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Comparison of Upper Extremity Proprioception among Team Athletes[i]

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Abstract

Shoulder strength flexibility and proprioception are of great importance for athletes who do overhead activities and throwing sports. In volleyball, basketball, and handball, the shoulder muscles work under heavy conditions under the technical load of the game. In this study, it was aimed to compare the shoulder force senses (FS) of team athletes. A total of 36 healthy individuals, including 14 volleyball, 12 basketball, and 10 handball players, with a mean age of 19± 2,68 participated in the study. First, the maximal isometric voluntary contraction (MVIC) levels of the participants were measured during shoulder joint flexion, then the 50% MVIC target force value was determined, and a two-trial FS test was performed with this value. The target force value was evaluated by visual feedback from the computer screen. In the data analysis, independent t-tests and ANOVA tests were applied in the SPSS 28.0 for Mac package program. When the results of the research were examined, no statistical significance was found between the measurements of Trial1 and Trial2 in terms of gender. However, when the FS averages are examined, it has been determined that women have a better sense of force than men. It was determined that the median of the MVIC values was 70,35 and the participants were divided into two groups as lower and upper. A statistically significant difference was found between the determined MVIC groups and age, training age, gender, branch, and BMI. No statistically significant difference was found between the MVIC groups and the distance of the sense to the target. The difference in values can be explained by the fact that individuals with low MVIC have a better sense of force than individuals with high MVIC.

Keywords: Proprioception, Force Sense, Volleyball, Basketball, Handball

Takım Sporcularında Üst Ekstremite Propriosepsiyonlarının Karşılaştırılması

Öz

Baş üstü aktivite ve fırlatma sporu yapan sporcularda, omuz kuvveti esnekliği ve propriosepsiyonu oldukça büyük bir öneme sahiptir. Omuz eklemi hem mobilite hem de stabilitenin önemli olduğu kompleks bir eklemdir. Voleybol, basketbol ve hentbolde oyunun getirdiği teknik yüklenme altında omuz kasları ağır şartlar altında çalışmaktadır. Bu araştırmada takım sporcularının omuz bölgesi kuvvet duyularını karşılaştırmak amaçlanmıştır. Araştırmaya yaş ortalamaları 19± 2,68 olan 14 voleybol, 12 basketbol ve 10 hentbol oyuncusu olmak üzere toplam 36 sağlıklı birey katılmıştır. Katılımcıların önce maksimal izometrik istemli kasılma (MVIC) seviyeleri omuz eklemi fleksiyonu sırasında ölçülmüş, daha sonra %50 MVIC hedef kuvvet değeri belirlenmiş ve bu değerle ikişer denemeli kuvvet algısı (FS) testi yapılmıştır. Hedef kuvvet değeri, bilgisayar ekranından görsel geri bildirim ile değerlendirilmiştir. Elde edilen verilerin analizinde SPSS 28.0 for Mac paket programında bağımsız t-testi ve ANOVA testleri uygulanmıştır. Araştırma sonuçları incelendiğinde Deneme 1 ve Deneme 2 ölçümleri arasında cinsiyet açısından istatistiksel olarak bir anlama rastlanmamıştır. Ancak algı ortalamalarına bakıldığında kadınların erkeklerden daha iyi kuvvet algısına sahip oldukları tespit edilmiştir. MVIC değerleri medyanının 70,35 olduğu tespit edilmiş ve katılımcılar alt ve üst olmak üzere iki gruba ayrılmıştır. Belirlenen MVIC grupları ile yaş, antrenman yaşı, cinsiyet, branş ve BKİ arasında istatistiksel olarak anlamlılık tespit edilmiştir. MVIC grupları ile algının hedefe uzaklığı arasında istatistiksel olarak bir anlamlılığa rastlanmamıştır. Bulunan değer farklılıkları MVIC değerleri düşük olan bireylerin kuvvet algılarının, MVIC değerleri yüksek olan bireylere göre daha iyi olmasıyla açıklanabilir.

Anahtar kelimeler: Propriosepsiyon, Kuvvet Algısı, Voleybol, Basketbol, Hentbol

Introduction

Proprioception, which is necessary for motor control and joint stability during daily activities and sports practices, can be defined as recognizing and placing the body according to its position and orientation in space. It is the body's own sense of position and movement, which includes the senses of perceiving the static position, displacement, speed of movement, acceleration, and force produced by the muscle of the extremities and body segments (Tuğay and Tuğay, 2015; Ager et al., 2017). In other words, it is the ability to communicate the position taken by the joints, to interpret the transmitted, and to give a conscious or unconscious response to the stimulus to make the target posture and movement (Bayramoğlu, 2005).

The shoulder joint is a complex joint where both mobility and stability are important. Its wide range of motion is due to the simultaneousness of its active and passive structures for dynamic neuromuscular control. Active and passive structures contribute to proprioceptive awareness through inputs from mechanoreceptors located in the shoulder complex. Proprioception refers to the sum of the neurologic feedback consisting of versatile systems that regulate motor control and behavior and are considered important for general physical health (Ager et al., 2017).

Shoulder strength, flexibility, and proprioception are necessary parameters to create maximum speed in throwing performance for elite athletes in sports branches where the upper extremity is dominant (Wilk et al., 2002). During the throwing, the athlete should use all his muscles from the lower extremity to the upper extremity (Neil, 2012). Optimal coordination is essential for this whole chain of events to happen. For example, the importance of the throwing technique of handball players is determined by realizing their lower and upper extremity strengths with whole-body coordination (Ikeda et al., 2007).

In elite athletes, shoulder muscles work under heavy conditions under the technical load brought by the game. Muscle strength constitutes the power source of various activities. Athletes need strong muscle groups against maximum load. This situation not only improves the sportive performance in competition and training but also protects the integrity of the shoulder complex and reduces the number and severity of injuries. It has also been stated in the literature that basketball is a dynamic sport that requires skills such as free throw, passing, dribbling, shooting, and sudden acceleration in the game, in addition to the existing muscle strength, endurance, and aerobic and anaerobic power of the players. On the other hand, volleyball's physical performance needs such as hitting, serving, blocking, and digging include a high level of strength in the shoulder, elbow, and hand. To ensure shoulder stabilization and also to avoid problems in power development during

successful hitting and blocking, the muscles of the shoulder area should be especially strong (Pu et al., 1989; Smith et al., 1992; Dupuis and Tourny-Chollet, 2003; Okazaki et al., 2015).

The study aims to compare the shoulder area force senses of volleyball, basketball, and handball players.

Method

A total of 36 healthy individuals, including 14 volleyball (14 females), 12 basketball (2 females and 10 males), and 10 handball (3 females and 7 males) players with a mean age of 19,0 ± 2,68 years, participated in the study. IsoForce (TUR Therapietechnik GmbH, Berlin, Germany) isokinetic dynamometer was used to determine the participants' maximum voluntary isometric contraction (MVIC) and force senses (FS).

MVIC and FS Measurements

The participants ' shoulder maximum strengths and FS were measured with an IsoForce (TUR Therapietechnik GmbH, Berlin, Germany) isokinetic dynamometer. The flexion movement of the dominant shoulder was taken into account for the measurements. First, MVIC was measured in 3 repetitions. The best of these repetitions was recorded. Then the FS test was performed with 50% of the measured MVIC. All values recorded as a result of the tests with 50% MVIC determined separately for each individual were recorded (Dover and Powers, 2003; Proske and Gandevia, 2012; Han et al., 2016; Li et al., 2016; Kaynak et al., 2019; Altun, 2020). Participants held the test position for 5 seconds during all measurements so that we could define the value precisely. After the FS test was performed by sight twice, the participants were blindfolded and asked to re-establish the target force and maintain it for 5 seconds. To avoid fatigue, a 90-second rest was given between trials. FS test results were calculated from the absolute difference between the targeted and reproduced forces.

Analysis of Data

It was determined by the Shapiro-Wilk test that the obtained data were normally distributed, and descriptive statistics, independent t-test, and ANOVA were applied in the analysis with SPSS for Mac 28.0.

Results

Table 1

Demographic Information of Participants

		Volleyball	Basketball	Handball	Total
Sex	F	14	2	3	19
	M	0	10	7	17

Age (year)	16,07±0,73	20,58±1,78	21,2±1,13	19±2,68
Weight (kg)	60,79±4,79	80,27±10,64	72,46±16,51	70,52±13,63
BMI (kg/m^2)	20,32±1,35	24,54±1,99	23,09±7	22,49±4,36
Muscle Mass (kg)	28,18±2,2	37,77±8,11	33,51±7,87	32,86±7,45
MVIC (N)	64,46±11,89	89,59±30	91,55±27,18	80,36±26,29
Training Age (yıl)	8,214±2,15	9,33±1,92	7,8±4,26	8,47±2,82
Body Fat %	10,51±2,73	13,05±4,46	13,24±10,07	12,12±6,06

When Table 1 is examined, it was determined that the average age of the volleyball players was 16,071±0,73 years, the average height was 172,35±5,108 cm, the average weight was 60,792±4,797 kg, the average BMI was 20,321±1,354 kg/cm^2, the average muscle mass was 28,185±2,204 kg, the average MVIC was 64,464±11,896 N, the average training age was 8,2143±2,154 years, and the average body fat percentage was 10,514±2,732. The average age of the basketball players was 20,583±1,781 years, the average height was 179,75±5,429 cm, the average weight was 80,275±10,648 kg, the average BMI was 24,546±1,992 kg/cm2, the average muscle mass was 37,774±8,111 kg, the average MVIC was 89,59±30,006 N, the average training age was 9,333±1,922 years, and the average body fat percentage was 13,058±4,463. The average age of the handball players was 21,2±1,135 years, the average height was 174±8,806 cm, the average weight was 72,46±16,515 kg, the average BMI was 23,093±7,002 kg/cm2, the average muscle mass was 33,51±7,876 kg, the average MVIC was 91,55±27,183 N, the average training age was 7,8±4,263 years, and the average of body fat percentage was 13,24±10,071.

Table 2

T-test Results of Participants' FS Test Results by Gender

	Sex	**n**	$\overline{X}$	**Sd**	**F**	**p**
Trial 1	F	19	4,368	2,929	3,678	0,064
	M	17	6,412	7,8427		
Trial 2	F	19	4,211	3,7798	2,601	0,116
	M	17	6,059	5,9105		

When the t-test of the FS test results according to gender was examined, no statistically significant difference was found (p>0.05). However, in both trials, women seem to have lower results than men which means they have a better sense of force.

Table 3

ANOVA Results of Participants' FS Test Results by Branches

	Volleyball	**Basketball**	**Handball**	**p**
Trial 1	4,286	5,667	6,4	,671
	±2,4315	±8,7629	±5,0155	
Trial 2	4,786	5,667	4,8	,887
	±4,1357	±6,4994	±4,1312	

The results of the analysis showed that there was no significant difference between the FS test results of the participants in both trials in terms of the branches (p=,671, p=,887). However, when the average FS test scores are compared, we can say that volleyball players have a better sense of force than basketball and handball players.

Table 4
Descriptive Statistics and the ANOVA Results of the Mean of the Participants' FS Test Results by MVIC Groups and Branches

	MVIC	Volleyball	p	Basketball	p	Handball	p	Total	p
Trial 1	<70,35	3,9±2,02	,284	2,75±3,09	,441	5,33±4,93	,686	3,88±2,76	,137
	≥70,35	5,66±3,78		7,12±3,09		5,33±4,93		6,77±7,55	
Trial 2	<70,35	5,36±4,52	,336	4,5±5,44	,681	2,33±2,08	,237	4,66±4,36	,618
	≥70,35	2,66±0,57		6,25±7,24		5,85±4,45		5,5±5,51	

In Table 4, demographic statistics and ANOVA results of the average scores of the participants' strength sense test according to branches and MVIC groups are given. When Trial 1 was examined, the average score of the volleyball players with below 70,35 MVIC in the FS test was 3,909; the average score of the basketball players was 2,750; and the average score of the handball players was 5,333. The average score of the volleyball players with a 70,35 or higher MVIC was 5,667; the average score of the basketball players was 7,125; and the average score of the handball players was 5,333. When Trial 2 was examined, the average score of the volleyball players with below 70,35 MVIC in the FS test was 5,364, the average score of the basketball players was 4,5, and the average score of the handball players was 2,333. In the same test, the average score of the volleyball players with a 70,35 or higher MVIC was 2,667, the average score of the basketball players was 6,25, and the average score of the handball players was 5,857. There was no significant difference between the mean scores of the FS test for all groups. In both trials, it was shown that there was no significant difference between the results of the FS test in terms of the branches ($p > 0,05$). However, when the MVIC values are compared, we can say that the group with the low MVIC value achieved better FS results in total in both trials, that is, their sense of forces was better. In other words, we can say that improving the strength of the shoulder muscles in team sports using the thrower arm may cause their proprioception to worsen.

Discussion and Conclusion

It is an important finding that will contribute to the literature that participants with a high MVIC value recorded worse results in the FS test than those with a low MVIC value. Kaynak et al.

(2019) have a study in which they obtained similar results. However, there are few studies that show an association between MVIC and FS.

In team sports, testing the components and comparing the data within the branch or with different branches are important key elements in terms of trainers and literature in order to fight one-on-one with the opponent and then reach the common goal by hitting the target (Karadenizli, 2017). Proprioception is a somatosensory sense that includes joint movement (kinesthesia) and joint position sense and provides information about the movements and position of the body. Proprioceptive senses are the senses that provide information about the physical state of the body, such as the sense of position, the sense of pressure coming from the soles of the feet, and the sense of balance (Lephard et al., 2017).

Considering the studies conducted in recent years, the evaluation of proprioceptive sense in different sports branches and the creation of appropriate training programs have gained an important place in preventing sports injuries (Groppel and Nicholas, 2009; Shemy and Battecha, 2017). Proprioception plays an important role in the normal function of shoulder muscles and protection against potential instability of the shoulder. There are also studies that say that the appropriate use of proprioceptive sensory training in the post-injury treatment process and training programs may have positive effects on returning to sports (Lephart and Jari, 2002). Proprioceptive training of the upper extremity is used less frequently in rehabilitation programs compared to proprioceptive training of the lower extremity. However, since the throwing movement has an important place in upper extremity sports, sensitive joint position sense is very important. It plays an important role in both dynamic shoulder stability and performance mechanoreceptor activity (Ergen et al., 2007).

Çelebi and Zergeroğlu (2017) also stated that with the increase in participation in sports activities, the health and physical fitness of the individual improves, the number of sports injuries increases and the efforts to prevent sports injuries include warming up and cooling down, flexibility exercises, coordination, balance, and proprioceptive exercises.

In the literature, there are many studies examining the muscle strength, joint range of motion, and proprioception of the extremities that are used or not dominantly used in athletes (Rogol et al., 1998; Janwantanakul et al., 2001; Safran et al., 2001; Chu et al., 2002; Crockett et al., 2002; Reagan et al., 2002; Osbahr et al., 2002; Ellenbecker et al., 2002; Mair et al., 2004; Lubiatowski et al.; 2014, Ihalainen et al., 2016).

Safran et al. (2001) evaluated the proprioceptive differences between dominant and non-dominant shoulders of 21 baseball pitchers without shoulder instability and surgery history. As a result of the evaluation made by these researchers, starting from 75% of the maximal external rotation

(ER) and leading it to the internal rotation (IR), it was stated that the error scores in the dominant shoulders of the cases were significantly higher than in the non-dominant shoulders. In their study, Carpenter et al. (1998) investigated the effect of muscle fatigue on shoulder proprioception in 20 individuals without shoulder problems. Proprioception was tested first when individuals were resting, and then after exercising until they were tired on an isokinetic testing machine. It was reported that there was a decrease in the proprioceptive sense due to fatigue in the IR and ER.

In the literature, studies on individual branches have reported that upper extremity muscle fatigue changes the glenohumeral and scapulothoracic kinematic relationship. It has been reported that there are changes in the scapular position and movements or power imbalance in the injuries that develop due to overuse on the shoulder (Suzuki et al., 2006). In a study by Wang et al (1999), it was determined that the quality of the movement depends on the interaction between the scapula and glenohumeral kinematics in swimming and similar sports that the need for shoulder movement is extremely high. In the master's thesis conducted by Sarı (2019), ER flexibility, IR, and horizontal adduction range of motion were found to be lower in the shooter's shoulder than in the other shoulder ($p<0,05$). It was determined that the muscle strength values of individuals with and without scapular dyskinesia were similar ($p>0,05$). In adolescent tennis players, sports-specific adaptations occur in the shoulder girdle. Detecting these adaptations in the early period is very important in terms of identifying the athletes at risk. These changes, which may become permanent in the future, may cause severe and irreversible injuries.

In a study conducted by Kurt et al (2021), on swimmers, although there is no relationship between glenohumeral joint position sense and swimming performance in physically disabled swimmers, the importance of proprioceptive sensory evaluation and training in training and rehabilitation programs is emphasized in order to take precautions against any injury that may occur. In a study conducted by Kocahan et al. (2018) on athletes engaged in shooting sports, it was determined that the shoulder joint isometric muscle strength and proprioception of the arm holding the air gun and the same sense of the other arm were similar to each other. Additionally in the same study, the muscle strength of the men was stronger than that of the women and the proprioceptive senses of men and women were similar.

As a result, we can say that besides the other components developed, proprioceptive training and evaluations should be done regularly in athletes, if proprioceptive characteristics are not improved enough, individuals may be insufficient in their performance and more studies should be done on the measurement of FS.

Statement of Researchers' Contribution Rates

The first and second authors contributed equally to the study, with 35%, and the third author contributed 30%.

Conflict Statement

The authors do not have a statement of conflict regarding the research.

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[i] Bu çalışma 6. Uluslararası Akademik Spor Araştırmaları Kongresi'nde özet bildiri olarak sunulmuştur.