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Effect of SAMGHA tripod on eye and hand reaction time and accuracy in tennis

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ABSTRACT
Purpose. This study investigated the impact of the SAMGHA tripod on reaction time and hitting accuracy in intermediate tennis players (USTA NTRP 3.0–4.0).
Methods. Thirty participants were randomly assigned to an experimental group (n = 15) using the tripod or a control group (n = 15) with standard training. Pre- and post-tests measured simple and choice reaction times and sweet spot hitting accuracy.
Results. Results showed that the experimental group significantly improved: simple reaction time decreased from 0.527 to 0.263 s, and choice reaction time from 0.455 to 0.362 s, and hitting accuracy rose from 45.47% to 81.60% for forehand and 44.87% to 81.53% for backhand (I < 0.001).
Conclusions. It can be mentioned that the experimental group showed greater improvement in reaction time and hitting accuracy compared to the control group, which demonstrated no significant changes. Therefore, the results suggest that the SAMGHA tripod may have potential in supporting perception and motion relevant to tennis performance.
Key words: reaction time, augmented training, tennis performance

Introduction

Tennis is a highly dynamic sport, requiring players to develop and maintain a variety of technical skills, such as forehand and backhand strokes, volleys, and serves [1]. These skills are essential for competitive success and must be continuously refined [2]. One of the most critical factors in tennis performance is reaction time – the player's ability to process external stimuli and respond with the appropriate motor action [3] – where the high speed of play demands reactions within fractions of a second [4].

In the context of motor control and movement mechanisms, reaction time is typically divided into two types: simple reaction time, involving a single stimulus and response, and choice reaction time, which requires responding to multiple stimuli with different actions [3, 5]. Improved reaction time has been strongly associated with enhanced performance in fast-paced sports, including tennis [6].

Traditional tennis training primarily focuses on physical conditioning, technical execution, and tactical strategies, often overlooking cognitive elements such as perceptual speed and neuromotor coordination [7]. However, recent developments in sports technology have introduced augmented training tools that target specific performance components. These tools, such as strobe glasses, motion sensors, and cognitive training systems, aim to improve reaction speed, coordination, and accuracy [8].

Among these innovations is the SAMGHA tripod, a specialised training tool designed to simulate the balance and weight of a tennis racquet. This device was developed by Austtasit Chainarong, who pioneered its design as part of a sports innovation initiative. It is manufactured by SAMGHA Sports Innovation, based in Chonburi, Thailand. The tripod facilitates repetitive drills that enhance eye–hand coordination, muscle memory, and fine motor control. It offers structured movement training that mimics the dynamic condi-

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tions of real tennis matches, helping reinforce neuromotor responses and improve stroke consistency.

Notably, Papale et al. [9] examined specific eye–hand exercises aimed at improving fine motor skills and reducing hand tremors. Their results show that targeted neuromotor drills can minimise tremors and enhance overall hand control, which is directly relevant to the results of this study. Thus, it further underscores that precise eye–hand interventions, like a tripod-based program, not only address fine motor coordination but may also improve stroke execution in tennis. This study was designed to investigate the effect of the SAMGHA tripod on reaction time and hitting accuracy among intermediate-level tennis players, defined as those with a United States Tennis Association (USTA) National Tennis Rating Program (NTRP) rating of 3.0–4.0. This level was chosen because players in this range are still developing consistency and benefit most from feedback-rich training environments [6].

Therefore, this study aims to evaluate whether augmented training using the SAMGHA tripod improves eye–hand reaction time and stroke accuracy in intermediate tennis players. It is hypothesised that participants who undergo tripod-based training will show significantly greater improvements in these variables compared to those who follow standard practice routines.

Material and methods

Research design

This study employed a quasi-experimental design to evaluate the effects of the SAMGHA tripod on reaction time and stroke accuracy in tennis. Participants were recruited from local tennis clubs and selected based on their skill level, specifically those rated between 3.0 and 4.0 on the United States Tennis Association (USTA) National Tennis Rating Program (NTRP) scale, which corresponds to intermediate-level players [10].

Participants

To determine the sample size for this research, the G*Power program was used, selecting the analysis method of Linear Multiple Regression: Fixed model, R^2 deviation from zero. The power of the test was calculated using a type II error (β) of 20%, resulting in a power of 80% (1 – β) and a significance level of 95% (α = 0.05). The calculation results indicated that the appropriate sample size was 26 people. However, to account for potential dropouts, the sample size was increased to 30 people.

The participants included 30 male tennis players aged 18 and over who met the inclusion criteria of being healthy, injury-free, and consistently using a single forehand and backhand technique. Participants were randomly assigned to one of two equal groups: experimental (n = 15) and control (n = 15) using a computerised random number generator to ensure unbiased allocation. The experimental group underwent tripod-based training, while the control group followed their regular practice routines without any augmented training aids. Ethical approval for the study was obtained from the Burapha University Ethics Committee, and written informed consent was obtained from all participants.

Training protocol

The experimental group participated in an 8-week training program, with sessions held three times per week, each lasting 60 min. The training focused on improving forehand and backhand strokes, using drills specifically designed to enhance precision and reaction speed. The SAMGHA tripod (Figure 1) was used to simulate the weight and balance of a tennis racquet, allowing the participants to practice stroke mechanics under controlled conditions. Each session was structured to include warm-ups, targeted drills with the tripod, and cool-downs, ensuring a comprehensive approach to skill development. The detailed structure, duration, and relative intensity of each training component are presented in Table 1 (SAMGHA tripod training schedule).

The control group continued their regular tennis activities, which included standard practice drills without any specific training programs or the use of the

Figure 1. SAMGHA tripod

Table 1. SAMGHA tripod training schedule

Activity	Description	Duration	Intensity
Warm-up	light jogging, jumping jacks or rope jumps	5 min	RPE 10–11
Dynamic stretching	dynamic stretches targeting key muscle groups example: 15 s of three-leg throws, followed by 15 s of rest, repeat for 8 sets, totalling 4 min, with 1-minute rest between rounds, complete 8 rounds	5 min	RPE 10–11
Training program SAMGHA tripod	use the arm holding the tennis racquet to perform alternating throws for the designated period, with rest intervals in between	40 min	beginner: RPE 12–13 intermediate: RPE 14–15
Cool down and static stretching	static stretching to relax the muscles and aid recovery	10 min	RPE 10–11

Note: Program summary
Training level
Beginner: Gentle dynamic movements and basic drills
Intermediate: Higher intensity movements and increased duration of each rep
Frequency: 3 sessions/week (Monday, Wednesday, Friday)
Session duration: 60 min/session
Program duration: 8 weeks
Schedule: Evening sessions only
RPE – Rated Perceived Exertion Scale

SAMGHA tripod. The duration and frequency of their activities were the same as those of the experimental group. Also, both groups were assessed before and after the training period to evaluate changes in performance.

Measurement tools

Zepp Tennis 2

The participants were tested over two trials using a coach's feedback and the Zepp Tennis 2 sensor. Each participant hit 10 shots per trial. The best shot was selected based on the highest percentage. A normality test was used, and outliers were removed. The Zepp Tennis sensor, developed by Zepp Labs, Inc., headquartered in Silicon Valley, California, USA, is a wireless motion-tracking device designed to attach to the butt end of a tennis racquet. It utilises tri-axial accelerometers and gyroscopes to capture key swing metrics, including swing type, speed, spin, and impact location [11]. The sensor is compatible with smartphones operating on Android OS 5.0 or higher that support Bluetooth 4.0 LE or newer. Previous validation studies have confirmed the device's reliability and accuracy, particularly for sweet spot detection, with an accuracy rate exceeding 90%, and intra-class correlation coefficients (ICC) greater than 0.80 for swing parameters.

Computerised cognitive test battery

The computerised cognitive test battery used in this study was developed and approved by the Department of Physical Education [12], Ministry of Tourism and Sports, Thailand. The battery has been previously used in standardised national assessments and validated in pilot studies for young adult athletes, with reported reliability coefficients > 0.85 for both simple and choice reaction time tasks. Each participant completed 10 trials per test, and outliers (>2 standard deviations from the mean) were excluded to ensure data consistency.

Data analysis

Data were analysed using the Jamovi statistical software (version 2.6.26). Based on the results of the Shapiro–Wilk test and visual inspection of Q–Q plots, the data met the assumptions for parametric analysis. Paired samples *t*-tests were used to compare pre- and post-training performance within each group, while independent sample *t*-tests were applied to assess differences between the experimental group (EG) and the control group (CG). Statistical significance was defined as $p < 0.05$.

Results

The demographic characteristics of the experimental and control groups, as presented in Table 2, demonstrate comparable baseline attributes, ensuring that the groups were well-matched before the intervention. The experimental group had a mean age of 21.00 ± 0.926 years, a mean weight of 55.50 ± 11.50 kg, and a mean height of 168.00 ± 8.96 cm. In comparison, the control group had a mean age of 21.30 ± 0.900 years, a mean weight of 53.50 ± 3.11 kg, and a mean height of 167.00 ± 4.99 cm.

The results demonstrated significant improvements in reaction times within the experimental group. Simple reaction time decreased from an average of 0.527 s before training to 0.263 s after training, indicating a substantial reduction. Choice reaction time also improved, with averages declining from 0.455 s to 0.362 s. These improvements were statistically significant ($p < 0.001$), suggesting that training with the tripod effectively enhanced the participants' reaction speeds.

In contrast, the control group did not show significant changes in reaction times, with only minimal variations observed between pre- and post-training tests. This suggests that the standard practice routine was insufficient to produce noticeable improvements in cognitive processing speed.

Table 2. Demographic characteristics of the sample groups

Data	Experimental group (n = 15) (mean ± SD)	Control group (n = 15) (mean ± SD)
Age (years)	21.00 ± 0.926	21.30 ± 0.900
Weight (kg)	55.50 ± 11.50	53.50 ± 3.11
Height (cm)	168.00 ± 8.96	167.00 ± 4.99

The experimental group also exhibited significant improvements in hitting accuracy. Forehand hitting accuracy increased from 45.467% to 81.600%, while backhand hitting accuracy improved from 44.867% to 81.533%. These gains underscore the effectiveness of the tripod in enhancing hitting precision, attributed to the consistent feedback and its ability to simulate the feel of actual tennis play.

In contrast, the control group did not demonstrate significant improvements in accuracy, further highlighting the importance of tripod-based training in developing specific tennis skills.

Data from both groups were collected through pre- and post-training assessments comprising the simple and choice reaction time tests and the sweet-spot accuracy tests for forehand and backhand strokes.

The research results, as detailed in Table 3, show that the training intervention had a significant impact on improving reaction time and hitting accuracy among the experimental group. Participants in the experimental group, who underwent training with a tripod, demonstrated substantial improvements in both simple and choice reaction times, as well as in hitting the sweet spot of the tennis racquet in forehand and backhand strokes.

The simple reaction time test results indicated a significant reduction in reaction time for the experimental group, from 0.527 ± 0.0485 s before the training to 0.263 ± 0.0476 s after the training ($p < 0.001$). The choice reaction time test also showed improvement, with reaction times decreasing from 0.455 ± 0.0236 s to 0.362 ± 0.0500 s ($p < 0.001$). In contrast, the control group showed no significant changes in reaction times,

Table 3. Comparison of mean differences in simple reaction time test, choice reaction time test, sweet spot (forehand), and sweet spot (backhand) within the experimental and control groups before and after training (n = 30)

Type of test	Group	Reaction time (mean ± SD)		Mean difference (mean)	t	p-value
		before training	after training			
Simple reaction time test (s)	EG	0.527 ± 0.0485	0.263 ± 0.0476	0.2647	16.66	< 0.001**
	CG	0.533 ± 0.0320	0.538 ± 0.0317	–0.00467	–0.388	0.704
Choice reaction time test (s)	EG	0.455 ± 0.0236	0.362 ± 0.0500	0.0933	7.79	< 0.001**
	CG	0.444 ± 0.0238	0.445 ± 0.0259	–0.00133	–0.136	0.894
Sweet spot forehand (%)	EG	45.467 ± 2.7997	81.600 ± 5.2617	–36.1333	–24.75	< 0.001**
	CG	43.800 ± 2.5967	43.467 ± 3.6227	0.33333	0.263	0.796
Sweet spot backhand (%)	EG	44.867 ± 2.9488	81.533 ± 4.5177	–36.6667	–32.74	< 0.001**
	CG	44.400 ± 1.8822	43.467 ± 3.4407	0.93333	0.989	0.339

EG – experimental group, CG – control group; ** $p < 0.001$
Statistical significance was set at $p < 0.05$, while highly significant results were denoted as p < 0.001.

Table 4. Comparison of mean differences in simple reaction time test, choice reaction time test, sweet spot (forehand), and sweet spot (backhand) between the experimental group and the control group before and after training (n = 30)

Type of test	Time period	Reaction time (mean ± *SD*)		Mean difference (mean)	*t*	*p*-value
		EG	CG			
Simple reaction time test (s)	BT	0.527 ± 0.0485	0.533 ± 0.0320	0.00600	0.400	0.692
	AT	0.263 ± 0.0476	0.538 ± 0.0317	–0.275	–18.66	< 0.001**
Choice reaction time test) (s)	BT	0.455 ± 0.0236	0.444 ± 0.0238	–0.01133	–1.309	0.201
	AT	0.362 ± 0.0500	0.445 ± 0.0259	0.0833	5.73	< 0.001**
Sweet spot forehand (%)	BT	45.467 ± 2.7997	43.800 ± 2.5967	–1.66667	–1.690	0.102
	AT	81.600 ± 5.2617	81.600 ± 3.6227	38.133	23.12	< 0.001**
Sweet spot backhand (%)	BT	44.867 ± 2.9488	44.400 ± 1.8822	–0.46667	–0.517	0.609
	AT	81.533 ± 4.5177	43.467 ± 3.4407	38.067	25.96	< 0.001**

EG – experimental group, CG – control group, BT – before training, AT – after training; ** $p < 0.001$
Statistical significance was set at $p < 0.05$, while highly significant results were denoted as $p < 0.001$.

indicating that their standard practice routine did not significantly enhance cognitive processing speed. In terms of hitting accuracy, measured by hitting the sweet spot on forehand and backhand strokes, the experimental group showed marked improvement. Forehand accuracy increased from 45.467 ± 2.7997% to 81.600 ± 5.2617%, while backhand accuracy improved from 44.867 ± 2.9488% to 81.533 ± 4.5177% ($p < 0.001$). Conversely, the control group displayed only small changes, suggesting that the tripod-based training was effective in enhancing precision.

The comparative analysis presented in Table 4 highlights significant differences between the experimental and control groups. The experimental group outperformed the control group in all measured parameters after the training intervention, highlighting the impact of the augmented training approach on both reaction speed and hitting accuracy.

As shown in Table 4, the research shows a significant difference between the experimental group and the control group in tests of response ability and tennis hitting accuracy. The measurements were conducted before and after training in various forms, including the simple reaction time test, choice reaction time test, and hitting the sweet spot of the tennis racquet in both forehand and backhand strokes.

Discussion

This study aims to investigate the effect of the SAMGHA tripod on eye–hand reaction time and stroke accuracy in intermediate tennis players. The results of this study indicated that the SAMGHA tripod significantly enhanced reaction time and hitting accuracy in tennis players, particularly among those at the intermediate level. This finding is consistent with the theoretical framework of motor learning, which suggests that targeted, repetitive practice can lead to improved performance in both cognitive and motor skills [13].

Reaction time is a critical skill in tennis as it affects a player's ability to anticipate and respond to the ball quickly. The significant reduction in both simple and choice reaction times observed in the experimental group aligns with previous studies emphasising the importance of targeted training for cognitive processing speed. For instance, Arney et al. [10] found that training methods focusing on reaction time can significantly improve players' performance by enhancing their ability to process visual stimuli rapidly and execute precise movements. This study corroborates these findings, demonstrating that the tripod effectively reduced reaction time by simulating match-like conditions, enabling players to respond more quickly in real-game scenarios.

The tripod's design replicates the weight and balance of a tennis racquet, enabling players to practice under conditions that closely resemble actual gameplay. This feature of augmented training creates a realistic and engaging practice environment, enhancing skill retention and facilitating the transfer of skills to competitive settings. According to Deng et al. [14], training that incorporates realistic simulations can enhance the neural pathways associated with motor responses, leading to more efficient execution of learned skills [15]. The tripod's ability to replicate the conditions of a real tennis match could explain the significant improvements seen in the experimental group's reaction times.

The study also identified a significant improvement in hitting accuracy, particularly in strokes targeting the sweet spot of the racquet [16]. This finding is critical, as hitting the ball at the sweet spot optimises power and control, both of which are essential for successful gameplay [17]. The enhancements observed in both forehand and backhand accuracy indicate that the tripod offers a stable and consistent training platform, enabling players to refine their strokes with greater precision.

Previous research by Williams and Hodges [18] underscores the importance of feedback in skill acquisition, emphasising that immediate and consistent feedback can significantly enhance learning outcomes, particularly in precision sports such as tennis. The tripod's ability to provide real-time feedback on stroke mechanics enables players to make necessary adjustments, thereby improving their overall hitting accuracy. As mentioned earlier, the training program for the experimental group utilised a new tool, the 'SAMGHA' tripod, which was designed to enhance coordination between perception and motion. In contrast, the control group did not undergo a similar training program. Therefore, the outcomes observed in the experimental group may reflect the combined effects of both the tripod tool and the training program, rather than the effect of the tripod alone. Moreover, the increased accuracy observed in the experimental group compared to the control group suggests that augmented training with devices like the tripod offers greater benefits than traditional practice alone.

These findings are further supported by Papale et al. [9], who demonstrated that targeted neuromotor exercises can significantly enhance fine motor control and reduce hand tremors. Their results highlight the potential of specific sensorimotor drills in improving motor precision, which parallels the improvements observed in this study regarding stroke accuracy and reaction speed. Both studies reinforce the idea that fine-tuned eye–hand coordination can lead to measurable gains in sports requiring quick reflexes and precise execution, such as tennis. The tripod's effectiveness in reducing reaction time and increasing sweet-spot accuracy may thus be partially attributed to its neuromotor stimulation properties, which is consistent with the mechanisms identified.

The design of the tripod, which emphasises throwing and receiving to develop racquet grip, particularly in reinforcement training programs, requires repeated practice. This repetition is closely related to the rhythm of hand clenching during the moment of impact between the racquet and the tennis ball. These findings support Leech et al. [13], who highlighted that targeted training programs can accelerate the motor learning process, leading to automatic improvement of skills.

The research findings are significant for coaches and players seeking to enhance their performance in tennis competitions. Integrating the tripod as a reinforcement training tool in regular practice can help develop focused and efficient hitting skills [19]. This approach is particularly beneficial for beginner to intermediate players, as consistent use of the tripod during training can improve concentration and hitting effectiveness, ultimately boosting overall performance.

However, the limitations of this study were its focus on intermediate players, and that other tennis skills, such as serving and volleying, were not examined [20]. Additionally, comparing the tripod training program with other tools could provide valuable insights into the most effective methods for developing tennis skills. Further research exploring these areas would help broaden the understanding of how various training interventions impact overall performance in tennis.

Conclusions

In summary, this study shows that training with the SAMGHA tripod can effectively improve reaction time and hitting accuracy in tennis. The findings highlight the potential of tripod training as a valuable tool for enhancing tennis performance.

Ethical approval

The research related to human use complied with all the relevant national regulations and institutional policies, followed the tenets of the Declaration of Helsinki, and was approved by the Burapha University Research Ethics Committee, receiving certification on August 25, 2023 (approval No.: IRB1-086/2566).

Informed consent

Informed consent was obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

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