

TRAUMATOLOGY

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The risk prediction of posterior hamstring muscles injury to top athletes in the Karate kata discipline

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Abstract

Background. Karate is a very popular and fairly new Olympic martial art. It is of Japanese origin and was established in Okinawa in the second half of the 19th century. Karate requires a high degree of motor control, and functional abilities such as agility, speed, and coordination. Imbalance or low level of motor skills with regard to the kinesiological and physiological structure of movement can lead to muscle injuries. Based on experience from coaching practice, we focused on injuries of the posterior thigh muscles. The aim of the work is to predict the risk of injury to the posterior thigh muscles in karate through the eccentric strength of the posterior thigh muscle diagnosis. **Material and Methods.** The tested group consisted of top karate athletes at the national team level in Slovakia. There were 11 women and 14 men in our group. All of them compete in the kata discipline. The average age of the women was 20 and the BMI factor in this group was 22.43 (SD $\pm$ 2.21). The average age in the male group was 23, and their BMI was 23.72 (SD $\pm$ 1.38). All the monitored competitors are at the top level of technical karate maturity, (Dan) and had been competing at the national or international level for three years or more. We used the diagnostic device NordBord – Hamstring Testing System to test the monitored parameters. NordBord is a special device that is based on the principle of measuring the eccentric and isometric force of a hamstring. **Results.** Based on our measurements, we noted a high risk of injury in terms of imbalance between the right and left posterior thigh muscles for three men (21, 42%) in the tested group. High risk in terms of low eccentric muscular strength of the posterior thigh muscles was found in four men's test results (28, 57%). However, we found an increased risk in only one (9, 09%) of the monitored males in terms of both factors. In the group of women, there was a high risk of injury due to muscle imbalance between the right and left posterior thigh muscles in four (36, 36%) of the monitored women and the same number for high risk of injury due to low eccentric muscular strength of the posterior thigh muscles. Two women (18, 18%) had an increased risk in terms of both risk factors. **Conclusions.** Based on our study at a local level, we recommend introducing regular testing of the eccentric strength of the posterior thigh muscles and the implementation of preventive compensation programs aimed at eliminating both risk factors.

Introduction

Karate is still a fairly new Olympic discipline and a martial sport. The popularity of this sport is rising every day for all age groups but especially among children. Karate got more popular by becoming an Olympic discipline. The so-called modern karate is a speed-force martial art that requires a high degree of mental and motor control, in the form of functional motor skills such as agility, reaction speed, acceleration speed, and coordination, etc. [Zemkova *et al.* 2006]. Karate requires important motor control as well as the involvement of the motor cortex in demanding coordination, static, and dynamic movements [Kalinowski *et al.* 2019].

An important part of sporting performance in Karate considering motoric control is the gnostic and stereognostic abilities of Karate. Sports karate contains two competing disciplines, namely “kata” and “kumite” of individuals or teams. Kate is a Japanese word describing detailed patterns of movements practiced either solo or in pairs. Kata are executed as a specified series of a variety of moves, with stepping and turning, while attempting to maintain a perfect form of fighting demonstration. In the category of individuals, it is the so-called a contactless form of sports karate. The kata sports discipline is focused on demonstrating the maximum combat effectiveness of offensive and defensive techniques in one specific unit – form. In terms of the structure of sports performance, the kata discipline requires, in addition to high psychological resilience, a high level of coordination skills in specific movements and positions [Zemkova *et al.* 2006].

The specific structure of the movement in karate, as in other top sports performances, brings along a certain risk of injury. The posterior thigh (ischio-crural) muscles are formed by m. biceps femoris, m. semitendinosus, m. semimembranosus. Their function is the extension in the hip and flexion in the knee. Damage to the posterior thigh muscles is a common type of injury in various sports with a dominant cyclic structure of movement (athletics, football, etc.), but also in acyclic sports such as karate, kickboxing, taekwondo, tennis, etc. The duration of treatment of posterior thigh muscle injuries varies from a few days to a few months [Malinovsky, 2017]. Injuries to the posterior thigh muscles are most common in sports requiring running, jumping or sudden changes of direction, and in martial arts they are, among other things, typical for various forms of kicks and specific forms of movement. The risk factors for injury to the posterior thigh muscles can be divided into internal and external [Andreansky *et al.* 2018]. Hamstring injuries occur most often in the eccentric phase of movement when the eccentric contraction changes to concentric in the swing phase of movement [Croisier *et al.* 2008]. It is this factor that is typical of injuries occurring in the contactless discipline of karate kata. Because it is during the top performance of martial forms that the ischio-crural mus-

cles are extremely eccentrically loaded, especially with kicks that have a swing ballistic character of movement in their maximum range [Slizik, Kysel 2012].

At the same time, it is proven that eccentric muscle contraction is a very important part of sports performance [Gronek *et al.* 2019]. Other potential risk factors include muscle imbalance and reduced range of motion in the lumbar joint [Stefanovsky *et al.* 2019]. According to the mechanism, injuries of the posterior thigh muscles are divided into direct (laceration, contusion) and indirect (complete, incomplete). The rehabilitation phase is divided into several parts, namely the acute, subacute, remodeling phase, functional phase, and return phase [Liska *et al.* 2019]. The muscle structure itself also plays an important role in the development of a muscle injury. Injuries to the posterior thigh muscles are characterized by a high rate of repetition. The severity of posterior thigh muscle injury varies from mild damage to total rupture [Ahmad *et al.* 2013].

Boostani *et al.* [2011] found that muscular trauma was the most frequent type of injury reported by female karate practitioners (38.4%), followed by muscular contusion (15.1%) and strain (7.5%) and dislocation (7.5%).

Vences Brito *et al.* [2020] found that 51.8% ($n=254$) from the sample of 490 karate practitioners from 9 different karate styles, 105 females and 385 males reported one or more injuries. No statistical differences were found between the sexes. The most frequent injuries were fractures (16.1%) and trauma (15.6%) in both sexes and occurred in the lower limb (64.3% in females and 52.0% in males). The mechanism responsible for most injuries in females were falls (12.5%), while in males it was punch actions (10.3%). Injuries were reported as moderate to severe, causing inactivity of practice of between 8 and 21 days and higher, respectively. Most injuries occurred in the preparatory period (63.6% females, males 53.2%), and mainly occurred in training (85.5% in females and 84.5% in males).

Material and Methods

Participants

The tested group consisted of 25 top karate athletes in Slovakia – 11 women and 14 men. They were all competitors in the karate kata discipline. None of them suffered any acute or chronic musculoskeletal disorders that could affect the testing. The average age of women was 20 years. The youngest girl was 16 years old and the oldest was 25 years old. The performance level of the monitored athletes was at the level of the national team. All monitored competitors were holders of the master level of technical maturity “Dan” and had a minimum of three or more years of experience at the international top level competitions. The average weekly training load of the monitored competitors per year was 9 training units.

The average share of regeneration and training units within the annual training cycle was 1/4. The average BMI figure in the female group was 22.43 (SD $\pm$ 2.21). The average body weight in the female group was 59.38 kg (SD $\pm$ 7.98) and the average height in the female group was 163.38 cm (SD $\pm$ 8.23). The lowest BMI factor in the group of women was 18.97 and the highest BMI was 24.46. The average age in the male group was 23 years. The average BMI figure in the male group was 23.72 (SD $\pm$ 1.38). The youngest was 16 years old and the oldest was 35 years old. The average body weight in the male group was 75 kg (SD $\pm$ 7.68) and the height 175 cm (SD $\pm$ 8.3). The lowest BMI in the male group was 21.08 and the highest BMI was 26.46.

We used the NordBord diagnostic device to test the monitored parameters. The NordBord Hamstring Testing System is a certified diagnostic device based on the principle of traction measurement of eccentric and isometric hamstring force. The NordBord diagnostic device was developed at Queensland University of Technology in 2014. The creators of this patented device are Dr. Anthony Siddle and Dr. David Opar. The largest space of the NordBord is a kind of a surface where probands kneel during testing. To objectify the measurement, a zero value on the scale is determined according to the location of the knees due to the length of the foreleg. To set the zero measurement value was used anthropometric parameter – lower leg length.

The tested proband fastens the ankles to the hooks and then performs the required movement in the form of a deliberately slow forward fall. The traction force on the individual hooks fixing the ankles records the unilateral parameters of the eccentric or isometric muscle activity of both lower limbs. In this position, the ankle joint should form an angle of 90 degrees with the fixing hooks. The amount of muscle activity is measured in Newton units. This form of diagnosis focuses on the eccentric muscle strength that manifests itself during an exercise called the “nordic hamstring.” NordBord allows testing in other rear thigh muscle exercises such as the Razor Curl; at 30 degrees and at 60 degrees. NordBord also allows you to measure the isometric activation of the posterior thigh muscles. The advantage of this device is its efficiency and speed of testing. NordBord software has two separate platforms, the scoreboard and the dashboard. The scoreboard gives the tester and the athlete real-time feedback on how powerful it is. The scoreboard compares the difference between the right and left lower limbs. The system also allows you to export data to excel format for further statistical processing.

The Testing protocol – research design: All athletes in the monitored group warmed up and exercised together before testing. Our probands underwent a specific form of warm-up and warm-up focused on the activation, toning and mobilization of the lower limbs with the guidance of a top qualified trainer with an inter-

national experience. The total warm-up and exercise time was 30 minutes. All probands were afterwards instructed how to carry out the testing correctly, we asked them to pay attention to all the details, followed by a clear demonstration of performing the testes exercise. After taking the correct position on the main platform of the device, we filled the data considering the knee position in the ScoreBord section. The proband then relieves (releases) the sensors (fixation hooks) and starts testing. Probands have a preview of the current course of the test on the screen for the entire duration of the test. As part of the Nordic Hamstring test, we require maintaining one line between the knees, hips and shoulders of the probands throughout its implementation. In case of deviation from the optimal technique, the proband will be warned. If the incorrect execution persists, we repeat the test. Each subject has two attempts to achieve their maximum performance. The authors evaluated both legs and recorded – maximum results.

The method of determining the risk of injury:

As the examples of high probability of posterior thigh muscle injury of karate athletes we identified those, for whom the value of the eccentric muscular strength of the posterior thigh muscles was recorded below 337 N. We determined this value according to “Valid Performance”. Another risk factor we chose was an imbalance of the eccentric muscle strength magnitude of the posterior thigh muscles between the right and left lower limbs. We determined a disproportion above 10% to be risky in terms of the probability of injury. As the examples of high probability of posterior thigh muscle injury for women, we identified those with the value of the eccentric muscular strength of the posterior thigh muscles recorded below 230N. We had to determine this value solely on the basis of our own experience due to the absence of similar studies carried out with karate athletes before. Another risk factor we chose was the imbalance of the eccentric muscle strength magnitude of the posterior thigh muscles between the right and left lower limbs. We determined a disproportion above 10% to be risky in terms of the probability of injury.

Statistics

We used basic forms of descriptive statistics to evaluate the data. We evaluated the range of the set (n), median, arithmetic mean, standard deviation (SD). We also used the minimum and maximum values. We used the IMB SPSS statistics V27 programme.

Ethical approval: 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 subsequent amendments or comparable ethical standards. Informed consent was obtained from

all individual participants involved in the study.

Results

The number of men tested was 14. The average eccentric muscle strength of the karate athletes tested was 344.93 N (SD ± 62) in the left posterior thigh muscle, for the right posterior thigh muscle it was 349.29 N (SD ± 52). The average difference in the amount of the eccentric muscle strength of the posterior thigh muscles for men was 6.85%, the median of the values of the size of the eccentric muscle strength in the left posterior thigh muscle was 354N and in the right posterior thigh muscle 345N. The smallest recorded eccentric muscle force was 215N in the left posterior thigh muscle and 226N on the right posterior thigh muscle. The highest value recorded on the left thigh muscle was 455N and in the right thigh muscle 423N. The smallest difference between the right and left posterior thigh muscles was 1% and the highest difference recorded was 15%.

A high risk of injury due to imbalance between the right and left posterior thigh muscles was marked for the three men (21, 42%). Four men (28, 57%) were at high risk due to the low eccentric muscular strength of the posterior thigh muscles. Only one man (9, 09%) had an increased risk of both factors. A bilateral comparison of the amount of the eccentric muscle strength of posterior thigh muscles is shown in **Figure 1**.

The number of women was 11. The average amount of the eccentric muscle strength of the karate patients we tested was 256N in the left posterior thigh muscle (SD ± 54). The average magnitude of the eccentric muscle strength women’s right posterior thigh muscle was 252N (SD ± 48). The average difference in the amount of the eccentric muscle strength of the posterior thigh muscles was 6.36%, the median values of the amount of women’s eccentric muscle strength in the left posterior thigh muscle were 257N and 250N in the right posterior thigh muscle.

The smallest eccentric muscle force recorded was 166N in the left posterior thigh muscle and 173N in the right posterior thigh muscle. The highest value recorded in the left thigh muscle was 342N and in the right thigh muscle 316N. The smallest difference between the right and left posterior thigh muscle was 1% and the highest difference was found for women 11%. A high risk of injury due to the imbalance between the right and left posterior thigh muscles was noted for four women (36, 36%). Also four women (36, 36%) were at high risk due to the low eccentric muscular strength of the posterior thigh muscles. Two women (18, 18%) had an increased risk of injury to the posterior thigh muscles from both factors. A comparison of the magnitude of the eccentric muscular strength of the posterior thigh muscles of women athletes is shown in **Figure 2**.

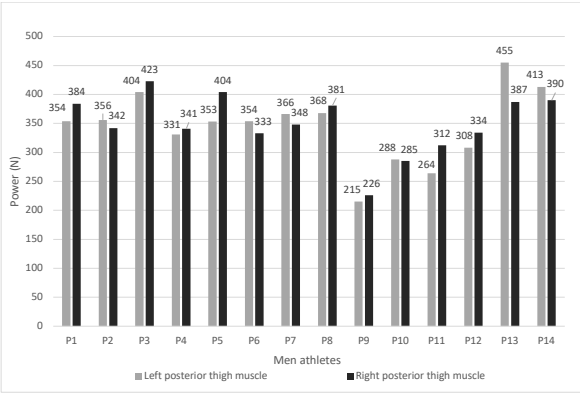


Figure 1. The comparison of the values of the posterior hamstring thigh muscles eccentric muscular strength of karate athletes – men

The left side of the figure shows the eccentric muscles force N and the low end side of the figure shows the number of the tested karate athlete.

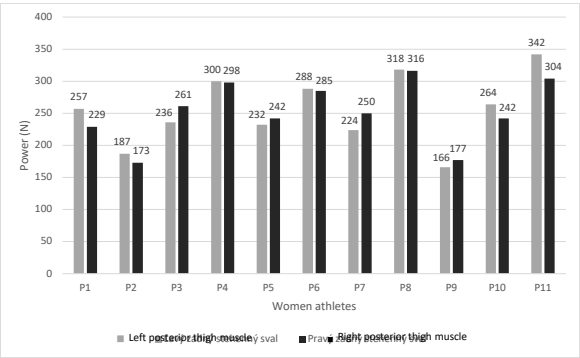


Figure 2. The comparison of the values of the posterior hamstring thigh muscles eccentric muscular strength of karate athletes – women

The left side of the figure shows the eccentric muscle force N and the low end side of the figure shows the number of the tested karate athlete.

Discussion

As our local research was a kind of a pilot study in this area carried out with the top kata athletes, due to the absence of similar research in an identical sports environment, we decided to use the results of similar studies from other sports or research with a different setting. In a study by Tischer *et al.* [2016] there were 300 karate athletes from 65 countries tested. 7 participants competed in both kumite and kata disciplines. 87 kata only and 206 kumite. The most injured segment that required medical attention was the knee (kata 28.7%, kumite 26.7%). In kata, the second most common injured segment was the shoulder (22.9%). In kumite, the ankle segment was the second most frequently injured segment (22.9%). The elbow was more often hit in the kata group, while in the

kumite group it were the arms and legs. Head injuries were more common in the kumite group. According to Tisher *et al.* [2016], the risk of injury to kumite was reduced by the addition of protective equipment in the form of certified protectors, but nevertheless the potential risk of injury should not be underestimated. The same is true for kata.

The aim of the study by Ghasemi *et al.* [2010] was to determine the incidence, type, and mechanism of injuries of Iranian karate athletes. There were 760 included in the testing. 289 injuries were recorded in 739 matches. More injuries occurred in the upper limbs than in the lower. The most common were musculoskeletal injuries (44.2%). Facial injuries accounted for 32.6%. The most common cause of the injury was a technical error of the opponent (71%). The Nordic hamstring diagnostic method places high demands on the eccentric muscular strength of the posterior thigh muscles. It requires a high degree of eccentric muscular strength of the posterior thigh muscles.

Podrigalo *et al.* [2017] indicate the importance of the goniometry method for the prevention of injuries in martial arts athletes. They confirmed the distinctions of the goniometric indicators of martial arts athletes' limb joints. It was found that sportsmanship level of kick-boxers influences to a certain extent on movements' amplitude. The found distinctions reflect clearly specific to the kind of sports. Wrestlers have higher amplitude of movements in wrist joints that determines a reliable grip in a fight. Kick boxers have a better amplitude of movements in the elbow and shoulder joints. It permits to punch with higher strength. The closeness of goniometric indicators of different sportsmanship kick-boxers proves equal orientation of their training. Need in constant keeping combat stance conditions reduction of in-movement amplitude in the right wrist joint and outside movement in the left shoulder joint of experienced athletes.

Romanenko *et al.* [2020] put attention on the importance of investigating functional asymmetry in martial arts athletes. The number of the pushes in the test, the reaction rate, and the duration of pushes were significantly higher in experienced athletes. The asymmetry due to the lower duration of pushes with the right hand compared to the left hand in beginners was determined. The asymmetry was not confirmed in experienced athletes. The reaction rate for the left hand significantly increased compared to stage 1 in beginners: at stage 2 ($t = -2.41$), at stage 3 ($t = -2.23$), at stage 4 ($t = -2.30$) and at stage 5 ($t = -2.68$). This dependency was less expressed for the right hand. It was confirmed the increase of the reaction rate in comparison with stage 1: at stage 3 ($t = -2.39$), at stage 4 ($t = -2.00$) and at stage 5 ($t = -2.32$). The differences in the dynamics of the test were more expressed in experienced athletes. The decrease in the number of pushes compared to stage 1: stage 2 ($t = 2.53$), stage 4 ($t = 2.89$) and stage 5 ($t = 2.61$) was determined. For the right

hand, this pattern was more expressed. The decrease in the number of pushes was determined compared with stage 1: stage 2 ($t = 2.17$), stage 3 ($t = 2.07$), stage 4 ($t = 2.39$) stage 5 ($t = 2.94$). Experienced athletes have confirmed significant changes in the reaction rate with their left hand compared to stage 1: stage 4 ($t = -2.33$) and stage 5 ($t = -2.06$). For the right hand, this pattern was confirmed only for the final stage of the test ($t = -2.35$).

The aim of the study by Van der Horst *et al.* [2015] was to test the effectiveness of Nordic hamstring exercise on the incidence and seriousness of posterior thigh muscle injuries. The intervention group consisted of 292 footballers and the control group consisted of 287 footballers. The exercise lasted 13 weeks. There was a significant reduction in the incidence of posterior thigh muscle injuries in the group that exercised regularly but exercise did not affect the seriousness of the injury. The efficacy of the Nordic hamstring exercises was also tested by Petersen *et al.* [2015], who tested 461 footballers in comparison to the 481 footballers who did not practice Nordic hamstring exercises. The exercise took 10 weeks. 52 injuries to posterior thigh muscle in the control group and 15 injuries in the intervention group were recorded. According to Petersen the inclusion of eccentric exercises results in a strong reduction of injuries to the posterior thigh muscles.

Timmins *et al.* [2016] tested the potential factors that are associated with the occurrence of the posterior thigh muscles injury in professional athletes. The structure and composition of the posterior thigh muscles in athletes were also noted down. The group consisted of 152 football players. Among the most important risk factors of injury of the posterior thigh muscle of soccer players is the low eccentric muscle strength of the posterior thigh muscles. Another predictive factor of the occurrence of the injury was the shortening of the muscle folders inside the long head of m. biceps femoris. Based on the data shown above, we may with great probability assume that the predictions of injuries with a similar mechanism of the incidence will occur for karate as it does in the case of football. Bourne *et al.* [2017] determined the effectiveness of the Nordic hamstring on the long head of the biceps. The study lasted for 10 weeks. The length of the muscle folders was assessed using ultrasound. In comparison to the basic examination, was the long head of m. biceps femoris prolonged. Similar changes were also in the m. semitendinosus. The same results were recorded also in the group that did the exercise called “hip extension”. This exercise also had a better effect on the muscle hypertrophy of the long head of the biceps. The mere injury of the back thigh muscle also influences the size of the muscle force. Reduce the size of the eccentric muscle power of posterior thigh muscles after injuries may also lead to increased risk of the posterior thigh muscles injuries recurrence. The posterior thigh muscles injuries leads also to neuromuscular inhibition.

Haze *et al.* [2014] found out whether posterior thigh muscle injuries affect its eccentric muscle power. 99 players with 17 injuries to posterior thigh muscles were included in a test. The injured footballers had lower improvement of eccentric muscle power, than those, who were not injured. The injury of the posterior thigh muscles also leads to an alteration of muscle activation as well as to neural disadaptation and therefore to an increased risk of repetition of posterior thigh muscle injuries.

The aim of the research by Opar *et al.* [2012] was to test electromyographic activity of the posterior thigh muscles during exercises demanding high activation of these muscles. The test set consisted of 26 recreational athletes. 13 had in the past, injuries of the posterior thigh muscle, and 13 formed a control sample. The athletes underwent special testing by isokinetic dynamometer and also EMG examination. EMG activity was recorded during eccentric contraction of the posterior thigh muscles. The athletes who had previously injured their posterior thigh muscle have reported less muscle activation than the kontralateral healthy limb.

Liska *et al.* [2019] found the size of the eccentric muscle forces for professional ice-hockey players and football players. The test set consisted of 30 professional ice-hockey players and 30 football players. The average values of eccentric muscle power for ice-hockey players were 419,8N for the left posterior thigh muscle and 420,9N for the right side one. For football players there were average values of eccentric muscle strength the following values: left posterior thigh muscle 419,6N, right posterior thigh muscle 428,6 N. Between the football players and ice-hockey players there has been a statistically significant difference. A high risk of injury of the posterior thigh muscle was recorded for the eight soccer and six ice-hockey players. Rehabilitation and preventive exercise make an important part of sport [Moc Kralova *et al.* 2015]. To prevent injuries in karate is also possible to use other types of exercise. A typical example are the exercises aimed at efficient work of the deep stabilisation system [Bahiraei *et al.* 2019], which also include exercises aimed at optimization of the breathing system [Buchtelova *et al.* 2018].

An important role also plays in the exercises for improving the neuromuscular, proprioceptive control [Ondra *et al.* 2017; Cieminski, 2018] and also sensor motoric function [Buchtelova *et al.* 2018]. Another important type of exercise in the prevention of injury is compensatory exercise [Maixnerova *et al.* 2018]. Important in the prevention of injuries is also stretching [Kabesova *et al.* 2019].

The main limitation in our study was to determine the risk of injury. We set the risk of injury on the basis of the standardized values for soccer players. Although this value may not reflect the true value for the karate athletes. The risk of injury for women, we identified, on the

basis of our own experience, which does not necessarily represent a causal relationship between our estimated value and the risk of the posterior thigh muscle injuries. In both cases are needed further longitudinal studies that map the relationship between the size of the eccentric muscle strength and injury of the posterior thigh muscles. However, we can state that due to the fact that our study was a pilot, despite the modified form of assessing the prediction of the risk of posterior thigh muscle injury in top karatists in the kata discipline, we managed to bring new objective knowledge in this area.

Conclusions

Based on the results of our research, we can state that for the top karate athletes we monitored, we noticed a potentially increased risk of injury to the posterior thigh muscles in terms of both monitored risk factors. Based on our measurements, from the point of view of the risk factor of imbalance between the right and left posterior thigh muscle, we recorded a high risk of injury for 21,42% of the men we monitored. High risk in terms of low eccentric muscular strength of the posterior thigh muscles was found for 28,57% of the men we monitored. However, we found an increased risk for only 9,09% of the monitored men in terms of both factors simultaneously.

In the group of women, there was a high risk of injury due to muscle imbalance between the right and left posterior thigh muscles in 36,36% of monitored women, and a high risk of injury due to low eccentric muscular strength of the posterior thigh muscles was also found for 36,36% of monitored women. 18,18% of women had an increased risk in terms of both risk factors.

Based on our results, we can also state that the Nord-Bord diagnostic method is a suitable and effective method for predicting the possible risks of injury to the posterior thigh muscles in karate practitioners. We also recommend, in the context of our study, introducing regular testing of the posterior thigh muscles of the top karatists, followed by the implementation of preventive individual training programs for the risk cases identified by tests. We can also say that the method used in our research can be used as a screening test in monitoring the functional state of martial arts athletes.

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Predykcja ryzyka wystąpienia urazu mięśnia dwugłowego tylnej części uda u czołowych zawodników dyscypliny Karate kata

Słowa kluczowe: mięśnie podkolanowe, mięśnie kulszowo-krzyżowe, siła mimośrodkowa, uszkodzenie mięśnia, karate kata

Streszczenie

Tło. Karate to bardzo popularna, dość nowa olimpijska sztuka walki. Jest ona pochodzenia japońskiego i powstała na Okinawie w drugiej połowie XIX wieku. Karate wymaga wysokiego stopnia kontroli motorycznej i zdolności funkcjonalnych takich jak zwinność, szybkość, i koordynacja. Brak równowagi lub niski poziom zdolności motorycznych w odniesieniu do kinezyologicznej i fizjologicznej struktury ruchu może prowadzić do urazów mięśniowych. Bazując na doświadczeniach z praktyki trenerskiej, autorzy pracy skupili się na urazach mięśni tylnej

części uda. Celem pracy było przewidywanie ryzyka wystąpienia urazu tylnych mięśni uda w czasie treningu karate poprzez diagnozę siły mimośrodkowej tylnych mięśni uda.

Materiał i metody. Badaną grupę stanowili czołowi zawodnicy karate na poziomie kadry narodowej Słowacji. W badanej grupie było 11 kobiet i 14 mężczyzn. Wszyscy startujący w dyscyplinie kata. Średnia wieku kobiet wynosiła 20 lat, a współczynnik BMI w grupie kobiet wynosił 22,43 ($SD \pm 2,21$). Średnia wieku w grupie męskiej to 23 lata, BMI w grupie męskiej wyniosł 23,72 ($SD \pm 1,38$). Wszyscy badani zawodnicy byli na najwyższym poziomie dojrzałości technicznej karate, zwanym Dan i startowali w zawodach na poziomie krajowym lub międzynarodowym od trzech lat lub dłużej. Do badania monitorowanych parametrów wykorzystano urządzenie diagnostyczne NordBord - Hamstring Testing System. NordBord to specjalne urządzenie, które działa na zasadzie pomiaru siły mimośrodkowej i siły izometrycznej ścięgna udowego.

Wyniki. Na podstawie przeprowadzonych pomiarów stwierdzono wysokie ryzyko urazu w zakresie braku równowagi pomiędzy prawymi i lewymi mięśniami tylnej części uda u trzech mężczyzn (21,42%) z badanej grupy. Wysokie ryzyko w zakresie niskiej siły mimośrodkowej mięśni tylnej części uda stwierdzono w wynikach badań czterech mężczyzn (28,57%). Natomiast podwyższone ryzyko w zakresie obu czynników stwierdzono tylko u jednego (9,09%) z monitorowanych mężczyzn. W grupie kobiet wysokie ryzyko urazu z powodu nierównowagi mięśniowej pomiędzy prawymi i lewymi mięśniami tylnej części uda wystąpiło u czterech (36,36%) monitorowanych kobiet i tyle samo dla wysokiego ryzyka urazu z powodu niskiej siły mimośrodkowej mięśni tylnej części uda. Dwie kobiety (18,18%) miały zwiększone ryzyko w zakresie obu czynników ryzyka.

Wnioski. Na podstawie niniejszych badań na poziomie lokalnym autorzy rekomendują wprowadzenie regularnego badania siły mimośrodkowej tylnych mięśni uda oraz wdrożenie profilaktycznych programów kompensacyjnych mających na celu eliminację obu czynników ryzyka.