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Isokinetic Profile of Knee Flexors and Extensors Strength of the Faculty of Sport and Physical Education Female Students

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Original scientific paper

Abstract
The aim of this study was to construct anisokinetic strengthprofile of female students of Faculty of Sport and Physical Education, and identify H/Q ratio, as well as, to determine thepeak torque value given by flexors and extensors of the knee joint. Based on the results of isokinetic testing,isokinetic dynamic knee stabilizers strength profile of physically active women was constructed. Active women were students at the Faculty of Sport and Physical Education. Values of peak torque during the knee extension was 148.19 ± 25.54 Nm for the dominant and 150.09 ± 23.81 for the non-dominant leg, and the knee flexion was 76.65 ± 13.35 Nm for the dominant and 76.14 ± 16 Nm for the non-dominant leg, while the ratio between these two values is 0.52 ± 0.06 for dominant and 0.51 ± 0.07 for the non-dominant leg.

Key words: **Isokinetic profile, Knee, Female students, Concentric contraction testing.**

Introduction

Physical strength is one of the fundamental motor skills in man (Metikoš et al., 1989), and therefore, the evaluation of the actual state and accurate insight into the strength of the muscles have always been the goal of all who are associated with sport, the athletes, coaches, scientists, doctors and others.

There are many definitions of power, but one by Zatsiorsky (1995) according to which, the strength of a man is his ability to overcome external resistance or to act against resistance by muscle strain, is the most popular in the professional and academic literature.

Of the 230 joints in the human locomotor apparatus, the knee joint *(art. genus)* is the largest and most complicated joint of them all. Itsability to resist any adverse external factors is poor, and therefore it is most infringing. Most frequent reasons of knee injuries lies in imbalances in power of musclesstabilizing it, that is, the strength ratio of *m.quadriceps and m.bicepsfemoris-hamstring.* A common cause, beside that could be the existence of so called bilateral deficit, in which, there is an imbalance in power of muscles of two legs. Weaker leg is more prone to injury.

It was the aim of this study to construct the isokinetic strength profile, by determining the peak torque value given by flexors and extensors of the knee joint. Besides that, the goal was to determine whether these values were in the range recommended for healthy, physically active female population, and in line with previous researches, when it comes to a similar pattern, and to compare these values between the bilateral muscle groups.

Accurate assessment of human muscle performance was the focus of research scholars who have studied the physical exercise through many decades. Scientists who have studied the physical exercise and were interested in comparing the effects of different programs on strength and stamina, wanted to accurately measure muscle strength and power. Rehabilitation medicine practitioners wanted to document the effectiveness of therapeutic exercise which helped patients who have recovered from musculoskeletal injuries. They wanted to have an insight into pace of recoveryof strength or power (Kovač, 2010).

Only isokinetic instrumentation provides 1) the possibility of isolated testing of a particular joint and associated musculature in biomechanically correct position, 2) the possibility that the subject applies as much force he himself can produce, 3) amplitude and velocity at which the testing are flexible, which is very important when used for medical purposes, 4) evaluation of agonist and antagonist groups participating in the movements of a particular joint can be made along the entire range of motion, and 5) possibility to assess individual muscle group of the contralateral limb so, it could be, if done according to an identical protocol, used as a basis for comparison.

Of course, what matters most is the quantification of force, or the fact that only the isokinetic testing can lead to numerical values that provide a detailed insight into the strength of all muscle groups, agonists and antagonists, bilateral comparison, the amplitude of motion, amount of work and endurance expressed via fatigue index (Desnica-Bakrač, 2003).

There are many studies in which theaim was to determine the agonist/antagonist ratio of certain muscle groups. Campbell and Glenn (1982), for example, stated that the ratio of hamstring/quadriceps, in assessing muscle function, is more important than peak torque, because, according to them, the big difference between these two groups is the most common cause of muscle injuries of the lower extremities. Range within which this value should beare defined by Clanton and Coupe (1998). According to them, the value of H/Q ratios, for healthy physically active female population,should be between 0.50 and 0.60.

Many authors evaluated, and proved accuracy and validity of isokinetic parameters in their studies. Among the first to address this topic were Perrin (1986),Feiring et al.(1990), McCleary and Anderson (1992), and later, Soderberg (2004), Drouin et al. (2004) and Almosnino et al. (2011). It is important to note that all the authors have put special emphasis on peak torque and proved that the results of isokinetic, concentric test give valid indicators of maximum muscle strength.

Besides the validity and reliability of the concentric testing, the reason for this was the fact that during eccentric testing,higher axial force are generatedthan in the case of concentric testing, thereby it increases the risk of occurring injuries (Dvir, 2004). This is supported by the fact that in the study which had over 687 examinees - football players (Croisiere et al., 2008), 8 of them haven't successfully completed eccentric isokinetic testing due to the occurrence of pain. Also, Orchard et al. (2001) in their case study reported *m.bicepsfemoris* longhead strain caused by eccentric isokinetic testing, that was proven by magnetic resonance imaging (MRI).

Methods

Sample of subjects

The sample consists of 30 physically active women, post-adolescentage - students at the Faculty of Sport and Physical Education in Sarajevo, aged between 19 and 23 years, body height 169.13 ± 3.86 and weight 61.57 ± 5.45, with relatively homogeneous characteristics in terms of anthropometry.

Sample of variables

Following the example of many previous studies (Kazazović, 2009; Kovačević, 2009; Tsang and DiPasquale, 2011; Alić, 2012), and given that many (Kannus and Yasuda, 1992; Alangari and Al-Hazzaa, 2004; Jaiyesimi and Jegede, 2005) quote that isokinetic peak torque values parameters are commonly used and valuable to assess the performance of the human muscle, and in the end to construct isokinetic strength profile (Fousekis et al., 2010; Larrat et al., 2007), this study used only the peak torque values.

1. BH- Body height
2. BW - Body weight
3. PTED - Dominant leg, knee extension peak torque
4. PTEND - Non-dominant leg, knee extension peak torque
5. PTFD - Dominant leg, knee flexion peak torque
6. PTFND - Non-dominant leg, knee flexion peak torque
7. HQRD - Dominant leg, knee flexors and extensors strength ratio
8. HQRND - Non-dominant leg, knee flexors and extensors strength ratio

Isokinetic testing was conducted according to the following protocol:

1. Musculoskeletal screening
2. General warm-up and stretching of the body
3. Setting the subject in the optimum stabilization
4. Alignment of the joint and the rotation axis at the dynamometer
5. Verbal introduction to the concept of isokinetic exercise
6. Correction of gravity
7. Warming up (3 submaximal and 1 maximal repetition)
8. Maximum test at a predefined speed; 60^0/s (3 repetitions)
9. Testing the contralateral limb

Statistical analysis

Following the example of previous authors who have dealt with these issues, the study used only descriptive statistics.

Results

Table No. 1 presents the central and dispersion parameters for a set of variables of isokinetic testing.

Discussion

Reviewing the results of descriptive statistics from the table 1, it can be observed that the peak torque values during the extension of the knee was 148.19 ± 25.54 Nm for the dominant and 150.09 ± 23.81 Nm for the non-dominant leg.

On a sample of 20 healthy physically inactive women, aged between 23 and 35 years, Yoon et al. (1991) obtained results which had value of 82.4 ± 12.9 ft-lbs for the dominant and 85.3 ± 15.0 ft-lbs for the non-dominant leg. According to Van Vlack (1989):

$$1\ Nm \sim 0{,}7375621483695506\ ft - lbs$$

Table1.

Descriptive Statistics							
	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
BH	30	162	178	169.13	3866	.083	- .497
BW	30	52	74	61.57	5450	.293	- .590
PTED	30	100.9	201.0	148,193	25.5413	.325	- .464
PTEND	30	95.7	203.6	150,090	23.8143	.108	.108
PTFD	30	52.8	104.6	76,657	13.3537	.402	- .526
PTFND	30	43.5	118.3	76,143	16.0021	.567	.811
HQRD	30	.37	.64	.5206	.06000	- .056	.179
HQRND	30	.40	.70	.5078	.07368	.709	.023

From these results, it can be calibrated that this group of women during the extension of the knee at 60°/s, dominant leg exerted a force of 60.72 ± 9.5 Nm, while when it comes to non-dominant, this value was 62.86 ± 11.0 Nm, it is noticeable that the girls from the Faculty of Sport are far more potent, even 244% when we consider the dominant and 238%when it comes to non-dominant leg knee extension than physically healthy, inactive women.

On the other hand, when we look at professional athletes, Mendonça et al. (2007), who in their study had a sample of 6 Brazilian female Taekwondo athletes, they came up with the findings that the peak torque, when normalized with body mass is 300.2 Nm/kg for the dominant and 300.1 Nm/kg for the non-dominant leg.

The above normalization is done according to the formula by Ikeda et al. (2002):

$$Peak\ TQ/BW = Peak\ Torque/Body\ Weight * 100$$

If the results of this study are normalized in this way, the values obtained are 240.69 Nm/kg for the dominant and 243.77 Nm/kg for the non-dominant leg. Taking into account that in the aforementioned study elite athletes are in the sample of subjects,lower level of average value of the peak torque among students of the Faculty of Sport and Physical Education (19.8%) when it comes to the dominant and (18.8%)in non-dominant leg is completely understandable and logical.

The results of isokinetic testing that was done on the students, in a study of Almosnino et al. (2011), which are in the sample, which consisted of 20 students, aged 22.4 ± 2.3 years, who were actively engaged in sports 5 ± 2 hours per week, show that the value of knee extension peak torque was 142 ± 16 Nm. The results obtained by these authors, on the sample that was consisted of students of the School of Kinesiology and Health Studies (*ON, Canada)*do not differ much from the results of this study. In fact, the mere difference of ~ 4% indicates that the knee extension peak torque values that were accomplished by female students of Faculty of Sport wasvery similar with almost identical population.

In addition, Wilkerson et al. (2004) in their experimental group had 11 female students, second division basketball players (National Association of Intercollegiate Athletics), age 19 ± 1.4 years, who did not have history of injuring their lower extremities. The results of isokinetic testing of the knee extensors in this study had a value of 169.82 ± 26.78 Nm, which is 12.73% higher than the value that the girls in this studyhad. Consideringthat there is not much difference in age, based on the results of the study Lue et al. (2000), and Camic et al. (2010), in which the weight and height of the body have Piersonscorrelation coefficient value of the r = 0.56 and 0.62 with a peak torque of knee extension force, the difference in weight of 21% and height of 2.5% significantly contributed to the rise of force knee extensors in these girls.

When it comes to hamstring, or the knee flexor group, reviewing the results of descriptive statistics in Table No. 1, it can be observed that knee flexion peak torque values were 76.65 ± 13.35 Nm for the dominant and 76.14 ± 16 Nm for the non-dominant leg. When compared with healthy, physically inactive women, aged between 23 and 35 years Yoon et al. (1991), which were tested with a similar protocol, concentric testing at angular velocity of 60°/s, who had the peak torque value of 44.2 ± 10.2 ft-lbs or 32.57 Nm for the dominant and 45.2 ± 10, 2 ft-lbs or 33.31 Nm for the non-dominant leg, it can be seen that the girls from the Faculty of Sport are far more potent, even 235% when we consider the dominant and 228%when it comes to non-dominant leg knee flexionthan physically healthy, inactive women.

As during the extension, by comparing peak torque force in flexion, with professional athletes, 6 Brazilian Taekwondo athletes, from the study by Mendonça et al.(2007), whose normalized values amounted to 148 Nm/kg for the dominant and 152.1 Nm/kg for non-dominant is seen that in this case these professional female athletes have higher results than female students in this study. Taking into account that the normalized knee flexion peak torque values of students of Faculty of Sports amounts 124.5 Nm/kg when it comes to dominant and 123.66 when it comes to non-dominant leg, it may be noted that the students from this study have lower peak torque values by 15.9% when it comes to the dominant and 18.7% when it comes to non-dominant leg from top Brazilian Taekwondo competitors.

Comparing these results with the results of studies in which students have also participated in the Faculty of Sport (Almosnino et al., 2011), the knee flexion peak torque value was 76 ± 15 Nm, it can be concluded that, just as during the extension, no big difference were present. According to the values presented in table 1, where it can be seen that the knee flexion peak torque value of students at the Faculty of Sport was 76.66 ± 13.35 Nm for the dominant and 76.14 ± 16 Nm for the non-dominant, it can be concluded that there is minimal difference of ~ 1% between the results of these two studies.

Taking into consideration the study of Wilkerson et al. (2004), who had a sample consisting of 11 students of the Faculty of Kinesiology and Exercise Science, which had weight of 21% and height 2.5% higher than the sample in this study, and their peak torque in flexion, at angular velocity of 60°/s, totaled 90.81 Nm, which is 15.5% higher than the value of female students of Faculty of Sport and Physical Education, based on the aforementioned conclusions (Lue et al., 2000;Camic et al., 2010), it can be concluded that there are certain similarities with the results of this study.

A review of previous studies, which were aimed to estimate the ratio of H/Q, can lead to a conclusion that there are large differences between the results of different authors. Specifically, when it comes to women, the lowest H/Q ratio value, at angular speed of 60°/s, which was used in this study, was 0.44 (Westing and Seger, 1989), and the highest 0.60 (Pincivero, 2003) while for men the lowest was 0.46 (Aagaard et al., 1997), and the highest 0.82 (Subaşi et al., 2004). Taking into consideration that the experimental groups in previous studies were different, it is evident that the conclusion of Baltzopoulos and Brodie (1989) that the H/Q ratio depends on the age, sex, level and type of activity, and the angular velocity at which the test is performed, is valid. Therefore, age, gender, activity level, gravity correction, fiber type which is dominant in the muscle and many other factorshave effect on H/Q ratio (Appen and Duncan, 1986).

When it comes to students, Rosen et al. (2001) in two groups, I-soccer players and II-softball players, got the value of 0.54 ± 0.19 for the right and 0.53 ± 0.07 for the left leg in the first and 0.56 ± 0.09 for right and 0.54 ± 0.1 for the left in the second group. Furthermore, in their studies Almosnino et al. (2011) and Wilkerson et al. (2004), also on the sample consisting of physically active students, got the value of H/Q ratio of 0.53, while Kovačević (2009), in whose studywere involved female students of the Faculty of Sport and Physical Education, similar to Fillyaw et al. (1986), in which the sample were students who trained football, came to a value of 0.54. Garceau et al. (2010), who in the sample of subjects had 22 students, obtained the value of 0.51. Also, Tsang and DiPasquale (2011) in two groups of students had the H/Q ratio of 0.50 and 0.51.

Looking at the above studies, it can be concluded that the H/Q ratio of tested student group at Faculty of Sport, presented in Table No. 1, is not much different from any group of women who had no history of lower extremity injuries, regardless of where they physically active or not. Taking into consideration, that all of these values, when analyzed together,have H/Q ratio value of 0.52 ± 0.02,so it can be concluded that the results for the dominant leg, which have a value of 0.52 ± 0.06, are indistinguishable from the analyzed studies, while the results which are shown on the non-dominant leg, which amounted to 0.51 ± 0.07, are lower by ~ 2% than the results of the studiesmentioned earlier.

Based on these results it can be concluded that the values of reciprocal ratio of leg muscle strength, from this study, are in the range recommended for healthy, physically active population. That meansfor girls of post adolescent age.

Conclusion

Based on the results it can be concluded that the value of provided tests, includingPeak Torque of dynamic knee stabilizers were helpful in creatingisokinetic strength profile for postadolescent, physically active, female population, namely students of the Faculty of Sport and Physical Education. Comparing these results, above in paper, with similar studies, it is evident that the mean value of strength test results, for subjects who participated in this study,are not significantly different from the values measured at other Universities.

Furthermore, compared to physically inactive female population, it can be concluded that the students of the Faculty of Sport and Physical Education are far stronger than inactive group, as well as, the same results, when compared with eliteathletes,tell us that these students are slightly behind, which is reasonable.Furthermore, when it comes to H/Q ratio, it can be concluded that the values of reciprocal ratio of leg muscle strength for tested student population, is in the range that is recommended for healthy, physically active female subjects. These results suggest that the isokinetic profile constructed in this study can be used as a basis for further comparison with similar studies.

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