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Examination of Visual Reaction Times in Female Taekwondo Athletes After Fatigue

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Abstract

Taekwondo is a combat sport characterized by high-intensity actions and rapid decision-making, making visual–motor reaction time an important component of performance. Despite its relevance, research examining reaction times under resting and fatigued conditions in young taekwondo athletes remains limited. The present study aimed to compare the visual–motor reaction times of female taekwondo athletes during resting and post-fatigue conditions. Seventeen healthy female athletes (age: 18.82 ± 1.13 years; height: 165.82 ± 5.35 cm; body weight: 57.18 ± 5.07 kg) voluntarily participated. Following a taekwondo-specific warm-up, visual–motor reaction tests were performed using the FitLight™ system (Fitlight Sports Corp., Canada) for both dominant and non-dominant hands, with three trials administered for each hand; the best score was used for analysis. Athletes then completed a fatigue protocol based on a validated taekwondo match simulation model, after which post-fatigue measurements were conducted ten minutes later. Reaction time data were analyzed using a 2×2 repeated-measures ANOVA. Findings revealed no significant differences between resting and post-fatigue reaction times, nor between dominant and non-dominant hands. These results suggest that acute fatigue induced by a taekwondo match simulation protocol may not substantially influence visual–motor reaction performance in young female taekwondo athletes.

Keywords: Visual- Motor Reaction time, Fatigue, Taekwondo.

Özet

Yorgunluk Sonrası Kadın Taekwondo Sporcularının Görsel Reaksiyon Sürelerinin İncelenmesi

Taekwondo, yüksek yoğunluklu aksiyonlar ve hızlı karar verme süreçleriyle karakterize edilen bir dövüş sporudur; bu nedenle görsel–motor reaksiyon süresi performansın önemli bir bileşenidir. Bu önemine rağmen, genç taekwondo sporcularında dinlenik ve yorgunluk koşulları altında reaksiyon sürelerini inceleyen araştırmalar sınırlıdır. Bu çalışmanın amacı, kadın taekwondo sporcularının dinlenik ve yorgunluk sonrası koşullarda görsel–motor reaksiyon sürelerini karşılaştırmaktır. On yedi sağlıklı kadın sporcu (yaş: 18,82 ± 1,13 yıl; boy: 165,82 ± 5,35 cm; vücut ağırlığı: 57,18 ± 5,07 kg) gönüllü olarak çalışmaya katılmıştır. Taekwondo'ya özgü bir ısınma protokolünün ardından, baskın ve baskın olmayan el için FitLight™ sistemi (Fitlight Sports Corp., Kanada) kullanılarak görsel–motor reaksiyon testleri uygulanmış; her el için üç deneme yapılmış ve analizlerde en iyi skor kullanılmıştır. Daha sonra sporcular, geçerliliği kanıtlanmış bir taekwondo maç simülasyon modeline dayalı bir yorgunluk protokolünü tamamlamış ve yorgunluk sonrası ölçümler on dakika sonra gerçekleştirilmiştir. Reaksiyon süresi verileri 2×2 tekrarlı ölçümler varyans analizi (ANOVA) ile analiz edilmiştir. Bulgular, dinlenik ve yorgunluk sonrası reaksiyon süreleri arasında ve baskın ile baskın olmayan el arasında anlamlı bir fark olmadığını göstermiştir. Bu sonuçlar, taekwondo maç simülasyon protokolüyle oluşturulan akut yorgunluğun, genç kadın

taekwondo sporcularında görsel–motor reaksiyon performansını önemli ölçüde etkilemeyebileceğini düşündürmektedir.

Anahtar Kelimeler : Görsel-Motor Reaksiyon süresi, Yorgunluk, Taekwondo.

INTRODUCTION

Taekwondo is a high-intensity fighting sport branch consisting of three two-minute rounds, with technical and tactical components (4, 14). This dynamic sport causes lactate levels to vary from 5.0 to 14 mmol 11 mmL1 due to the high physiological intensity requiring generally exceeding 90% of the maximum heart rate (3, 7). During combat, taekwondo is characterized by periods of intermittent exertion and rest, typically ranging from 1:2 to 1:7 (7). It also involves dynamic movements such as high kicks and fast kicks and requires athletes to develop strength, flexibility, endurance and agility; which contributes to the cardiovascular benefits of taekwondo by improving high levels of physical fitness and increasing endurance (17) In addition, it has been reported that these athletes use high peak anaerobic power properties in the lower extremities to help achieve success in competitions (3).

Although Taekwondo is a close-contact sport, visual and auditory signals are important in determining competitors' actions as athletes receive no tactile warning from their competitors before being attacked (5). Because the ability to react to a blow for defensive or offensive purposes is important in various fighting sports, even a millisecond difference in reaction time can determine the athlete who wins (25). Reaction time functions as a reliable indicator of the rate at which sensory stimuli are processed by the central nervous system and its application in motor response form (9).

Reaction time varies depending on the sensory pathways that capture the stimuli. Athletes typically display response times of about 200 ms for visual alerts and 150 ms for auditory alerts (25). The shorter reaction time indicates a person's higher efficiency of neural processing and provides information about the speed of processing (25). Reaction time is affected by factors such as gender (13, 15), fatigue (21), caffeine (23), age (9), arousal level (10), physical activity (32), and physical fitness (24). Wadoo et al. (32) reported that men have faster reaction times than women for both auditory and visual stimuli, and that young adults who exercise regularly have faster reaction times than young adults with a sedentary lifestyle. Another study reported that professional taekwondo athletes who underwent long-term intensive training exhibited better neuromotor performance, responded more quickly to sport-specific stimuli, and showed better physiological performance in terms of higher excitability in trained muscles compared to amateurs and non-athletes (5).

The fact that taekwondo athletes have to participate in multiple competitions in the same day, the sudden accelerations they make during competition, high-intensity kicks, and short recovery times cause rapid fatigue accumulation (4). Fatigue is a phenomenon characterized by neuromuscular changes that affect the body's force production capacity and cause impairments in performance (30). Fatigue affects various components of the sensorimotor system, including muscle fibers, the central nervous system, and neuromuscular junctions, and increases the risk of injury by causing a decrease in muscle efficiency in force production (1). It has been noted that central fatigue, particularly that originating from the central nervous system, negatively impacts cognitive processes such as decision-making, attention, and reaction time (20). The literature shows a limited number of studies examining reaction times in young taekwondo athletes under resting and fatigue conditions (26). This study aims to compare the visual-motor reaction times of female taekwondo athletes under resting and fatigue conditions.

METHOD

Participants

Seventeen healthy female taekwondo athletes who were actively participating in regular training programs volunteered for the study. All measurements were taken during the competition period. The subjects had a mean age of 18.82 ± 1.13 years, a height of 165.82 ± 5.35 cm, and a body weight of 57.18 ± 5.07 kg. Athletes were instructed not to consume food at least one hour prior to the assessments; however, water intake was allowed.

None of the subjects had any upper-extremity musculoskeletal injury affecting function within three months prior to measurements. The study was approved by the local Ethics Committee of the Selçuk university (Protocol number 261, 31.10.2025) and informed consent was obtained from all subjects.

Table 1. Demographic Characteristics of the Participants

	N	Min.	Max.	Mean	Std. Deviation
Age (year)	17	17,00	21,00	18,82	1,131
Height (cm)	17	157,00	176,00	165,82	5,352
Body weight (kg)	17	50,00	70,00	57,17	5,065

Experimental Design

The current study adopted an experimental design and all measurements were taken over the course of three separate testing sessions. The first visit was a familiarization trial to ensure that participants adapted to the measurement protocol; no visual–motor reaction data were collected during this session. At the second visit, a taekwondo-specific warm-up and stretching protocol (15 minutes) was applied before measuring participants' visual–motor reaction times with the FitLight™ system (Fitlight Sports Corp., Canada). Three trials for each participant on both dominant and nondominant hands in randomized order were conducted, with analysis based on the best score from among three attempts. The fatigue protocol was completed by participants during their third visit. Visual-motor reaction tests were repeated 10 minutes after completion of the fatigue protocol as post-fatigue measurements to assess changes in reaction performance. Assessments for both dominant and nondominant hands were randomized within all sessions.

Fatigue Protocol

The fatigue stimulus was based on the taekwondo match simulation protocol used in this study. This protocol has been cited in literature as a valid and reliable method for reproducing the physiological demands of an actual taekwondo bout. The simulation consists of three rounds of 2 minutes with 1 minute passive rest between rounds. In each 2-minute round, athletes kick for 10 seconds consecutively at maximal speed and force followed by 10 seconds active recovery which may consist of light bouncing or small movements; these cycles are repeated continuously throughout the round. This structure has been shown to elicit physiological responses such as heart rate elevation, perceived exertion, and muscular fatigue that closely resemble those found under real competitive conditions. Therefore it is widely accepted as an appropriate model for inducing laboratory fatigue under controlled conditions (4).

Visual–Motor Reaction Test

Visual–motor reaction time was measured with the FitLight™ (Fitlight Sports Corp., Canada). The protocol included a simple motor reaction task for 10 seconds to visual stimuli randomly illuminated on six wireless light discs configured in a semi-circle on a table. The center of each disc was positioned 40 cm from the center of the semi-circle and 25 cm apart from each other. Subjects were instructed to stand in an upright posture with their test hand in the central starting position of the semi-circle. The participant placed their hand at the starting point before beginning the test and, when activated by light, reached out and touched the glowing disc then returned their hand to its original starting position. This continued for all ten seconds during which period lights would glow randomly until complete. Participants turned off each light as quickly as possible then immediately returned to starting point before responding to next stimulus. At completion of testing, mean reaction time over ten second interval was automatically computed and recorded by FitLight device (28).

Statistical Analyses

Statistical analyses were performed using the SPSS 27.0 software package. Descriptive statistics were reported as mean ± standard deviation values. The normality of the data was assessed by the Shapiro–Wilk test; all variables were normally distributed. A 2 × 2 repeated-measures ANOVA was used to analyze resting and post-fatigue measurements on dominant and non-dominant hand values. This analysis tested main effects for time (resting–post-fatigue) and hand dominance (dominant–non-dominant) as well as the time × hand interaction. ANOVA results are reported with F values, p values, and partial eta-squared (η^2p) as an effect

size. Effect sizes were interpreted using conventional criteria: $\eta^2p \approx .01$ is considered small, $\eta^2p \approx .06$ is medium, and $\eta^2p \geq .14$ is large (6). The statistical significance level was set at $p<.05$.

FINDINGS

Table. 2. Descriptive Statistics of Reaction Time Measurements

Measurement (sec)	Mean	Standard dev.
Dom. Resting Test	.537	.028
Dom. Post-Fatigue Test	.541	.025
Non-dom. Resting Test	.524	.023
Non-dom. Post-Fatigue Test	.547	.014

Table 3. Comparison of Motor Reaction Measurements Between Resting and Post-Fatigue Conditions

Effect	F(1,16)	p	Partial η^2
Time (Resting–Post-fatigue)	1.31	.269	.076
Hand (Dominant–Non-dominant)	3.75	.071	.190
Time × Hand	4.47	.051	.218

Note. Statistical significance was set at $p < .05$. Partial η^2 represents effect size.

There was no statistically significant difference between the reaction time measurements taken under resting conditions and those taken after fatigue, $F(1,16) = 1.31$, $p = .269$, $\eta^2p = .076$.

Dominant and non-dominant hand measurements also did not differ significantly, $F(1,16) = 3.75$, $p = .071$, $\eta^2p = .190$.

The interaction effect between time and hand dominance was not statistically significant, $F(1,16) = 4.47$, $p = .051$, $\eta^2p = .218$; however, the relatively large effect size suggests a potential differential response between dominant and non-dominant hands following fatigue.

DISCUSSION AND CONCLUSION

This study investigated the effect of fatigue, induced using a taekwondo-specific match simulation, on visual-motor reaction time in female taekwondo athletes. The findings showed that fatigue did not statistically significantly affect visual-motor reaction time. Studies in the literature on the effect of fatigue on reaction time have yielded different results. Sant'Ana et al. (26) reported that reaction time and spinning kick strikes were negatively affected by fatigue in taekwondo athletes. Similarly, Pavelka et al. (22) found that acute fatigue, induced by applying the upper body Wingate test to mixed martial arts fighters, significantly increased simple visual reaction time after fatigue compared to before fatigue.

In contrast to these studies in the literature, Tavahomi et al. (29) reported that the effect of fatigue on selective reaction time was insignificant, Lima et al. (18) reported that serum lactate concentration, which is closely related to muscle fatigue, did not affect the motor reaction time of high-level judokas, and Karakaya et al. (12) reported that visual reaction time did not change in measurements taken before and after shuttle run to exhaustion in elite karate athletes. The dynamic nature of Taekwondo, its high intensity, the need to constantly react to visual stimuli, and its regular practice may have led to the development of chronic adaptation in cognitive resilience processes against fatigue (5). Yordanova et al. (33) stated that experience level had a significant effect on the visual-motor selective reaction times of boxers. They reported that increasing boxing experience significantly shortened the overall reaction time. Engeroff et al. (8) stated that upper extremity training improves visual-motor reaction time and enhances cognitive choice reaction performance.

Another noteworthy finding of this study was the absence of a significant difference in visual-motor reaction times between the dominant and non-dominant hands of female taekwondo athletes. This result can be explained by the fact that both upper extremities play an equal role in block defense, balance, and counter-attack situations in taekwondo, and that both the dominant and non-dominant hands are used continuously during training (27). Visual reaction time for both dominant and non-dominant hands was reported to be improved by 8 weeks of hand-eye coordination training in taekwondo athletes (19). In taekwondo,

the advantage of performance on a left-right basis using both sides effectively to respond to surprise moves during competition is another feature (16).

The reaction timer device may have limited fatigue effects in this study since it assessed a simple reaction task. Simple reaction tasks are less susceptible to fatigue because they involve lower decision-making and cognitive load than complex or selective reaction tasks (28). Simple reaction time tasks require one stimulus presence for the participant to react (11), while selective reaction time tasks require different responses for different types of stimuli (2). Therefore, simple reaction time has been noted as significantly shorter than selective reaction time (31).

This study involved only female taekwondo athletes, which limits the generalizability of the findings. In addition, the device used to assess visual-motor reaction time in female taekwondo athletes measured only simple reaction time; thus, complex or selective reaction time could not be assessed. Future studies are recommended to investigate both genders and include a more complex reaction task for thorough assessment.

In conclusion, this study demonstrated that acute fatigue induced by taekwondo-specific match simulations did not significantly affect visual-motor reaction time in young female taekwondo athletes and did not create a difference between dominant and non-dominant hand performances. The lack of change in visual-motor reaction times after fatigue in female taekwondo athletes suggests that cognitive and neuromuscular mechanisms can maintain balance in performance outcomes even under fatigue conditions.

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