EVALUATION OF BILATERAL ASYMMETRY OF CONCENTRIC AND ISOMETRIC KNEE EXTENSION-FLEXION STRENGTH IN MALE FENCERS[2]

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ABSTRACT

Fencing is an Olympic combat sport in which two athletes fight through their weapons such as epee, foil and sabre. During the competition, athletes hold the weapon with their dominant arm and stay in defense or attack positions by stepping forward, behind or right/left with dominant leg in front. Depending upon chronic applications structural and/or functional asymmetries between dominant and non-dominant extremities are shown with cross-sectional area and performance measurements. The aim of this study was to compare dominant and non-dominant knee flexion-extension strength values of epee fencers. The study was conducted on nine athletes whose age average was 18,1± 1,4 years. Strength measurements of dominant and non-dominant knees were carried out by using concentric and isometric modules of isokinetic dynamometers (Cybex II). Angular velocities were determined as 240- 180- 120- 60˚/s and 5 repetitions were done at each velocity. The highest value was accepted as the maximal strength. Isometric contraction was carried out at 60˚ knee joint angle (when full extension is accepted as 0º) during 5 seconds. Ratios of Hamstrings/ Quadriceps were calculated with ratios of strength of flexor and extensor muscles at every angular velocity. Results were analyzed with independent sample t-test and data were given as ±SEM. Strength values of dominant leg were found statistically significantly higher than those of non-dominant leg in 240º/s, 180º/s, 120º/s extension movement and isometric contraction (p<0.05). When examining flexion movement, it was recorded that strength of dominant leg was higher than that of non-dominant leg at 240º/s velocity and during isometric contraction (p<0.05). There was no meaningful difference in H/ Q ratios between dominant and non dominant legs (p<0.05). These findings suggest that, there is an important difference in terms of dominant and non-dominant leg strength in high level fencers, though ratio of H/Q is similar, differences in strength performance may affect adversely general performance of the athletes and increase the risk of injury.

Key Words: Fencing, Isometric strength Isokinetic strength, strength asymmetry, H/Q ratio

ESKRİMCİLERDE DOMİNANT-NONDOMİNANT DİZ EKSTANSİYON- FLEKSİYON KUVVET ASİMETRİSİ DEĞERLENDİRİLMESİ

ÖZ

Olimpik bir spor olan eskrim epe, flöre ve kılıç branşlarından oluşmaktadır. Maçlar sırasında sporcular dominant kolda silahı tutarlar ve dominant bacak önde iken ileri, geri, yanlara adımlamalar yaparak savunma veya atak pozisyonunda olurlar. Kronik uygulamalara bağlı olarak dominant ekstremite ile non dominant taraf arasında yapısal ve- veya fonksiyonel asimetriler, enine kesit alanı ve performans ölçümleri ile gösterilmektedir. Bu araştırmanın amacı epe eskrimcilerinde dominant ve non dominant diz fleksiyon-ekstansiyon kuvvet değerlerini karşılaştırmaktır. Çalışmaya yaş ortalaması 18,1± 1,4 yıl olan 9 erkek sporcu katıldı. Kuvvet ölçümleri dominant ve non dominant dizde izokinetik dinamometrenin (Cybex II) konsantrik ve izometrik modülleri kullanılarak yapıldı. Açısal hızlar 240- 180- 120- 60˚/sn olarak belirlendi ve her hızda 5 tekrar yapıldı. En yüksek değer maksimal kuvvet olarak değerlendirmeye alındı. İzometrik kasılma 60˚ diz eklem açısında (full ekstansiyon 0˚ kabul edildiğinde) 5 sn süre ile yapıldı. Hamstring/Quadriceps oranları her açısal hızda fleksör ve ekstensör kas kuvvetlerinin oranı ile hesaplandı. Sonuçlar bağımsız gruplarda t testi ile analiz edildi ve aritmetik ortalama±standart hata olarak verildi. Ekstansiyon hareketinde 240˚/sn, 180˚/sn, 120˚/sn ve izometrik kasılmada dominant bacaktaki kuvvet değerlerinin nondominant bacaktan istatistiksel olarak anlamlı oranda yüksek olduğu bulundu (p<0,05). Fleksiyon hareketine bakıldığında, 240˚/sn hızda ve izometrik kasılma sırasında dominant bacaktaki kuvvetin non-dominant bacaktan daha yüksek olduğu kaydedildi (p<0,05). Baskın ve baskın olmayan bacakta H/Q oranlarında anlamlı farklılık tespit edilmedi (p>0,05). Bulgular eskrimcilerde dominant dizde non dominant tarafa göre anlamlı kuvvet farkı olduğunu gösterdiğinden branşa yönelik kuvvet çalışmalarına ihtiyaç vardır.

Anahtar Kelimeler: Eskrim, İzometrik kuvvet, İzokinetik kuvvet, Kuvvet asimetrisi, H/Q oranı

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INTRODUCTION

Fencing is an Olympic combat sport in which athletes aim to get points by touching the opponent with a weapon. Fencing is practiced with three different weapons; the foil, the epee and the sabre; athletes are on defense or attack position during the whole competition. Athletes must decide quickly and make a move in a short time during the competitions which consist of 3x 3 mins periods with 1 minute rest between. Competitions are held on a platform sized 14x 2 m (Tsolakis et al 2010, Rodineau and Bouvărd 1999). During elimination tournament athletes make about 140 attacks, 200 deflections and cover a distance like 250-1000 m (Turner et al 2013). Competitions last 1-2 days and athletes play almost twenty matches during the competition. Fencing is a sport which consists of movement rows during which athletes repeat low volume activity or resting intervals and explosive movements (Turner et al 2013). Athletes should move quickly with legs and get points by stretching with legs and arms and turn back to their defense position again. The fast transition between attack and defense is provided by basic waiting position called “on guard”.

In fencing, success is a result of component of technique, tactic and performance (Bottoms et al 2011). Improving performance is related to efficiency of psychomotor and neuromuscular components (Tsolakis et al 2010). In fencing in which movements are carried out in a short time and at a great speed, a lot of factors such as aerobic and anaerobic power, speed, endurance, explosive power, flexibility and reaction time. Strength is the most important component of performance (Redondo et al 2014, Tsolakis et al 2010).

During the fencing competitions which include waiting for the right moment by moving back and front, as well as arms holding the weapon, legs also need strength, speed and endurance. In competitions which consist of stepping back and front, jumps and attacks in order to get points, a successful performance is ensured by strength and power characteristics of arm and leg muscles (Vertopoulos et al 2010). Especially lunge movement (Klinger and Adrian 1983), most frequently used, takes place with the concentric and eccentric contractions of knee extensor and flexors.

A performance difference develops in time between dominant and non dominant extremities. Thus, many researchers examined especially strength differences between dominant and non-dominant sides and found different results (Bigliani et al 1997, Knapik et al 1991, Kramer and Balsor 1990). It is known that strength difference between dominant and non-dominant extremities increases the risk of injury (Croisier et al 2008)

As well as dominant and non-dominant extremities, Hamstring/Quadriceps (H/Q) is also used to compare strength differences. The ratio of strength generated by H/Q which are located in order to immobilize the joints with ligaments and join the movement is known to be between 0,5-0,8 (Bennell et al 1998); when this ratio gets closer to 1, the risk of injury is reported to decrease (Orchard et al 1997). While some researchers point that imbalance in the ratio of H/Q (especially when lower than 0,6) has negative effects on hamstring injuries (Gabbe et al 2005), others state that this ratio has nothing to do with the risk of hamstring injuries (Bennel et al 1998).

Although there have been limited researches about fencing, fencing is reported as an asymmetric sport (Margonato et al 2008) because of differences in measurements of circumference- diameter and strength between dominant and non-dominant extremities. Chronically repeating the same movement results in strength difference (Azemar 1999). Indeed, it was reported that there is asymmetry in forearm, shoulder (Tsoiakis et al 2006, Margonato et al 1994) and femur cross-sectional areas (Tsolakis and Vagenas 2010, Tsoiakis and Katsikas 2006, Margonato et al 1994).

In literature there are limited number of research related to strength values of dominant, non-dominant knee extension-flexion, H/Q ratios and the risk of injury in fencing. Because knee extension and flexion muscle groups are important in lunge that is a basic fencing movement (Yiou and Do 2000, Harmenberg et al 1991) the aim of this study was to show ratios of dominant, non-dominant knee extension and flexion strength and H/Q in fencers. It was predicted that there would be strength asymmetry between dominant (anterior) and non-dominant (posterior) legs in elite fencers based on chronic applications.

METHODS

Participants

The participants were 9 male fencers who compete at national and international competitions. Their age average is 18,1± 1,4 years. Demographic characteristics of the athletes, whose sport experience is 6,3± 1,4, were presented in table 1. It was important that sportsmen haven't had any lower limb injury. Study was conducted after receiving ethics committee approval from Faculty of Selçuk University.

Anthropometric Measurements

Measurements of bodyweights and height of the athletes were done with SECA bascule. Skinfold thicknesses (biceps, triceps, subscapular and suprailiac) were measured with Holtain skinfold caliper. Body fat percentage was calculated according to formula of Durning and Womersley (1974).

VO_{2max} Measurement

Aerobic capacity of the athletes was determined by using Bruce protocol test which included 7 stages of 3 minutes running against incremental speed and inclination at each stage (Cooper and Storer 2003).

Strength Measurements

In strength measurement, knee extension and flections movements were based on. Measurements were carried out with Cybex NORM (Lumex Inc., Ronkonkoma, New York, USA). The device was calibrated as suggested by the producer before the study. Each subject warmed up with bicycle ergometer (Monark 839E, Sweden) at 50 W work load for 5 minutes with 5 min rest. After warming up, subjects were seated on dynamometer and tied. Rotation axis of knees (lateral femoral epicondyle) was aligned with mechanic axis of dynamometer and tied with mechanic handle. Concentric and isometric modules of isokinetic dynamometer were used. Length and position of dynamometer was prepared optimally for subject. All measurements were done by one single person for standardization of the results. Because the subjects were not used to mechanism they applied 3 repetitions as warm-up and 4 repetitions at maximal speed in order to get used to the mechanism.

Measurements started with dominant extremity. The leg at the same side with the arm which holds the weapon was accepted dominant. Athletes carried out 5 s extension and 5 s flexion isometric contraction at the speed of 240˚/s, 180 ˚/s, 120˚/s,60˚/s respectively and at 60˚ knee angle as well as 5 maximal concentric knee extensions-flexions. There are 60 s intervals between measurements. It was stated that 60 s intervals are enough for recovery (Parcell et al 2002). After the completion of dominant knee measurements, non-dominant knee measurements were done according to the same protocol. All athletes were verbally encouraged throughout the test. Highest power at each set was accepted as peak torque. Ratios of H/Q were calculated with flexion/extension strength ratios for each angular velocity.

Statistical Analysis

Normal distribution analysis of variables obtained from the measurements was done with Shapiro-Wilk's test. Concentric and isometric strength values at the angular velocities of 240-180-120-60˚ /s and differences between dominant and non-dominant leg in terms of H/Q ratios were analyzed with independent samples t test. Results were given as ±SEM. Statistical analysis was done with SPSS 16 (Chicago, IL, USA). Significance level was accepted as $p<0.05$.

RESULTS

Values of bodyweight, height, body fat percentage and VO_{2max} were given in table 1.

Table 1: Demographic characteristics of the athletes

Age (year)	18,1± 1,4
Sport age (year)	4,3±1,4
Bodyweight (kg)	67,2± 3,3
Height (cm)	176,4± 2,1
Body fat percentage (%)	13,8± 1,1
VO_{2max} (ml/kg/min)	49,2± 2,4

n=9, (Average± Standard error)

When strength values of dominant, non-dominant knee extension-flexion was examined; strength values of 240˚/s, 180˚/s, 120˚/s in extension movement and dominant leg in isometric contraction were found meaningfully higher than those of non-dominant leg ($p<0.05$). As for flexion movement, at the speed of 240˚/s and during the isometric contraction strength of dominant leg was recorded to be higher than that of non-dominant one ($p<0.05$).

Table 2: Peak Torque values of dominant-non dominant knee extension flexion

Angular velocity	Dominant	Non dominant
240°/s Extension Peak Torque (Nm)	127,5± 6,1	109,1± 6,9*
240°/s Flexion Peak Torque (Nm)	74,3± 4,6	62,7± 2,6*
180°/s Extension Peak Torque (Nm)	150,2± 7,9	129,8± 5,7*
180°/s Flexion Peak Torque (Nm)	84,8± 5,5	74,4± 3,9
120°/s Extension Peak Torque (Nm)	172,5± 7,5	153,2± 5,5*
120°/s Flexion Peak Torque (Nm)	104,5± 6,1	91,7± 5,9
60°/s Extension Peak Torque (Nm)	189,6± 11,1	176,4± 5,4
60°/s Flexion Peak Torque (Nm)	118,7± 10,3	104,0± 7,3
Isometric Extension Peak Torque (Nm)	254,7± 11,8	225,2± 5,7*
Isometric Flexion Peak Torque (Nm)	181,6± 2,1	168,2± 2,7*

*p<0.05 statistically meaningful difference in dominant extremity strength production

It was seen that H/Q ratios are between 58% and 62% at all angular velocities, there was no statistical difference found in terms of H/Q ratios between two extremities.

DISCUSSION

The most important finding of this study was that dominant and non-dominant strength difference was determined in knee extension-flexion movements. In literature, while there have been similar findings in the studies implemented to fencers, there are also different findings (Poulis et al 2009, Koutedakis et al 1993). Many researchers stated that there are anatomic and functional asymmetries. Guilhem et al (2014) showed that concentric extension strength values of dominant hip and knee were higher than those of non-dominant ones. It was highlighted that there was a meaningful difference between dominant and non-dominant arms in terms of reaction time in elite fencers (Johne et al 2013). However, some studies reported that there was no strength difference between these two extremities (Poulis et al 2012, Koutedakis et al 1993).

As for the studies in other sport branches related to this matter, while Daneshjoo et al (2013) found a similarity in H/Q ratios and strength values in both knees in a study conducted to footballers, Harbili (2015) stated that this ratio was similar in footballers, basketball players and weight-lifters. Aktug et al (2016) found that dominant knee strength and H/Q ratios were higher than those of non-dominant ones in flexion-extension movements performed at the speed of 240°/s in footballers. In a study which examined shoulder and knee strength values in volleyball, it was showed that strength values of dominant side were higher than non-dominant side (Markou and Vagenas 2006).

Different results in the same sport branches can be explained with differences in different characteristics of athletes and measurement methods. In fencing, athletes always hold the weapon with the same hand and move with the front leg (hand with weapon sided). The front leg is stated to play an important role in preserving postural balance of the athletes (Szilagui 1993, Szabo 1982) and lunge movements which is a basic. Thus, there may be an asymmetry between the leg-shoulder in the front and leg-shoulder in the back.

The necessity for adding strength trainings to the routine trainings including basic technical and tactical practices was suggested (Asadi et al 2016, Freitas 2016, Manolopoulos et al 2004). In order to avoid functional asymmetries, strength practices are stated to be necessary (Turner et al 2014). In this study, high peak torque values were seen in dominant leg in terms of both extension and flexion movements. This finding makes us to think that asymmetry between two legs exists independently of speed. Nevertheless, when H/Q ratio was calculated during concentric contraction, it was seen that there were similar ratios for both extremities. H/Q ratio gives information about stabilization of knee joint and is used to evaluate the risk of injury as well as being used during recovery period after injuries (Yamamoto 1993, Koutedakis et al 1997). Because hamstring muscle group cannot make an eccentric contraction during strong knee extension hamstring injuries happen (Croisier et al 2008). Although strength difference between dominant and non-dominant knees was found, the fact that H/Q ratios were similar can be explained with the fact that muscle strength of both quadriceps and hamstring groups of non-dominant knee was lower than those of dominant knee. In this case, ratio doesn’t change though strength values change. Redondo et al (2014) added strength training practices to fencing trainings and found that maximal strength of upper and lower bodies, explosive power and fencing performance of the athletes who applied the strength trainings increased meaningfully compared to those of athletes who didn’t apply. Mentioned researchers indicated that 6week strength training is enough for development of strength and other performances.

During the competitions, athletes move front, back and slide to the right and left in “on guard” position for defense and attack. When this situation is considered, the necessity of the development of both aerobic and anaerobic systems comes into exist. Aerobic energy pathway is the metabolic pathway which is important during submaximal activities and rest periods. In order to perform explosive movements at a great speed alactic and lactic anaerobic capacities of the athletes must be high (Turner et al 2013, Bottoms et al 2011, Li et al 1999). In their study, Roi and Bianchedi (2008) stated that fencers had a lower aerobic capacity compared to endurance athletes whereas they have higher values compared to sedentary group. They reported almost similar findings as this study. Although VO_{2max} values in this study are similar to those in the study of Abdollah et al (2014), they are slightly lower than those in the study applied to international fencers by Koutedakis et al (1993). From our point of view, this difference may stem from individual differences, training experiences of the athletes and sport age differences.

There are some constraints of the current study: Because the number of the athletes was few, there is a need for wide range of subjects. Moreover, a sedentary group or athletes from different sport branches may contribute to the comparison of the results of the study as control group. Because measurements were carried out during off-season, it is not known how the variables would be affected if the measurement was carried out during the season.

CONCLUSION

As a result, there is a need for plyometric trainings including eccentric contractions, one foot jumps, full and half squats, stepping and jumps peculiar to fencing and non-dominant leg strength exercises in order for asymmetry, that was determined in the knee muscles, to be decreased.

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