INTERNATIONAL JOURNAL OF SPORTS EXERCISE & TRAINING SCIENCES
http://dergipark.gov.tr/useeabd
e-ISSN 2149-8229 Vol 3, Issue 4, 161–168, (2017) Original Article

The Evaluation of Balance Performance for Elite Male Karate Athletes After Fatigue

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Abstract

Aim: his study aimed to examine the effect of the tiredness in karate athletes, which was created with the help of a special simulation that was organized particularly to the branch in karate athletes, on the balance performance of karate athletes.

Material and Methods: 16 male karate athletes were included in the study; these athletes have been doing karate for the Turkish national team and their active sports careers continue (age: 23.31±4.27 years, height: 173.4±4.91 cm, weight: 68.8±8.17 kg, BMI: 22.85±1.96 kg/cm2). Balance test was conducted for the athletes before the exercise test protocol that was prepared particularly for the karate-do sport and in the first 10 minutes and 30 minutes after the protocol ended.

Results: As a result of all the parameters recorded, no statistically significant change was observed in the static balance parameters of the karate players participated in the research on their kicking feet, balancing feet and double feet, and also in their dynamic balance parameters on their double feet ($p>0.05$). The evaluations for the stability limits dynamic balance tests reveal that there is a statistically significant difference between the pre-test and post-test values (of the overall balance, forward-right and forward-left data) ($p<0.05$).

Conclusion: Consequently, it was presented that additional time is needed for karate athletes to recover their balance after bout tiredness and the given relaxation time is not enough for some dynamic balance parameters.

Keywords
Balance,
Fatigue,
Karate,

Article Info
Received: 30.08.2017
Accepted: 14.12.2017
Online Published: 19.12.2017

DOI: 10.18826/useeabd.336577

INTRODUCTION

Balance, as a basic motor skill in everyday life and sports, includes a complex network of neural links, central and peripheral feedback mechanisms (Evangelos, Georgios, Konstantinos, Gissis, Papadopoulos &Aristomenis, 2012; Ness, Comstock & Schweinle, 2016; Abichandani &Hule, 2017). The postural balance consists of visual, kinesthetic and vestibular information. In order to obtain balance, the visual, vestibular and proprioceptive systems must form an afferent data integration (Evangelos *et al.*, 2012; Camliguney, Ramazanoglu, Erkut Atilgan, Yilmaz & Uzun, 2012; Abichandani & Hule, 2017).

Static and dynamic balance, while developing basic motor skills also, help athletes to optimize their movements. Dynamic balance is more challenging because it requires the ability to maintain equilibrium during a transition from a dynamic to a static state. This requires an effective integration of visual, vestibular, and proprioceptive inputs to produce an efferent response to control the body within its base of support (Abichandani & Hule, 2017).

In sports, the standing limb in the kicking action in soccer and taekwondo is important to ensure stability needed for successful execution (Vando, Filingeri, Maurino, Chaabène, Bianco, Salernitano, Foti & Padulo, 2013; Jaakkola, Linnamo, Woo, Davids, Piirainen & Gråstén, 2017). In fighting sports (judo and taekwondo) balance and stability are a key performance (Zago, Mapelli, Shirai, Ciprandi, Lovecchio, Galvani & Sforza, 2015). Karate involves repeated sequences of strikes and defences. Though of a relatively short duration, fights require maximal intensity and a high level of motor and functional abilities including speed, agility, muscle strength and flexibility, coordination and balance (Filingeri, Bianco, Zangla, Paoli & Antonio, 2012; Tabben, Sioud, Haddad, Franchini, Chaouachil, Coquart, Chaabane, Chamaril & Chollet, 2013). For athletes to be successful, they are expected to have not only a good measure of technical and tactical skills but also a high physical performance (Beneke, Beyer, Jachner, Erasmus & Hütler, 2004). Every technic that complies with competition criteria is scored according to an evaluation of the details requiring ability such as speed, power, balance, aesthetics,

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timing, and control (Okus, 2013; Zago, *et al.*, 2015). During the competition, implementing postural strategies quickly is important in terms of demonstrating effective offensive and defensive techniques. To shorten offensive and defensive preparation time, athletes start the competition with the body position they designed before (Ramazanoglu, Tatar, Camliguney, Kucuk, Atilgan & Cotuk, 2007). Thus, in karate competitions, movements of the opponent affect balance.

Fatigue is a complex process involving peripheral central nervous contribution and psychological factors (Shirazi, Jahromi, 2013). It may be attributed to metabolical or neurological factors controlled peripherally and centrally by the neuromuscular systems. It is demonstrated that fatigue affects the neuromuscular control. Neuromuscular control can be evaluated in several levels including the brain, spinal cord or muscle as well as the muscular activation pattern and postural control. Karate competitions (kumite) is said to require high level of metabolic demands (Nunan*,* 2006). Long-term practices and privatizations of karate athletes bring different sensory and postural adaptations along with it (Filingeri *et al.,* 2012).

Studies have reported increased postural sway with localized muscle fatigue at isolated muscle groups (Dickin, Doan*,* 2008; Gribble Grzegorz, Marian, Pawel, Wojciech, B, Wojciech, C., Kajetan & Grzegorz*,* 2013). It appears that there is a relationship between lower extremity fatigue and postural control deficits, however, no previous studies have investigated on elite karate athletes balance parameters before/after a fatiguing exercise. Therefore, the purpose of this study was to examine the balance parameters of elite karate athletes before/after a fatiguing exercise and measure the effect of fatigue on recovery time.

METHOD

Participants

16 male karate athletes were included in the study; these athletes have been doing karate for the Turkish national team and their active sports careers continue (age: 23.31±4.27 years, height: 173.4±4.91 cm, weight: 68.8±8.17 kg, BMI: 22.85±1.96 kg/cm^2). This study was conducted during their tournament season. The balance test was conducted in the university laboratory. The results were evaluated by the Marmara University, Medical Faculty Institutional Ethics Committee, and they gave their informed consent to the experimental procedure as required by the Helsinki Declaration (1964).

Material: The Biodex Balance System (Shirley, New York, USA) stabilimeter was used for balance measurements. When the athletes stepped on the Biodex Balance System balancing equipment, the reference points which were located on the platform were used in order for every measurement to be performed in the same foot positions. These reference points were designated on the stabilimeter by recording the axes on which the heels and fingertips were placed, and the subjects were made to step on the same points with barefoot in all the repetitive balance measurements. After adequate information is given to the athletes, every subject was given the opportunity to trial three times, and the tests were initiated when the athletes felt ready. Earphones were used in order to avoid the athletes to be negatively affected by environmental stimuli.

In accordance with the predetermined aim, static postural stability, dynamic postural stability and limits of stability tests were carried out as balance measurements before the tiresome exercise and after 30 minutes. In addition, postural stability static balance test was carried out after 10 minutes of the completion of the exercise.

The tiresome exercise utilized in the study consists of 5 sets of 3 minutes each. While the numbers of repetition and relaxation allowance times varied, the attack times were left constant. The loads were planned to be carried out with the stimuli that came randomly with 4 technical applications (2 hand and 2 foot techniques) in 7 seconds. During the test, the Kizami Zuki, Oi Mawashi Geri, Gyaku Zuki and Kizami Mawashi Geri techniques were implemented respectively. In order to determine the stimulations, an audio file was prepared with special software.

Static Balance Tests: In the single foot balance measurements, the athletes were asked to put their hands on the iliac crests and their toe in the air to touch the medial malleolus. During the test, the athletes were told that they had to centralize the red spot on the screen. Three measurements of 30 seconds each were carried out at the first level, and relaxation allowance times of 1 minute each were given between tests.

On the other hand, the athlete was taken to the top of the balancing equipment for the static balance measurements on double feet (stable base). After the feet were positioned on the platform and the athlete assumed a comfortable position, the information was recorded and the test was carried out. During the test, the athletes were told that they had to centralize the red spot on the screen. Three measurements of 30 seconds each were carried out at the first level, and relaxation allowance times of 1 minute each were given between tests.

Dynamic Balance Tests: The athlete was taken to the top of the balancing equipment for the dynamic balance measurements on double feet (moving base). The athlete information was entered to the balancing equipment screen. After the feet were positioned on the platform and the athlete assumed a comfortable position, the test was carried out. The athletes were told that they had to centralize the red spot on the screen while they were on the moving base and maintain the positions of their feet during the test. 3 measurements of 30 seconds each were carried out, and relaxation allowance times of 1 minute each were given between tests.

The athlete was taken to the top of the platform for the stability limit test and the dynamic balance test. The athlete information was entered to the balancing equipment screen. The feet were positioned on the platform with an angle that the athlete can be at ease. The feet positions were told to be maintained. The athlete was asked to transfer his/her centre of gravity to anterior-posterior, medial-lateral and other directions – totally to 8 different points – displayed on the screen as soon as possible and in a linear way. The time that s/he continued the test by keeping his/her feet positions was determined. The end of this test changes from athlete to athlete. As soon as the athlete is unbalanced, the test is terminated. The stability limit test score is calculated by averaging 8 different point averages within the dynamic limits. In addition, high scores reveal the fact that postural control is good.

Procedures: All the athletes participated in our study was tested on different days and in the same time periods, and all the test measurements were completed in the Marmara University, Athlete Health and Research Centre Laboratory. During the research, the laboratory properties (humidity, temperature, pressure) were tried to be kept approximately the same.

The athletes were informed about the rules and requirements. They were asked to eat at least 2 hours before the test on the test day, not to use stimulants like tea, coffee and medicine, not to exercise 24 hours before the test and avoid challenging exercises on the test day, and to bring their equipment of their branch of sports used under bout conditions (karate gi, gloves, stilts and tibia protector).

After the athletes arrived in the laboratory, the test protocol was explained to them during the 10-minute passive relaxation before the test started. Before the tiresome exercise, the athletes were put to pre-tests. (It contains static, dynamic balance test and stability limits balance measurement.) Afterwards, the athletes warmed up for 15 minutes. After the warm up and the completion of all the preparations for the tiresome exercise, the exercise was taken. As soon as the exercise ended, the athletes were taken to the balance laboratory and static balance measurements were performed at the 10. minutes. Afterwards the athletes were put to post-tests. (It contains static, dynamic balance test and stability limits balance measurement.) It was performed at the 30. minute.

Before the tiresome exercise
Pre-tests
Static balance tests: Balance measurement on single foot with open eyes (Kicking foot and balance foot)
Balance measurement on double foot with open eyes
Dynamic balance tests: Balance measurement on double foot with open eyes Stability limits balance measurement

Warm Up / Tiresome Exercise

After the tiresome exercise
Static balance tests: Balance measurement on single foot with open eyes (Kicking foot and balance foot)
Balance measurement on double foot with open eyes

After the tiresome exercise
Post-tests
Static balance tests: Balance measurement on single foot with open eyes (Kicking foot and balance foot)
Balance measurement on double foot with open eyes
Dynamic balance tests: Balance measurement on double foot with open eyes
Stability limits balance measurement

Figure 1. Schematic representation of the procedure and study design

Statistical Analysis
The findings of the study were reached by using statistical methods were analysed (mean and standard deviation). Testing for normality was done for all parameters and according to the results which were found to be non-normal distribution, the Nonparametric Friedman Test was utilized in order to determine the significance in measurements that are iterated three times or more. The Wilcoxon Test was used in order to determine the significance of the difference between the pre-test and post-test measurements. In these analyses, the results were evaluated in the 95% confidence interval and $p<0.05$ significance level.

RESULTS

Table 1. The evaluation of the static balance indexes on single foot (kicking and balancing foot) with open eyes

	Mean±SD			
	1st Measurement	2nd Measurement	3th Measurement	p
Kick Feet Overall Index	0.78±0.17	0.86±0.19	0.80±0.24	0.210
Kick Feet AP Index	0.51±0.10	0.57±0.15	0.52±0.14	0.570
Kick Feet ML Index	0.46±0.13	0.50±0.16	0.47±0.20	0.646
Balance Feet Overall Index	0.72±0.12	0.79±0.16	0.84±0.41	0.449
Balance Feet AP Index	0.48±0.09	0.54±0.12	0.48±0.10	0.282
Balance Feet ML Index	0.41±0.07	0.44±0.10	0.55±0.47	0.627
Double Feet Balance Overall Index	0.28±0.08	0.33±0.13	0.31±0.10	0.368
Double Feet Balance AP Index	0.21±0.05	0.25±0.10	0.24±0.08	0.570
Double Feet Balance ML Index	0.11±0.07	0.14±0.09	0.12±0.06	0.829

There is no statistically significant difference between the overall, anterior-posterior and medial-lateral (overall, AP and ML) static balance test results of the karate players participated in the research on their kicking feet, balancing feet and double feet ($p>0.05$).

Table 2. The evaluation of the dynamic balance pre- and post-test indexes on double foot

	Mean±SD		
	Pre-test	Post-test	p
Double Feet Balance Overall Index	2.24±1.34	2.00±0.95	0.535
Double Feet Balance AP Index	1.65±0.99	1.55±0.78	0.959
Double Feet Balance ML Index	1.16±0.72	0.96±0.43	0.109

There is no statistically significant difference between the dynamic overall balance, AP and ML test results of the karate players participated in the research on their double feet ($p>0.05$).

Table 3. The evaluation of the limits of stability test (LOS) dynamic balance pre-test and post-test scores

	Mean±SD		
	Pre-test	Post-test	P
LOS Trial Time (Score)	58.88±10.63	55.62±14.06	0.127
LOS Overall (Score)	39.94±8.66	44.62±7.93	**0.041***
LOS Forward (Score)	41.94±17.85	48.31±13.18	0.140
LOS Backward (Score)	52.19±22.84	51.44±20.55	0.955
LOS Right (Score)	47.13±14.37	45.13±20.85	0.569
LOS Left (Score)	42.06±11.94	48.81±18.00	0.266
LOS Forward-Right (Score)	44.75±12.34	53.31±12.18	**0.031***
LOS Forward-Left (Score)	42.56±14.84	54.75±17.45	**0.028***
LOS Backward-Right (Score)	42.12±11.91	47.13±10.26	0.147
LOS Backward-Left (Score)	38.63±14.17	42.69±13.70	0.154

*$p<0.05$

Evaluations for the stability limits dynamic balance tests of the karate players participated in the research are exhibited in Table 3. No statistically significant difference was found between the pre-test and post-test values of the trial time, forward, backward, right, left, backward-right and backward-left test results ($p<0.05$). Statistically significant difference was found between the pre-test and post-test values of the overall balance, forward-right and forward-left data ($p<0.05$).

DISCUSSION

In this study, the change in the balance performance of athletes before and after a tiresome exercise particular to karate was examined.

In our literature review, no studies have been found that examine the posturo-kinetic features of karate. Hence, a number of examinations should be made in order to understand the proximity of karate (kata-kumite) to posturo-kinetic features. Several studies suggest that short time and high-density karate practices as a method employed to develop static balance at early ages, in addition to that high-level karate performances require both static and dynamic balance (Filingeri *et al.*, 2012; Vando *et al.*, 2013).

Gribble Grzegorz *et al.*, (2013) focused on the same subject, and they observed that karate practices had positive long-term effects on postural control and the specialty effects of static balance of elite athletes increase body oscillation. They argued that this increase might stem from the increase of sensory-motor system. Researchers explored the effects of karate in establishing the postural control and they found a positive correlation between karate practices and improving postural control (Matthews M. J., Mathews H., Yusuf & Doyle, 2016; Gauchard, Lion, Bento, Perrin, & Ceyte, 2017; Witte, *Emmermacher & Pliske,* 2017)

Athletes did an exercise that continued until anaerobic threshold was reached and the density of the exercise was gradually increased. After the exercise, the dominant leg static balance performances of the athletes were compared. The comparisons revealed that the dominant leg static balance performance of basketball players and gymnasts decreased while there was no negative effect on the balance level of football players (Erkmen, Suveren, Goktepe & Yazicioglu, 2007). Our research reveals the fact that the expected tiredness actually occurred in the kicking foot overall (total) postural static stability, anterior-posterior and the medial-lateral scores of kumite athletes from the aerobic test, which was particularly designed for karate. However, overall balance parameters recovered to the beginning level (the level before the load) due to the 30-minute relaxation after the bout. In other words, the 30-minute relaxation time given to athletes improves the after-load balance parameters. Yaggie & Armstrong (2004) also found that dynamic balance on a moveable platform restored in 10 minutes after the exertion.

On the other hand, because there was weight transfer to the support leg during movements throughout the aerobic test in the support leg postural static overall, anterior-posterior and medial-lateral values and there was more weight on one foot in stands and forward attack steps, the expected tiredness was not statistically observed but it was observed as percentage. Consequently, the 30-minute relaxation time that was given to the athletes for them to recover was observed to be inadequate, and additional time was needed.

Ishizuka, Hess, Reuter, Federico & Yamada, (2011) measured the recovery time and how it limits the functional fatigue of football players using the Biodex Balance System. The participants completed tests both for fatigue and non-fatigue conditions. Ishizuka et al. found out that a 20-minute session of functional exercise affected dynamic balance negatively but it was recovered after a 10-minute rest. Findings from several studies seemed to confirm the decreased dynamic balance after the exertion (Matsumoto, 2006).

Susco, McLeod, Gansneder & Shultz, (2004) used the Balance Error Scoring System to measure balance changes and reported that balance deficits lasted up to 15 minutes after exertion induced by the functional fatigue protocol and the balance is recovered within a 20-minute rest. Nardone, Tarantola, Giordano & Schieppati, (1997) also suggested that increased body sway lasted approximately for 15 minutes after exertion induced by 25 minutes of treadmill running.

Judo athletes and dancers were examined with regard to balance control skills, they were compared with the control group and they revealed good static and dynamic balance in the measurements with open eyes. In the measurements with closed eyes on the other hand, judo athletes revealed a better stand. The accomplished result indirectly exhibits the fact that these two sport activities stimulate different proprioception channels (Perrin, Deviterne, Hugel & Perrot, 2002; de Mello, Sa Ferreira & Ramiro Felicio, 2017).

It is possible to indicate that visual level of information is more important for high-level judo athletes. The level of competition probably affects the sensual channels that are located in balance. The current visual information can be more important in postural kinetic activities for well-practiced judo athletes as the competition level increases (Paillard, Costes Salon, Lafont & Dupui, 2002; Rodrigues, Gotardi, Aguiar, 2017).

Despite the fact that the postural stability static and dynamic overall balance, anterior-posterior and medial-lateral values are not statistically significant on double feet, they create significant differences. Accordingly, it might be argued that the elite karate athletes are well-practiced and the practices have positive effect on the proprioceptive system just like the similar works.

Del Percio, Babiloni, Infarinato, Marzano, Iacoboni, Lizio & Veicsteinas, (2009) investigated the effects of tiredness in the visual-spatial attention processes of elite karate athletes and people who were not athletes. They tested the hypothesis that tiredness and muscle fatigue weakly affect the visual-spatial attention processes of elite karate athletes. They proved that the muscle fatigue processes of karate athletes displayed a better performance compared to the performance of the people who were not athletes and the visual-spatial attention of the tiredness and muscle fatigue of elite karate athletes was affected more compared to the people who were not athletes. The evaluation of the effect of muscle fatigue on proprioception revealed the fact that the overall tiredness that occurred worsened the proprioception (Forestier, Talestale & Nougier, 2002).

Significant differences and decreases were determined in the lower extremity dominant leg postural stability values (overall balance and anterior-posterior) of young football players before a 45-minute match and after the match (Yamada, Arliani, Almeida, Venturine, Santos, Astur & Cohen, 2012).

The examination of the parameters that affect dynamic balance in the limit test on double feet exhibits the fact that there was disturbance in their dynamic balances after the anterior-medial, anterior-lateral and all the balance values appeared to be statistically significant. There was 19% change in the anterior-medial balance value and 29% change in the anterior-lateral balance value. Although these results suggest muscle fatigue, the difference between the two balances might stem from the fact that one leg is dominant. In addition, this result about balance illuminates the effect of the tiredness that occurred as a result of the dynamic structure of the kumite competition model (Table 3).

Limitation of this study: The 10-minute static measurements and 30-minute static and dynamic measurements of the athletes were performed after tiresome exercise. Because, in karate games, athletes can relax for approximately 10 minutes between rounds, and they can participate in the final match of their weight 30 minutes after the matches at the earliest. Thus, the structure of the karate bout determined the 10-minute and 30-minute balance measurements that were performed after the tiresome exercise and that appeared in the protocol of our study.

CONCLUSION AND SUGGESTIONS

Consequently, it was observed that additional time is needed for karate athletes to recover their balance after bout tiredness and the given relaxation time is not enough for some dynamic balance parameters. However, the general observation of balance parameters indicated that the regular karate practices of elite athletes have positive effect on the proprioceptive system and other systems that function in balance control.

Acknowledgement
The tests were carried out at the Sports Science and Athlete Health Centre at Marmara University.

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CITATION OF THIS ARTICLE

Güler, M., Gülmez, İ., Ramazanoğlu, N., & Yılmaz, S. (2017) The Evaluation of Balance Performance for Elite Male Karate Athletes After Fatigue. *Int J Sport Exer & Train Sci, 3* (4), 161-168. DOI: 10.18826/useeabd.336577