: Participants with any diagnosed neurological disorders, any congenital deformity of the hand, participants with established visual impairments, cognitive limitations that interfere with the test, recent fracture, or any trauma to the dominant hand were excluded from the study.

Sample size calculation: It was calculated based on a 5% level of significance, 80% power, effect size of 0.6 and the required samples in each group were 45 that is a total of 90. This was calculated using G* power software. A total of 100 students were screened out of which 90 students who met the inclusion criteria were recruited into the study. Following the completion of screening by convenient sampling, students were allocated into two groups, 45 in group A (males) and 45 in group B (females).

Study Procedure

The students were made to sit comfortably on an adjustable chair (swivel or revolving chair) in front of the occluder where the mirror drawing apparatus was placed on the table. The mirror of dimension 15×15 inches was placed at one edge of the table. A wooden board was kept behind the mirror to support the mirror to stand independently. An occluder made of cardboard, with a dimension of 20×15 inches was placed at the other edge of the table upon the task sheet. A slot was cut along the bottom of the cardboard, so that the participant could insert his/her hand to draw. The occluder was kept in such a way that the participant could see only the task sheet in the mirror. The distance between the mirror and the occluder was maintained at 10 inches.

The participants were instructed to trace the star between the two bordered lines from the point marked as a start and not to cross the borders of the star and try to complete the star within the time given. They were also instructed not to lift the pen from the tracing sheet until the student completed the star. Four trials were given and a time limit of three minutes 30 seconds was given to complete each trial. Efficiency of index was calculated after the student completes four trials. The procedure of performing the task is shown in [Table/Fig-1].

[Table/Fig-1]: Performing the mirror drawing task.

Outcome Measure

The mirror drawing task aimed to check the time and error components of each participant. After instructing the participant, the tracing sheet was placed between the mirror and the occluder. The participant was asked to place the tip of the pencil on the start point of the tracing sheet. Four trials were given each participant with a session break of two minutes in between the trials.

Time taken to complete each trial was noted using a stopwatch and the number of errors which included touching the borders of the star, lifting the pen during the task and crossing the borders was manually calculated. The individual with more of errors in the respective group was considered to be the maximum error of that group. The efficiency index is calculated using the formula 10 (maximum number of errors minus the number of errors of each person) divided by time spent to complete the task [17].

STATISTICAL ANALYSIS

Data analysis was performed by Statistical Package for Social Sciences (SPSS) version 26.0 for windows, where the Independent sample t-test was used to compare age and efficiency index according to gender. The Spearman's ratio was used to find the relationship between mean error, meantime and efficiency index. The Mann-Whitney U test was used to compare the mean error and mean time according to gender.

RESULTS

The mean and standard deviation for age, mean error, mean time and efficiency index is shown in [Table/Fig-2]. The Independent t-test was used to compare age according to gender (p-value >0.05) and hence the distribution of age was homogeneous according to gender. Efficiency index showed a statistically significant difference when compared on the basis of gender (p-value=0.039) [Table/Fig-3].

Variables	Mean	SD
Age (years)	21.50	2.17
Mean error (n)	22.30	17.11
Mean time (sec)	148.49	40.01
Efficiency index (%)	5.06	2.09

[Table/Fig-2]: Mean and Standard Deviation of age mean error, mean time, efficiency index.
n: number of subjects; SD: Standard deviation

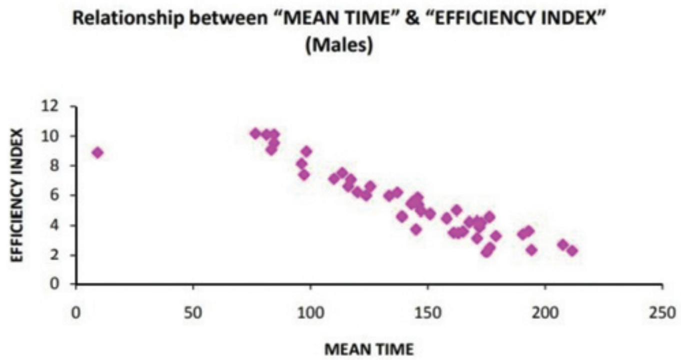
Variables	Groups	Mean	SD	t	p-value
Age (years)	Male	21.2	2.074	-1.318	0.191
	Female	21.8	2.242		
Efficiency index (%)	Male	5.52	2.29	2.099	0.039*
	Female	4.61	1.77		

[Table/Fig-3]: Comparison of age and efficiency index according to gender.
n: number of subjects; SD: Standard deviation; p-value >0.05 denotes no significant difference, p-value <0.05 denotes significant difference
The independent t-test was used to compare age according to gender
The independent sample t-test was used to compare the "efficiency index" according to gender

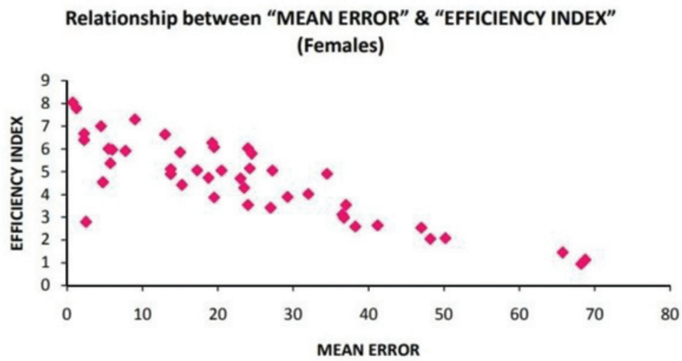
The Spearman's ratio was used to find the relationship between mean error, mean time and efficiency index. There was a positive correlation (p<0.05) between mean error and mean time among the males as well as females. The Spearman's ratios were negative for mean error and efficiency index; mean time and efficiency index. The same type of correlation was found between the mean error, mean time and efficiency index irrespective of gender as shown in [Table/Fig-4-6]. The Mann-Whitney U test was used to compare the mean error according to gender (p-value >0.05) and hence there was no difference in the mean error between males and females. The Mann-Whitney U test was used to compare the mean time according to gender (p-value >0.05) and hence there was no difference in the mean time between males and females as shown in [Table/Fig-7].

Variables	Males		Females		Irrespective of gender	
	Spearman's ratio	p-value	Spearman's ratio	p-value	Spearman's ratio	p-value
Mean error (n) and mean time (sec)	0.575	<0.001*	0.483	0.001*	0.523	<0.001*
Mean error (n) and efficiency index (%)	-0.752	<0.001*	-0.792	<0.001*	-0.757	<0.001*
Mean time (sec) and efficiency index (%)	-0.945	<0.001*	-0.82	<0.001*	-0.898	<0.001*

[Table/Fig-4]: Relationship between mean error, mean time and efficiency index.
n=number of subjects; p-value <0.05 denotes significant difference
The Spearman's ratio was used to find the relationship between "mean error", "mean time" and "efficiency index"



[Table/Fig-5]: Relationship between mean time and efficiency index (Males).



[Table/Fig-6]: Relationship between mean error and efficiency index (Females).

Variables	Groups	Median	IQR	"Z"	p-value
Mean error (n)	Male	17	9.88-30.75	-0.864	0.388
	Female	20.5	8.38-35.5		
Mean time (sec)	Male	145.7	114.75-171.5	0.388	0.244
	Female	150	128-183.25		

[Table/Fig-7]: Comparison of the mean error and mean time according to gender.
n: number of subjects; IQR: Inter quartile range; Z=Standard score, p-value >0.05 denotes no significant difference. The Mann-Whitney U test was used to compare the "mean error" and "mean time" according to gender

DISCUSSION

Hand-eye coordination is the regulated and synchronised movement of the hand and eye to perform a purpose. In other words, eye-hand coordination refers to the ability to complete a task. It involves everything from cooking our daily meals to moving heavy things, as well as other sports performances and games [18].

In the current study, 100 students were screened and 90 students were recruited after they met with the inclusion criteria after which we divided them into two groups according to the gender group A was male and group B was female with 45 students each in the groups.

In present study, we found out a positive correlation between mean error and mean time in both males and females, which suggests that as error increased for the task there was an increase in time [17], the result also showed that there was a negative correlation between mean error and mean time with efficiency index in both the genders which means as a mean error decreased there was an increase in efficiency index and as mean time decreased there was increased in efficiency index [17]. The mean error and time taken to complete the task were also in females compared to male young adults although there was no significant difference between them. Also, the study proved there was a statistically significant difference (p-value <0.05) found in the efficiency index between males and females, where it has reflected male population is more efficient in mirror drawing task than females. The cerebellum, a brain structure that helps regulate consciousness and the pons, a brain structure linked to the cerebellum that helps drive consciousness, are both larger in men than in women [11]. Since, the presence of anatomical difference also could be the reason for males to achieve more advantage in hand-eye coordination. Hence, it answers the research question and proves that there is a gender difference in hand-eye coordination in young adults.

Sex differences in visuomotor tracking were investigated by Mathew J et al., [18]. They looked at sex differences in a visual-occulo-manual motor task that involves tracking a moving target with the hand. They also looked into whether men and women had different hand kinematics and gaze strategies. They claim that men have a distinct advantage in hand tracking accuracy and hand kinematics. So, this adds to the evidence in present study that males had better hand-eye coordination [18].

A study on gender differences in motor coordination on a visual test was undertaken by Chraif M and Aniţei M. They used the Vienna testing system to administer two hand coordination tests. The findings revealed that young male students are statistically more precise in completing the task, but young female students can calibrate, fix errors and learn from them. Hence, this study also correlates with the present study [19].

The goal of Valtr L et al., study was to see if there were any gender differences in the performance of motor tasks using Movement Assessment Battery for Children-2 (MABC-2) test in adolescents aged 15-16 years. The results showed that the boys performed much better than the girls in the aiming and catching tests. In dynamic balancing tasks, there was no significant difference between the genders. As a result, this research backs up the present study findings [20].

The study done by Bressel E et al., to assess the speed and accuracy of acquiring a motor skill on land versus in chest-deep water concluded that with practicing, both groups' time and errors decreased dramatically; nevertheless, drawing time was longer in water than on land. Hence, this article supports the present study findings [21]. More right hemisphere activation was linked to improved spatial problem-solving in males with superior spatial aptitude, according to Ray WJ et al., [22]. Visual-spatial talents, such as aiming at stationary or moving targets, as well as throwing and intercepting projectiles, have always been dominated by men. Males have also excelled at mental rotation, numeric problem solving and tasks requiring the maintenance and manipulation of a visual image in working memory, all of which are underlying cognitive processes [22].

Adult brain volume sexual dimorphisms were more obvious in the cortex, with women having greater volumes to cerebrum size, particularly in the frontal and medial paralimbic cortices. Men had larger volumes in the frontomedial cortex, hypothalamus and amygdala in accordance with their cerebrum size. The cerebellum, a brain structure that helps regulate consciousness and the pons, a brain structure linked to the cerebellum that helps drive consciousness, are both larger in men than in women [11]. Since, there is anatomical difference could also be the reason for males to achieve more advantage in hand-eye coordination.

Hence, it can be concluded that the mirror drawing task improves hand-eye coordination through procedural memory. With repeated practice, the number of errors and time taken to complete the task will be reduced. Also, it clearly shows there is a greater male advantage in the efficiency of hand-eye coordination in young adults.

Limitation(s)

The study has not measured the long-term benefits of the test. Selection of small age range 19-26 years may not reveal the appropriate results.

CONCLUSION(S)

Hand-eye coordination is a complex procedure and any simplifying rule that might help us understand its neural underpinnings are potentially useful. The present study results demonstrate that the mirror drawing task improves hand-eye coordination. Moreover, it clearly shows a greater male advantage in the efficiency of hand-eye coordination compared to females. It is important to focus visually on a task to master it early and perform accurately therefore it is advisable to the participant especially females, to focus on the task in which they are engaged to accomplish it faster. There is a need for longitudinal studies on long time scale to establish if capacity of motor planning or anticipatory control determines the final level of acquisition of the skill.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 27, 2022
- Manual Googling: Nov 10, 2022
- iThenticate Software: Nov 16, 2022 (13%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jul 25, 2022**
Date of Peer Review: **Sep 10, 2022**
Date of Acceptance: **Nov 18, 2022**
Date of Publishing: **Jan 01, 2023**