ORIGINAL ARTICLE
Physical Therapy Journal of Indonesia (*PTJI*) 2026, Volume 7, Number 1: 185-192
E-ISSN : 2722-6034 ; P-ISSN : 2722-0125

Influence of physical education learning models on flexibility recovery and functional mobility in martial arts

Fahmy Fachrezzy[1*], Uzizatun Maslikah[1], Hernawan[1], Made Bang Redy Utama[1], Muhammad Gilang Ramadhan[1], Sri Indah Ihsani[1], Ayu Purnama Wenly[1], Saipulloh Ibrahim[1]

[1]Faculty of Sports Science and Health, Universitas Negeri Jakarta, Indonesia

[*]Corresponding author: Fahmy Fachrezzy, Faculty of Sports Science and Health, Universitas Negeri Jakarta, Indonesia; fahmyfachrezzy@unj.ac.id

Received: 2025-10-24
Accepted: 2026-02-20
Published: 2026-05-28

ABSTRACT

Background: Flexibility and functional mobility are two important parts of Taekwondo performance. It is thought that new ways of teaching will help athletes recover faster and move better. The purpose of this study was to determine how a Sports Education-based learning model combined with active recovery affected the recovery of flexibility and functional mobility in Taekwondo athletes.

Methods: This study was a quasi-experimental study using a pre-test and post-test control group design. Twenty-eight Taekwondo athletes (aged 16 to 20) were divided into two groups. The experimental group using a sports education model with active recovery, and the control group using regular training. The intervention lasted six weeks. The sit-and-reach test and the shoulder-wrist test were used to measure flexibility during the acute and chronic phases. Functional movement screening (FMS) and the multidirectional kick height test were used to assess functional mobility.

Results: Multivariate analysis of variance (MANOVA) showed that there were big differences between the groups ($p<0.05$). The experimental group showed faster recovery of flexibility after exercise, bigger improvements in FMS scores, especially in the active straight leg raise and rotary stability components, and big increases in kicking height and accuracy.

Conclusion: The sport education model with active recovery speeds up the recovery of flexibility and improves the functional mobility of Taekwondo athletes. This makes it a good suggestion for developing training programs.

Keywords: flexibility recovery; functional mobility; sport education; taekwondo.

Cite This Article: Fachrezzy, F., Maslikah, U., Hernawan, Utama, M.B.R., Ramadhan, M.G., Ihsani, S.I., Wenly, A.P., Ibrahim, S. 2026. Influence of physical education learning models on flexibility recovery and functional mobility in martial arts. *Physical Therapy Journal of Indonesia* 7(1): 185-192. DOI: 10.51559/ptji.v7i1.402

INTRODUCTION

Taekwondo is a martial art that people all over the world compete in. To be good at it, you need to know a lot of complicated moves, especially when it comes to the fast, dynamic, and varied kicking elements (chagi).[1,2,3] Two important physical traits that are very important for the technique to work well are flexibility and functional mobility. The amplitude and range of the kick depend on how flexible the pelvic and leg muscles are.[4,5,6,7] Functional mobility, on the other hand, is the combination of flexibility, strength, stability, and neuromuscular control that allows for efficient, safe, and specific movements based on the situation of the match or poomsae.[8,9,10,11]

Taekwondo athletes often lose a lot of flexibility after hard training sessions because their muscles are tired and they have too many metabolites in their bodies. This flexibility recovery process could make you more likely to get hurt (like a hamstring or hip strain) and make it harder to do well in future training sessions if it's not done correctly.[12,13,14] Sadly, traditional methods of teaching or training in physical education and taekwondo coaching often put more emphasis on repeating techniques, tactics, and physical conditioning than on systematic and integrated strategies for flexibility recovery.

People often do cool-downs in a boring way, with passive static stretching, without thinking about the principles of specificity and the load the athlete just went through. This is where new ways of teaching physical education can give us a new way of looking at things. Models like sports education are meant to make learning real, get students more involved, and make them more responsible for the whole training process.[15,16] This model could serve as a framework for incorporating active recovery activities like dynamic stretching, myofascial release, or PNF as essential components of the learning cycle.[17,18] By placing athletes in a more active role (as coaches, managers, or referees) within the context of the Training "season," it is hoped that their awareness of the importance of recovery and functional mobility will increase, which in turn will accelerate the physical adaptation process.[19-23]

However, the extent to which the application of the learning model is specifically effective in speeding up the recovery of flexibility and increasing the functional mobility of taekwondo athletes is still not widely explained in the literature. Most research on recovery focuses on passive methods or purely physiological interventions, not from a pedagogical perspective. Therefore, this study aims to test the effect of implementing a sports education learning model integrated with an active recovery module on these two variables. This study aims to furnish empirical evidence and pragmatic recommendations for coaches, physical education instructors, and martial arts practitioners in enhancing training programs that not only elevate technical proficiency but also preserve musculoskeletal health and expedite the athlete's recovery process.

METHODS

Study design

This study utilized a quasi-experimental pre-test and post-test control group design to investigate the impact of various physical education (PE) learning models on flexibility recovery and functional mobility among martial arts athletes. Participants were divided into two parallel groups: an experimental group utilizing a sport education-based learning model combined with active recovery and a control group adhering to a traditional learning model featuring static cooldown. We took outcome measures at the beginning of the study, during certain acute recovery phases, and after the intervention was over.

Setting for the study and length of the intervention

The intervention took place at the Gymnasium of Universitas Negeri Jakarta (UNJ), specifically within the Taekwondo High-Performance Sports Club, Faculty of Sports Science and Health UNJ, Indonesia. The program went on for eight weeks, with three 90-minute training sessions each week. To keep ecological validity, all of the intervention sessions were added to the athletes' regular Taekwondo training schedule.

Participants

The study population comprised all active student-athletes enrolled in KOP Taekwondo FIKK UNJ (n=40). Participants were selected through purposive sampling according to specific inclusion criteria: active undergraduate at FIKK UNJ, at least one year of continuous Taekwondo training within KOP, belt rank between blue and black, no severe musculoskeletal injury in the past three months, and willingness to engage in all study procedures, as evidenced by written informed consent. A total of 30 participants satisfied the eligibility criteria and were subsequently allocated to either the experimental group (n=15) or the control group (n=15) through a computerized randomization procedure.

Group allocation and intervention fidelity

Participants were assigned in a 1:1 ratio through computer-generated simple random assignment to experimental (n=15) and control (n=15) groups. To maintain intervention fidelity, training frequency, session duration, and core Taekwondo training components (warm-up, technical drills, and sparring exposure) were standardized across groups; the principal distinction lay in the learning model and recovery strategy employed during the recovery phase. Attendance was tracked, and participants had to finish at least 85% of the sessions to be included in the final analysis. **Figure 1** shows the overall design of the study and the flow of the intervention.

Intervention protocol

Table 1 shows a brief comparison of how the groups' sessions are structured. The experimental group incorporated sport education components (contextual learning, structured roles, and authentic performance tasks) alongside a 20-minute guided active recovery module, which included dynamic stretching, partner-assisted proprioceptive neuromuscular facilitation (PNF), and self-myofascial release (SMR). **Table 2** shows the detailed structure of the experimental condition's sessions, and **Table 3** shows the weekly program's progress. The control group adhered to a traditional model that focused on coach-led direct instruction and massed practice, concluding with a 10-minute static cooldown routine. The established session structure for the control condition is delineated in **Table 4**.

Outcome Measures

Flexibility was assessed using standardized field test targeting key joint-muscle complexes relevant to Taekwondo performance: sit-and-reach test (lumbar spine and hamstring flexibility) and shoulder-wrist flexibility test (shoulder girdle and anterior chain flexibility). Flexibility measurements were obtained at three time points: (1) baseline-pretest, prior to the intervention; (2) acute post-test, immediately following a high-load training session at weeks 1,4, and 8; (3) post-intervention-posttest, conducted 24 hours after the final training season. Acute flexibility recovery was operationalized as the change between pre- and immediate post-session values, while program-level outcomes were derived from post-intervention scores.

General functional mobility was evaluated using the functional movement screening (FMS), consisting of seven movement patterns: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raises, trunk stability push-up, and rotary stability. We used the composite FMS score as a measure of the quality of all the movements. A sport-specific test battery was used to measure taekwondo-specific functional mobility. The tests were (1) the Active Kick Height Test, which measured the highest controlled height of yeop chagi and dollyo chagi; (2) the Dynamic Balance Test, which measured post-kick stability using a force plate if one was available or a validated field alternative (the modified Y-balance test); and (3) the Speed and Accuracy Kick Test, which counted the number of controlled ap chagi delivered to a target within 10 seconds.

Measurement reliability

All assessments were carried out by trained evaluators adhering to standardized testing protocols. Before collecting data, assessors went through sessions to get to know the tools and calibrate them. A pilot reliability assessment was performed on a subsample of participants, utilizing intraclass correlation coefficients (ICC) and standard error of measurement (SEM) to evaluate measurement consistency, demonstrating acceptable reliability across all outcome variables.

Data analysis

We used SPSS version 28.0 to do the statistical analyses. The Shapiro-Wilk test and Levene's test were used to check the assumptions of normality and homogeneity of the data. We used multivariate analysis of variance (MANOVA) to look at the differences between groups on several dependent variables. The significance level was set at $\alpha = 0.05$. When substantial effects were detected, post-hoc analyses were performed to investigate intergroup disparities for each outcome variable. We used a paired-samples t-test to look at changes between the pretest and posttest within each group. We used effect sizes to add to the inferential statistics. For MANOVA results, we used partial eta squared ($\eta 2p$), and for comparisons within groups, we used Cohen's d. When it was appropriate, 95% confidence intervals were given.

RESULTS

Table 5 shows a total of thirty individuals were split equally between an experimental group ($n = 15$) and a control group ($n = 15$). Age, height, body mass, body mass index, training experience, flexibility, and overall Functional Movement Screening (FMS) score were among the baseline parameters that did not differ statistically significantly between the two groups ($p > 0.05$). This homogeneity shows that both groups were well matched before the intervention, creating a trustworthy baseline for assessing how physical education learning models affect functional mobility and flexibility recovery.

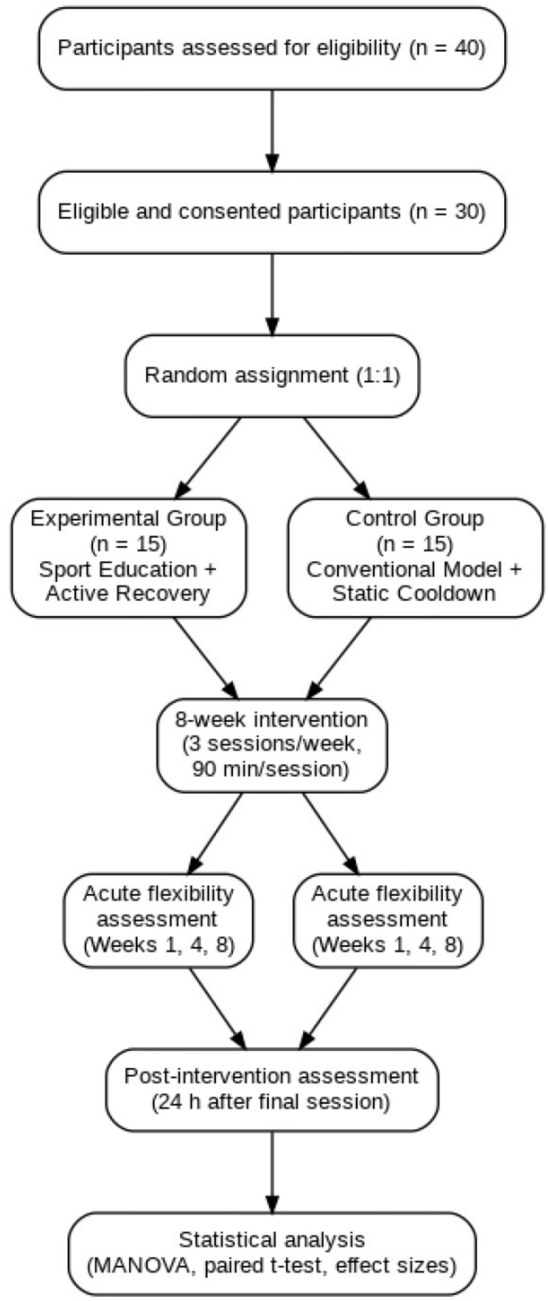

Figure 1. Study design and intervention flow

Table 1. Comparison of training session structure between groups

Session Component	Experimental Group	Control Group
Total duration	90 minutes	90 minutes
Learning model	Sport Education model (student-centered contextual learning with structured roles)	Direct instruction/command-based model (coach-centered)
Flexibility & recovery	Integrated as a core component (20-minute active recovery module)	Static cooldown performed as end routine (10 minutes)
Primary emphasis	Learning through modified games, internal competition, and body awareness	Technical repetition, physical conditioning, and task compliance

Table 6 shows recovery @:/]_right after high-load training sessions at weeks 1, 4, and 8. At baseline and in the first week of the intervention, there were no significant differences in post-acute sit and reach scores between the groups (p>0.05). Nonetheless, substantial inter-group differences were noted at week 4 (p=0.008) and week 8 (p=0.001), with the experimental group exhibiting superior post-acute flexibility scores relative to the control group. These results indicate that different groups had different responses to acute flexibility during the intervention.

Table 7 shows how the scores for the FMS components and the total FMS scores changed. Within-group analyses revealed substantial pre-post enhancements across all seven FMS components in the

Table 2. **Detailed session structure for experimental group (90 minutes)**

Time	Phase	Activities	Pedagogical and Physiological Objectives
0-15 min	Preparation & warm-up	Dynamic stretching and games-based low-intensity activities	Increase core temperature, dynamic mobility, and early engagement
15-65 min	Contextual learning phase	Conditional games, simulated matches (scrimmages), and team-based video analysis	Develop technical and tactical skills in authentic performance contexts
65-85 min	Guided active recovery module	Dynamic stretching (5-8 min); partner-assisted PNF stretching (7-10 min); self-myofascial release (SMR) (≈5min)	Facilitate acute flexibility recovery, enhance joint range of motion, reduce myofascial tension
85-90 min	Reflection & closure	Structured reflection and session summary	Promote self-regulation and metacognitive awareness of training processes

Table 3. **Weekly program structure for the experimental group**

Phase (Week)	Learning focus	Example core activities	Active recovery composition
Pre-season (Weeks 1-2)	- Team formation - Role familiarization - Fundamental movement patterns	- Game-based stance drills - Partner feedback kicking - Paired poomsae simulations	- Dynamic stretching (7 min) - PNF (hamstring, psoas) (8 min) - Foam rolling (calves, quadriceps, hamstring) (5 min)
Regular season-Development (Weeks 3-5)	- Complex techniques - Basic tactics in competitive contexts	- Conditional sparring - Team-based poomsae competition - Technical circuit drills	- Dynamic stretching (5 min) - PNF (+shoulders, adductors) (10 min) - SMR using ball (plantar fascia, gluteals) (5 min)
Regular season-Application (weeks 6-7)	- High-intensity application - Tactical optimization	- Internal round-robin tournament - Video-based feedback - Interval kicking drills	- Multi-joint mobility flow (8 min) - PNF (rotational patterns) (7 min) - SMR with diaphragmatic breathing (5 min)
Post-season (Week 8)	- Performance peak - Evaluation - Transition	- Championship simulation - Performance review	- Full recovery module (20 min) combining all recovery techniques with emphasis on autonomic downregulation

PNF, proprioceptive neuromuscular facilitation; SMR, self-myofascial release

Table 4. **Fixed session structure for the control group**

Time	Phase	Activities	Instructional Approach
0-15 minutes	Warm-up	Jogging, skipping, and basic static stretching (15-20 s holds)	Coach-led direct instruction
15-65 minutes	Main training	Isolated techniques drills, poomsae repetition, step sparring, and physical conditioning exercises	Command-based instruction and massed practice
65-85 minutes	Cooldown	Passive static stretching (30 s holds x 2 repetitions per muscle group); no partner-assisted or SMR components	Self-directed with general supervision
85-90 minutes	Closure	Coach announcements	One-way communication

experimental group (all p<0.05). The most significant enhancements were noted in the in-line lunge, active straight leg raises, and rotary stability components. Conversely, the control group did not demonstrate significant pre-post variations in any individual FMS component or in the overall FMS scores (all p > 0.05). The comparison of changes in total FMS scores showed that the experimental group did much better than the control group.

Table 8 shows the results of the Taekwondo-specific functional mobility tests. All performance indicators in the experimental group showed significant improvements from before to after the experiment. These included dollyo chagi kick height, yeop chagi kick height, kick accuracy, and dynamic balance (all p<0.05). There was a big change in dollyo chagi kick height in the control group (p=0.041), but changes in yeop chagi kick height, kick accuracy, and dynamic balance were not statistically significant (p>0.05).

Table 9 shows a summary of the results of the multivariate analysis. MANOVA test showed that the group had a significant main effect on the combined dependent variables (Pillai's Trace = 0.085, p < 0.001), which means that there were overall

Table 5. Baseline characteristics of participants in both experimental and control groups

Variable	Experimental group (n=15) Mean ± SD	Control group (n=15) Mean ± SD	*p*-value
Age, years	18.93 ± 1.16	19.20 ± 1.08	0.521[a]
Height, cm	172.40 ± 5.67	170.87 ± 4.95	0.432[a]
Body mass, kg	65.73 ± 6.84	67.20 ± 5.91	0.549[a]
Body mass index, kg/m^2	22.12 ± 1.85	22.98 ± 1.42	0.158[a]
Training experience, years	3.47 ± 1.06	3.80 ± 1.15	0.714[a]
Flexibility, cm	14.2 ± 3.1	13.8 ± 2.9	0.714[a]
Total FMS score	13.5 ± 1.8	13.1 ± 1.6	0.512[a]

Cm, centimetre; FMS, functional movement screening; kg, kilogram; kg/m², kilogram per meter squared; SD, standard deviation;
[a], independent t test

Table 6. Acute flexibility recovery

Measurement time	Experimental Group Mean ± SD	Control Group Mean ± SD	Difference Mean ± SD	p-value
Pre-test (baseline), cm	14.2 ± 3.1	13.8 ± 2.9	+0.4	0.714
Post-acute Week 1, cm	12.1 ±2.8	10.5 ± 3.0	+1.6	0.132
Post-acute Week 4, cm	13.8 ± 2.5	10.8 ± 2.7	+3.0	0.008
Post-acute Week 8, cm	15.0 ± 2.3	11.2 ± 2.6	+3.8	0.001

Cm, centimetre; SD, standard deviation

Table 7. Changes in general functional mobility

FMS Component (Maximum Score)	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Δ Changes	p-value (Δ)
Deep Squat (3)	Experimental	1.9 ± 0.5	2.6 ± 0.5	+0.7	0.002
	Control	1.8 ± 0.6	2.0 ± 0.6	+0.2	0.312
Hurdle Step (3)	Experimental	1.7 ± 0.7	2.5 ± 0.5	+0.8	0.001
	Control	1.6 ± 0.5	1.9 ± 0.6	+0.3	0.185
In-Line Lunge (3)	Experimental	1.8 ± 0.6	2.7 ± 0.5	+0.9	0.000
	Control	1.7 ± 0.6	2.0 ± 0.6	+0.3	0.221
Active Straight Leg Raise (3)	Experimental	2.0 ± 0.6	2.8 ± 0.4	+0.8	0.000
	Control	1.9 ± 0.7	2.1 ± 0.6	+0.2	0.408
Shoulder Mobility (3)	Experimental	2.1 ± 0.6	2.6 ± 0.5	+0.5	0.012
	Control	2.0 ± 0.5	2.2 ± 0.6	+0.2	0.275
Trunk Stability Push-Up	Experimental	1.9 ± 0.7	2.5 ± 0.5	+0.6	0.005
	Control	1.8 ± 0.6	2.0 ± 0.6	+0.2	0.334
Rotary Stability (3)	Experimental	1.6 ± 0.5	2.4 ± 0.5	+0.8	0.000
	Control	1.5 ± 0.6	1.7 ± 0.6	+0.2	0.297
Total FMS (21)	Experimental	13.5 ± 1.8	18.1 ± 1.5	+4.6	0.000
	Control	13.1 ± 1.6	14.0 ± 1.8	+0.9	0.142

FMS, functional movement screening; SD, standard deviation differences between the experimental and control groups. Furthermore, a significant group x time interaction effect was identified (Wilks' Λ=0.215, p<0.001), indicating that temporal changes varied significantly between groups regarding the combined outcomes of flexibility recovery and functional mobility.

Table 8. Taekwondo-specific functional mobility outcomes

Specific test	Group	Pre-test Mean ± SD	Post-test Mean ± SD	% improvement	*p*-value
Dollyo Chagi Kick Height (cm)	Experimental	142.3 ± 8.5	158.7 ± 7.2	+11.5%	0.000
	Control	140.8 ± 9.1	147.5 ± 8.4	+4.8%	0.041
Yeop Chagi Kick Height (cm)	Experimental	138.5 ± 7.9	155.2 ± 6.8	+12.1%	0.000
	Control	137.2 ± 8.3	143.1 ± 7.9	+4.3%	0.052
Kick Accuracy (repetitions/10 s)	Experimental	12.6 ± 1.5	15.8 ± 1.2	+25.4%	0.000
	Control	12.3 ± 1.7	13.2 ± 1.5	+7.3%	0.121
Dynamics Balance Score (0-100)	Experimental	78.4 ± 6.1	89.7 ± 4.8	+14.4%	0.000
	Control	77.1 ± 5.8	80.3 ± 5.5	+4.2 %	0.096

Cm, centimetre; S, seconds; SD, standard deviation

Table 9. Summary of hypothesis testing with multivariate analysis of variance (MANOVA)

Effect	Test Statistic	value	*p*-value	Conclusion
Group effect (experimental vs control)	Pillai's Trace	0.856	0.000	Significant multivariate difference between groups
Group x Time interaction	Wilks' Lambda	0.214	0.000	Significant differential changes over time between groups.

DISCUSSION

This study aims to analyze the influence of the sports education learning model integrated with the active recovery module on the recovery of flexibility and functional mobility in Taekwondo students at FIKK UNJ. The results of the study consistently showed that the experimental group receiving the treatment experienced significant and greater improvements in all dependent variables compared to the control group. This finding supports the research hypothesis that the innovative, holistically designed learning model is not only effective in the context of skills learning, but also in optimizing physiological adaptation, particularly recovery and mobility. This is in line with evidence that SEM tends to improve the quality of the learning experience through a more structured season, roles/ responsibilities, and social engagement compared to conventional learning.[24]

Effectiveness of the integrated model in accelerating acute flexibility recovery. The results show that the experimental group had faster flexibility recovery (sit and reach) after strenuous exercise, with the difference becoming increasingly significant between weeks 4 and 8. At week 8, the experimental group's flexibility even exceeded baseline immediately after strenuous exercise, while the control group remained significantly below baseline. This phenomenon can be explained by several mechanisms. First, the structured active recovery module (combined dynamic stretching, PNF, and SMR) physiologically contributes to increased ROM and tissue flexibility by increasing local temperature/ circulation and decreasing soft tissue stiffness. Meta-analytic evidence suggests that foam rolling and stretching generally have a positive impact on ROM, with effects varying depending on duration and protocol.[25,26] In addition, the mechanistic basis of PNF (e.g. autogenic/reciprocal inhibition and changes in strain tolerance) has been widely described in scientific studies.[27]

Second, the sport education approach creates a collaborative learning environment where partner-assisted PNF is performed with high awareness and precision. Social interaction and accountability within the partner enhance the quality of stretching technique execution and adherence to recovery procedures. In general, DOMS literature indicates that post-exercise recovery strategies (including stretching, massage, and other methods) can influence pain perception and functional recovery, although their effectiveness depends on the type of intervention and timing of its implementation.[28] These findings are also supported by studies comparing recovery modalities (e.g., foam rolling vs. static stretching) on neuromuscular and perceptual parameters after intense exercise and journal reviews comparing several recovery interventions to relieve DOMS.[29,30]

The overall improvement in general functional mobility (FMS), with a 4.6-point increase in the experimental group's total FMS score, is a crucial finding, given that low FMS scores are often associated with increased injury risk in athletes, although evidence of the FMS-injury relationship is not always consistent across populations. Meta-analyses of journals indicate controversy about the predictive power of FMS for injury, so interpretation of scores should be cautious and context-based.[31,32]

The highest improvements were seen in the in-line lunge (+0.9), rotary stability (+0.8), active straight leg raise (+0.8), and hurdle step (+0.8) components. These components are directly related to taekwondo movement patterns. In-line lunge reflects dynamic stability in stance and transition; rotary stability measures core control during rotational movements that are dominant in roundhouse kicks; while active straight leg raise and hurdle step relate to flexibility and hip motor control for high kicks.

These improvements are supported by two pillars of intervention. The first pillar is an active recovery module that specifically targets increasing active range of motion (ROM) and motor control, not just passive flexibility. The second pillar is a sport education learning design rich in games and simulations. Activities such as conditional sparring and tag games with varying stances force athletes to continuously move through various functional movement patterns under time pressure and tactical decisions. In general, neuromuscular training and exercises that demand motor control contribute to improvements in fitness/performance components (strength, balance, and coordination) that theoretically support movement efficiency and stability during complex tasks.[33] In the context of taekwondo, some evidence also suggests that certain warm-up/preparation protocols (including variations of foam rolling with vibration) may influence performance and flexibility/tendency speed-related parameters in elite taekwondo athletes.[34]

Positive transfer to taekwondo-specific functional mobility, the most important practical result being significant improvements in all taekwondo-specific tests. Increases in kick height (dollyo chagi and yeop chagi) by over 11% and kick accuracy by 25.4% in the experimental group indicate that improvements in general FMS successfully transfer into improved technical performance. This can be explained by the principle of adaptation specificity. The active recovery module and core sessions in the sports education model are designed with movement patterns highly relevant to taekwondo requirements (e.g., PNF for the hamstring-hip complex pattern in high kicks). Furthermore, the sports education environment, which emphasizes exploration and internal competition, allows athletes to practice applying their increased ROM and stability in situations close to real competition, thereby strengthening specific muscle-motor connections.[35] In contrast, the minimal improvement in the control group suggests that conventional training with a static cool-down is not a sufficient stimulus to create the neuromuscular adaptations needed to significantly improve functional mobility.

This study has several limitations. First, the sample size was limited to Taekwondo students at the Universitas Negeri Jakarta, Indonesia, with intermediate to advanced skill levels, so generalization to junior or elite athletes requires caution. Second, although training intensity was monitored, control for physical activity outside the program, such as independent training, was not rigorous. Based on these limitations, future research suggests for replication with a broader population and a variety of other martial arts, adding biochemical measurements (such as creatine kinase/CK levels) or objective muscle strength measurements (myotonometry) to complement recovery data, and conducting a follow-up study to assess retention of improvements in functional mobility after the intervention program is discontinued.

CONCLUSION

Based on the discussion above, it can be said that the Sport Education learning model combined with an active recovery module has been shown to be better than the traditional model at helping student athletes recover from acute flexibility problems and improving their general and Taekwondo-specific mobility. This effectiveness is due to the combination of the physiological benefits of active recovery and the educational benefits of a learning environment that is relevant, collaborative, and meaningful.

ETHICAL APPROVAL

The protocol received approval from the institutional ethics committee of Universitas Negeri Jakarta, Indonesia (approval number: 73/UN39.14/PT.01.05/1/2026). All participants gave written informed consent, and privacy was protected during the data collection and analysis.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

FUNDING

No specific funding was received for this study from public, commercial, or not-for-profit funding agencies.

AUTHOR CONTRIBUTIONS

FF designed the study, collected data, processed it, and wrote the manuscript. UM, MBRU, MGR, SII, APW, and SI collected data and revised the manuscript.

REFERENCES

1. Sousa J, Puerto JM, Beltrán VH, Louro H, Godoy SJ. Effective techniques analysis in taekwondo: A systematic review. Retos: nuevas tendencias en educación física, deporte y recreación. 2024(53):78-90.
2. Avramov D, Grigorova S. Investigation of the speed of the individual movement and the specific motor reaction in taekwondo. InT., Iancheva, S., Djobova, M., Kuleva, Proceeding book of the International Scientific Congress "Applied Sports Sciences 2022 Dec 2 (Vol. 1, pp. 127-132).
3. Kurniawan R, Daryanto ZP, Rahmat A. The Effect of Physical Training on Increasing Kick Speed in Taekwondo Athletes. Competitor: Jurnal Pendidikan Kepelatihan Olahraga: Universitas Negeri Makassar. 2024;16(3):570.
4. Orellana-Lepe G, Warnier-Medina A, Olivares-Fernández P, Aguilar-Gajardo S, Olivares-Arancibia J, Sepulveda RA. Efecto agudo del entrenamiento con vibraciones de cuerpo completo sobre la patada circular en atletas de Taekwondo (Acute effect of whole-body vibration training on the roundhouse kick in Taekwondo athletes). Retos. 2023 Mar 31;48:667-73.
5. Lugmaña LG, Bonilla MV. La flexibilidad como factor predominante para mejorar la ejecución de las técnicas altas del taekwondo. MENTOR: Revista de Investigación Educativa y Deportiva. 2024;3(9):972-85.
6. Civan AH, Uzun ME, Bezci Ş, Yayvan E, Şahin M, Köktaş E, Doğan İ. Taekwondo Sporcularının Esneklik Dikey Sıçrama ve Denge Performanslarının İncelenmesi. Mediterranean Journal of Sport Science. 2025 Sep 9;8(3):465-77.
7. Ölmez C, Aydemir B, Ölmez SN. Taekwondo tekme performansını etkileyen faktörlerin belirlenmesi. Mediterranean Journal of Sport Science. 2022 Jun 6;5(2):192-209.

8. Lia CG, Greco F, Muscari MA, Spadafora M, Chiodo S, Emerenziani GP, Quinzi F. Increased Functional Mobility in Healthy Elderly Individuals After Six Months of Adapted Taekwondo Practice. Applied Sciences. 2025 Aug 13;15(16):8932.
9. Barramuño-Medina M, Aravena-Sagardia P, Valdés-Badilla P, Hernandez-Martinez J, Espinoza-Palavicino T, Sandoval C, Gálvez-García G. Neuromuscular Strategies in Novice and Advanced Taekwondo Athletes During Consecutive Roundhouse Kicks. Applied Sciences. 2025 Jul 27;15(15):8356.
10. Barramuño-Medina M, Aravena-Sagardia P, Valdés-Badilla P, Hernandez-Martinez J, Espinoza-Palavicino T, Sandoval C, Gálvez-García G. Neuromuscular Strategies in Novice and Advanced Taekwondo Athletes During Consecutive Roundhouse Kicks. Applied Sciences. 2025 Jul 27;15(15):8356.
11. Fachrezzy F, Maslikah U, Hermawan I, Jariono G, Nugroho H. Physical training methods to improve the physical condition components of elite Taekwondo athletes in the Kyorugi category: A systematic review. Physical Education Theory and Methodology. 2024 Oct 30;24(5):829-41.
12. Kurt C, Gürol B, Nebioğlu İÖ. Effects of traditional stretching versus self-myofascial release warm-up on physical performance in well-trained female athletes. Journal of musculoskeletal & neuronal interactions. 2023;23(1):61.
13. Heiderscheit BC, Sherry MA, Silder A, Chumanov ES, Thelen DG. Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. journal of orthopaedic & sports physical therapy. 2010 Feb;40(2):67-81.
14. Opar DA, Williams MD, Shield AJ. Hamstring strain injuries. Sports medicine. 2012 Mar;42(3):209-26.
15. Schiff NT, Supriady A. Sports education model (SEM) on students' motivation and physical activity in classroom: A literature review. Jurnal SPORTIF: Jurnal Penelitian Pembelajaran. 2023 Mar 25;9(1):40-58.
16. JAbellán J, Segovia Y. Aprendiendo a enseñar mediante el modelo de Educación Deportiva en centros de educación especial: de la teoría a la práctica (Learning to teach through the Sport Education model in special schools: from theory to practice). Retos. 2024 Oct 2;59:138-45.
17. Mantilla JI. Construyendo un marco en el desarrollo y creación de circuitos funcionales en el deporte de alto rendimiento una visión desde la fisioterapia: un estudio de reflexión. riccafd: Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte. 2020;9(3):74-90.
18. Ivan F. Developing Personalized Recovery Strategies for Athletes: Methods and Approaches. American Journal of Sports Science. 2023;11(2):50.
19. Civan AH, Uzun ME, Bezci Ş, Yayvan E, Şahin M, Köktaş E, Doğan İ. Taekwondo Sporcularının Esneklik Dikey Sıçrama ve Denge Performanslarının İncelenmesi. Mediterranean Journal of Sport Science. 2025 Sep 9;8(3):465-77.
20. Yaşar S, Tutar M, Kale M. 13-18 Yaş Aralığındaki Taekwondo Sporcularında Dinamik ve Propriyoreseptif Nöromüsküler Fasilitasyon (PNF) Egzersizlerinin Esnekliğe Etkisinin Karşılaştırılması. GSI Journals Serie A: Advancements in Tourism Recreation and Sports Sciences. 2024 Feb 2;7(1):177-87.
21. Arjang N, Mohsenifar H, Amiri A, Dadgoo M, Rasaeifar G. The acute effect of static versus proprioceptive neuromuscular facilitation stretching combined with kinesiology taping® of hamstring muscles on functional tests in adolescent taekwondo athletes. Türk Fizyoterapi ve Rehabilitasyon Dergisi. 2023 Apr 4;34(1):21-8.
22. Lugmaña LG, Bonilla MV. La flexibilidad como factor predominante para mejorar la ejecución de las técnicas altas del taekwondo. MENTOR: Revista de Investigación Educativa y Deportiva. 2024;3(9):972-85.
23. Chinchey Ttito JA, Garavito Marrou HA. ESTRATEGIAS DE RECUPERACIÓN POST-ENTRENAMIENTO QUE REALIZAN LOS DEPORTISTAS DE LAS SELECCIONES DE KARATE, TAEKWONDO, JUDO Y WUSHU DE UNA UNIVERSIDAD PRIVADA DE LIMA, PERÚ.
24. Zhang J, Xiao W, Soh KG, Yao G, Anuar MA, Bai X, Bao L. The effect of the Sport Education Model in physical education on student learning attitude: a systematic review. BMC public health. 2024 Apr 2;24(1):949.
25. Akbar S, Soh KG, Jazaily Mohd Nasiruddin N, Bashir M, Cao S, Soh KL. Effects of neuromuscular training on athletes physical fitness in sports: A systematic review. Frontiers in physiology. 2022 Sep 23;13:939042.
26. Kurt C, Gürol B, Nebioğlu İÖ. Effects of traditional stretching versus self-myofascial release warm-up on physical performance in well-trained female athletes. Journal of musculoskeletal & neuronal interactions. 2023;23(1):61.
27. Hindle KB, Whitcomb TJ, Briggs WO, Hong J. Proprioceptive neuromuscular facilitation (PNF): Its mechanisms and effects on range of motion and muscular function. Journal of human kinetics. 2012 Apr 3;31:105.
28. Cheung K, Hume PA, Maxwell L. Delayed onset muscle soreness. Sports medicine. 2003 Feb;33(2):145-64.
29. De Oliveira F, Paz GA, Corrêa Neto VG, Alvarenga R, Marques Neto SR, Willardson JM, Miranda H. Effects of different recovery modalities on delayed onset muscle soreness, recovery perceptions, and performance following a bout of high-intensity functional training. International journal of environmental research and public health. 2023 Feb 16;20(4):3461.
30. Wei M, Liu X, Wang S. The impact of various post-exercise interventions on the relief of delayed-onset muscle soreness: a randomized controlled trial. Frontiers in physiology. 2025 Aug 4;16:1622377.
31. Trinidad-Fernandez M, Gonzalez-Sanchez M, Cuesta-Vargas AI. Is a low Functional Movement Screen score (≤ 14/21) associated with injuries in sport? A systematic review and meta-analysis. BMJ open sport & exercise medicine. 2019 Sep 18;5(1).
32. Kollock RO, Lyons M, Sanders G, Hale D. The effectiveness of the functional movement screen in determining injury risk in tactical occupations. Industrial health. 2019;57(4):406-18.
33. Akbar S, Soh KG, Jazaily Mohd Nasiruddin N, Bashir M, Cao S, Soh KL. Effects of neuromuscular training on athletes physical fitness in sports: A systematic review. Frontiers in physiology. 2022 Sep 23;13:939042.
34. Chen AH, Chiu CH, Hsu CH, Wang IL, Chou KM, Tsai YS, Lin YF, Chen CH. Acute effects of vibration foam rolling warm-up on jump and flexibility asymmetry, agility and frequency speed of kick test performance in taekwondo athletes. Symmetry. 2021 Sep 9;13(9):1664.
35. Paulauskas R, Pundzevicius V, Figueira B. Effects of eight weeks incremental elastic resistance training on roundhouse kick quality and physical performance in Taekwondo athletes in a randomized controlled trial. Scientific reports. 2025 Apr 29;15(1):15054