



Research Paper

Bridging the Gap: Enhancing Motor Skills and Balance Through Eye-hand Coordination Training in University Students



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ABSTRACT

Background: Eye-hand coordination is the integration of the vision and motor systems to produce a coordinated movement. Poor eye-hand coordination will result in decreased motor performance, thereby influencing academic activities. The common issues in eye-hand coordination are motor skills and dynamic balance.

Objectives: The aim of this study was to analyze the effects of eye-hand coordination exercises on motor skill and dynamic balance among university students with poor eye-hand coordination.

Materials & Methods: A quasi-experimental design via purposive sampling method was used. The participants were divided into the experimental and control groups. The experimental group performed eye-hand coordination exercises twice weekly for four weeks. The control group was given an education sheet about eye-hand coordination. A pre- and post-test of motor skill and dynamic balance was conducted using the mirror tracing test and star excursion balance test (SEBT).

Results: The mean age of participants was 20.9 years. When comparing the post-test results of mirror tracing test and SEBT between experimental and control groups, there was a significant improvement in motor skill ($P=0.007$), while there was no significant improvement in dynamic balance ($P=0.066$).

Conclusion: In summary, eye-hand coordination exercises were found to be effective in enhancing motor skills among university students with poor eye-hand coordination. However, there was no significant improvement in dynamic balance as a result of the eye-hand coordination exercises.

Keywords: Eye-hand coordination exercises, Motor skills, Dynamic balance, University students

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Highlights

- Poor eye-hand coordination can negatively impact motor performance in young adults.
- Eye-hand coordination exercises improve motor skills in university students.
- Task-specific training improves balance outcomes.

Introduction

Eye-hand coordination is a neurocognitive ability to coordinate the movement of hands to carry out a task with the visual information that the eyes have perceived.

It involves the gaze system, motor system, and visual system [1]. The gaze system helps detect and locate objects, the motor system is responsible for executing limb movements, and the visual system provides information to the other two systems [1]. According to Shandiz et al., normal eye-hand coordination develops in a sequential order and simultaneously involves an intricate interaction of both visual and motor systems [2]. When eye-hand coordination is impaired, it can significantly compromise the ability to perform tasks efficiently and reduce productivity across various aspects of daily life. A study conducted in 2020 demonstrated that the presence of incoordination leads to poor coordination abilities and a decreased capacity to learn and automate movement patterns [3]. Furthermore, if it is not adequately addressed or is underdiagnosed, it can also impact the learning process and academic achievement among school and university students [4]. Without good eye-hand coordination, students may struggle to perform fine motor skill tasks [5], such as writing and solving math problems, which can ultimately result in decreased academic performance. In addition to motor issues, poor eye-hand coordination can affect dynamic balance, leading to decreased mobility and making it more difficult to maintain stability and coordination during activities such as jogging or climbing stairs.

Eye-hand coordination and motor skills are intricately related and interdependent elements of movement performance. A study in 2014 revealed that girls performed better in terms of fine motor skills, whereas boys exhibited better gross motor skills than girls [6]. Boys are typically more powerful than girls and tend to engage in energetic activities, commonly known as gross motor skills, while girls usually prefer symbolic and pacific games and show more interest in fine motor skills. Improved motor skills and general physical performance are influenced by good

eye-hand coordination [7]. According to a study in 2014, an evaluation of 230 students showed that 15% of pre-schoolers exhibited motor skill issues, of whom 5% had severe and 10% had moderate issues [6]. Therefore, structured training exercises that enhance eye-hand coordination can assist with motor impairments or developmental problems by enabling children to acquire and master their motor skills more quickly.

Apart from motor skills, dynamic balance is also one of the common issues in eye-hand coordination. According to Mohamed Shapie, in dynamic balance, body senses, such as sight and hearing, work together to maintain a stable position [8]. The integration of several sensory systems, including vision, proprioception, and the vestibular system, is vital for both eye-hand coordination and dynamic balance. For instance, during activities like jogging, running, or participating in sports, eye-hand coordination assists in guiding muscle movement with the aid of vision, while dynamic balance controls movement to compensate for gravitational forces, helping to maintain stability and prevent falls. Impairment in eye-hand coordination can negatively affect dynamic balance by inhibiting the integration of sensory information from the proprioceptive, vestibular, and visual systems. This deficit may result in difficulties tracking objects, inaccurate distance judgments, delayed responses to visual signals, and challenges in responding quickly.

There are studies on eye-hand coordination, and the majority of them mainly focus on children and elderly adults, with or without disabilities [9]. For instance, Jamrern et al. examined the eye-hand coordination of elderly females aged between 60 and 70 years old after participating in the PARA rubber ball training program [10]. However, there is a lack of studies investigating eye-hand coordination exercises among students in higher education. Additionally, although some studies have demonstrated that eye-hand coordination exercises have a positive effect, personalized eye-hand coordination exercises or training programs developed for university students are lacking. In other countries, there are specialized training programs focused on eye-hand coordina-

tion. A study in 2018 developed a 4-week exercise program on eye-hand coordination for university students in the Department of Physiotherapy of [P. P. Savani University](#) [1]. In this exercise program, participants needed to perform eye-hand coordination exercises, such as tapping a bouncing ball and tapping a table tennis ball with a table tennis paddle, for 8 sessions of training.

In Malaysia, there is a study on eye-hand coordination training using a new technology known as Kinect hand-eye coordination technology (KIHECT) [11]. This KIHECT device serves as a rehabilitation tool for increasing eye-hand coordination accuracy. Lee et al. in Hong Kong assessed the impact of eye-hand coordination, but the outcome measures were different [12]. Their study focused on sitting balance, reaction time, movement time, and accuracy in finger-pointing tasks. Besides, the study carried out by Çetin et al. tested dynamic balance and visual attention performance after eye-hand coordination exercises, but it focused on boxers [13]. In conclusion, there is a lack of supportive evidence regarding motor skills and dynamic balance among university students in Malaysia. Hence, this study aimed to analyze the effects of eye-hand coordination exercises on motor skills and dynamic balance among university students with poor eye-hand coordination.

Materials and Methods

This quasi-experimental study used a pre- and post-test design to assess the effect of eye-hand coordination exercises on motor skills and dynamic balance among university students at [Universiti Tunku Abdul Rahman \(UTAR\)](#), Selangor, Malaysia. The participants were assigned to two groups (experimental and control). The independent variable was eye-hand coordination exercises, while the dependent variables were motor skills and dynamic balance. The dependent variables were assessed using the mirror tracing test for motor skills and the star excursion balance test (SEBT) for dynamic balance at baseline and at the end of week 4.

This study was carried out at the Physiotherapy Centre of [Universiti Tunku Abdul Rahman](#) (Sungai Long). Data were collected from November to December 2023, following the acceptance of ethical approval from the ethical committee and permission to collect data. Purposive sampling was employed in this study, and participants were randomly assigned to two groups by drawing lots. The sample size was calculated using G*Power software, version 3.1.9.4, which generated a total sample size of 46. According to the study by Overall et al., by applying the formula $N = N0/(1-DRP)$, where N = number

of subjects, $N0$ =originally estimated sample size, and DRP =anticipated dropout rate [14], the total sample size needed, after adding an additional 10% for the dropout rate, was 52 participants.

Participants included in the study were male and female students aged 18 to 25 years from [UTAR \(Sungai Long\)](#) who demonstrated poor eye-hand coordination. Eligibility also required proficiency in reading and writing in English and voluntary participation. Exclusion criteria included participants with neck pain, fractures of the upper or lower limbs, ligament injuries, immobilization, neurological deficits, such as stroke, traumatic brain injury, brain tumors, or spinal cord injury. Additionally, participants with visual impairments, including refractive errors, cataracts, or glaucoma, or those with vestibular problems, were excluded.

During recruitment of participants, the alternate-hand wall-toss test was carried out to examine the eye-hand coordination level. The eye-hand coordination levels were classified based on the scoring of the alternate-hand wall-toss test [15]. Participants who had average, fair, or poor eye-hand coordination, with scores of 29 or below on the test, were included in the study. Next, the Dix-Hallpike maneuver was performed to exclude those who had a positive result on the test. Then, demographic data, a consent form, and a personal data protection form were given to participants. Those who fulfilled all the criteria were provided with a briefing on the study.

Next, the participants were divided into the experimental and control groups with 23 participants each. The participants were assigned to two groups randomly by drawing lots. Accordingly, 52 folded papers were prepared, with 26 of them labeled '1' and the other 26 labeled '2.' Participants randomly picked a folded paper; those who drew the number '1' were placed in the experimental group, which underwent eye-hand coordination exercises, while participants who drew the number '2' served as the control group.

Both outcome measures were selected based on their established reliability in assessing visuomotor coordination. Participants completed the mirror tracing test by tracing a star pattern viewed in a mirror, with the completion time recorded. For the SEBT, participants stood at the center of an asterisk-shaped grid and, while balancing on one leg, reached maximally in eight directions with the opposite leg; the farthest reach in each direction was measured. Standardized protocols were followed, with the primary investigator administering the tasks. Each participant was given one practice trial,

followed by three recorded trials per test, with 30–60 seconds of rest between attempts. The order of the tests was fixed (mirror tracing followed by SEBT), and all scores were documented by the same trained assessor to ensure consistency.

For the experimental group, a total of five eye-hand coordination exercises were developed based on four research studies, and participants completed these exercises twice a week for 4 weeks [1, 10, 16, 17]. A total of 8 sessions were conducted, each consisting of 50 minutes of exercise. The five eye-hand coordination exercises are listed below:

Tapping a ball with the ground

A bouncing tennis ball is tapped with the ground using one hand. After fifty taps have been completed, the exercise is repeated using the opposite hand. After each set of exercises is performed, participants rest for 1 minute. A total of 3 sets of exercises were completed.

Tapping a table tennis ball in the air with a table tennis bat

A table tennis ball is tapped in the air in a vertical direction from upper body level to eye level using a table tennis bat with one hand. After fifty taps have been completed, the exercise is repeated using the opposite hand to hold the bat. After each set of exercises is performed, participants rest for 1 minute. A total of 3 sets of exercises were completed.

Tossing a ball from hand to hand

A tennis ball is tossed from waist level to overhead level and caught with one hand for 30 seconds. After 30 seconds, the exercise is repeated using the opposite hand to toss and catch the ball. After each set of exercise is performed, participants rest for 1 minute. A total of 3 sets of exercises were completed.

Cup stacking

Participants were instructed to upstack and downstack paper cups in the given patterns for 1 minute. After completing the task, they rested for 1 minute. A total of 3 sets of exercises were completed.

Juggling exercise

Two tennis balls are used for juggling by throwing and catching with both hands for 2 minutes. After complet-

ing the task, participants rest for 1 minute. A total of 3 sets of exercises were completed.

For the control group (passive), an education sheet was provided that included basic knowledge of eye-hand coordination and its importance in daily life.

After 4 weeks of intervention, a post-test of the mirror tracing test and SEBT was repeated for both experimental and control groups to assess the motor skills and dynamic balance of the participants.

Results

A total of 55 responses were collected from the Google link registration form. Three of the respondents were removed from the data analysis process. Table 1 describes the characteristics of the subjects based on the demographic information obtained. The normality test conducted showed that the data were normally distributed.

Comparison of pre- and post-test results of the mirror tracing test

Table 2 describes the comparison of pre- and post-test results of the mirror tracing test among experimental and control groups using a paired sample t-test. The average post-test scores of the mirror tracing test were significantly lower than the pre-test scores in both experimental and control groups ($P < 0.05$).

Table 3 displays the comparison of pre- and post-test results of the SEBT among the experimental and control groups using a paired sample t-test. The average post-test scores of the SEBT were significantly higher than the pre-test scores in both experimental and control groups ($P < 0.05$). However, in the control group, there was no significant difference between the pre- and post-test results ($P > 0.05$).

Comparison of the post-test results between groups

Table 4 illustrates the comparison of post-test results of the mirror tracing test among the experimental and control groups using an independent sample t-test. Levene's test for equality of variances showed that there was a significant difference in motor skills between the experimental and control groups ($P < 0.05$). This means that the assumption of equal variances is violated; thus, the t-test result was determined without assuming equal variances. For the t-test for equality of means, the P was < 0.05 , concluding that there was a significant difference

Table 1. Demographic data of participants

Variables	No. (%)	Mean±SD	X ²	P
Age (y)		20.9±1.472	166.37	0.064
18	4(7.7)			
19	2(3.8)			
20	13(25)			
21	20(38.5)			
22	5(9.6)			
23	6(11.5)			
24	1(1.9)			
25	1(1.9)			
Gender		-	29.96	0.071
Male	20(38.5)			
Female	32(61.5)			
Program		-	19.4	0.496
Foundation level	5(9.6)			
Undergraduate level	47(90.4)			
Courses		-	19.4	0.496
Foundation	5(9.6)			
Health sciences	47(90.4)			
Year of study		2.46±0.803	52.11	0.756
1	5(9.6)			
2	23(44.2)			
3	19(36.5)			
4	5(9.6)			

Abbreviations: N: Number of participants; SD: Standard deviation; X²: Chi-square value.

Table 2. Comparison of the pre- and post-test results of the mirror tracing test among experimental and control groups

Group	Mean±SD		P
	Mirror Tracing Test		
	Pre-test	Post-test	
Experimental	3.2±1.98	1.63±0.586	0.000
Control	3.31±1.78	2.54±1.492	0.001



Table 3. Comparison of the pre- and post-test results of dynamic balance (SEBT) among the experimental and control groups

Group	Mean±SD		P
	SEBT		
	Pre-test	Post-test	
Experimental	92.04±14.087	103.35±8.804	0.000
Control	96.54±10.578	98.32±10.447	0.163



in the intervention's effect on motor skills in terms of the post-test results of the mirror tracing test.

Table 5 shows the comparison of post-test results of the SEBT among the experimental and control groups using an independent sample t-test. Levene's test for equality of variances indicates that there was no significant difference in dynamic balance between both the experimental and control groups, as the P was >0.05. This means that equal variances were assumed; therefore, the t-test result was determined by focusing on the "equal variances assumed" row. For the t-test for equality of means, the P was >0.05, concluding that there was no significant difference in the intervention's effect on dynamic balance in terms of the post-test results of the SEBT.

Discussion

This present study aimed to determine the effectiveness of the eye-hand coordination exercises on motor skills and dynamic balance among university students with poor eye-hand coordination. Eye-hand coordination is interrelated with motor skills and dynamic balance [18] [8]. Szabo et al. showed that eye-hand coordination exercises have a positive impact on various factors, including coordination level, motor development, and balancing skills [19]. Nevertheless, there is a lack of research studies and literature on how eye-hand coordination exercises influence motor skills and dynamic balance.

The demographic data analysis indicated that the average age of participants was 20.9 years, with females making up 61.5% of the sample and males comprising 38.5%. Statistical analysis showed that the chi-square values for age and gender were 166.37 and 29.96, respectively, with P of 0.064 and 0.071. These results suggest no significant relationship between demographic factors and the alternate-hand wall-toss test scores, which measure eye-hand coordination levels. However, contrasting findings have been reported in other studies. Van Halewyck et al. explored eye-hand coordination in relation to age and physical activity, finding that both factors significantly influenced coordination during discrete manual aiming tasks [20]. While coordination improved with age, older adults performed movements more slowly and less forcefully. Similarly, Szabo et al. examined age-related differences in coordination and proprioceptive motor control among 110 participants [19]. Their findings showed that males exhibited significantly better eye-hand coordination than females. These variations may arise from differences in sample sizes and population diversity, as larger, more heterogeneous groups might yield different outcomes than smaller samples.

The study findings demonstrated that eye-hand coordination exercises effectively enhanced motor skills. The experimental group exhibited a notable improvement in motor skills (49.06%), as measured by the mirror tracing test, which was significantly higher than the improvement observed in the control group (23.26%).

Table 4. Post-test comparison of mirror tracing among the experimental and control groups using independent sample t-test

Motor Skill	Levene's Test for Equality of Variances		T-test for Equality of Means	
	Homogeneity of Variance	P	P (2-tailed)	Mean Difference
Post-test of the mirror tracing test	Equal variances assumed	0.000	0.006	-0.908
	Equal variances not assumed		0.007	-0.908



Table 5. Post-test comparison of dynamic balance (SEBT) among the experimental and control groups using an independent sample t-test

Dynamic Balance	Levene's Test for Equality of Variances		T-test for Equality of Means	
	Homogeneity of Variance	P	P (2-tailed)	Mean Difference
Post-test of the SEBT	Equal variances assumed	0.433	0.066	5.035
	Equal variances not assumed		0.066	5.035



These results suggest that practicing eye-hand coordination exercises can positively impact motor skill development. These findings align with the study by Paul et al. [21], who showed that eye-hand coordination training and sports vision exercises significantly improved motor and sensory performance in university-level table tennis players. Participants with superior coordination skills performed better in complex motor tasks, responded effectively to external stimuli, and executed controlled movements. Similarly, Gosewade et al. found significant improvements in fine motor skills among participants engaging in Pranayama and eye exercises [22]. Patel and Bansal emphasized that mastering eye-hand coordination fosters further motor skill development [1], while Sutapa et al. highlighted the role of regular coordination exercises in enhancing neural connections, sensory processing, and motor abilities [23]. The most common factor for improvement may be that these exercises are specifically designed to enhance the synchronization between visual input and motor output. Repeated engagement in eye-hand coordination exercises promotes neuroplasticity [24], which is the brain's ability to adapt and form new neural connections. This process enhances sensory-motor integration, enabling participants to process visual information more effectively and translate it into precise motor actions. The exercises likely improved participants' visual-spatial skills, which are critical for navigating the reversed visual feedback in the mirror tracing test. Regular practice of coordinated movements during the intervention likely facilitated the development of muscle memory [25].

In contrast, dynamic balance showed limited improvement in this study. While the experimental group exhibited a 12.29% increase in dynamic balance scores compared to 1.84% in the control group, statistical analysis indicated no significant difference between the groups. This suggests that the short intervention period may not have been sufficient to produce substantial effects on dynamic balance. This finding is consistent with the research by Çetin et al., who reported that brain exercises focusing on eye-hand coordination did not significantly

improve dynamic balance among boxers [13]. However, Shapie and Rohizam found significant improvements in dynamic balance following a six-week speed, agility, and quickness training program, emphasizing the importance of longer intervention periods [8]. The shorter duration of four weeks in the current study may explain the limited impact observed on dynamic balance. Other factors include the possibility that if participants already had a relatively good level of dynamic balance, the room for measurable improvement might have been limited. Ceiling effects could reduce the observable impact of the exercises on balance. Additionally, variability in participants' baseline physical fitness, balance abilities, or motivation levels could have influenced the effectiveness of the intervention. Dynamic balance is influenced by multiple factors, including core strength, lower limb strength, and neuromuscular coordination, which may not have been directly targeted during the intervention. Improvements in dynamic balance often require a neuromuscular adaptation phase, during which the body learns to incorporate sensory inputs effectively. A longer training period might have been necessary to observe significant adaptations.

This study faced some limitations. The small sample size (52 participants) limits the generalizability of the findings. Moreover, participants were limited to foundation and health sciences students. Participant adherence was inconsistent due to class schedules and exams, which may have affected the reliability of the results. The short intervention period of four weeks likely limited the ability to observe long-term effects, particularly on dynamic balance. Additionally, the use of a non-standardized mirror tracing test may have impacted the validity and reliability of motor skill assessments. Future studies should address these limitations by recruiting larger, more diverse samples to improve generalizability. Extending the intervention period to six weeks or more could help capture long-term effects, particularly on dynamic balance. Implementing standardized testing methods will ensure reliable and valid measurements, enhancing the robustness and comprehensiveness of future research.

Conclusion

The current study provides compelling evidence that eye-hand coordination exercises are effective, demonstrating a significant positive impact on motor skills among young adult students with poor eye-hand coordination. These targeted exercises or training regimens enhance skill acquisition and refine performance in tasks requiring coordinated movements. However, the study found no significant improvement in dynamic balance through eye-hand coordination exercises. These findings contribute valuable evidence-based insights, emphasizing the benefits of targeted interventions in both academic and practical settings.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Scientific and Ethical Review Committee (SERC) at [University Tunku Abdul Rahman \(UTAR\)](#), Petaling Jaya, Malaysia (Code: U/SERC/248/2023). Informed consent was obtained from all participants upon recruitment. The purpose and procedures of the study were clearly explained to the participants upon receiving the consent form. All participants were notified that their information and responses would always be kept confidential, and their participation was completely voluntary. The participants retained the right to withdraw from the study at any time.

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Authors contributions

Conceptualization: Kiruthika Selvakumar; Methodology: All authors; Investigation, software, validation, formal analysis, project administration, and writing the original draft: Eunice Tay Wan Xin; Supervision, review, and editing: Kiruthika Selvakumar and Deepak Thazhakkattu Vasu.

Conflict of interest

The authors declared no conflict of interest.

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