Central European Journal of Sport Sciences and Medicine | Vol. 53, No. 1/2026: 37–52
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2026.1-04

"TALKING ABOUT PENCAK SILAT TRAINING INNOVATION": COACHES' EFFORTS TO IMPROVE EXERCISE BEHAVIOR AND TECHNICAL PERFORMANCE AMONG YOUNG ATHLETES WITH AUGMENTED REALITY

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Abstract This study aims to investigate the effects of augmented reality training (ART) towards exercise behavior, and technical performance among young athletes. A 9-week experiment was adopted in this study. Fifty young male Pencak Silat athletes were involved as participants, and they were assigned into ART (n=25), and control (n=25) groups. Measurements of exercise behavior (exercise intensity, exercise time, exercise frequency), and technical performance (target punching test, target kick test) were conducted at pre-, mid-, and post-intervention. This study generated two main research findings. First, there were significant effects interaction of condition vs. time (p=0.001), condition (p=0.019), and time (p<0.001) on the exercise behavior variable in the exercise intensity indicator. At the same time, we observed the effects of the interaction of condition vs. time (p=0.015), condition (p=0.023), and time (p<0.001) in the exercise time indicator, while the exercise frequency indicator showed the effects of interaction of condition vs. time (p<0.001), condition (p=0.005), and time (p<0.001). Second, there was a significant effect on interaction of condition vs. time (p<0.001), condition (p=0.001), and time (p<0.001) on the technical performance variable in the target punching test indicator. The target kick test indicator showed the effects interaction of condition vs. time (p<0.001), condition (p=0.001), and time (p<0.001). Post-hoc analysis showed that the ART group has higher score than the TT group in terms of increasing exercise behavior and technical performance. The conclusion is that the 9-week ART program has proven effective in improving aspects of exercise behavior and technical performance among young Pencak Silat athletes.

Key words: technology-based training, habitual behavior, competitive performances, combat sports

Introductions

In recent decades, training methodologies for combat sports has shown significant progress by involving the application of modern technology (Lygouras & Tsinakos, 2024; Witkowski et al., 2017). Previous studies involved trainers in combat sports with virtual reality (Ritter et al., 2022; Witte et al., 2022), or augmented reality (Usra et al., 2024). Pencak Silat is one type of combat sport that is popular in Asian countries. In addition, similar to other combat sports (e.g., Karate, Taekwondo, Judo, Boxing, MMA or Muay Thai) in Pencak Silsat in order to achieve peak performance, athletes are required to have high performance and the role of coaches must innovate in implementing effective training methods. Currently, Pencak Silat coaches must dare to innovate and try to combine training methods by involving the use of modern tools such as augmented reality.

Conceptually, augmented reality is interpreted as a technology that presents a training atmosphere with a combination of virtual objects and real world (Soltanabadi et al., 2023; Usra et al., 2024). In addition, training session with augmented reality presented something new, and different from traditional training, young athletes acquired and learned numerous skills from a 3-D avatar (Cossich et al., 2023). Involving augmented reality in long-term training programs must be provided to young combat sport athletes, considering the convenience to access anytime, anywhere (Franzò et al., 2023). On the other hand, Pérez-Muñoz et al. (2024) explained that augmented reality assisted a fun training experience, and increased motivation. In particular, augmented reality has been claimed to be used as training to improve several important aspects, such as psychology, health (Piqueras-Sola et al., 2024), and the performance of young athletes in competition (Sohail et al., 2022). In addition, Chang et al. (2019), explained that another benefit that can be provided by the continuous application of augmented reality technology was an increase in high motor skills. Although the benefits of augmented reality had been reported by previous studies (Calabuig-Moreno et al., 2020), unfortunately the benefits of augmented reality on exercise behavior, and technical performance among young athletes had not been investigated.

Exercise behavior is a theory that explains certain actions or behaviors in young athletes during training sessions to achieve goals in sports (Chen et al., 2022). Basically, exercise behavior must be fostered and improved

optimally, because this is closely related to the development of awareness of young athletes' behavior in carrying out exercise (Yan et al., 2024). In addition, the benefits of exercise behavior were confirmed by several previous studies, for example, regular exercise behavior had the potential to reduce the risk of chronic diseases, avoid obesity (Liu et al., 2024) to the risk of mental illness (Li et al., 2024; Harada, 2022). Young athletes are in puberty, which is a golden period to develop skills and good training habits, however, in this period, young athletes experience behavioral changes such as anxiety and high stress, which has an impact on low participation in training (Boonsem et al., 2021). Exercise behavior can be improved among young athletes by several factors, such as family, social, school, individual (Chen et al., 2022).

Technical performance is an absolute item or factor that must be the focus among young athletes (Usra et al., 2024). High technical performance is the main key for young athletes to show effective movements (e.g., punches, kicks) during competition (Brechney et al., 2022). In addition, many previous studies acknowledged that without high technical performance, young athletes will not develop their skills, and it is difficult to achieve success in combat sports. On the other hand, technical performance is an important factor similar with physical, psychological or tactical factors, thus technical performance among young athletes must be optimally improved (Folhes et al., 2023). Meanwhile, Zhang et al. (2022), explained that young athletes with high technical performance carry out attack and defense strategies effectively, which allows a great opportunity to achieve victory.

Previous studies had explored the application of augmented reality, but there was a marked gap in its application, mostly in the context of physical education (Chang et al., 2019; Liang et al., 2023; Moreno-Guerrero et al., 2020; Paramitha et al., 2024), and ignored the potential of augmented reality in the field of combat sports training, especially Pencak Silat. In addition, there was still limited research that thoroughly investigated the application of augmented reality during long-term Pencak Silat training to improve exercise behavior, and technical performance among young athletes. Thus, this study aims to analyze the impact of augmented reality during Pencak Silat training to improve training behavior, and technical performance among young athletes. Our hypothesis is young athletes in the augmented reality group during Pencak Silat training achieved higher results in exercise behavior, and technical performance variables compared to the control group.

Methods

Participants

Participants in this research are from young Pencak Silat athletes at Medan State University (Indonesia). The a priori sample size requirement was measured using G*Power (version 3.1.9.4; Franz Faul-University of Kiel, Germany). The F test with ANOVA repeated measures analysis (effect size f=0.30 [large], α err prob=0.05, power [1-β err prob]=0.80, number of groups=2, number of measurements=3). The calculation results showed that at least 20 young Pencak Silat athletes were needed to participate in this study. However, considering the dropout rate in training was 10%, it was planned to involve at least 60 young athletes.

Then, screening was carried out using inclusion criteria (Fig. 1), such as: (I) young male and female athletes, (II) not suffered severe injuries in the last 1 month, (III) did not have any history of chronic diseases (heart, asthma), (IV) did not have any visual and hearing impairment, (V) did not participate in national or international championship events, (VI) 100% attendance rate, and (VII) free from mental conditions that can affect the pre-, mid-, and posttest processes. Their biodata were collected, and stored by the research team. In the final screening, 10 young athletes were excluded because they failed to meet the rules stated in the inclusion criteria. Thus, this resulted in a final

study group of 50 young athletes, and they were randomly assigned (https://www.randomizer.org/) to enter the ART (n=25; male=15; female=10), and TT (n=25; male=15; female=10) (Table 1). The Human Research Ethics Committee of Medan State University, Indonesia (ethics approval code: 0601/UN33.6/LL/2024) was granted permission for the study. In addition, informed consent was obtained from the young athletes, and their parents. This study follows the ethical rules issued by the Declaration of Helsinki (2024).

Table 1. Participant characteristics data from both training groups

Characteristic	ART (n=25)	TT (n=25)
Age (years)	18.3±0.90	18.0±0.79
Height (cm)	163±1.98	164±2.36
Weight (kg)	59.2±2.13	60.3±2.10
BMI (kg/m2)	22.0±0.95	22.8±1.03
Pencak Silat training experience (years)	1.39±0.48	1.51±0.50
Augmented reality training experience (years)	1.25±0.44	1.32±0.47

ART=Augmented reality training, TT=Traditional training, *n*=Participants, BMI=Body mass index.

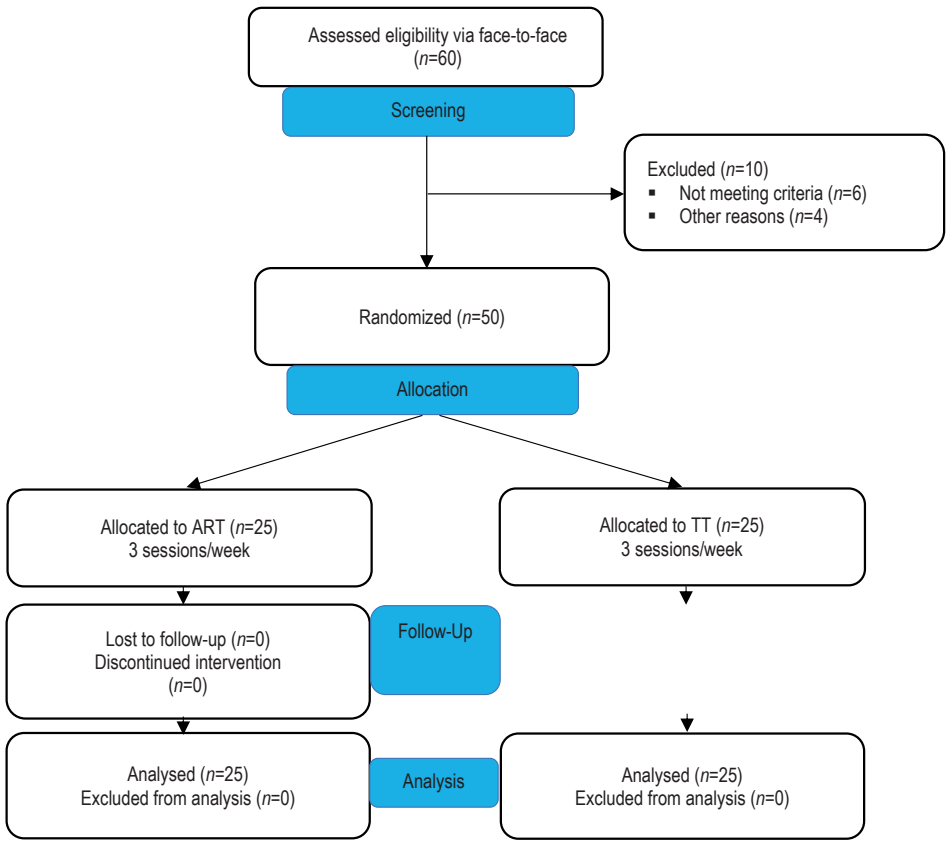

Figure 1. Diagram Flow of participants

Measure

Exercise Behavior. The test used to measure exercise behavior included three test questions, (i) exercise intensity, (ii) exercise time, and (iii) exercise frequency (Li et al., 2024). This test was answered on a Likert scale with 1–5 points according to its level. In this study, the scoring was modified, the score for each test (exercise intensity, exercise time, and exercise frequency) was used for statistical analysis, as a quantitative indicator towards the evaluation of young athletes' exercise behavior. If the group obtained higher score, then the amount of physical exercise behavior would be higher. In this study, the intra-class correlation coefficient (ICC) value of each question in physical exercise intensity, exercise time, and exercise frequency was tested (Table 3).

Technical Performance. In order to measure the level of technical performance ability of young athletes, an instrument adopted from previous studies was applied (Usra et al., 2024). This instrument has 2 types of tests, namely: (i) target punching test, the athlete stood upright facing a punching bag (Bran-JUOIFIP), after hearing the command "GO", the participants punch the target on the punching bag as quickly as possible for 1 minute, and (ii) target kick test, the athlete was required to kick towards the target on the punching bag for 1 minute (Kabadayı et al., 2022). Scoring was calculated by counting the number of punches and kicks that hit the target. If the number of punches and kicks that hit the target increased, the technical performance score would be higher. In this study, the ICC value has been tested and it is presented in Table 3.

Design and Procedures

A 9-week true experimental study with details of 3 sessions/week was adopted in this study. This study was conducted from November 2024 to January 2025 at the gymnasium of Medan State University. In the first week, all participants carried out a pre-test, namely filling out an exercise behavior questionnaire (physical exercise intensity, exercise time, exercise frequency), and a technical performance test (target punching test, target kick test) from 09:00 to 12:00 am. In the second week, participants were randomly assigned to enter the ART and TT groups, both groups carried out their respective programs until week 5. Then in week 6, all participants in ART and TT carried out a mid-test at 09:00 to 12:00 a.m. The ART and TT programs were continued in weeks 7 to 8. In week 9, all participants carried out a post-test at the same time as the previous test (Fig. 2). All activities from start to finish were closely monitored by the research team.

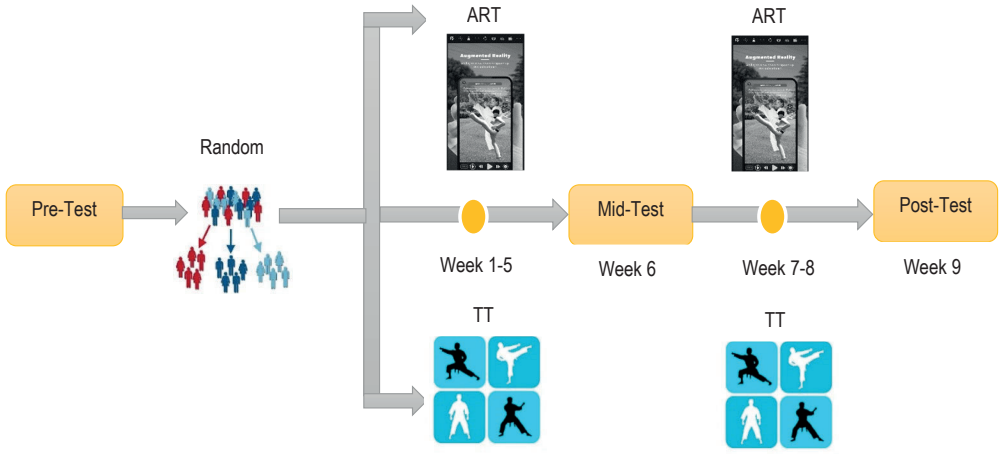

Figure 2. Experimental design

ART Program

The ART program was carried out 3 sessions per week, on Monday, Wednesday, and Friday during the Pencak Silat training schedule from 07:00 am to 08:00 am. The trainers assigned to the ART group have 10 years of training experience, and there are experts in the field of technology-based Pencak Silat. The participants carried out ART sessions for 60 minutes in one day. Daily activities in ART started with warm-up that focuses on the muscles throughout the body for 5 minutes. Continued with the main training, the augmented reality application was installed on an Android smartphone with the type Infinix Note 40 Pro Plus + 5G, and Samsung Galaxy A55 5G and distributed to the participants. In augmented reality, an avatar or animation demonstrated Pencak Silat movement skills, such as punches and kicks. Participants were instructed to analyze each Pencak Silat movement skill through the augmented reality technology application for 10 minutes. After that, participants conducted independent training for 40 minutes. If participants forgot the movements in Pencak Silat, they would allowed to observe them again in augmented reality. The activity ended with 5-minute cool-down (Table 2).

Table 2. 9-week ART program

Activities	Duration	Decription
Warm-up	5 min	The initial activity for participants was to stretch the muscles of the upper and lower body.
Main exercise	10 min	First, participants were instructed to analyze each punch and kick movement in an augmented reality tool.
	40 min	After observing an avatar in augmented reality demonstrating each movement, participants were instructed to practice independently, and if participants forgot the punch or kick movements, they could rewatch the augmented reality.
Cool-down	5 min	After the training activity was completed, all participants were instructed to perform a cool-down on the muscles throughout the body.

Control Group Program

The trainer in charge of the TT group had 12 years of training experience and was an expert in Pencak Silat. Participants in the control group were instructed to maintain their daily routine (TT) for 60 minutes. No special training or exercise program was given to this group. The TT group program was implemented according to the schedule applied to the ART group.

Statistical analysis

Descriptive statistics were presented in mean ± standard deviation. Shapiro-Wilk's ($p \geq 0.05$) was used to analyze the normality of the data and the reliability value of each variable was presented in ICC. We conducted the Delta percentage ($\Delta\%$) test in this study. In addition, Two-Way Repeated Measure (T-WRM) ANOVA, was used to test the effects of condition (ART vs. TT), time (pre- vs. mid- vs. post-test), and the interaction between condition (ART vs. TT) vs. time (pre- vs. mid- vs. post-test) on exercise behavior, and technical performance. The effect size for ANOVA was determined based on partial eta squared ($\eta p2$) as follows: $\eta p2<0.01$ (small effect), $0.01<\eta p2<0.06$ (medium), and $\eta p2>0.14$ (large effect) (Cohen, 2013). The Cohen's d was calculated for the pairwise differences: trivial (<0.20), small (0.2<0.50), moderate (0.5<0.80), and large (>0.80). Bonferroni post-hoc test was used for pairwise comparisons on EB and TP. The significance level of this study was set as 0.05. All data were analyzed using Jamovi v.2.3.28 (The Jamovi Project, Sydney, Australia).

Results

Table 3 shows that the ICC value is in the range of 0.88–0.95, which proves that the reliability value of each parameter (EB and TP) is in the high category. In addition, it can be observed that the data in this study distributes normally (Table 3). Meanwhile, for descriptive statistical values including mean, standard deviation, ICC to delta percentage ($\Delta\%$), we present them in Table 4.

Table 3. Reliability and normality of variable test

Parameters	ICC	ART			TT		
		SW-Pre	SW-Mid	SW-Post	SW-Pre	SW-Mid	SW-Post
Exercise Behavior							
Training intensity (score)	0.889	0.093	0.109	0.215	0.149	0.131	0.155
Practice time (score)	0.870	0.134	0.070	0.149	0.088	0.080	0.096
Exercise frequency (score)	0.924	0.231	0.189	0.166	0.133	0.178	0.146
Technical Performance							
Target punching test (score)	0.977	0.098	0.279	0.118	0.221	0.198	0.247
Target kick test (score)	0.940	0.065	0.060	0.135	0.077	0.071	0.088

ICC=Intra-class correlation coefficient; SW=Shapiro-Wilk's; ART=Augmented reality training; TT=Traditional training; EB=Exercise Behavior; TP=Technical Performance.

Table 4. Descriptive statistics

Parameters	Condition	Pretest Mean±SD; (95% CI)	Midtest Mean±SD; (95% CI)	Posttest Mean±SD; (95% CI)	%Δ
Exercise Behavior					
Exercise intensity (score)	ART (*n*=25)	1.80±0.57 (1.56 to 2.04)	2.80±0.57 (2.56 to 3.04)	4.60±0.50 (4.39 to 4.81)	59.92
	TT (*n*=25)	1.72 0.45 (1.53 to 1.91)	2.72±0.45 (2.53 to 2.91)	3.76±0.43 (3.58 to 3.94)	48.19
Exercise time (score)	ART (*n*=25)	1.64±0.49 (1.44 to 1.84)	2.80±0.50 (2.59 to 3.01)	4.52±0.51 (4.31 to 4.73)	66.08
	TT (*n*=25)	1.96±0.53 (1.74 to 2.18)	3.20±0.50 (2.99 to 3.41)	4.44±0.50 (4.23 to 4.65)	51.01
Exercise frequency (score)	ART (*n*=25)	1.72±0.54 (1.50 to 1.94)	3.48±0.58 (3.24 to 3.72)	4.80±0.40 (4.63 to 4.97)	70.13
	TT (*n*=25)	1.80±0.57 (1.56 to 2.04)	2.96±0.53 (2.74 to 3.18)	4.04±0.61 (3.79 to 4.29)	50.47
Technical Performance					
Target punching test (score)	ART (*n*=25)	11.3±1.72 (10.6 to 12.0)	16.0±1.73 (15.3 to 16.7)	19.3±1.82 (18.6 to 20.1)	31.11
	TT (*n*=25)	13.5±1.39 (12.9 to 14.1)	14.6±1.42 (14.0 to 15.1)	15.8±1.46 (15.2 to 16.4)	8.18
Target kick test (score)	ART (*n*=25)	10.2±1.54 (9.61 to 10.9)	16.4±1.58 (15.8 to 17.1)	19.3±1.88 (18.5 to 20.1)	39.23
	TT (*n*=25)	11.8±1.49 (11.2 to 12.5)	13.3±1.49 (12.7 to 13.9)	14.9±1.86 (14.1 to 15.6)	12.37

ART=Augmented reality training, TT=Traditional training, SD=Standard deviation, CI=Confidence interval, %Δ=Delta percentage, ES=Effect size.

The results of T-WRM ANOVA (Table 5) reveals that there are significant condition effects with ($F_{(1.48)}$=6.38; p=0.019; η$p2$=0.21), time ($F_{(1.48)}$=693.19; p<.001; η$p2$=0.96), and condition vs. time interaction ($F_{(1.48}$=23.80; p<.001; η$p2$=0.49) on the EB parameters in the exercise intensity indicator. At the same time, the effects of condition ($F_{(1.48)}$=5.89; p=0.023; η$p2$=0.19), time ($F_{(1.48)}$= 400.97; p<.001; η$p2$=0.94), condition vs. time interaction ($F_{(1.48)}$=4.57; p=0.015; η$p2$=00.16) on the training time indicator and training frequency on the effects of condition ($F_{(1.48)}$=9.39; p=0.005; η$p2$=0.28), time ($F_{(1.48)}$=446.11; p<.001; η$p2$=0.94), and condition vs. time ($F_{(1.48)}$=16.08; p<.001; η$p2$=0.40). Further results of T-WRM ANOVA show that there is a significant condition effect with ($F_{(1.48)}$=13.9; p=0.001; η$p2$=0.36), time ($F_{(1.48)}$=353.6; p<.001; η$p2$=0.93), and condition vs. time interaction ($F_{(1.48)}$=97.1; p<.001; η$p2$=0.80) on the TP parameters in the target punching test indicator. Meanwhile, the target kick test indicator shows a condition effect ($F_{(1.48)}$=25.4; p=0.001; η$p2$=0.51), time ($F_{(1.48)}$=394.3; p<.001; η$p2$=0.94), and the condition vs. time interaction ($F_{(1.48)}$=102.7; p<.001; η$p2$=0.81) (Table 5).

Post-hoc Bonferroni tests showed that the increase in EB scores from pre-, mid-, to posttest was higher in ART than in TT (Fig. 3). Furthermore, we also observed that the increase in TP scores from pre, mid-, to posttest was higher in ART than in TT (Fig. 4).

Table 5. Summary of T-WRM ANOVA Results

Parameters	F(1.48)	p	η_{p2}
EB			
Exercise intensity (score)			
Condition	6.38	0.019	0.21
Time	693.19	<.001	0.96
Condition vs. time interaction	23.80	<.001	0.49
Exercise time (score)			
Condition	5.89	0.023	0.19
Time	400.97	<.001	0.94
Condition vs. time interaction	4.57	0.015	0.16
Exercise frequency (score)			
Condition	9.39	0.005	0.28
Time	446.11	<.001	0.94
Condition vs. time interaction	16.08	<.001	0.40
TP			
Target punching test (score)			
Condition	13.9	0.001	0.36
Time	353.6	<.001	0.93
Condition vs. time interaction	97.1	<.001	0.80
Target kick test (score)			
Condition	25.4	<.001	0.51
Time	394.3	<.001	0.94
Condition vs. time interaction	102.7	<.001	0.81

EB=Exercise Behavior, TP=Technical Performance.

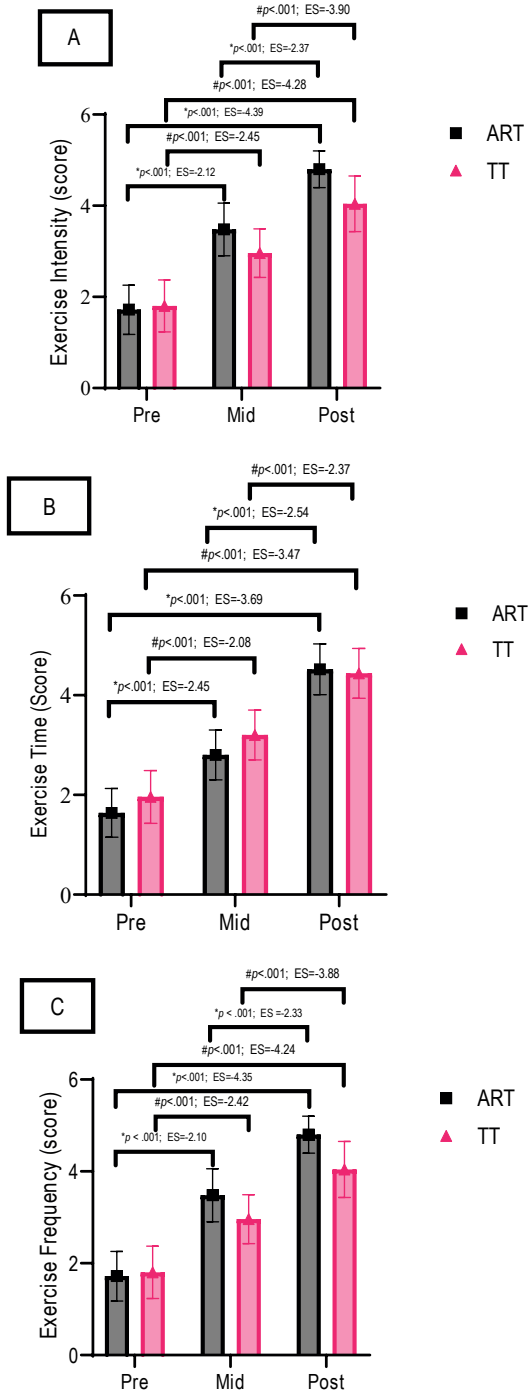

Figure 3. Changes in exercise behavior: (A) exercise intensity, (B) exercise time, and (C) exercise frequency. *Significant differences between pre-, mid-, and post-test in ART. #Significant differences between pre-, mid-, and post-test in TT.

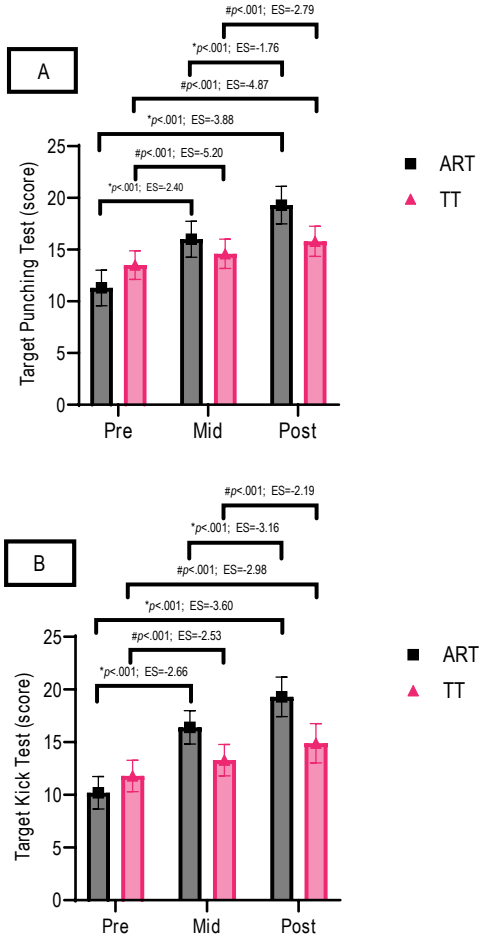

Figure 4. Changes in technical performance: (A) target punching test, and (B) target kick test. *Significant differences between pre-, mid-, and post-test in ART. #Significant differences between pre-, mid-, and post-test in TT.

Discussion

Our current research aims to investigate the effects of ART during Pencak Silat training on improving exercise behavior (training intensity, training time, training frequency), and technical performance (punching, kicking) among young athletes.

This study acknowledged two main findings. First, this study answered hypothesis, that ART has a higher positive effect than TT on improving exercise behavior related to indicators of exercise intensity, exercise time, and exercise frequency of young athletes. This is because the two training methods have different characteristics and training stages. For example, ART presented a 3-D avatar animation in a real environment (Loia & Orciuoli, 2019), so that young athletes can analyze in detail every movement demonstrated by the avatar (Cossich et al., 2023). Additionally, another advantage of the ART program is that young athletes can observe the virtual avatar anywhere

and anytime (i.e., during breaks or at home), in case they forget the movements (Bali & Fridhi, 2023), in this way it has the potential to improve the quality of exercise behavior (Salatino & Burin, 2024).

Technology such as augmented reality is currently a new innovation in combat sport training (Septri et al., 2023), especially Pencak Silat, and this can provide a meaningful movement experience for young athletes in conducting long training sessions effectively (Usra et al., 2024). A previous study reported that augmented reality presented during combat sport training sessions can trigger athletes to increase their interest in training (Zhang & He, 2022). Another report revealed that augmented reality technology was a significant major factor in increasing aspects of self-efficacy, academic performance (O'Connor & Mahony, 2023), repetitive behaviors, and executive function (Nekar et al., 2022). On the other hand, several researchers acknowledged that the presence of augmented reality created a realistic, interesting, and fun training environment (O'Connor & Mahony, 2023; Viscione & D'elia, 2019) and it was different to the routine training from coaches, and more traditional. We found an interesting fact that in the first week, athletes showed negative behavior (unenthusiastic) in carried out training activities through augmented reality, which cause the ART score results were smaller than TT in the pre-test stage (Fig. 3). However, in the second week there was a significant change in behavior, which shows the difference in scores in the pretest, midtest to posttest stages. Ng et al. (2019) supports the findings in this research, where the application of an augmented reality program causes significant changes in psychological behavior. According to Nekar et al. (2022), augmented reality was able to foster the intention and enthusiasm of young athletes to train hard. In line with Paramitha et al. (2024), the continuous use of augmented reality during training sessions was an effective way to increase the level of grit and learning satisfaction among young athletes.

Basically, sports behavior among young athletes can be influenced by several important factors such as the surrounding environment (Nekar et al., 2022), coach behavior (Choi et al., 2020), harmonious relationships between coaches, and young athletes (Zhang & Rhim, 2024) until the application of a training method. This finding is in line with Liang et al. (2023), who reported that the augmented reality training method group, and TT (control), both had positive effects on the development of young athletes, but the augmented reality training method group showed higher scores than TT in increasing motivation, and learning behavior in young athletes. These results proved that low exercise behavior in young athletes would be improved if the coach applied the right training method.

The second finding in this study proves that the ART group had a higher positive effect than TT on improving technical performance variables among young athletes. It was observed from the movement experience presented by each group, ART was able to create a fun, challenging training process, and provide guidance for young athletes to learn each movement (e.g., punching, kicking) in Pencak Silat. In addition, the ART program provided clear guidance about incorrect movements, and should not be done until the movement is correct. A previous study reported similar results, integrating augmented reality-based training for 11 weeks proved effective in improving technical performance among young karate and Pencak Silat athletes (Usra et al., 2024).

Basically, to learn punching and kicking movements in Pencak Silat, the application of sophisticated, modern technological tools such as augmented reality was needed, and it was a necessity in sports and physical education (Pérez-Muñoz et al., 2024), because augmented reality helped coaches to demonstrate punching and kicking movements correctly to young athletes. If young athletes were continuously and repeatedly given stimuli through augmented reality, the cognitive ability to record each movement would be better (Salatino & Burin, 2024), and the ability to mastering each movement would be faster (Nekar, Kang et al., 2022). In addition, we agreed with other studies that showed the integration of augmented reality technology during training sessions had a positive

impact on motoric aspects (Chang et al., 2019; Moreno-Guerrero et al., 2020). Likewise, the benefits of using augmented reality during teaching in physical education had been confirmed by several research groups, these benefits included improving physical performance and skills development (Chang et al., 2019; Liang et al., 2023). Some researchers reported an increase in motor skills (Pérez-Muñoz et al., 2024).

Strengths, Limitations, Future study prospects

The main strength of this research was creating an easy-to-use augmented reality training program that was specifically designed for young athletes in Pencak Silat. In addition, the 3D avatars presented in augmented reality technology were made as realistic as possible, so they were similar to real-world conditions, which allowed athletes to have no difficulty in learning movement tasks. However, we realized that there were several limitations in this research, for example: (i) the number of meetings was only 9 weeks, which could not fully cover long-term research on adaptation to technical performance training in Pencak Silat, (ii) participants only involved male gender, thus limiting generalization to a wider population such as women. In addition, (iii) the program designed in ART was specifically for young Pencak Silat athletes, and could not be applied to other combat sports. Therefore, several improvements in the future research are recommended. First, increasing the number of meetings, for example 14 weeks or more. Second, involving a more diverse number of participants by examining the gender between young male and female athletes, age. Third, involving young athletes from other types of combat sports (e.g., Karate, Taekwondo, Judo, Muay Thai, Capoeira, Wing Chun, and Boxing). Finally, creating a more diverse augmented reality training program that includes several other types of combat sports.

Conclusion

This study highlighted that the demonstration of ART and TT for nine weeks had significant effects towards the changes in exercise behavior, and technical performance. The ART group showed significantly higher than TT. Thus, the conclusion in our current study proves that the implementation of the ART program can improve exercise behavior (e.g., exercise intensity, exercise time, exercise frequency), and technical performance (e.g., punching, kicking) among young Pencak Silat athletes.

Practical applications

Promoting augmented reality innovation into combat sport training, specifically Pencak Silat, is a problem that must be overcome in the future. If the augmented reality tools have not been created and applied from now on, then the improvement of achievement among young athletes will be less than optimal. Contributions and implications for the practice of using the advantages of augmented reality can be an innovative and effective training in improving exercise behavior (e.g., training intensity, training time, training frequency), and technical performance (e.g., punching, kicking) among young Pencak Silat athletes. In fact, it is expected that the presence of this research can solve the shortcomings in integrating technology, especially augmented reality, in Pencak Silat training. In addition, in future practice, it is expected that young athletes and coaches can continuously use augmented reality technology to optimize the achievement of training goals.

Acknowledgements We thank all members of the research group, and all students who have participate.

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Cite this article as: Sinulingga, A., Kasih, I., Simatupang, N., Lobo, J., Selian, S., Kurtoğlu, A., & Setiawan, E. (2026). "Talking about Pencak Silat Training Innovation": Coaches' Efforts to Improve Exercise Behavior and Technical Performance among Young Athletes with Augmented Reality. *Central European Journal of Sport Sciences and Medicine*, *1*(53), 37–52. https://doi.org/10.18276/cej.2026.1-04