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Effects of Changes in the Taekwondo Competition System on Match and Training Load: A Longitudinal Analysis Across 2021–2023

tuğçe yeşilçimen
Gedik University
Ahmet Talha ÖZTÜRK
İstanbul Esenyurt Üniversitesi
Ebrar Şevval COŞKUN
sevval.coskun@gedik.edu.tr

Gedik University
Sinan BOZKURT
Marmara University

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Abstract

This study examined the effects of the World Taekwondo competition system revision introduced in 2022 on the technical–tactical behaviors, match load, rating of perceived exertion (RPE), kicking force, and Frequency Speed of Kick Test (FSKT) performance of elite male taekwondo athletes. Twenty elite male taekwondo athletes (age: 20.0 ± 3.2 years; height: 183.0 ± 1.3 cm; body mass: 66.0 ± 2.5 kg; BMI: 18.7 ± 0.8 kg/m²) participated voluntarily. Following anthropometric assessments and a taekwondo-specific warm-up protocol, athletes completed a three-round competition simulation and the FSKT. Based on match-analysis findings, participants undertook an eight-week training program consisting of extensive interval training, high-intensity interval training, and taekwondo-specific technical–tactical exercises. The same protocol was implemented in 2021, 2022, and 2023. Data were analyzed using repeated-measures ANOVA, paired-samples t-tests, and Pearson correlation analysis ($p < 0.05$). Significant reductions in RPE were observed following training across all years, while FSKT performance improved significantly ($p < 0.05$). Changes were also identified in technical distribution, scoring techniques, and kicking-force values. The 2022 competition system revision influenced technical–tactical behaviors, match load, and performance requirements. Furthermore, the implemented training program improved kicking force, fatigue tolerance, and overall performance.

Introduction

Taekwondo is an Olympic combat sport in which speed, explosive power, and a broad technical repertoire play a central role, while strategic decision-making and reaction speed are key determinants of performance (Bridge et al., 2014). Due to the dynamic nature of the sport, competitive success is not solely dependent on the athlete's physical and technical capacities but is also closely associated with the rules established and periodically updated by the World Taekwondo Federation (WTF). To increase match intensity, enhance spectator appeal, and encourage athletes to adopt a more active style of competition, the WTF has implemented various rule modifications over time. These rule changes directly influence athletes' offensive and defensive behaviors through adjustments in scoring criteria, round duration, definitions of active and passive periods, and penalty regulations (Kazemi & Pieter, 2011; Kazemi et al., 2006; Yeşilçimen & Yücel, 2025).

In this context, the effects of changes in competition rules on performance have been investigated through parameters such as technical-tactical distribution, match intensity, and competition tempo (Kumartaşlı et al., 2022; Imamoglu et al., 2010). In their analysis of the 2023 Turkish Taekwondo Championships, Yeşilçimen and Yücel (2025) reported a significant increase in active competition time under the updated competition system and identified *yop chagi* and *palding chagi* as the most frequently employed techniques. Similarly, Kumartaşlı et al. (2022), in their study covering World Taekwondo Championships held between 2012 and 2018, demonstrated that rule modifications substantially altered technical preferences and scoring patterns. Imamoglu et al. (2010) further reported that following rule updates, athletes exhibited a greater diversity of techniques and that the balance between offensive actions and counterattacks changed. Moreover, Bridge et al. (2014) emphasized that athletes competing at the international level are exposed to considerable physiological demands and that modifications to competition rules may alter the nature of these demands.

In 2022, the World Taekwondo Federation (WTF) introduced comprehensive modifications to the competition system. Under the revised regulations, matches consist of a maximum of three rounds separated by one-minute rest intervals, scores are reset at the end of each round, and the athlete who wins two rounds is declared the

winner of the match. The primary objective of this rule modification was to increase technical diversity, reduce passive fighting behaviors, and enhance match intensity. Nevertheless, the long-term effects of such structural changes on athletes' technical preferences, offensive and counterattacking strategies, and overall match intensity have been addressed only in a limited number of studies (Janowski et al., 2020). The majority of existing research has focused exclusively on technical-tactical parameters observed during competition (Avakian et al., 2016). In particular, studies simultaneously examining the effects of rule modifications through both match simulations and sport-specific field tests remain scarce (Xu, Zhang, & Luo, 2025).

Therefore, the present study aimed to compare match simulation and Frequency Speed of Kick Test (FSKT) results obtained in 2021, 2022, and 2023 in order to investigate the effects of the 2022 rule modification on the performance of elite male taekwondo athletes. This study is expected to contribute to the literature by providing a multidimensional evaluation of the effects of the revised competition rules on athletic performance in elite taekwondo. While technical-tactical indicators obtained from match simulations—including the number of techniques executed, scoring actions, sensor activations, and penalties—were evaluated, FSKT analyses were used to assess athletes' technical execution frequency, fatigue tolerance, and accuracy rates. This comprehensive approach is intended to provide a more detailed understanding of how rule modifications influence competition dynamics and performance, thereby contributing both to the scientific literature and to practical applications in training design and performance analysis.

Hypotheses

H1a

Following the implementation of the revised World Taekwondo competition system in 2022, significant differences exist across years in the technical distribution, scoring techniques, kicking force, and rating of perceived exertion (RPE) of elite male taekwondo athletes.

H0a

Following the implementation of the revised World Taekwondo competition system in 2022, no significant differences exist across years in the technical distribution, scoring techniques, kicking force, and rating of perceived exertion (RPE) of elite male taekwondo athletes.

H1b

Significant differences exist in match load and technical-tactical performance following the implementation of the revised competition system in 2022.

H0b

No significant differences exist in match load and technical-tactical performance following the implementation of the revised competition system in 2022.

H1c

Significant differences exist in athletes' rating of perceived exertion (RPE) values following the eight-week training program.

H0c

No significant differences exist in athletes' rating of perceived exertion (RPE) values following the eight-week training program.

H1d

Athletes' competitive performance and load tolerance differ significantly following training programs designed according to the technical-tactical and physiological demands of the revised competition system.

H0d

Athletes' competitive performance and load tolerance do not differ significantly following training programs designed according to the technical-tactical and physiological demands of the revised competition system.

MATERIALS AND METHODS

Study Participants

The sample size was determined through a priori power analysis conducted using G*Power 3.1 software, which indicated that a minimum of 20 participants was required (Bozkurt & Yeşilçimen, 2023). Accordingly, 20 elite male black-belt taekwondo athletes were recruited for the study. The participants had a mean age of 20.0 ± 3.2 years, mean height of 183.0 ± 1.3 cm, mean body mass of 66.0 ± 2.5 kg, and mean body mass index (BMI) of 18.7 ± 0.8 kg/m². The athletes had an average training experience of 9.0 ± 1.2 years and regularly participated in structured training programs five days per week, with each session lasting approximately 2 hours.

Prior to participation, all athletes underwent a comprehensive medical evaluation conducted by a sports physician. This assessment included a detailed medical history, a general physical examination, and resting electrocardiography (ECG). The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and was approved by the Ethics Committee of the Institute of Educational Sciences at Marmara University (Approval No: 2021/114). Institutional permission to conduct the study was obtained from the relevant sports club administration. All participants received both written and verbal information regarding the purpose, procedures, potential risks, and voluntary nature of the study. Written informed consent was obtained from each participant prior to data collection. Throughout the research process, participant confidentiality and data security were strictly maintained, and participants were informed that they could withdraw from the study at any time without providing any justification.

Athletes were eligible for inclusion if they had competed in official international-level competitions within the previous three years, possessed a minimum of five years of regular taekwondo training experience, and maintained a training and competition attendance rate exceeding 90%. Athletes were excluded if they had sustained a musculoskeletal injury within the previous six months, failed to regularly attend the scheduled testing and training sessions, used any medication or ergogenic aid that could potentially influence the study

outcomes, or were deemed medically unsuitable for participation by the sports physician following the comprehensive health evaluation conducted prior to the study.

Research Design

This study was conducted as an experimental design with repeated measures within the framework of a quantitative research approach. The training program was developed in coordination with the club's technical staff. During the eight-week intervention period, the athletes participated in training sessions twice per week (Monday and Friday). Each training session consisted of a warm-up phase, technical–tactical skill training, model training, and a cool-down phase. At the end of each week, athletes performed official match simulations comprising three 2-minute rounds (3 × 2 min).

All training sessions were conducted using a methodological approach in which taekwondo-specific technical and tactical elements were integrated with physical performance parameters such as endurance, strength, and speed. This approach aimed to prioritize technical–tactical development through the balanced integration of different training loads while emphasizing physical components according to individual performance requirements. The study consisted of three phases, and the flowchart of the research process is presented in Fig. 1. The same methodological approach was adopted in the applications conducted in 2021, 2022, and 2023, and data collection procedures were standardized across all years through the use of comparable protocols.

Study Procedures

The anthropometric assessments of the athletes were conducted by a certified researcher in accordance with the standardized protocols recommended by the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart et al., 2011; Agopyan et al., 2022). Within this scope, standing height and body mass measurements were obtained. Body composition and body mass index (BMI) were assessed using a Tanita MC-780MA segmental body composition analyzer (Tanita Corp., Japan), which is based on multi-frequency segmental bioelectrical impedance analysis.

Standing height measurements were performed using a Seca 220 stadiometer (Seca, Germany) with millimeter-level precision. During the measurements, participants were instructed to stand upright on a flat surface with their feet together and their heads positioned in the Frankfurt plane. Body mass index (BMI) was subsequently calculated from the obtained anthropometric data.

Warm-Up Protocol

Prior to each match simulation, the athletes completed a standardized 15-minute warm-up protocol consisting of taekwondo-specific movements. The warm-up procedure commenced with basic footwork drills, guard-position transitions, and dynamic warm-up exercises. Subsequently, repetitions of nine fundamental taekwondo techniques were performed: Baldeung Chagi, Yop Chagi, Dwi Chagi, Dolryo Dollyo Chagi, Dollyo Chagi, Naeryo Chagi, Bandae Chagi, Bandae Dollyo Chagi, and Jireugi. The warm-up protocol was composed of the primary techniques commonly utilized during competition (Yeşilçimen & Yücel, 2025).

Frequency Speed of Kick Test (FSKT) Protocol

In this study, the taekwondo-specific multiple-set Frequency Speed of Kick Test (FSKT_mult) was administered. As part of the protocol, each athlete performed maximal kicking efforts for 10 seconds and completed a total of five sets, with a 10-second passive recovery interval between consecutive sets.

Performance evaluation was based on the total number of kicks performed in each set, the cumulative number of kicks across all five sets, and kicking fatigue-related variables (Santos et al., 2016).

To determine the decline in performance throughout the test, the Kick Decrement Index (KDI) (Fig. 2.) was calculated. This index was derived from the data obtained during the protocol and was used to quantitatively assess the athletes' performance decrement across successive sets (Santos et al., 2016).

Match Simulation

The match simulation protocol was designed and implemented in accordance with the official World Taekwondo (WT) competition rules. Each match consisted of three 2-minute rounds, separated by 1-minute passive recovery intervals. Simulations were conducted under the supervision of one nationally certified central referee, two side referees, and one table referee responsible for monitoring the scoring process.

To recreate an authentic championship environment, athletes competed wearing full WT-approved taekwondo uniforms (dobok) and protective equipment, including an electronic chest protector, headgear, shin guards, forearm guards, and a mouthguard. During the matches, athletes were permitted to have their own coaches present in the designated corner area. Coaches were allowed to provide technical instructions and exercise their official protest rights in accordance with WT regulations.

Scoring was automatically recorded using a WT-approved electronic body protector system (Daedo EBP, Spain). Manual referee intervention was applied only in cases involving clearly executed techniques not registered by the electronic system or in instances of rule violations. All matches were recorded using a high-resolution video camera to enable detailed technical and tactical analyses.

This procedure was standardized to enhance the reliability of the measurements and to ensure that the technical–tactical responses exhibited by the athletes closely reflected those observed under actual competitive conditions (Yeşilçimen & Yücel, 2025).

Kicking Force

All protective equipment used during the match simulations was inspected by the referee prior to the athletes entering the competition area and was verified to be approved by the World Taekwondo Federation (WTF).

Kicking force measurements were obtained using an electronic body protector (EBP; Daedo, Spain) system capable of recording impact force in bar units. In addition to providing protection to the trunk region, the EBP system incorporates an integrated measurement and scoring mechanism that electronically detects the validity and scoring value of applied kicks. During the measurements, scoring and force data were simultaneously recorded in an electronic format (Imamoglu et al., 2010).

Match Analysis

Data obtained from the match simulations were derived from high-resolution video recordings. The camera was positioned at a height of 1.7 m and a distance of 2 m to ensure full visibility of all kicking actions, and the simulations were recorded at a sampling rate of 120 Hz (Imanaka & Nakamoto, 2023).

Each match was examined in detail across all three rounds with respect to technical and tactical actions. During the analysis process, offensive and defensive phases were evaluated separately. For each phase, the total number of kicks, the number of scoring kicks, the number of kicks that made contact with the electronic body protector but did not result in a score (non-scoring contact kicks), and the number of kicks that failed to make contact with the body protector were recorded (Yeşilçimen & Yücel, 2025).

Scoring kicks were defined as techniques that were detected by the electronic system with sufficient impact force and consequently registered as valid points. Non-scoring contact kicks referred to kicks that made contact with the electronic body protector but failed to exceed the scoring threshold required for point registration. In addition, kicks that did not make any contact with the protective equipment were also included in the analysis. This approach enabled a comprehensive evaluation of both technical effectiveness and accuracy. Analyses were conducted independently by two experienced coaches holding Level III Taekwondo Coaching Licenses. To enhance the validity and reliability of the measurements, the results obtained by both evaluators were compared and inter-rater agreement was established (Yeşilçimen & Yücel, 2025).

Rating of Perceived Exertion (RPE)

The Borg CR-10 Rating of Perceived Exertion (RPE) scale was used to determine athletes perceived exertion levels (Borg, 1998). Participants were asked to rate their perceived effort after each round on a scale ranging from 0 (no exertion at all) to 10 (maximal exertion). Scale scores of 0–4 was classified as low, 5–6 as moderate, and ≥ 7 as high perceived exertion (Borg, 1998; Xuan et al., 2023). The obtained RPE values were used in the analyses to determine athletes' perceptual responses to match load.

Training Program

Based on the findings obtained from the match analyses, an eight-week training program was implemented that included taekwondo-specific technical–tactical exercises, extensive interval training, and high-intensity interval training (HIIT), designed according to the technical–tactical and physiological demands of the revised competition system.

Table 1

Detailed weekly training plan of the taekwondo-specific intervention program implemented over the 8-week period, including warm-up, main training, and cool-down components.

Week	Warm-up	Main Training Phase	Cool-down
1–3	15 min dynamic warm-up over 20 m including guard stance locomotion, light kicking drills, knee raises, taekwondo-specific mobility, followed by resistance band activation in the last 5 min	20 min technical training + extensive interval training. First 5 min: nine taekwondo techniques (Baldeung Chagi, Yop Chagi, Dwi Chagi, Dollyo Dollyo Chagi, Dollyo Chagi, Naeryo Chagi, Bandae Chagi, Bandae Dollyo Chagi, Jireugi), ~ 12 repetitions each with 1 min rest between techniques. Next 15 min: partner-based offensive/defensive combinations (1 min work / 1 min rest blocks). Extensive interval structure: 10 repetitions × 3 sets, 2 min work / 2 min rest, 5 min inter-set rest, ~ 70% maximal kicking force. Total main aim: technical efficiency and endurance development	10 min total: 5 min low-intensity taekwondo-specific movement (guard transitions, light technique execution, stretching) + 5 min resistance band stretching
4	15 min dynamic warm-up identical structure (locomotor drills, mobility, neuromuscular activation with resistance bands)	HIIT protocol: 60 s work / 60 s rest (1:1), 10 repetitions × 2 sets. Set structure includes offensive combinations with integrated defensive responses. Intensity: ~80% maximal kicking force and tempo. Set rest: 5 min	10 min standardized recovery with low-intensity movement and stretching
5	15 min taekwondo-specific dynamic warm-up and mobility preparation	Short-interval HIIT: Block A = 15 s work / 15 s rest ×10; Block B = 30 s work / 30 s rest ×6. Both blocks combined into 1 set, performed for 2 sets. Emphasis on high-frequency combat simulation and offensive–defensive transitions. Intensity: ~85% maximal kicking force and tempo	10 min standardized cool-down with progressive stretching and breathing control
6	15 min neuromuscular activation-focused dynamic warm-up	Mixed interval training: 20 s work / 10 s rest (2:1) ×8 repetitions ×3 sets. Focus on explosive kicking execution and fatigue resistance. Intensity: 85–90% maximal kicking force and tempo. Short-bout explosive technical execution with balanced offensive and defensive distribution	10 min structured cool-down including low-intensity movements and static stretching
7–8	15 min dynamic warm-up + taekwondo-specific neuromuscular priming	Pre-activation phase: whistle-based combinations (3 s work / 9 s rest, 5 s work / 15 s rest, 2 s work / 6 s rest), 3 sets with 2 min rest between sets. Main phase: 9 taekwondo techniques under randomized 1–5 s micro-bout structure, 2 min loading + 1 min rest, 4 sets × 3 repetitions. Inter-set rest progressively increased (5 min, 7 min, 9–10 min). Training performed on moving target pads. Intensity: high; focus on technical accuracy, kicking tempo, and target hit rate	10 min standardized cool-down (low-intensity guard transitions, light techniques, resistance band stretching, static stretching)

The eight-week training program implemented in the present study is presented in Table 1. The training plan was structured according to a progressive periodization model aimed at improving both technical performance and physiological adaptations in taekwondo athletes. During the first three weeks, an extensive interval training approach was employed. This phase combined technical skill development with moderate-intensity interval

work performed at approximately 70% of maximal kicking force, with the aim of enhancing technical efficiency and establishing foundational endurance adaptations (Jones & Smith, 2026).

Beginning in Week 4, a high-intensity interval training (HIIT) structure was introduced, and training intensity was progressively increased. Week 4 consisted of a 1:1 work-to-rest ratio protocol performed at approximately 80% of maximal kicking force and tempo. In Week 5, short-duration, high-frequency interval formats were implemented to replicate the rapid fluctuations in work rate and tempo commonly observed during taekwondo competition. During Week 6, a mixed-interval protocol with a 2:1 work-to-rest ratio was applied to enhance fatigue resistance and sustain technical performance under increasing physiological stress, with training intensity ranging between 85% and 90% of maximal kicking force.

In Weeks 7 and 8, the training structure was redesigned according to the temporal characteristics of offensive and defensive actions reported in taekwondo competition analyses (Boutios et al., 2022). Following a short pre-activation phase, athletes performed taekwondo-specific techniques under randomized 1–5 s micro-bout conditions using moving target pads. This competition-oriented structure was designed to improve technical accuracy, kicking tempo, target hit rate, and decision-making speed under conditions that closely resembled actual match demands.

Throughout the intervention period, warm-up and cool-down procedures were standardized across all sessions to ensure methodological consistency and minimize potential confounding effects. Overall, the training program integrated technical–tactical practice, extensive interval training, high-intensity interval training, and competition-specific simulation exercises within a progressive periodization framework designed to address the evolving demands of modern taekwondo competition.

Statistical Analysis

Prior to data analysis, the assumption of normality was assessed using the Shapiro–Wilk test. Based on the observed distributional characteristics of the data, both parametric and non-parametric statistical methods were employed. Rating of Perceived Exertion (RPE) data, consisting of repeated measurements obtained across three assessment years (2021, 2022, and 2023), two measurement occasions (pre-test and post-test), and three rounds, were analyzed using a 3 (Year) × 2 (Time) × 3 (Round) repeated-measures analysis of variance (Repeated Measures ANOVA).

The assumption of sphericity was evaluated using Mauchly's test. When violations of sphericity were detected, degrees of freedom and p-values were adjusted using the Greenhouse–Geisser correction. Effect sizes were calculated as partial eta squared (η^2), with values of 0.01, 0.06, and 0.14 interpreted as small, medium, and large effects, respectively (Cohen, 1988). Multiple comparisons were conducted using Tukey's Honestly Significant Difference (HSD) post hoc test.

Pre-test and post-test comparisons of the FSKT subtests and total score were performed using the Wilcoxon signed-rank test due to violations of the normality assumption. Effect sizes were expressed as the rank-biserial correlation coefficient (rb), with values of 0.10, 0.30, and 0.50 representing small, medium, and large effects, respectively (Cohen, 1988; Kerby, 2014).

For all analyses, the level of statistical significance was set at $\alpha = 0.05$. Statistical analyses were performed using JAMOVI software (Version 2.3.21; The jamovi Project, Sydney, Australia).

Results

Table 2
Technical Analysis of the 2021 Match Simulation: Pre-Test and Post-Test Results.

		Pre-Test Round 1		Pre-Test Round 2		Pre-Test Round 3		Post-Test Round 1		Post-Test Round 2		Post-Test Round 3	
Technical Variables		Off	Def	Off	Def	Off	Def	Off	Def	Off	Def	Off	Def
Baldeung Chagi	Total Count	65	67	61	67	72	70	77	74	70	68	72	69
	Score	8	9	11	12	13	17	21	18	18	19	23	24
	Perceived Hit (Bar)	17	13	14	12	15	15	25	19	23	21	19	20
	Unperceived Hit	40	45	38	43	44	38	31	37	29	28	30	25
Yop Chagi	Total Count	59	63	61	68	74	71	66	67	62	73	76	70
	Score	15	16	14	12	12	14	19	20	22	23	21	25
	Perceived Hit (Bar)	11	10	13	24	17	13	16	15	13	20	20	18
	Unperceived Hit	33	37	34	32	46	45	31	32	27	30	35	27
Dwi Chagi	Total Count	34	46	29	48	32	53	35	50	31	44	33	58
	Score	8	6	7	9	6	11	7	14	7	12	8	15
	Perceived Hit (Bar)	9	10	8	13	10	13	9	16	8	14	9	18
	Unperceived Hit	17	30	14	26	16	29	19	20	16	18	16	25
Emphasized Baldeung Chagi	Total Count	43	24	42	37	46	39	43	35	40	32	34	44
	Score	6	5	7	4	8	6	10	8	10	7	9	11
	Perceived Hit (Bar)	13	8	9	6	13	9	13	9	9	5	8	10
	Unperceived Hit	24	11	26	27	25	24	20	18	21	20	17	23
Dollyo Chagi	Total Count	40	31	38	43	57	51	62	53	57	33	60	45
	Score	9	8	10	11	17	15	18	19	21	15	22	17
	Unperceived Hit	31	23	38	32	40	36	44	34	36	18	38	28
Naeryo Chagi	Total Count	25	38	44	47	46	45	46	54	47	53	49	52
	Score	8	14	13	14	12	12	18	21	17	19	20	17
	Unperceived Hit	17	24	31	33	34	33	28	33	30	34	29	35

Bandae Chagi	Total Count	49	48	46	39	36	46	44	46	57	48	58	39
	Score	12	11	14	9	14	11	16	15	27	15	23	19
	Unperceived Hit	37	37	32	30	22	35	28	31	30	33	35	20
Bandae Dollyo Chagi	Total Count	41	32	46	43	43	47	41	48	42	58	52	40
	Score	12	11	17	15	14	18	15	19	16	21	23	12
	Unperceived Hit	29	21	29	28	29	29	26	29	26	37	29	28
Jireugi	Total Count	35	37	36	35	47	38	32	39	35	42	40	42
	Score	13	8	12	9	12	9	12	11	17	15	13	14
	Unperceived Hit	22	29	24	26	35	29	20	28	18	27	27	28

Off. = Offensive actions, Def. = Defensive actions, BC = Baldeung Chagi, YC = Yop Chagi, DC = Dwi Chagi, EBC = Emphasized Baldeung Chagi, DCG = Dollyo Chagi, NC = Naeryo Chagi, BCG = Bandae Chagi, BDC = Bandae Dollyo Chagi, J = Jireugi.

Table 2 presents the numerical distribution of the techniques performed by the athletes across three rounds during the pre-test and post-test match simulations conducted in 2021. The table includes data for Baldeung Chagi, Yop Chagi, Dwi Chagi, Dolryo Dollyo Chagi, Dollyo Chagi, Naeryo Chagi, Bandae Chagi, Bandae Dollyo Chagi, and Jireugi, including the total number of kicks, the number of scoring kicks, the number of non-scoring contact kicks that made contact with the electronic body protector (bar contact), and the number of non-contact kicks. The table provides a comparison of technique utilization before and after the training intervention.

Table 3
Technical Analysis of the 2022 Match Simulation During Pre-Test and Post-Test Assessments

		Pre-Test Round 1		Pre-Test Round 2		Pre-Test Round 3		Post-Test Round 1		Post-Test Round 2		Post-Test Round 3	
Technical Variables		Off	Def	Off	Def	Off	Def	Off	Def	Off	Def	Off	Def
Baldeung Chagi	Total Count	78	73	74	78	65	71	81	73	76	79	81	74
	Score	17	14	12	15	16	16	26	22	23	26	28	23
	Perceived Hit (Bar)	17	22	18	17	18	18	21	20	18	17	22	21
	Unperceived Hit	43	37	44	46	31	37	31	31	32	36	31	30
Yop Chagi	Total Count	66	72	69	74	72	63	76	75	78	73	86	72
	Score	13	14	15	19	17	12	23	21	25	26	28	23
	Perceived Hit (Bar)	14	20	21	15	14	14	19	17	18	21	19	20
	Unperceived Hit	39	38	33	40	41	37	34	37	35	26	39	29
Dwi Chagi	Total Count	44	55	37	53	37	49	42	56	39	52	43	68
	Score	4	10	7	9	6	8	9	11	8	9	8	13
	Perceived Hit (Bar)	6	14	12	13	10	13	10	16	12	14	15	18
	Unperceived Hit	34	31	18	31	21	28	23	29	19	29	20	37
Emphasized Baldeung Chagi	Total Count	53	31	50	45	51	46	52	42	45	39	37	52
	Score	6	5	7	4	8	6	10	8	7	11	12	11
	Perceived Hit (Bar)	13	8	9	6	13	9	16	9	9	8	9	10
	Unperceived Hit	34	18	34	35	30	31	26	25	29	20	16	31
Dollyo Chagi	Total Count	49	48	46	41	36	54	68	62	63	41	68	53
	Score	15	18	14	11	14	19	19	24	26	14	24	23
	Unperceived Hit	34	30	32	30	22	35	49	38	37	27	44	30
Naeryo Chagi	Total Count	41	39	50	47	46	49	47	55	57	54	52	62
	Score	12	11	17	15	14	16	19	18	14	19	14	21
	Unperceived Hit	29	28	33	32	32	33	28	37	43	35	38	41

Bandae Chagi	Total Count	58	55	48	53	43	57	54	58	63	56	59	40
	Score	16	18	17	16	15	14	19	21	18	18	17	14
	Unperceived Hit	42	37	31	37	28	43	35	37	45	38	42	26
Bandae Dollyo Chagi	Total Count	53	36	44	47	44	54	52	48	42	58	52	40
	Score	14	12	11	12	13	16	18	19	15	21	17	15
	Unperceived Hit	39	24	33	35	31	38	34	29	27	37	35	25
Jireugi	Total Count	46	28	48	36	59	48	44	47	45	47	49	47
	Score	16	8	14	9	21	19	12	17	14	17	16	15
	Unperceived Hit	30	20	34	27	38	29	32	30	31	30	33	32

Off. = Offensive actions, Def. = Defensive actions, BC = Baldeung Chagi, YC = Yop Chagi, DC = Dwi Chagi, EBC = Emphasized Baldeung Chagi, DCG = Dollyo Chagi, NC = Naeryo Chagi, BCG = Bandae Chagi, BDC = Bandae Dollyo Chagi, J = Jireugi.

Table 3 presents the numerical distribution of the techniques performed by the athletes across three rounds during the pre-test and post-test match simulations conducted in 2022. The table includes data for Baldeung Chagi, Yop Chagi, Dwi Chagi, Dolryo Dollyo Chagi, Dollyo Chagi, Naeryo Chagi, Bandae Chagi, Bandae Dollyo Chagi, and Jireugi, including the total number of kicks, the number of scoring kicks, the number of non-scoring contact kicks that made contact with the electronic body protector (bar contact), and the number of non-contact kicks. The table provides a comparison of technique utilization before and after the training intervention.

Table 4
Technical Analysis of the 2023 Match Simulation During Pre-Test and Post-Test Assessments

		Pre-Test Round 1		Pre-Test Round 2		Pre-Test Round 3		Post-Test Round 1		Post-Test Round 2		Post-Test Round 3	
Technical Variables		Off	Def	Off	Def	Off	Def	Off	Def	Off	Def	Off	Def
BC	Total Count	82	78	77	81	66	81	91	96	93	92	90	84
	Score	21	22	22	19	15	17	29	31	30	27	23	24
	Perceived Hit (Bar)	20	19	17	17	19	20	28	31	25	23	25	21
	Unperceived Hit	41	37	38	44	32	44	34	34	38	42	42	39
Yop Chagi	Total Count	75	80	80	77	81	75	96	84	85	89	77	74
	Score	17	19	14	19	16	18	27	24	23	26	21	24
	Perceived Hit (Bar)	21	20	20	20	21	24	33	25	25	22	25	19
	Unperceived Hit	37	41	46	38	44	33	36	35	37	41	31	31
Dwi Chagi	Total Count	41	50	32	43	44	44	51	52	41	54	53	49
	Score	9	13	7	10	9	12	15	14	13	18	11	14
	Perceived Hit (Bar)	7	10	8	13	16	13	12	13	12	12	19	17
	Unperceived Hit	25	27	17	20	19	19	24	25	16	24	23	18
Emphasized Baldeung Chagi	Total Count	43	35	38	31	40	38	47	41	43	45	41	38
	Score	11	9	13	7	14	7	14	13	14	10	13	7
	Perceived Hit (Bar)	13	12	10	9	8	10	15	12	10	15	9	9
	Unperceived Hit	19	14	15	15	18	21	18	16	19	20	19	22
Dollyo Chagi	Total Count	53	41	49	50	62	54	61	55	59	53	65	54
	Score	17	19	20	14	19	10	23	26	23	18	24	12
	Unperceived Hit	32	22	29	36	43	44	38	29	36	35	41	42
Naeryo Chagi	Total Count	41	46	49	47	45	45	46	54	47	53	49	52
	Score	8	14	13	18	16	15	18	21	17	19	20	17
	Unperceived Hit	33	32	36	29	29	30	28	33	30	34	29	35

Bandae Chagi	Total Count	39	38	35	44	41	40	43	53	52	56	54	46
	Score	18	16	13	14	12	14	19	21	20	15	18	19
	Unperceived Hit	21	22	22	30	29	26	24	32	32	41	36	27
Bandae Dollyo Chagi	Total Count	37	30	43	33	31	42	45	47	42	38	37	40
	Score	13	9	14	8	7	6	17	16	13	12	11	12
	Unperceived Hit	24	21	29	25	24	36	28	31	29	26	26	28
Jireugi	Total Count	49	48	46	47	41	42	47	50	58	64	61	48
	Score	20	19	16	18	15	19	22	21	25	27	24	22
	Unperceived Hit	29	29	30	29	26	23	25	29	33	37	37	26

Off. = Offensive actions, Def. = Defensive actions, BC = Baldeung Chagi, YC = Yop Chagi, DC = Dwi Chagi, EBC = Emphasized Baldeung Chagi, DCG = Dollyo Chagi, NC = Naeryo Chagi, BCG = Bandae Chagi, BDC = Bandae Dollyo Chagi, J = Jireugi.

Table 4 presents the numerical distribution of the techniques performed by the athletes across three rounds during the pre-test and post-test match simulations conducted in 2023. The table includes data for Baldeung Chagi, Yop Chagi, Dwi Chagi, Dolryo Dollyo Chagi, Dollyo Chagi, Naeryo Chagi, Bandae Chagi, Bandae Dollyo Chagi, and Jireugi, including the total number of kicks, the number of scoring kicks, the number of non-scoring contact kicks that made contact with the electronic body protector, and the number of non-contact kicks. The table provides a comparison of technique utilization before and after the training intervention.

Pre-test and post-test comparisons of the FSKT variables for 2021, 2022, and 2023 were analyzed using the Wilcoxon signed-rank test. In 2021, significant improvements were observed from pre-test to post-test in FSKT1–5 and the total FSKT score (all $p < 0.001$), with effect sizes indicating near-perfect effects (ES = − 0.95 to − 1.00). Examination of percentage changes revealed that the greatest improvement occurred in FSKT5 (27.8%), while the total FSKT score increased by 22.2%. No significant change was observed in the FSKT KDI score in 2021 ($p = 0.178$, ES = − 0.36).

In 2022, statistically significant improvements were found in all FSKT subtests and the total score (all $p \leq 0.005$). However, effect sizes were generally lower than those observed in 2021 (ES = − 0.77 to − 1.00), and percentage improvements were more modest (7.7%–16.3%). Notably, the FSKT KDI score decreased significantly in 2022 (9.66 to 4.66; $p = 0.001$, ES = 0.82, Δ = −51.8%).

In 2023, significant improvements with perfect effect sizes were observed in all FSKT subtests and the total FSKT score (all $p < 0.001$, ES = − 1.00). Percentage improvements ranged from 21.2% to 25.0%, while the total FSKT score increased by 22.8%. No significant change was detected in the FSKT KDI score in 2023 ($p = 0.240$).

When all three years were considered collectively, the pre-test to post-test improvements in FSKT performance scores were consistent and associated with large effect sizes. In contrast, the FSKT KDI exhibited a different

pattern across years, showing a marked decrease in 2022, whereas no significant changes were observed in 2021 or 2023. The panel graph presented in Fig. 3 visually illustrates these year-specific patterns of change across the FSKT variables.

According to the repeated-measures ANOVA results, a significant main effect of year was observed ($F(1.45, 27.50) = 15.73$, $p < 0.001$, $\eta p^2 = 0.453$). Athletes exhibited lower ratings of perceived exertion in 2021 compared with both 2022 ($p = 0.028$) and 2023 ($p < 0.001$). The main effect of time demonstrated the largest effect size ($F(1, 19) = 373.43$, $p < 0.001$, $\eta p^2 = 0.952$), indicating significant reductions in perceived exertion from pre-test to post-test across all years ($\Delta 2021 = -0.98$, $\Delta 2022 = -1.57$, $\Delta 2023 = -1.62$; all $p < 0.001$).

Furthermore, the magnitude of the pre-test to post-test change differed significantly across years, as evidenced by a significant Year × Time interaction effect ($F(1.90, 36.10) = 5.94$, $p = 0.007$, $\eta p^2 = 0.238$). In contrast, the main effect of round was not statistically significant ($F(2, 38) = 0.99$, $p = 0.383$, $\eta p^2 = 0.049$), indicating that perceived exertion levels did not differ significantly among the three rounds.

Figure 4 illustrates the changes in rating of perceived exertion across rounds according to year and measurement time.

According to the repeated-measures ANOVA results, a significant main effect of time was observed ($F(1, 19) = 136.07$, $p < 0.001$), indicating that participants reported significantly lower ratings of perceived exertion during the post-test compared with the pre-test (mean difference = 1.82, SE = 0.156, $p < 0.001$).

Neither the main effect of year ($F(1.68, 32.00) = 0.29$, $p = 0.710$) nor the Year × Time interaction effect ($F(1.39, 26.33) = 1.27$, $p = 0.286$) reached statistical significance. These findings indicate that the magnitude and pattern of change in perceived exertion from pre-test to post-test were comparable across all three years.

Figure 5 illustrates the comparison of pre-test and post-test ratings of perceived exertion during the FSKT across the 2021, 2022, and 2023 assessment periods.

Discussion

The present study was conducted to determine the effects of the competition system revision introduced in 2022 on the match and training loads of elite taekwondo athletes, based on data obtained from match analyses and field tests conducted in 2021, 2022, and 2023. The effects of the eight-week training program developed according to the findings obtained from these analyses were evaluated through pre-test and post-test measurements of match performance, kicking force, rating of perceived exertion (RPE), and Frequency Speed of Kick Test (FSKT) performance in elite male taekwondo athletes. Furthermore, performance and load-related changes across 2021, 2022, and 2023 were compared to examine the impact of the revised competition system. The findings indicate that the rule modifications influenced not only technical preferences but also kicking frequency, scoring efficiency, and fatigue tolerance.

In the literature, Kumartaşlı et al. (2022), in their analysis of World Taekwondo Championships held between 2012 and 2018, reported year-dependent changes in technical preferences and scoring patterns. Similarly, the present study identified Yop Chagi and Baldeung Chagi as the most frequently used techniques, while the total number of techniques performed increased over the years. These findings suggest that the revised competition

system introduced in 2022 led to an increase in both technical execution frequency and technical diversity among elite taekwondo athletes. Baykan (2022), in an analysis of the semifinal and final matches of the 2019 World Taekwondo Championships, reported that Dollyo Chagi was the most frequently used technique, that body-targeted techniques were preferred more often, and that counterattacking techniques generated higher scoring success than offensive techniques. In contrast, the present study found that Yop Chagi was the most frequently used technique, whereas Baldeung Chagi yielded the highest scoring success. These differences may indicate that the structural changes implemented between 2021 and 2023 altered athletes' technical preferences and scoring strategies.

Indeed, Yeşilçimen and Yücel (2025), through an analysis of the 2023 Turkish Taekwondo Championships, reported an increase in active competition time following the implementation of the revised competition system and observed that athletes adopted a more dynamic competitive tempo. The increase in active time may be associated with the differences observed in technical preferences and technical distributions during competition. Furthermore, Barrientos et al. (2021) demonstrated that electronic scoring systems and rule modifications have substantially transformed the technical–tactical structure of taekwondo competition, particularly during the period leading up to the Tokyo 2021 Olympic Games, resulting in marked changes in athletes' performance strategies. Taken together, these findings suggest that rule modifications in taekwondo influence technical preferences, technical–tactical behaviors, and match load. The independent evaluation of each round and the resetting of scores at the end of every round may have encouraged athletes to favor techniques associated with higher scoring potential. The greater reward associated with counterattacking and dynamic techniques may also have contributed to changes in technical preferences. Similarly, Imamoglu et al. (2010) reported changes in both technical diversity and the balance between offensive and defensive actions following rule modifications. The observed year-to-year differences in technical distribution, kicking force (bar) values, and scoring techniques further indicate that the revised competition system affected athletes' technical preferences, technical–tactical behaviors, and overall technical performance.

Notably, the increases observed in kicking force values and scoring efficiency during 2023 suggest that athletes adapted more effectively to the technical and tactical demands imposed by the revised competition system. Moreover, the progressive increase in the proportion of successful scoring techniques indicates an improvement in technical execution effectiveness. Bridge et al. (2009) reported that the physiological demands imposed by international-level competition can influence technical performance and emphasized that changes in competition rules may alter the nature of these demands. The authors further suggested that athletes must enhance both their technical and physical capacities in order to adapt successfully to increased competition intensity.

The findings related to rating of perceived exertion also provide evidence regarding the increased demands imposed by the revised competition system. Tayech et al. (2022) reported a mean CR-10 value of 5 ± 2 across three rounds in elite taekwondo athletes, whereas Bridge et al. (2009) found that perceived exertion increased significantly as rounds progressed. In the present study, perceived exertion levels differed across years. Specifically, the higher RPE values observed in 2022 and 2023 compared with 2021 suggest that the revised competition system increased both the physiological and perceptual demands placed on athletes. Nevertheless, the significant reductions in RPE observed following the training intervention across all years indicate that the implemented training program enhanced the athletes' ability to tolerate competition-related loads. Furthermore, the variation in pre-test to post-test differences across years suggests that the

effectiveness of the training intervention may depend, at least in part, on the specific demands imposed by the prevailing competition system. These findings are further supported by the results reported by Yeşilçimen and Yücel (2025). The authors demonstrated that, following the implementation of the revised competition system, RPE values increased progressively throughout the course of competition and exhibited a particularly pronounced rise after the second and third rounds. The persistence of elevated RPE values even during the recovery period (Mean = 5.83) suggests that recovery time between successive matches may be insufficient. Therefore, to facilitate adaptation to the demands imposed by the revised competition system, training programs should incorporate both competition simulations and carefully structured loading–recovery cycles.

The FSKT findings revealed that similar performance patterns were maintained across years, whereas performance improved consistently following the training intervention. The significant main effect of time and the higher post-test values observed in all years indicate that the implemented training program positively influenced kicking performance and fatigue resistance. When considered alongside the reductions observed in RPE values, these findings suggest that athletes were able to sustain similar or even higher levels of performance while experiencing lower perceived exertion. Collectively, these results indicate that training loads designed according to the technical–tactical and physiological demands of the revised competition system contributed positively to performance development.

The improvement observed in FSKT performance becomes even more meaningful when considered together with the changes in kicking frequency and fatigue tolerance. Descriptive data indicated that athletes in 2023 were able to perform a greater number of kicks across all five sets while exhibiting lower performance decrements associated with fatigue. These findings are consistent with those reported by Girard et al. (2011) regarding repeated-sprint performance and fatigue. The authors emphasized that high-intensity interval training and sport-specific loading play a critical role in enhancing resistance to fatigue.

Similarly, Ulupınar et al. (2021) reported that the FSKT is an effective tool for distinguishing taekwondo athletes of different performance levels and highlighted the kicking decrement index as an important indicator of fatigue tolerance. From this perspective, the eight-week training program implemented in the present study appears to have improved athletes' ability to sustain repeated kicking performance while reducing fatigue-related performance decline. Consequently, the program contributed positively to overall performance development. In addition, Öztürk et al. (2026) reported significant differences in total FSKT scores between national- and international-level taekwondo athletes, further emphasizing the sensitivity of the test in detecting performance-related differences.

Da Silva Santos et al. (2016) demonstrated that extensive interval training performed at controlled intensities is effective in simultaneously improving technical accuracy as well as aerobic and anaerobic capacities in taekwondo athletes. Likewise, Bartel et al. (2022) reported that both aerobic and anaerobic energy systems play essential roles in taekwondo-specific high-intensity interval exercise performance. Therefore, it is reasonable to suggest that the extensive interval and HIIT protocols implemented in the present study supported such adaptations and contributed to the observed improvements in scoring efficiency.

The HIIT protocols applied in this study appear to have enhanced athletes' anaerobic capacity and their ability to sustain performance during short-duration, high-intensity exercise. Hernandez-Martinez et al. (2024) demonstrated that controlled-intensity training in combat sports is effective in simultaneously improving

technical accuracy as well as aerobic and anaerobic capacities. Similarly, Monks et al. (2017) reported significant improvements in anaerobic capacity following an 11-session HIIT intervention in collegiate taekwondo athletes. More recently, Song and Sheykhlouvand (2024), in a study comparing taekwondo-specific HIIT and short sprint interval training, demonstrated that both methods improved cardiorespiratory fitness and anaerobic power, although sprint-based HIIT elicited greater mechanical stress and physiological demands. From this perspective, the improvements observed in FSKT performance following the 2022 rule modification may be attributed both to the suitability of the implemented training protocols and to athletes' adaptation to the increased physiological demands imposed by the revised competition structure.

The eight-week training protocol implemented in the present study integrated extensive interval training, high-intensity interval training (HIIT), and taekwondo-specific technical–tactical exercises. The findings demonstrated that this approach was effective in enhancing both technical–tactical performance and physical capacities. Haddad et al. (2011) showed that the Rating of Perceived Exertion (RPE) method is a valid tool for monitoring training load during intensive training camps in young taekwondo athletes. Similarly, Markovic et al. (2008) reported elevated heart rate and blood lactate responses during competition in elite female taekwondo athletes, highlighting the importance of high-intensity training stimuli capable of meeting competition demands. Furthermore, Ojeda-Aravena et al. (2021) investigated the effects of a four-week taekwondo-specific technical training protocol on general and sport-specific physical fitness and reported considerable inter-individual variability in responses, although positive adaptations were generally observed.

The adaptation of training principles reported in these studies and their integration with taekwondo-specific technical–tactical exercises formed the foundation of the positive outcomes observed in the present investigation. In particular, the short-duration, high-intensity training sessions implemented during Weeks 7 and 8 appeared to enhance athletes' explosive power production and acceleration capacity, which was subsequently reflected in improved performance during match simulations. Ouergui et al. (2020) reported that repeated sprint training and repeated high-intensity technical training induced similar physical adaptations in adolescent taekwondo athletes; however, sport-specific technical exercises produced more pronounced improvements in agility and technical performance. Likewise, Apollaro et al. (2024), in a recent review emphasizing the importance of sport-specific anaerobic testing in taekwondo, highlighted the critical role of the FSKT and other taekwondo-specific assessments in monitoring athlete performance and optimizing training programs.

One of the major strengths of the present study is its longitudinal perspective, which enabled the evaluation of the effects of the competition system revision across a three-year period. In addition, the combined use of match simulations and field-based performance assessments (FSKT) provided a multidimensional evaluation of athlete performance. Nevertheless, several limitations should be acknowledged. First, the study was conducted exclusively with elite male taekwondo athletes; therefore, the findings cannot be directly generalized to female athletes or individuals from different age categories. Second, although match simulations were designed to closely replicate official competition conditions, they may not fully reflect the psychological, tactical, and environmental demands encountered during actual tournament competition.

The findings of the present study also offer several practical implications for coaches and sport scientists. First, the effects of rule modifications on athlete performance should be continuously monitored, and training programs should be adjusted accordingly. Second, integrating extensive interval training and HIIT protocols with taekwondo-specific technical–tactical exercises appears to be an effective strategy for simultaneously

enhancing athletes' physical and technical capacities. Third, the regular implementation of field-based assessments such as the FSKT may provide valuable information regarding fatigue tolerance and performance development. Finally, during the adaptation process to revised competition regulations, particular emphasis should be placed on improving technical accuracy and movement control, as these factors appear to be critical for maximizing competitive effectiveness under the demands of the modern taekwondo competition system.

Conclusion and Implications

The present study demonstrated that the competition system revision introduced in 2022 influenced the technical–tactical behaviors, kicking force, rating of perceived exertion (RPE), and Frequency Speed of Kick Test (FSKT) performance of elite male taekwondo athletes, based on match analyses and field-test data collected in 2021, 2022, and 2023. Following the rule modification, changes were observed in technical distribution, scoring techniques, and kicking force values, while increases were identified in both the frequency of technical executions and technical diversity. Furthermore, ratings of perceived exertion differed across years, suggesting that the revised competition system imposed greater physiological demands on athletes.

Following the eight-week training program designed according to the findings obtained from the match analyses, positive changes were observed in kicking force, FSKT performance, and ratings of perceived exertion. The improvements in post-test FSKT scores across all years, together with the significant reductions in RPE values, indicate that the implemented training program enhanced both performance and fatigue resistance. These findings suggest that extensive interval training, high-intensity interval training (HIIT), and taekwondo-specific technical–tactical exercises, when designed according to the technical–tactical and physiological demands of the revised competition system, may contribute substantially to performance development.

From a practical perspective, coaches and performance specialists should continuously monitor the effects of rule modifications on competition demands and adapt training programs accordingly. Integrating competition-specific technical–tactical exercises with extensive interval and HIIT protocols may represent an effective strategy for optimizing both physical and technical performance in elite taekwondo athletes.

Future studies should examine the effects of competition rule modifications in more diverse populations, including female athletes and different age categories. In addition, longitudinal investigations conducted under actual competition conditions are recommended to provide a more comprehensive understanding of the long-term adaptations associated with changes in the taekwondo competition system.

Limitations

Several limitations of the present study should be acknowledged. First, the study was conducted exclusively with elite male taekwondo athletes aged between 18 and 25 years. Therefore, the findings cannot be generalized to female athletes, different age groups, or athletes competing at different performance levels.

Second, all participants included in the study were elite athletes with extensive training and competitive experience accumulated over many years. Consequently, the results may not be directly applicable to novice or recreational taekwondo practitioners.

Third, although the match simulations used in this study were standardized to closely replicate official competition conditions, they may not fully represent the psychological pressure, strategic decision-making processes, and environmental factors encountered during actual tournaments.

Fourth, the study evaluated technical–tactical performance indicators, kicking force, rating of perceived exertion (RPE), and Frequency Speed of Kick Test (FSKT) performance. However, other physiological, biomechanical, and psychological variables that may influence performance were not included in the scope of the investigation.

Future studies are recommended to include female athletes, individuals from different age categories, and athletes of varying performance levels. Furthermore, longitudinal investigations conducted under official competition conditions and incorporating a broader range of physiological and performance-related variables may contribute to a more comprehensive understanding of the effects of competition system modifications in taekwondo.

Abbreviations

CR-10
Category Ratio-10 Scale
EBP
Electronic Body Protector
FSKT
Frequency Speed of Kick Test
FSKT_mult
Multiple-Set Frequency Speed of Kick Test
ISAK
International Society for the Advancement of Kinanthropometry
KDI
Kick Decrement Index
RPE
Rating of Perceived Exertion
SE
Standard Error
WTF-WT
World Taekwondo Federation
ηp^2
Partial Eta Squared
rb
Rank-Biserial Correlation Coefficient
Off.
Offensive actions
Def
Defensive actions
BC
Baldeung Chagi

YC
Yop Chagi
DC
Dwi Chagi
EBC
Emphasized Baldeung Chagi
DCG
Dollyo Chagi
NC
Naeryo Chagi
BCG
Bandae Chagi
BDC
Bandae Dollyo Chagi
J
Jireugi

Declarations

Ethics approval and consent to participate: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study received the necessary approval from the Ethics Committee of Marmara University (Approval No: (2021/114). We confirm that all participants provided informed consent before taking part in the study. This ensures that they were fully aware of the study's purpose, procedures, potential risks, and their right to withdraw at any time.

Consent for publication: Not applicable.

Availability of data and material: The data supporting this study’s findings are available.

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Formal analysis: TY; Investigation: AÖ, TY, EŞC; Data Curation: EŞC, TY, AÖ, SB; Visualization: EŞC;

Supervision & Validation: SB; Project administration: AÖ, TY, EŞC, SB; Writing- Original Draft: AÖ, TY, EŞC; Writing - Review & Editing: TY, EŞC, AÖ, SB.

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Figures



Figure 1

Flowchart of the study design

$$\text{KICK DECREMENT INDEX (\%)} = \left[1 - \frac{(FSKT1+FSKT2+FSKT3+FSKT4+FSKT5)}{\text{Best FSKT SET X Number of Sets}}\right] \times 100$$

Figure 2

Kick decrement index formula (Santos et al., 2016).

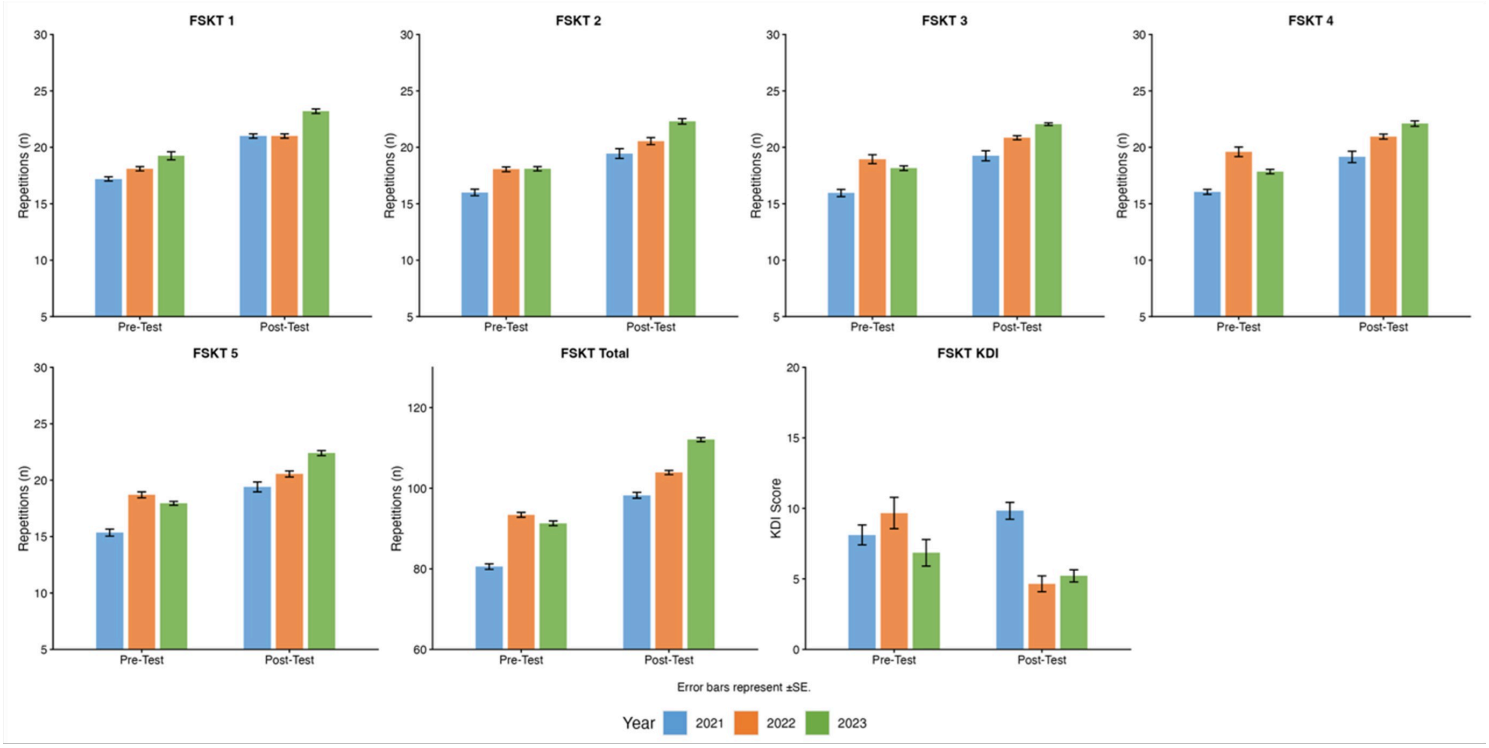


Figure 3

Pre-Test and Post-Test Comparisons of FSKT Variables Across Years

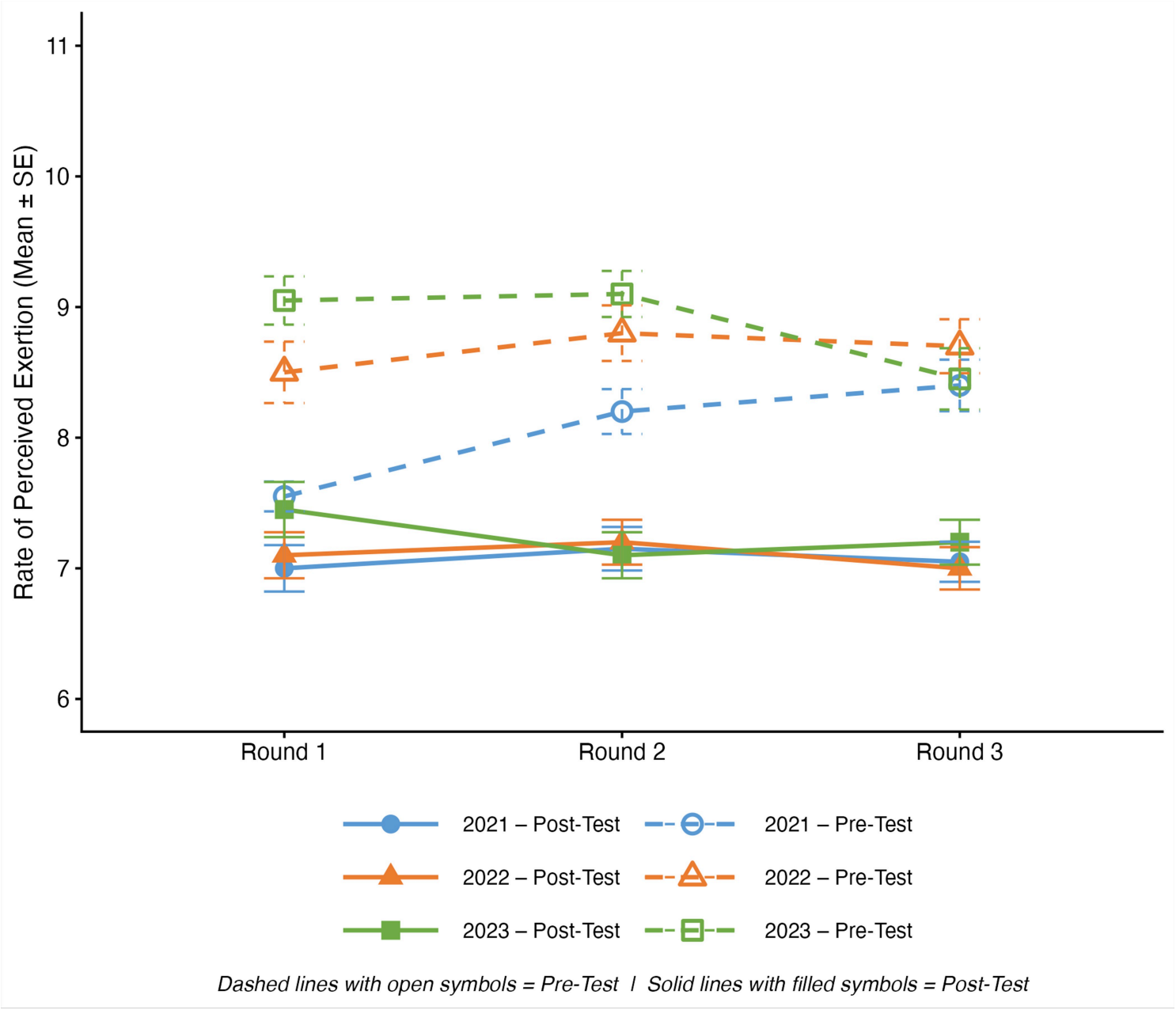


Figure 4

Changes in Rating of Perceived Exertion Across Rounds According to Year and Measurement Time

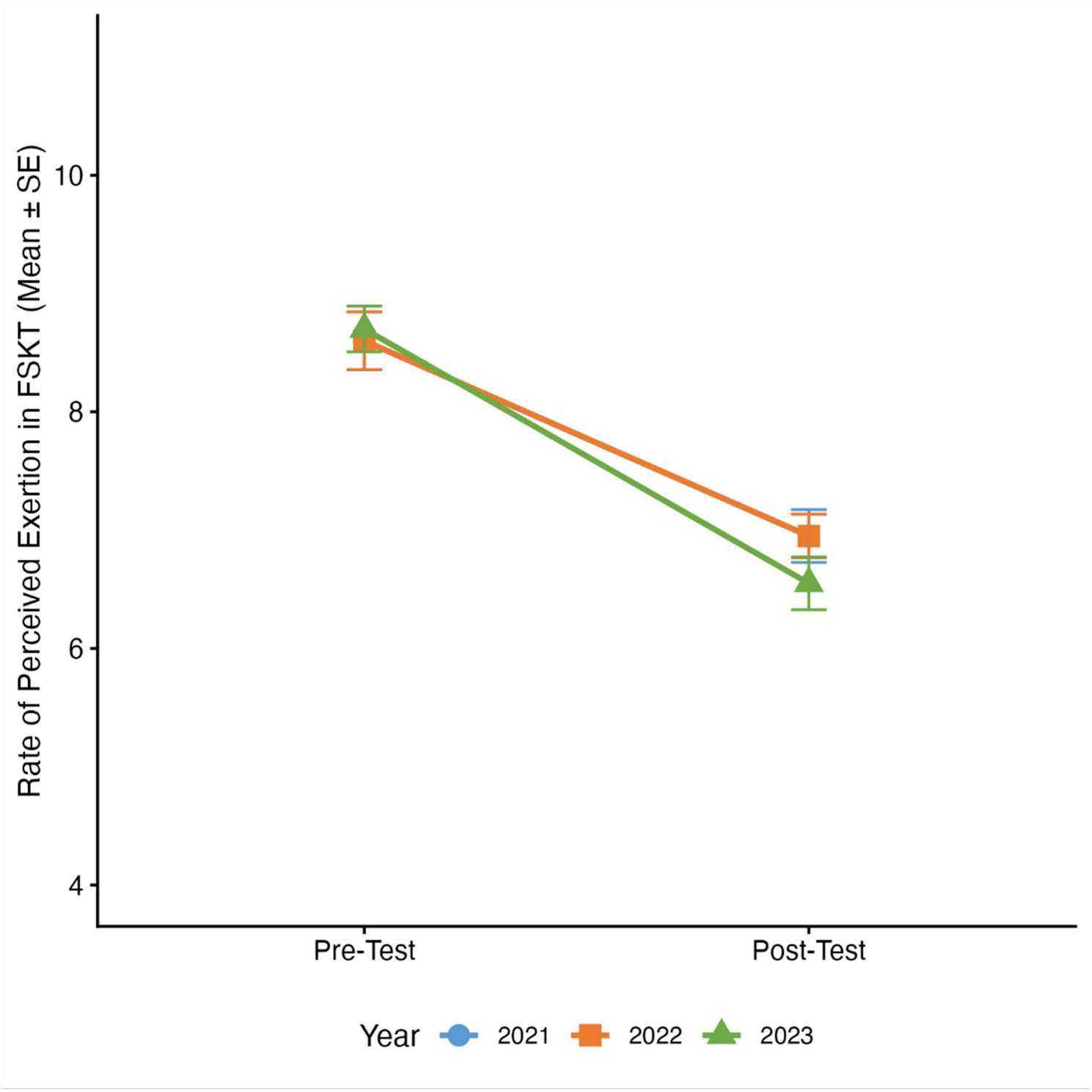


Figure 5

Comparison of Pre-Test and Post-Test Ratings of Perceived Exertion During the FSKT Across Years