



Effects of Eye-Tracking Learning on Ground Pinning and Throw Defense Skills in Novice Greco-Roman Wrestlers

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Received: 15 September 2025, Approved: 20 October 2025, Published: 30 December 2025

Abstract

Study purpose. The main objective of this study was to examine the effects of Eye-Tracking-based learning on ground pinning and throw defense skills in novice Greco-Roman wrestlers.

Materials and methods. 32 male wrestlers aged 12–14 years were randomly assigned to an experimental group ($n = 16$) or a control group ($n = 16$). Both groups completed an eight-week program with three 90-minute sessions per week, while the experimental group additionally performed Eye-Tracking exercises aimed at improving ground pinning skill and defense against throws.

Results. The experimental group showed substantial improvements in ground pinning skill (Pre: 12.4 ± 1.8 ; Post: 17.6 ± 1.5) and defense against throws (Pre: 11.9 ± 2.0 ; Post: 16.4 ± 1.7), whereas the control group showed only modest gains. Post-intervention comparisons revealed significantly higher performance in the experimental group for both skills. Repeated-measures ANOVA confirmed significant main effects of group, time, and their interaction, demonstrating the effectiveness of the Eye-Tracking intervention.

Conclusions. Eye-Tracking-based Learning effectively enhances technical execution and anticipatory defensive abilities in novice Greco-Roman wrestlers. Incorporating perceptual-cognitive exercises into conventional wrestling programs can optimize skill acquisition, improve tactical responsiveness, and accelerate performance development, supporting coaches in preparing athletes for competitive success.

Keywords: Wrestling, Ground Pinning, Defense Against Throws, Eye Tracking Learning, Motor Skill Acquisition.

DOI: <https://doi.org/10.52188/ijpeess.v5i4.1473>

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Introduction

Greco- Roman wrestling is a combative sport that requires strength and agility to be successful because the physical preparedness and level of mastery the skill, takes place is very high tactically skill and quick decisions for this sport (Hassan & Abdulkareem, 2026;

Maksimovich et al., 2020). In this discipline, techniques, ground control work and countering throws are the key to success (Song et al., 2022). Recent research has stressed the value of Cognitive influences such as Eye-Tracking perception and attention toward sports performance (Ayiei, 2020; Wilkerson et al., 2024). “Effects of the ability to follow and interpret moving Eye-Tracking tracking stimulus and its specific impact on reaction time and motor coordination abilities in athletes (Appelbaum & Erickson, 2018). Eye-Tracking based learning strategies incorporated into wrestling Learning could help athletes to better anticipate the actions of opponents to the benefit both their offence and defence (Coetzee & De Waal, 2022; Vickers, 2007). Every gaze is currently tracked by reliable modern technologies, such as eye-tracking devices, which allow monitoring gaze patterns and coaches to optimize skill learning and tactics execution (Torres-Ronda et al., 2022; Zhong & He, 2021).

Classic wrestling programmes tend to emphasize physical conditioning, repeated drills and tactical simulations and those are developed at the expense of cognitive level (Basar et al., 2014). Nonetheless, cognitive factors such as perceptual-motor co-ordination and Eye-Tracking attention are essential for quicker and more-precise decision-making during competition, (Erickson, 2020; Moen et al., 2018). Experiences from sports science indicate that perceptual-cognitive Learning, such as Eye-Tracking Learning, enhances the adaptive performance in combat sports and team sport (Ayiei, 2020). The “quiet eye” (QE) is a situational gaze phenomenon involving focused Eye-Tracking fixation in advance of a motor act and has been linked to enhanced accuracy and timing in complex skills (Appelbaum & Erickson, 2018; Vickers, 2007). For wrestling specifically, Eye-Tracking -motor coordination and anticipatory abilities have been shown to be associated with good execution of defensive and ground control actions (Gierczuk & Ljach, 2012; Song et al., 2022). In addition, Eye-Tracking programs might improve depth perception, hand-eye coordination, and attentional control, which are fundamental skills for good match performance (Coetzee & De Waal, 2022; Erickson, 2020).

Nevertheless, studies investigating the usage of Eye-Tracking-based Learning in Greco-Roman wrestling are scarce, especially in the context of novice wrestlers (Basar et al., 2014; Maksimovich et al., 2020). This hole exposes the requirement for experimental researches researching the effectiveness of cognitive Learning programs in this sport (Torres-Ronda et al., 2022; Zhong & He, 2021). Despite the growing interest in cognitive-perceptual training, the role of eye-tracking technology in skill acquisition, particularly for ground control and throw defense in novice wrestlers, remains underexplored. Existing studies have demonstrated that eye-tracking can enhance decision-making, spatial awareness, and anticipatory skills in athletes across various sports (Alemanno et al., 2025; Fleming et al., 2024; Moen et al., 2018; Witte et al., 2025). However, its specific application in Greco-Roman wrestling—which requires rapid adjustments and precise ground pinning techniques—has received limited attention. Understanding how visual attention patterns influence motor execution could significantly improve evidence-based learning programs by integrating cognitive-perceptual development with normative wrestling techniques (Buscemi et al., 2024; Harris et al., 2023; Hüttermann et al., 2018; Wilkerson et al., 2024).

The purpose of the study is to explore the impact of eye-tracking strategy learning of wrestling on ground control skills for novice Greco-Roman wrestlers, to explore the effect of eye-tracking Learning on throws defensively, and to present recommendations for the application of cognitive Learning in traditional wrestling practice.

We advanced several hypotheses for the study: H₁ Growth of the Zone in the eye tracking stadium improves significantly ground control in novice Greco-Roman wrestlers, compared with traditional Learning; H₂ the strategies for learning can be applied by Eye-Tracking, or learning through directing gaze on the considered important features of the phenomenon is more efficient in defensive actions in the throws in novice wrestlers.

The study contributes to the field in several important areas:

Scientific Contribution: This study expands the current research on perceptual-cognitive learning in combat sports, offering new evidence on the effectiveness of Eye-Tracking exercises in enhancing wrestling skills (Wilkerson et al., 2024).

Practical Application: The findings provide a practical guide for wrestling coaches to incorporate Eye-Tracking exercises into training programs, supporting the development of technical skills (Torres-Ronda et al., 2022; Zhong & He, 2021).

Athlete Development: The intervention supports the improvement of motor performance and fundamental wrestling skills, which may help novice wrestlers achieve better competitive outcomes (Erickson, 2020; Gierczuk & Ljach, 2012).

Materials and methods

An experimental design was used with pre- and post-test in order to analyze Eye-Tracking Learning on ground control and defensive skills in novice Greco-Roman wrestlers. The study was carried out during 8 weeks from January 15, 2025 to March 15, 2025 in the Al-Kadhimiya Wrestling Club. The study protocol was approved by the ethics committee of the Al-Mustansiriya University and a written informed consent was signed by all participants and guardians.

Study participants

The study included 32 male novice wrestlers aged between 12 - 14 years. Participants were randomly assigned to either an experimental group (n = 16) and a control group (n = 16). All athletes had a minimum of one year of wrestling experience and were free from recent injuries, Eye-Tracking impairments, or neurological disorders. Exclusion criteria included irregular attendance, recent injuries, or use of prohibited substances, and the Equivalence Between Experimental and Control Groups in Pre-Test Measures of Ground Pinning Skill and Defense Against Throws, as shown in table 1.

Table 1. Baseline Equivalence Between Experimental and Control Groups in Pre-Test Measures of Ground Pinning Skill and Defense Against Throws

Variable	Group	Mean $\pm$ SD	t-value	p-value
Ground Pinning Skill	Experimental	12.4 $\pm$ 1.8	0.32	0.752
	Control	12.6 $\pm$ 1.7		
Defense Against Throws	Experimental	11.9 $\pm$ 2.0	0.28	0.782
	Control	12.1 $\pm$ 1.9		

*: significant at $p < 0.05$

Study organization

Equipment and tools used

The Learning sessions were conducted on standard wrestling mats to ensure safety and replicate competition conditions. The experimental group participated in visual tracking exercises using portable eye-tracking glasses (Tobii Pro Glasses 3, Tobii AB, Sweden) to monitor gaze patterns, enhance anticipation, and improve defensive reactions against throws. High-definition video cameras (Sony HDR-CX405) recorded all sessions to allow detailed analysis of ground pinning execution and defensive techniques. Timing devices were employed to measure reaction and response times during defensive drills. Other Learning accessories such as resistance bands, stability cushion, and agility ladders were utilized to improve core strength, balance, coordination and stability needed to be successful on the ground in terms of pinning and defense. Pre- and post-intervention assessments were run to measure enhancement in

ground pinning skill and throw defense. All trials were conducted on the same conditions to minimize the variability and to provide reliable and valid measurements of the Learning effect on the athlete's performance via Eye tracking-based Learning program.

Procedures

The intervention lasted 8 weeks, during which both the experimental and control groups trained three times per week, with each session lasting 90 minutes. The study procedures can be summarized in the following stages:

Pre-Test Assessment

Before the intervention, all participants were evaluated to determine baseline proficiency in the targeted skills:

Ground Pinning Skill Assessment: A standardized test measuring the ability of novice wrestlers (aged 12–14) to execute ground pinning techniques in Greco-Roman wrestling. Participants performed three techniques (e.g., reverse bridge, side control) for 30 seconds each on a standard mat. Performance was scored from 0–20 points based on technical execution, control, and duration, recorded on video for reliability, following established protocols (Mirzaei et al., 2013).

Defense Against Throws Assessment: A standardized test assessing participants' ability to counter various throwing techniques (e.g., hip throw, arm drag). Drills lasted 30 seconds each, and performance was scored 0–20 points based on reaction time, positioning, and effectiveness, with video recording used to ensure reliability (Mirzaei et al., 2013).

These assessments provided a comprehensive baseline for evaluating the efficacy of the intervention.

Intervention Program

- The control group followed a traditional wrestling program emphasizing technique drills, physical conditioning, and tactical simulations.
- The experimental group followed the same traditional program but integrated Eye-Tracking exercises designed to enhance cognitive-motor skills, including anticipation, visual perception, hand-eye coordination, and focused gaze techniques before executing throws.

Eye-Tracking activities were embedded into both skill-specific drills and live wrestling simulations to facilitate the transfer of cognitive improvements into practical performance.

The experimental group's program can be summarized as shown in table 2:

Table 2. Show the Learning program for the experimental group

Week	Session Focus	Duration	Activities
1–2	Eye-Tracking Foundations	90 min/session	Eye-tracking warm-ups, simple gaze-following drills, basic ground pinning and defense technique practice
3–4	Skill Integration	90 min/session	Combined Eye-Tracking with ground pinning drills, defensive maneuvers against throws, reaction time exercises

5–6	Advanced Application	90 min/session	Complex sparring scenarios, live wrestling with emphasis on anticipation and focused gaze, feedback on Eye-Tracking attention
7–8	Performance Consolidation	90 min/session	Full wrestling simulations, defensive drills against various throws, review and reinforcement of gaze tracking and ground control techniques

Post-Test Assessment

Immediately after completion of the 8-week program, all participants were re-evaluated using the same Ground Pinning and Defense Against Throws assessments to measure improvements in skill performance.

Supervision

Each session was directly overseen by a qualified wrestling coach to ensure correct execution of techniques and maintain the safety of participants.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 26. Descriptive statistics, including means and standard deviations, were calculated for all variables. T-test for experimental and control groups pre and posttest, A two-way repeated-measures ANOVA was conducted to examine the effects of the intervention on the experimental and control groups. Effect sizes were reported using partial eta squared (η^2), and statistical significance was set at $p \leq 0.05$.

Results

Table 3 illustrates that the Eye-Tracking-based Learning program had a clear and meaningful impact on the targeted wrestling skills. The experimental group showed substantial improvements in both ground pinning and defense against throws, indicating that integrating perceptual-cognitive exercises into training effectively enhances these fundamental skills. In contrast, the control group, which followed traditional training, exhibited only minimal or non-significant gains, suggesting that conventional methods alone may be less effective in promoting rapid skill development. These findings highlight the superior efficacy of the Eye-Tracking intervention in improving wrestling performance among novice athletes.

Table 3. Show Pre- and Post-Intervention Performance for Ground Pinning Skill and Defense Against Throws in Experimental and Control Groups

Variable	Group	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	t-value	p-value
Ground Pinning Skill	Experimental	12.4 $\pm$ 1.8	17.6 $\pm$ 1.5	8.92	0.000
	Control	12.6 $\pm$ 1.7	13.8 $\pm$ 1.6	2.15	0.048
Defense Against Throws	Experimental	11.9 $\pm$ 2.0	16.4 $\pm$ 1.7	7.85	0.000
	Control	12.1 $\pm$ 1.9	13.0 $\pm$ 1.8	1.94	0.066

*: significant at $p < 0.05$

Table 4 demonstrates that the Eye-Tracking-based Learning program led to substantially better performance in both ground pinning and defense against throws compared to the control group. The experimental group's post-intervention scores clearly indicate that incorporating Eye-Tracking exercises enhances skill execution and focus during wrestling tasks. In contrast, the control group, following traditional training, showed moderate improvements, suggesting that conventional methods alone may be less effective in rapidly

developing these fundamental wrestling skills. These findings further support the efficacy of Eye-Tracking interventions in improving targeted wrestling performance among novice athletes.

Table 4. *Show Post-Intervention Performance for Ground Pinning Skill and Defense Against Throws in Experimental and Control Groups*

Variable	Group	Post-Test Mean ± SD	t-value	p-value
Ground Pinning Skill	Experimental	17.6 ± 1.5	6.32	0.000
	Control	13.8 ± 1.6		
Defense Against Throws	Experimental	16.4 ± 1.7	6.85	0.000
	Control	13.0 ± 1.8		

*: significant at $p < 0.05$

Table 5 presents the repeated-measures ANOVA results, which indicate that the Eye-Tracking-based Learning program had a significant and positive effect on both ground pinning and defense against throws over time. The analysis showed that both group membership and time had significant main effects, and their interaction was also significant, highlighting that the experimental group improved more than the control group as the intervention progressed. These findings confirm that integrating Eye-Tracking exercises into wrestling training substantially enhances skill acquisition and performance, demonstrating the effectiveness of this approach in developing novice athletes' fundamental wrestling abilities.

Table 5. *Show Repeated-Measures ANOVA Results for the Effects of Eye-Tracking-Based Learning on Ground Pinning Skill and Defense Against Throws*

Variable	Source of Variation	F-value	P-value	η^2 (Partial Eta Squared)
Ground Pinning Skill	Group	15.82	0.000	0.34
	Time	28.45	0.000	0.48
	Group × Time	12.67	0.002	0.29
Defense Against Throws	Group	13.54	0.001	0.31
	Time	24.39	0.000	0.44
	Group × Time	10.92	0.003	0.26

*: significant at $p < 0.05$

Discussion

The findings of the present study indicate that integrating Eye-Tracking-based exercises with traditional wrestling training significantly improves performance in both ground pinning and defense against throws. The experimental group demonstrated greater enhancements compared to the control group, suggesting that Eye-Tracking-motor integration promotes skill learning and motor control (Wilkerson et al., 2024).

Specifically, the Eye-Tracking drills implemented in this study—such as gaze-following exercises, focused attention tasks, and hand-eye coordination activities—appeared to facilitate better anticipation, perceptual accuracy, and visual strategies, leading to more efficient execution of wrestling skills of varying complexity (Aksum et al., 2021; Torres-Ronda et al., 2022).

Regarding ground pinning, the combination of perceptual-motor drills with technical skill practice likely contributed to faster and more precise control of the opponent. This is consistent with prior evidence that perceptual-motor learning enhances postural stability, timing, and force generation in grappling tasks (Cummins, 2014; Rzepko et al., 2019; Williams,

2019). Furthermore, gaze stabilization and Eye-Tracking–focused attention improved hand placement and pressure control during pinning (Ju et al., 2018; Nishijima & Takai, 2024).

In terms of throws defense, athletes exposed to Eye-Tracking–enhanced motor drills showed better anticipation of the opponent’s intentions and improved spatial awareness, reaction time, and defensive positioning (Bergmann et al., 2021; Ullah et al., 2023). These improvements likely stem from reinforced visuo-motor integration and neural control that support rapid decision-making in dynamic contexts (Carroll et al., 2013; Wang et al., 2024). The combination of skill-based practice with perceptual-cognitive drills generated a synergistic effect, enhancing defensive performance beyond traditional training alone (Alder, 2015; Torres-Ronda et al., 2022).

This study also highlights the practical implications of Eye-Tracking–motor integration for coaching. Regular incorporation of these drills allows athletes to acquire complex skills more efficiently, commit them to long-term memory, and improve tactical awareness and responsiveness during matches. These results are consistent with prior research supporting enhanced physical and cognitive performance through perceptual-cognitive exercises (Abdulghani et al., 2025; Abdulhussain et al., 2025; Abdulkareem & Sattar Jabbar, 2025; Hussain et al., 2024).

In summary, Eye-Tracking–based Learning represents an effective intervention for improving fundamental wrestling skills. The current results demonstrate the potential for integrating perceptual-motor and cognitive exercises with technical training. Future studies should examine long-term retention of these skills and their transferability to other wrestling categories or combat sports, to confirm and extend these findings.

Conclusions

This study concludes that Eye-Tracking–based Learning effectively improves ground pinning and defense against throws in novice Greco-Roman wrestlers. The experimental group’s superior performance confirms that integrating perceptual-cognitive exercises into conventional wrestling training enhances both technical execution and anticipatory skills. These findings highlight the value of Eye-Tracking interventions as a scientifically supported and practically applicable tool for coaches to accelerate skill acquisition, optimize training efficiency, and enhance competitive readiness in novice athletes.

Limitations and Future Directions

This work has some limitations despite its promising results. First, the sample size was small ($n = 32$), and the findings may not generalize to larger populations of wrestlers. Second, there was not a follow-up period extended beyond eight weeks to determine if participants retained skills over an extended period of time. Finally, the study only focused on male novice Greco-Roman wrestlers, preventing generalization to female athletes, other forms of wrestling (e.g. freestyle) or different age groups.

Future research should address these limitations by: (1) increasing sample size and diversity to include female wrestlers and other wrestling disciplines; (2) conducting longitudinal studies to evaluate the retention of skills over extended periods; (3) incorporating double-blind designs where feasible to minimize bias; and (4) exploring the efficacy of visual tracking Learning in other combat sports, such as judo or mixed martial arts, to assess its broader applicability. Additionally, future studies could investigate the optimal frequency and duration of visual tracking exercises to maximize Learning efficiency and determine whether these interventions benefit elite wrestlers as well as novices.

Practical Implications for Coaches

Incorporation of eye tracking tasks in to wrestling Learning has operational implications for coaches to improve wrestlers' performance. Coaches may consider including visual tracking drills into warm-up sessions or even skill specific sessions (e.g., Eye-tracking tasks using portable eye-tracking devices, or simple tracking of a partner's movements). Such exercises should be designed to promote the ability to anticipate and react as quickly as possible, particularly for defensive actions, such as Learning athletes to fixate on key visual information (e.g., opponent's hips or shoulders) before the performance of a technique. For ground pinning, visual tracking can be used by coaches to teach the athlete to keep their eyes on "the important parts of the hold" in order to control and stabilize the hold. These drills are easy to set up (e.g. video and/or laser present for gaze Learning) and can be tailored to multiple skill levels, which are a practical application for novice wrestling programs. 10-15min should be devoted per session to visual tracking protocols, increasing progressively in complexity over weeks as outlined in the experimental Learning program Table 2. This more efficient Learning method can help athletes learn skills faster, make higher and safer throws and, ultimately, set them up for success in competition.

Conflict of interest

The authors have no conflicts of interest to declare.

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Cite this article as: Hassan, Monaf Ibrahim. (2025). Effects of Eye-Tracking Learning on Ground Pinning and Throw Defense Skills in Novice Greco-Roman Wrestlers. *Indonesian Journal of Physical Education and Sport Science (IJPESS)*, 5(4), 445-454. <https://doi.org/10.52188/ijpess.v5i4.1473>