

Optimizing instructional approaches to improve poomsae performance in young Taekwondo practitioners

Serik Kunay*, Yernar Ospankulov, Yerik Tugelbayev, Aizhan Murat, Rysgul Kokebayeva

Abai Kazakh National Pedagogical University, Almaty, Kazakhstan.

* Correspondence: Serik Kunay; serik.kunai@mail.ru

ABSTRACT

The objective of this study was to investigate strategies aimed at enhancing the performance of young taekwondo practitioners in the execution of intricate formal exercises integrated into their training regimen. The study employed virtual reality technology in the form of the FitXR VR fitness app, compatible with Meta Quest 2 VR, to train our taekwondo-poomsae practitioners. The participants were divided into two groups, each comprising 15 practitioners (12-14 years old). Group 1, consisting of both male and female participants, underwent training using traditional training methods (TTP), while Group 2 received instruction through integrated training methods (ITM), also inclusive of male and female participants. The integrated training method (ITM) involved the incorporation of virtual reality technology alongside traditional training techniques. Coaches conducted assessments of practitioners' performance in two stages: initially at the commencement of training (pre-training), and subsequently upon completion of training (post-training). The analysis of results indicated a notable improvement in practitioners' performance with the integrated training method (ITM) when compared to the traditional training method (TTM). Moreover, the integrated training method (ITM) demonstrated a twofold enhancement in practitioners' balancing skills, agility, and endurance in comparison to the traditional training method (TTM). This highlights the efficacy of integrating virtual reality technology into the training process, emphasizing its potential to significantly augment practitioners' overall performance and proficiency in executing complex formal exercises within the domain of taekwondo.

KEYWORDS

Taekwondo; Poomsae; Training Methods; Virtual Reality; Performance Enhancement

1. INTRODUCTION

Taekwondo, a traditional Korean martial art, boasts various categories, with sparring, poomsae, and breaking being the most common (Kang et al., 2021; Jeong & Chun, 2022). The Korea Taekwondo Association's formal inclusion in The Korea Olympic Committee in 1962 marked a significant step towards its recognition as an Olympic sport (Choi et al., 2013). Since the inception of the Taekwondo Hanmadang competition, poomsae competitions have proliferated globally, showcasing the artistry and skill of practitioners (Chung & Johnson, 2019). Poomsae competitions stand apart from sparring events, as they involve the performance of predetermined movements rather than actual combat (Jeong & Chun, 2022). Taekwondo most common categories are sparring, poomsae, and breaking (Kang et al., 2021; Jeong, & Chun, 2022). Korea Taekwondo Association formally join The Korea Olympic Committee in 1962 (Choi et al, 2013). Since the start of the Taekwondo Hanmadang competition various poomsae competitions have been held in various countries (Chung & Johnson, 2019). The Poomsae competition is different from the sparring competition (Jeong & Chun, 2022). In Poomsae, the opponent is the imaginer as the athlete is performing a different set of predetermined movements (Kazemi et al., 2016). Whereas, in sparring competition, the competitors are involved in actual combat (Wąsik et al., 2014). In Poomsae competition, athlete shows skills and mastery in various techniques such as punches, blocks, and kicks (Fachrezzy et al., 2021). In a sparring competition, athletes score points by striking the opponent (Chi, Song, & Corbin, 2004). The judging criteria in Poomsae are based on accuracy, timing, power, flow, facing expression, breathing, and perfection in the sequence and body movements (e.g. Koshcheyev, 2019; Chung & Johnson, 2019). Whereas, in sparring competitions, judges use the accuracy number of strikes, kicks, footwork, timing, and defense moves to assign scores (Kazemi et al., 2010; Ko et al., 2011).

In poomsae competitions, athletes demonstrate their proficiency in a series of techniques, including punches, blocks, and kicks, which are meticulously choreographed into a sequence (Fachrezzy et al., 2021). Conversely, sparring competitions involve direct combat, where athletes score points by striking their opponents (Chi et al., 2004). The judging criteria for poomsae emphasize factors such as accuracy, timing, power, flow, facing expression, breathing, and the perfection of sequences and body movements (Koshcheyev, 2019; Chung & Johnson, 2019). In contrast, sparring competitions are judged based on the accuracy of strikes, kicks, footwork, timing, and defensive maneuvers (Kazemi et al., 2010). Training methodologies play a pivotal role in

enhancing athletes' performance across sports disciplines (Tucker & Collins, 2012; Bompa & Buzzichelli, 2021; Iskakov, 2022).

Poomsae is a series of defensive and attacking movements as if the athlete is fighting with the actual opponent (Kazemi et al., 2016). It involves physical movements, breathing, cognitive process, spiritual, techniques, and character (Umoh, 2014). In sports, the role of training and systematic coaching holds a vital spot (Tucker, & Collins, 2012). High performance in sports requires systematic training to maintain physical fitness (Foran, 2001; Joyce & Lewindon, 2014). In poomsae, physical fitness is an essential element in performance (Mirmohammadi, 2017).

Physical fitness can be assessed through tests of balance, agility, and endurance (Aksen Cengizhan et al., 2019; Pate, 1983; Barber-Westin et al., 2015). Balance refers to the ability of the athlete to hold the body in a way that remains static and controlled (Kilroy et al., 2016). Agility refers to the athlete's ability to change direction rapidly or movement in body parts without hurdling the balance (Chatzopoulos et al., 2014). Endurance refers to the athlete's ability to perform tasks without experiencing significant fatigue to continue the performance (Izquierdo et al., 2002; García-Pinillos et al., 2015). Physical fitness in terms of athlete balance, agility, and endurance are critical aspects of poomsae competition (Fachrezzy et al., 2021; Kang et al., 2021). Taekwondo Poomsae training helps improve body competition, and physical fitness which is an important aspect for athletes (Lei et al., 2022). Physical fitness is directly linked with taekwondo poomsae performance (Fong & Ng, 2011; Mirmohammadi, 2017). A variety of training styles are adopted to train taekwondo practitioners ranging from traditional to innovative technology-based approaches (Na, 2009; Cui & Hu, 2022; Guo, 2022).

Training plays a crucial role in enhancing athlete performance by cultivating a balance between various abilities such as agility, endurance, and balancing skills (Baker & Cobley, 2007; Rodas, 2022). This is particularly evident in disciplines like poomsae, where athletes must demonstrate precise movements that require exceptional balancing skills, agility, and endurance (Fachrezzy et al., 2021; Kang et al., 2021). While numerous studies have examined poomsae performance and the efficacy of traditional training methodologies (Lin, 2020; Yang et al., 2018), there remains a scarcity of research on the integration of technology into poomsae training (Park & Ahn, 2016). However, the limited research available highlights the potential benefits of technological assistance in enhancing the evaluation system of poomsae (Choi & Joo, 2016). To effectively improve physical fitness and performance in poomsae, it is essential to adopt comprehensive training approaches that encompass various factors such as clear coaching, smart objectives, suitable

methods, techniques, materials, and equipment (Gabbett et al., 2006; Kraemer et al., 1988; Boullosa et al., 2020; Paul et al., 2016). Despite the importance of training methodologies, there exists a gap in the literature regarding the comparison between traditional training methods (TTM) and integrated training methods (ITM) in the context of poomsae. This gap necessitates further investigation to determine the effectiveness of different training approaches in enhancing poomsae performance.

Therefore, this study aims to address this gap by specifically focusing on comparing the effectiveness of traditional training methods (TTM) with integrated training methods (ITM) in poomsae. Based on the literature analysis, several hypotheses have been formulated to guide the research and provide insights into the optimal training approach for improving poomsae performance. By conducting a comparative analysis of traditional and integrated training methods, this study seeks to contribute to the advancement of training methodologies in poomsae and enhance the overall performance of athletes in this discipline. The role of training in developing athlete performance in terms of balancing abilities, agility, and endurance requires effective designing of training (Baker & Cobley, 2007; Rodas, 2022). Poomsae requires good balancing skills, agility, and endurance (Fachrezzy et al., 2021; Kang et al., 2021). Many studies conducted on the Poomsae performance and effectiveness of the training (Lin, 2020; Yang et al., 2018). However, the integration of technology in poomsae training is rare in the literature as the available studies only focus on traditional training methodologies and their effectiveness (Park & Ahn, 2016). Moreover, technological assistance in Poomsae provides valuable assistance to the evaluation system (Choi & Joo, 2016). Therefore, the role of training in improving physical fitness requires training (Gabbett et al., 2006; Kraemer et al., 1988). Different factors need to be considered for effective training such as clear coaching, smart objectives, methods, techniques, materials, and equipment (Paul et al., 2016; Boullosa et al., 2020). However, the use of virtual training programs' effectiveness as compared to the traditional training programs in poomsae is missing in the literature. This gap needs to be addressed therefore, we formulate this study with a specific focus on the comparison of traditional training methods (TTM) with integrated training methods (ITM). Furthermore, based on the literature analysis we have developed the following hypotheses were developed,

- Hypothesis 1: The integrated training method is more effective in developing athletes' balance as compared to the traditional training method.
- Hypothesis 2: The integrated training method is more effective in developing athletes' agility as compared to the traditional training method.

- Hypothesis 3: The integrated training method is more effective in developing athletes' endurance as compared to the traditional training method.
- Hypothesis 4: The integrated training method for Taekwondo poomsae is more effective than the traditional training method.
- Hypothesis 5: The traditional training method for Taekwondo poomsae is more effective than the integrated training method.

This study aims to evaluate training methods for Taekwondo practitioners, focusing specifically on poomsae techniques. Two sets of training approaches, traditional practices, and integrated practices, are examined to assess their effectiveness in improving Taekwondo skills (Poomsae). Poomsae involves the seamless integration of Taekwondo techniques into a pattern of moves, requiring precision and fluidity in execution.

Traditional training practices typically entail structured sessions focusing on fundamental techniques, forms, and discipline. In contrast, integrated practices incorporate innovative methods such as visual aids, technology-driven tools, personalized coaching, and a supportive training environment. By comparing the outcomes of these two approaches, the study aims to identify strategies to enhance existing training methods for young Taekwondo practitioners, ultimately improving their proficiency in poomsae. Furthermore, the study's findings aim to contribute to the ongoing evolution of training methodologies in Taekwondo, with a specific focus on enhancing poomsae techniques. By refining training methods to encompass a holistic approach addressing physical, mental, and technical aspects, young Taekwondo practitioners can elevate their performance in poomsae competitions. This research endeavor underscores the significance of continuous improvement and innovation in the realm of Taekwondo training, paving the way for the development of skilled and disciplined athletes in the sport's diverse categories.

The importance of training in sports holds a very important spot in theory and practicality (Tucker & Collins, 2012; Bompa & Buzzichelli, 2021; Iskakov, 2022) variety of training methodologies has been developed for various sports ranging from classical to modern training approaches. This study is designed to assess the training methods for Taekwondo practitioners. The study uses two sets of training approaches, traditional practices, and integrated practices to explore the effectiveness of each method. Therefore, the study aims to improve existing training methods of young taekwondo practitioners to improve Taekwondo techniques (Poomsae). Poomsae is the sequence of the Taekwondo techniques linked together into a pattern of moves (Hoang & Ahn, 2023).

Numerous studies have delved into the realm of poomsae and its efficacy in training, exemplified by research conducted by Yoo et al. (2018); Lei et al. (2022); Jeong et al. (2022). These studies have collectively contributed to a deeper understanding of poomsae performance and the various training methodologies employed within the discipline. However, despite this wealth of research, there remains a need to further refine and enhance training methodologies for poomsae practitioners.

In response to this need, the current study was meticulously designed to refine the training methodology for poomsae through the implementation of an integrated training method juxtaposed against the traditional training approach. By scrutinizing the comparative effectiveness of these two methods, this study endeavors to shed light on novel avenues for optimizing the training regimen tailored for taekwondo poomsae practitioners. Through empirical investigation and analysis, this study aims to unlock insights that will inform the development of a more efficient and targeted training approach.

The overarching goal of this research paper is to propel the evolution of training methodologies in poomsae, ultimately aiming to foster the growth and development of taekwondo poomsae practitioners. By refining and enhancing the training methods utilized within the discipline, this study aspires to equip practitioners with the tools and techniques necessary to excel in poomsae competitions. Through a meticulous examination of the effectiveness of integrated versus traditional training methods, this study aims to pave the way for the establishment of best practices in poomsae training, thereby enhancing the overall performance and proficiency of taekwondo poomsae practitioners.

2. METHODS

2.1. Participants and procedure

The Taekwondo Poomsae participants were systematically organized into two distinct groups, each comprising 15 dedicated practitioners. Over the duration of six months, from March 2023 to December 2023, Group 1 underwent a regimen of traditional training, while Group 2 immersed themselves in an integrated training approach. This comprehensive study took place at the Arena Fitness Sport Complex in Almaty, Kazakhstan, where the young practitioners, all aged between 12 and 14 years, diligently participated in their respective training programs. The assessment of their performance was meticulously executed through a series of individualized physical and technical-tactical tests, including the Jump test, Long test, and the Force- resistance test, which encompassed

evaluations such as the elbow flexion test, front-back, front-forward, side-back, side-forward, round-back, and round-forward.

Furthermore, both training methodologies focused on enhancing the critical attributes of balance, agility, and endurance in the participating athletes. In the traditional training approach, supervision and progress monitoring followed a conventional trajectory, with experts providing judgments based on physical observation. On the other hand, the integrated training method seamlessly blended traditional approaches with cutting-edge technology. The inclusion of the FitXR VR fitness app specifically designed for Meta Quest 2 marked a significant advancement in training techniques. After successfully completing the virtual reality lessons, athletes transitioned to real-world environments to practice and showcase their acquired skills, moves, and techniques. This pivotal phase was evaluated by a panel of five judges stationed around the sparring area, which consisted of an 8-meter square with a 2-meter safety zone. The assessment, conducted in two stages – pre-training and post-training, followed a stringent protocol to ensure a comprehensive and accurate evaluation of the participants' progress and performance.

In the Poomsae platform, depicted in Figure 1, there are four judges positioned at each corner, each accompanied by a recorder and a technical assistant situated 2 meters away from the platform. The platform itself is a square with dimensions measuring 8 meters by 8 meters, ensuring ample space for the competitors to execute their routines. Additionally, there is a safety area extending 12 meters beyond the edges of the platform, providing a buffer zone to minimize the risk of injury during performances.

To further facilitate the competition, the coaches representing the Red and Blue teams are strategically positioned 2 meters away from the center point of the outer line of each contestant's side. This positioning allows the coaches to effectively monitor and guide their respective competitors throughout their performances, providing real-time feedback and support as needed. Overall, the layout of the Poomsae platform is meticulously designed to ensure a fair and organized competition environment, with provisions in place to uphold safety standards and facilitate optimal performance from the participants.

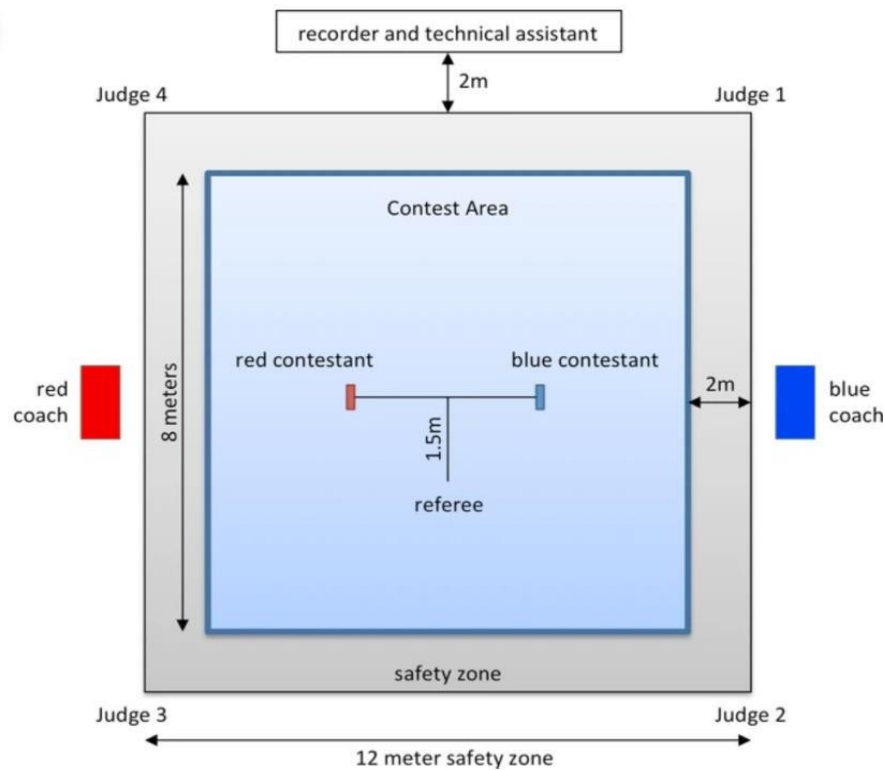


Figure 1. Taekwondo-Poomsae Square-platform

2.2. Research models

The study developed two distinct research models, each tailored to investigate the hypotheses posited in the research. Model 1 was constructed to employ regression and correlation analysis methodologies in order to evaluate the proposed hypotheses thoroughly. Through this model, the relationships between variables were meticulously examined to discern any significant associations as per the hypotheses. Meanwhile, Model 2 utilized mean values as a primary analytical tool to compare and contrast the interplay between variables within the context of the study.

Within Model 1, regression analysis was utilized as a statistical technique to explore the relationships between the independent and dependent variables outlined in the hypotheses. Additionally, correlation analysis was employed to determine the strength and direction of the relationships between the variables under investigation. This approach allowed for a comprehensive assessment of the hypotheses, enabling the researchers to discern any discernible patterns or trends within the data. On the other hand, Model 2 adopted a comparative approach by utilizing mean values to examine the association of variables in the study. By analyzing the mean values of the variables across different groups or conditions, researchers were able to discern any notable

differences or similarities in their associations. This method facilitated a nuanced understanding of how various factors interacted within the research context, offering valuable insights into the overarching hypotheses of the study. Overall, the utilization of these distinct research models enabled a multifaceted examination of the hypotheses, enhancing the comprehensiveness and depth of the study's findings.

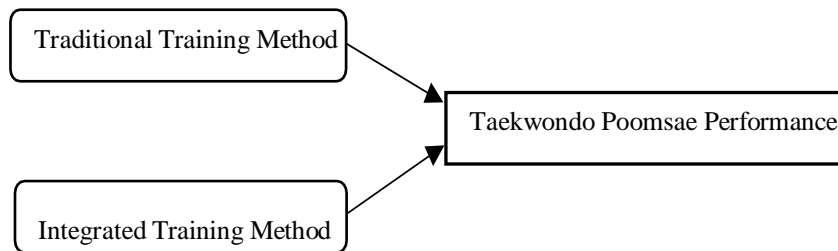


Figure 2. Research Model 1 (Hypotheses 4, 5)

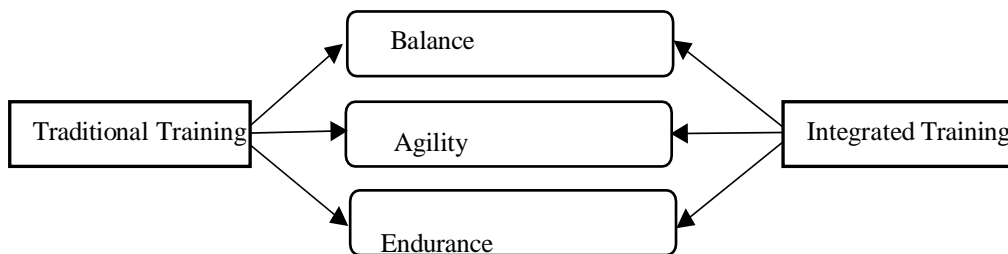


Figure 3. Research Model 2 (Hypotheses 1, 2, 3)

2.3. Instruments

All constructs and items in this study were assessed using a Likert five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Traditional Training Method (TTM) was evaluated through a self-developed scale comprising 20 items, which underwent pre-testing. Analysis using SPSS V21 yielded a Cronbach's alpha value of 0.93, indicating high internal consistency. An example item from this scale is: "I feel like I am making exceptional progress in my Poomsae skills during training." Similarly, the Integrated Training Method (ITM) was measured using a self-developed scale with 22 items, also subjected to pre-testing. The Cronbach's alpha value for this scale was calculated as 0.92, denoting strong internal reliability. An exemplar item from the ITM scale is: "I feel like I am improving my Poomsae skills significantly during training."

The Taekwondo Poomsae Performance (TPP) instrument utilized in this study was self-developed and comprised 20 items. Pre-testing was conducted, and the resulting Cronbach's alpha value was 0.91, indicating excellent internal consistency. A sample item from the TPP scale is: "The students can perform the Poomsae with outstanding coordination and fluidity." Additionally, the Balance, Agility, and Endurance (BAE) scale was self-developed and consisted of 20 items. Analysis using SPSS V21 revealed a Cronbach's alpha value of 0.92, suggesting high internal reliability. An example item from the BAE scale is: "Students were able to maintain good balance during rapid movement moves." These scales collectively provided a comprehensive assessment of the various dimensions and aspects related to the training methods and performance outcomes of young taekwondo practitioners in mastering complex formal exercises, specifically Poomsae.

2.4. Statistical analyses

All statistical analyses were performed using IBM SPSS Statistics Version 21. Descriptive statistics including mean, standard deviation, and variance were calculated to summarize the key variables. The internal consistency of the measurement instruments was evaluated using Cronbach's alpha. Pearson correlation coefficients were computed to examine the relationships between variables. Furthermore, regression analysis was conducted to assess the predictive relationship between variables. Statistical significance was set at $p < .05$.

3. RESULTS

There exists a positive association between TTM and TPP which is statistically significant ($\beta = .614$; $p=0.000$). Table 1, shows that a .614 unit increase in TTM leads to a one unit increase in dependent variable TPP. Moreover, there exists a positive and statistically significant association between ITM and TPP ($\beta = .310$; $p=0.000$). This can be interpreted as .310 units increase in ITM leads to one unit increase in TPP. Therefore, we accept Hypothesis 4 and reject Hypothesis 5. Therefore, our integrated training model is more effective in training Taekwondo-Poomsae as compared to the traditional training model of training.

Table 1. Regression analysis results between variables

Paths	Estimate	Standard Error	f-value	Mean Square	p-value	R Square
TTM \square TPP	.614	.092	53.470	9.136	0.000	.753
ITM \square TPP	.310	.050				75.3%

Note. Significance levels: *** $p < .001$; * $p < .05$; Traditional Training Method (TTM); Integrated Training Method (ITM); Taekwondo Poomsae Performance (TPP).

Table 2 presents correlations between different variables: Traditional Training Methods (TTM), Integrated Training Methods (ITM), and TPP (presumably referring to Total Poomsae Performance). Each cell in the table shows the Pearson Correlation coefficient between the respective variables.

Table 2. Pearson correlation coefficients among training methods and total poomsae performance

	TPP	ITM	TPP
TPP	1		
Pearson Correlation Sig. (2-tailed)	30		
N			
TTM	.692**	1	
Pearson Correlation Sig. (2-tailed)	.000		
N	30	30	
ITM	.819**	.554**	1
Pearson Correlation Sig. (2-tailed)	.000	.000	
N	30	30	30

Note. **: Correlation is significant at the 0.01 level (2-tailed).

The correlation coefficient between TTM and TPP is 0.692, which indicates a moderately strong positive correlation. This suggests that there is a significant relationship between the use of traditional training methods and overall poomsae performance. Similarly, the correlation coefficient between ITM and TPP is 0.819, indicating a strong positive correlation. This suggests that the use of integrated training methods is also significantly related to overall poomsae performance. Additionally, there is a correlation coefficient of 0.554 between TTM and ITM, indicating a moderate positive correlation between the two types of training methods. This suggests that there is some level of association between the use of traditional and integrated training methods. Overall, these results suggest that both traditional and integrated training methods are positively correlated with poomsae performance. Additionally, there is a moderate positive correlation between the two types of training methods. These findings imply that both traditional and integrated training methods can contribute to improved poomsae performance, and they may complement each other in training programs for taekwondo athletes.

Table 3 presents the mean scores for balance, agility, and endurance among athletes trained using Traditional Training Methods (TTM) and Integrated Training Methods (ITM). For athletes trained with TTM, the mean balance score is 2.7632, with a standard deviation of 1.95122, indicating a moderate variability in balance performance within the group. Similarly, the mean agility score for

TTM-trained athletes is 2.3421, with a standard deviation of 1.77484. The mean endurance score for this group is 3.6053, with a standard deviation of 2.23655. These values demonstrate a wide range of performance levels in agility and endurance among athletes trained with TTM.

Table 3. Descriptive statistics of balance, agility, and endurance scores under TTM and ITM training methods

		<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>Variance</i>	<i>p</i>
TTM-Traditional Training Method	Balance	30	2.7632	1.95122	3.807	<0.01
	Agility	30	2.3421	1.77484	3.150	<0.01
	Endurance	30	3.6053	2.23655	5.002	<0.01
ITM-Integrated Training Method	Balance	30	5.9474	1.91646	3.673	<0.01
	Agility	30	6.5526	1.97807	1.957	<0.01
	Endurance	30	6.2368	2.13635	4.564	<0.01

In contrast, athletes trained with ITM exhibit notably higher mean scores across all three categories. For balance, the mean score is 5.9474, with a standard deviation of 1.91646, indicating a tighter distribution of performance compared to the TTM group. The mean agility score for ITM-trained athletes is substantially higher at 6.5526, with a standard deviation of 1.97807, suggesting a more consistent and elevated level of agility within this group. Additionally, the mean endurance score for ITM-trained athletes is 6.2368, with a standard deviation of 2.13635, further demonstrating superior endurance performance compared to the TTM group.

Overall, the significance values (Sig) for all mean scores in both TTM and ITM groups are less than 0.01, indicating a statistically significant difference in performance between the two training methods across all categories. These findings provide empirical support for the effectiveness of Integrated Training Methods (ITM) in enhancing balance, agility, and endurance among athletes compared to Traditional Training Methods (TTM). Therefore, we accept Hypothesis 1, Hypothesis 2, and Hypothesis 3.

Table 4 provides a summary of the hypotheses, where it can be seen that all the hypotheses of the study were finally accepted, apart from hypothesis 5 that was rejected.

Table 4. Hypotheses summary

S/n	Hypotheses	Status
Hypothesis 1	The integrated training method is more effective in developing athletes' balance as compared to the traditional training method.	Accepted
Hypothesis 2	The integrated training method is more effective in developing athletes' agility as compared to the traditional training method.	Accepted
Hypothesis 3	The integrated training method is more effective in developing athletes' endurance as compared to the traditional training method.	Accepted
Hypothesis 4	The integrated training method for Taekwondo poomsae is more effective than the traditional training method.	Accepted
Hypothesis 5	The traditional training method for Taekwondo poomsae is more effective than the integrated training method.	Rejected

4. DISCUSSION

In the present study, the significance values for all scores in both TTM and ITM groups are less than 0.01, indicating a significant difference in performance between the two training methods across all categories. These findings provide empirical support for the effectiveness of Integrated Training Methods (ITM) in enhancing balance, agility, and endurance among athletes compared to Traditional Training Methods (TTM), which is in agreement with Fachrezzy et al. (2024), who reviewed physical training methods on Elite Taekwondo Athletes in The Kyorugi Category.

This study contributes to the existing body of knowledge by delving into the relationship between Traditional Training Method (TTM), Integrated Training Method (ITM), and Taekwondo Poomsae Performance (TPP) which is proposed in Kim (2021) based on cultural and social views. It reveals that incorporating modern technology into Taekwondo- Poomsae training methods yields more effective performance among practitioners which is specially discussed by DeMarco (2015). The traditional approaches in taekwondo training do lead to improvements in performance, the study observes that the use of integrated training methods results in twice the level of enhancement compared to TTM (Khazaei et al., 2023). Notably, ITM demonstrates a substantial positive impact on practitioners' performance in terms of balance, agility, and endurance, highlighting its efficacy over TTM.

Moreover, the research assesses the correlation between ITM and TTM with TPP, underscoring ITM's superior influence on practitioners' overall performance compared to TTM. Additionally, the study underscores the significance of balancing, agility, and endurance in bolstering performance levels.

So, by merging traditional training methods with innovative technology-driven approaches,

the study introduces a novel integrated training program that facilitates superior performance outcomes compared to traditional training methods in taekwondo (Kraemer et al., 2024). Consequently, present research contributes to the advancement of an enhanced training regimen tailored for poomsae practitioners, encompassing a comprehensive blend of traditional and technology-based methodologies. Furthermore, the study sheds light on the pivotal role of integrating technology-based training methods into traditional Taekwondo-Poomsae practices. By harnessing the potential of virtual reality (VR) in the training process, practitioners are provided with immersive and interactive learning experiences (Farooqui et al., 2023). VR simulations not only simulate real-world scenarios but also allow practitioners to visualize and practice complex movements in a controlled environment (Kraemer et al., 2024). This innovative approach not only enhances technical proficiency but also instills a sense of confidence and preparedness among practitioners when facing actual competition settings. Additionally, VR technology enables practitioners to receive real-time feedback on their performance, facilitating continuous improvement and refinement of their poomsae techniques.

Moreover, the study highlights the holistic nature of performance enhancement in Taekwondo- Poomsae, emphasizing the importance of balancing, agility, and endurance. These physical attributes are fundamental in executing precise and dynamic movements' characteristic of poomsae routines. Through a comprehensive training program that addresses these aspects, practitioners can achieve a higher level of proficiency and mastery in poomsae performance. The integration of technology-based training methods further enhances the development of these attributes by providing targeted exercises and feedback mechanisms tailored to individual needs. As a result, practitioners are better equipped to excel in the intricacies of poomsae competition, showcasing their skills with finesse and precision.

5. LIMITATIONS

The research was carried out at the Arena Sports Complex, involving a cohort of 30 male and female students aged between 12 and 14 years. Evaluation of group performance was limited to physical and technical-tactical assessments, encompassing tests such as the Jump test and Long test, as well as the Force-resistance test including elbow flexion and various directional tests (front-back, front-forward, side-back, side-forward, round-back, and round-forward). Due to the age of the participants and resource constraints, not all techniques and assessments were incorporated into the study. Additionally, the study utilized only one virtual reality application, FitXR VR fitness,

compatible with Meta Quest 2, which may limit the generalizability of the results.

6. CONCLUSIONS

In conclusion, the study represents a significant step forward in the optimization of training methods for Taekwondo-Poomsae practitioners. By exploring the efficacy of integrated training approaches that combine traditional methods with modern technology, the research provides valuable insights into enhancing performance outcomes in poomsae competitions. Through the incorporation of virtual reality and a focus on key physical attributes, practitioners are empowered to develop their skills to the fullest potential. This comprehensive approach not only advances the understanding of effective training methodologies but also contributes to the continual improvement and evolution of poomsae practices in the realm of Taekwondo.

7. RECOMMENDATIONS

In future investigations, it is recommended to expand the repertoire of training methods alongside the models utilized in this study to formulate a more comprehensive training regimen for poomsae practitioners. Furthermore, the integration of slow-motion technology could enhance the analysis of techniques and body movements, providing a deeper understanding of performance dynamics. Considering the age range of the participants in this study (12-14 years), future research endeavors could encompass diverse age groups to evaluate the efficacy of integrated training methods in fostering athletes' balancing, agility, and endurance across varying developmental stages. In summary, while the study provides valuable insights into the effectiveness of integrated training methods for poomsae practitioners within the specified age range, there are avenues for further exploration and refinement. By broadening the scope of training methods, incorporating advanced technological tools, and encompassing diverse age groups, future research endeavors can contribute to the development of more robust and tailored training programs aimed at optimizing performance outcomes in the realm of Taekwondo poomsae.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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