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The Comparison of Flexibility and Isokinetic Shoulder Strength in Wheelchair and Able-bodied Basketball Players

Tekerlekli Sandalye Basketbol ve Sağlıklı Basketbol Oyuncularının Omuz İzokinetik Kuvvet ve Esnekliğinin Karşılaştırılması

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This study was presented as a orally at the 1st International Health Sciences Congress (June 29th-July 1st 2017, Aydın, Turkey).

ABSTRACT Objective: The objective of this study is to compare the flexibility and strength of shoulder rotator cuff muscle of wheelchair basketball players (WBP), able-bodied basketball players (AB-BP) and healthy sedentary individuals. **Material and Method:** We included 17 WBP (in the age group of 22.5–39 years and a mean age of 28 years), 18 AB-BP (in the age group of 19.5–22 years and a mean age of 21.5 years), and 17 sedentary individuals (in the age group of 25–29 years and a mean age of 26 years) as a control group (CG) in this study. We evaluated flexibility via Apley's scratch test. Moreover, we measured the strength of the external rotator (ER) and internal rotator (IR) muscles with Cybex isokinetic dynamometer. **Results:** Apley's scratch test showed a significant difference among the three groups ($p<0.05$). The flexibility of shoulder rotator cuff muscle of WBP was found to be comparatively low than that of AB-BP and CG. There was a significant difference in terms of concentric–eccentric ER and IR muscles strength ($p<0.05$); however, there was no difference in terms of ER/IR ratio among the groups ($p>0.05$). Although there was no significant difference in terms of ER/IR ratio, this ratio was found to be lower in WBP than the normative values. The concentric-eccentric strength of shoulder rotator cuff muscles of WBP and AB-BP were similar and higher than those of CG. **Conclusion:** Inadequate flexibility and rotator cuff muscle imbalance are very important in terms of injury risk. To reduce the risk of injury and improve athletic performance, these parameters should be evaluated and necessary exercises should be included in the programs in case of any deficits. Exercise for stretching the shoulder ER and IR muscles should be added in the training programs of WBP. Additionally, the exercises for strengthening the ER muscle groups should also be included in the WBPs' training programs to achieve the normative value.

Keywords: Wheelchair; basketball; shoulder; rotator cuff strength; isokinetic assessment; flexibility

ÖZET Amaç: Bu çalışmanın amacı tekerlekli sandalye basketbol sporcuları (TSBP), sağlıklı basketbol sporcuları (SBP) ve sağlıklı sedanter bireyleri omuz rotator kas kuvveti ve esnekliği bakımından karşılaştırmaktır. **Gereç ve Yöntemler:** On yedi TSBP (22,5-39 yaş grubunda ve ortalama 28 yaşında), 18 KBP (19,5-22 yaş grubunda ve ortalama 21,5 yaşında) ve kontrol grubu (KG) olarak 17 sağlıklı sedanter birey (25-29 yaşında ve ortalama 26 yaş grubunda) çalışmaya dahil edildi. Esneklik Apley's scratch testi ile değerlendirildi. Eksternal rotator (ER) ve internal rotator (IR) kasların gücü Cybex izokinetik dinamometre ile ölçüldü. **Bulgular:** Üç grup arasında Apley's scratch testinde anlamlı fark bulundu ($p<0,05$). WBP esnekliğinin SBP ve KG ile karşılaştırıldığında daha düşük olduğu bulunmuştur. Gruplar arasında konsantrik-eksantrik ER ve IR kas kuvveti açısından anlamlı fark vardı ($p<0,05$), ancak ER/IR oranı açısından fark yoktu ($p>0,05$). ER/IR oran bakımından anlamlı bir fark olmamakla birlikte, bu oranın TSBP'de normatif değerlere göre daha düşük olduğu bulunmuştur. TSBP ve SBP'nin omuz rotator kaslarının konsentrik-eksantrik kuvveti benzer ve KG'dekilerden daha yüksekti. **Sonuç:** Yetersiz esneklik ve rotator manşet kas dengesizliği yaralanma riski açısından çok önemlidir. Yaralanma riskini azaltmak ve atletik performansı geliştirmek için bu parametreler değerlendirilmeli ve herhangi bir defisit durumunda antrenman programlarına gerekli egzersizler dahil edilmelidir. TSBP antrenman programlarına omuz ER ve IR kasları için germe egzersizleri eklenmelidir. Ayrıca, normatif değere ulaşmak için ER kas gruplarını kuvvetlendirmeye yönelik egzersizler de TSBP'lerin antrenman programlarına dahil edilmelidir.

Anahtar Kelimeler: Tekerlekli sandalye; basketbol; rotator manşet kuvveti; izokinetik değerlendirme; esneklik

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Wheelchair basketball has become one of the most popular paralympic sports in recent years.[1] Just like an able-bodied basketball game, it is a sport that requires shooting ball, performing layup shots, passing ball to one another, performing overhead passes, dribbling, and performing intense activities.[2] Additionally, it includes skills such as maintaining or continuing position on the court, adapting to changes in the dynamic position, and using a wheelchair.[3]

The ability of an athlete to maneuver and control wheelchair, which is crucial for success on the court, is related to the strength of upper extremity muscles.[4] Repetitive and excessive use of wheelchair during both sport and transfers of ball leads to an increased load on the upper limbs. This may cause the development of a rotator cuff syndrome with the imbalance of muscles in the shoulder region along with weakness in the humeral head depressors.[5] When the wheelchair is propelled forward for longer than 10–20 minutes, repeated shoulder muscle activity occurs at high levels.[6] As a result, this may cause strengthening in some of the muscles around the shoulder. Additionally, a change of load on the shoulder stabilizers may cause an imbalance among the shoulder muscles.[7] The strength deficit in the external rotators (ER) is shown to increase the risk of the overuse/chronic shoulder pain.[8] A previous study showed that an increase in the duration of wheelchair use alongside overhead sports activities brought about an additional risk factor for the development of rotator cuff syndrome in patients with paraplegia.[9]

The rotator cuff muscles are considered to be the most important dynamic stabilizers of the glenohumeral joint.[10] Because of their significance in functionality, the evaluation of strength and flexibility of ER and internal rotator (IR) muscles becomes necessary to identify the risk factors and prevent injuries. Isokinetic dynamometers are the devices that allow the recording of rotational moments at varying speeds and are often used to objectively assess the muscle performance. This assessment allows the identification of functional strength profile in patients with orthopedic problems and athletes with shoulder problems. It also helps in evaluating the muscle performance and dynamic functional stability of shoulder musculature in the overhead athletes. The isokinetic assessment often uses the ER/IR ratio to define the muscle imbalance in the shoulder. Modifications in the ER/IR ratio could lead to shoulder musculoskeletal dysfunction. For a healthy sedentary, any modification in this ER/IR ratio (0.60-0.80) is considered as an indication of impingement or instable pathology.[11]

Studies in the literature have classified the wheelchair basketball players (WBP) according to the etiological causes or classification scores and investigated the effects of trunk stability on the shoulder rotator cuff muscle strength.[7,12] However, no studies comparing WBP with able-bodied basketball players (AB-BP) in terms of flexibility and shoulder rotator cuff muscle strength have been found. The comparison between WBP and healthy sedentary individuals will allow us to examine the impact of both sports and wheelchair on the shoulder strength and flexibility. The comparison between WBP and AB-BP will eliminate the effects of sport, and we will investigate the impact of the wheelchair on shoulder strength and flexibility. The comparison of AB-BP and healthy sedentary individuals has shown the effects of sports on the shoulder strength and flexibility of athletes. For this reason, the objective of this study is to measure the strength and flexibility of shoulder rotator cuff muscles of WBP, AB-BP and compare these results with a control group (CG) consisting of sedanter healthy volunteers.

MATERIAL AND METHODS

PARTICIPANTS

A total of 52-male participants, 17 in WBP, 18 in AB-BP and 17 in CG, were included in the study with a power analysis of %95. Three sports clubs in Ankara were reached for the WBP to be included in the study. Seven of the 27 WBPs who agreed to participate in the study could not complete the evaluations due to the transportation problem. Three individuals wanted to quit the study and as a result, 17 subjects completed the study by completing all evaluations. Twenty athletes meeting the inclusion criteria for the AB-BP group were reached. Two individals left the study before completing the assessments. For the control group, 17 sedentary individuals who complied with the inclusion criteria, whose average age was matching wth WBP group, completed the evaluations. Participants gave written consent forms. WBPs and AB-BPs who had been active in basketball sports for at least two years were included in the study. Participants who had; systemic diseases, any shoulder problems in the last 3 months, undergone upper extremity surgery and those who had pain on the shoulder were not included. Healthy volunteers who engaged in regular sports for at least three days a week were also excluded.

Age, body weight, height, dominant side, classification score, disability, years of participation in sports and weekly training hours were reviewed and recorded. This study was approved by the Ethics Committee of Gazi University and the authors conformed to the ethical guidelines of the 1975 Declaration of Helsinki (Date:11.04.2016; No: 197).

MEASUREMENTS

Flexibility was evaluated with Apley's scratch test performed in sitting position.[13] Participants were asked to try to touch fingers of their hands on their backs with one upper extremity in flexion, abduction, external rotation, and elbow flexion positions while other upper extremity was in extension, adduction and internal rotation and elbow flexion position. In this position, the distance between the second fingers was measured (Figure 1). If the fingers overlapped each other, the distance was recorded as a negative value, if they did not touch each other, the value was recorded as a positive value, in centimeters. If the fingers were touching each other just at the tips, this value was assumed to be 0. The measurement was then repeated by exchanging positions of extremities.[13]

Strength of ER and IR muscles was measured with a Cybex isokinetic dynamometer (Cybex NORM®, Humac, CA, USA). Isokinetic evaluation was performed with participants sitting glenohumeral joint at 30° abduction and 30° flexion, elbow at 90° flexion, wrist at full pronation position.[14] Before commencing the study, 15 healthy subjects without a history of pain or dysfunction on shoulder were evaluated to assess test-retest reliability of Cybex NORM isokinetic device. The measurements were repeated after seven days. Intraclass correlation coefficient (ICC) values ranged between 0.81-0.95. Participants were seated in a vertical position on the seat of device. The stabilization of trunk was achieved with horizontal and pelvic bands and elbow was also stabilized with a band (Figure 2). To prevent excessive movement of the shoulder joint, range of motion was chosen as 50° IR and 40° ER.[15] Gravity compensation was turned on to eliminate the effect of gravity. Participants were done three submaximal repetitions at as warm-up, familiarization. The measurements were performed with 5 repetitions in 60°/sec for concentric and 90°/sec for eccentric test.[16] Resting periods

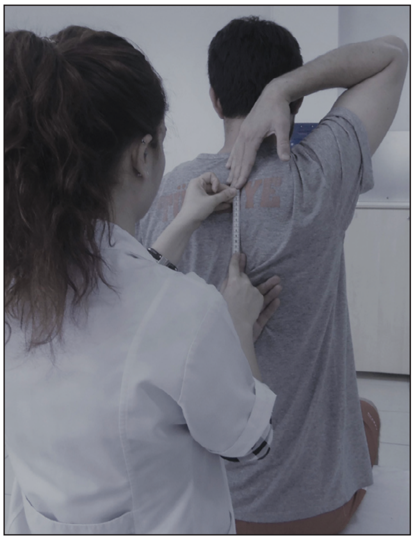

FIGURE 1: Apley's scratch test.

FIGURE 2: The evaluation of isokinetic strength of shoulder rotator cuff muscles.

TABLE 1: The comparison of the participants' demographic information and athlete's sports-related characteristics.

		WBP Median (IQR) (n=17)	AB-BP Median (IQR) (n=18)	CG Median (IQR) (n=17)	p	
Age (years)		28 (22.5/39)	21.5 (19.5/22)	26 (25/29)	0.000*	¶ Φ
Body weight (kg)		73 (59/77.5)	90.5 (78.75/96.75)	82 (74.5/87)	0.001*	¶
Height (cm)		178 (163.5/185)	192.5(184.5/201.75)	178 (173/182.5)	0.000*	¶ Φ
BMI (kg/m^2)		23.7(21.13/25.9)	23.93 (23.05/25.05)	25.62 (23.86/27.11)	0.354	
Dominance n (%)	R	14 (82.4)	18 (100)	15 (88.2)		
	L	3 (17.6)	0 (0)	2 (11.8)		
Age of starting sports (years)		16 (15/24.5)	9 (7/11.25)		0.000*	
Years of participation in sports (years)		12 (6.5/15)	11.5 (10/14.25)		0.987	
Weekly training hours (hours)		10 (8/10)	10 (7.75/15.75)		0.572	

* p<0.05 (Kruskal-Wallis Test for p value), ¶ differences amongst WBP and AB-BP, ¥ differences amongst WBP and CG, Φ differences amongst AB-BP and CG (Mann Whitney U Test for ¶, ¥ and Φ value).

of 20 seconds was provided between trials and tests, 90 seconds between sets.[7] Dominant and non-dominant sides were selected by performing a randomization to eliminate the effect of learning and fatigue. Same measurements were then repeated on other extremity. At the end of the test, peak torque (PT)/body weight (Nm/kg) and ER-IR PT ratios (ER/IR ratio) were recorded.

STATISTICAL ANALYSIS

Statistical analyzes of the study were performed using program "Statistical Package for Social Sciences" (SPSS) version 22.0 (SPSS Inc., Chicago, IL, USA). Normality distribution of the data was examined using visual (histogram and probability plots) and analytical methods (Kolmogrov-Smirno/Shapiro-Wilk Test). Variables with no normal distribution were indicated by median (IQR) and categorical variables were indicated by frequency and percent (%). Kruskal-Wallis Test was used to determine the difference amongst three groups. Type 1 error level was taken as 5%. Bonferroni correction was applied and p significance value to be used for binary comparisons was determined as 0.017. Mann Whitney U Test was used for analyzing binary comparisons.

RESULTS

The demographic characteristics of the participants and sports-related characteristics of the athletes are given in Table 1. When the age, height and body weight of the participants were compared in the groups, a statistically significant difference was found (p<0.05, Table 1). There was no significant difference between the groups in terms of BMI (p>0.05, Table 1). WBP and AB-BP were similar in years of participation in sports and weekly training hours (p>0.05, Table 1), however, age of starting sports was statistically different (p<0.05, Table 1). Descriptive

TABLE 2: Descriptive characteristics of WBP.

Classification score	**n (%)**
1	1 (5.9)
1.5	3 (17.6)
2	3 (17.6)
2.5	1 (5.9)
3	0 (0)
3.5	2 (11.8)
4	6 (35.3)
4.5	1 (5.9)
Type of disability	**n (%)**
Poliomyelitis	6 (35.3)
Amputations	5 (29.4)
Spinal cord injuries	2 (11.8)
Spina bifida	2 (11.8)
Amelia	1 (5.9)
Tumor	1 (5.9)
The assistive device for mobilization in their daily lives	**n (%)**
No-used	7 (41.2)
Crutches	3 (17.6)
Wheelchair	7 (41.2)

TABLE 3: Comparison of isokinetic shoulder rotator cuff muscle strengths and flexibility of WBP and AB-BP to the CG.

		WBP median (IQR) (n=17)	AB-BP median (IQR) (n=18)	CG median (IQR) (n=17)	p	
Apley's scratch test	Right ER-Left IR (cm)	11.5 (2/21.25)	0.5 (-3.87/7.5)	-0.5 (-4.25/3.5)	0.000*	¶ ¥
	Right IR-Left ER (cm)	13 (8.5/22.25)	3 (-3.87/11.12)	2 (-6/5)	0.001*	¶ ¥
Dom	Con ER PT/BW (Nm/kg)	42 (30/49.5)	34.5 (31.5/42)	27 (24/31.5)	0.001*	¥ Φ
Dom	Ecc ER PT/BW (Nm/kg)	48 (37.5/63)	40.5 (30/48.75)	30 (25.5/34.5)	0.001*	¥ Φ
Non-dom	Con ER PT/BW (Nm/kg)	27 (20/30)	27 (24/34)	20 (19/23)	0.001*	¥ Φ
Non-dom	Ecc ER PT/BW (Nm/kg)	39 (36/63)	36 (29.25/42.75)	33 (30/36)	0.006*	¥
Dom	Con IR PT/BW (Nm/kg)	80 (61.5/102.5)	63 (59.25/75)	54 (45/57)	0.000*	¥ Φ
Dom	Ecc IR PT/BW (Nm/kg)	92 (64.5/108.5)	72 (58.5/80)	60 (51/64.5)	0.002*	¥
Non-dom	Con IR PT/BW (Nm/kg)	69 (57/86)	58.5 (50.2/66.7)	39 (34/45)	0.001*	¥
Non-dom	Ecc IR PT/BW (Nm/kg)	75 (63/99.5)	68.5 (51/74)	57 (49.5/63)	0.009*	¥
Dom	Con ER/IR	0.50 (0.42/0.56)	0.54 (0.44/0.61)	0.55 (0.47/0.59)	0.408	
Dom	Ecc ER/IR	0.56 (0.52/0.60)	0.58 (0.51/0.69)	0.54 (0.46/0.57)	0.271	
Non-dom	Con ER/IR	0.51 (0.49/0.63)	0.55 (0.48/0.62)	0.53 (0.48/0.61)	0.897	
Non-dom	Ecc ER/IR	0.61 (0.49/0.69)	0.61 (0.50/0.65)	0.57 (0.55/0.62)	0.751	

$p<0.05$ (Kruskal-Wallis Test for p value), *difference between the three groups, ¶ difference between WBP and AB-BP, ¥ difference between WBP and CG, Φ difference between AB-BP and CG (Mann Whitney U Test for ¶, ¥ and Φ value), PT: peak torque, BW: body weight, Con: Concentric, Ecc: Eccentric, Dom: Dominant, Non-dom: Non-dominant.

characteristics of WBP are given in Table 2.

When Apley's scratch test results were analyzed amongst the three groups, the scores of AB-BP and CG were found to be different when compared to the scores of the WBP for right ER-left IR and left ER-right IR ($p<0.05$, Table 3). Flexibility of WBP was found to be less than AB-BP and the CG.

According to isokinetic test results, there was a significant difference between the three groups in terms of concentric-eccentric ER and IR strength on dominant and non-dominant sides ($p<0.05$, Table 3) however, there was no difference in terms of ER/IR ratio ($p>0.05$, Table 3). Concentric ER and IR strength of dominant side, eccentric ER strength of dominant sides and concentric strength of non-dominant sides of the WBP and AB-BP were found to be similar and greater than that of the CG. Eccentric ER and IR of non-dominant sides and the eccentric IR strength of dominant sides were found to be greater in the WBP when compared to the CG. Concentric and eccentric ER/IR ratio was similar in the both sides in three groups.

DISCUSSION

We conducted this study to compare the flexibility and strength of shoulder rotator cuff muscles of WBP and AB-BP. The flexibility of WBP was significantly lower than that of AB-BP and CG. The concentric and eccentric strength of shoulder rotator cuff muscles of WBP and AB-BP were found to be higher than that of the CG. The review of literature revealed that there was no other study that assessed the eccentric strength of WBP and compared this group with AB-BP and CG in terms of flexibility and strength of shoulder concentric–eccentric rotator cuff muscle.

We found differences in age, height, and body weight among the three groups; however, there was no difference in the BMI. The reason was the presence of a difference in age among the groups, despite the fact that the sport participation year being the same, was that WBPs and AB-BPs had started participating in sports at different ages. This may be because AB-BPs began participating in sports after acquiring a disability via trauma or illness, whereas AB-BPs started participating in sports at a younger age. The body weight of WBPs may be lower due to their pathologies; for instance, individuals with spinal cord injury are wheelchair bound and have atrophy of the lower body or as in amputations in which the loss of an extremity leads to the loss of bodyweight. It is an expected result that AB-BPs who started participating in sports at a younger age were taller than WBPs who started participating in sports at a later age and the CG who did not participate regularly in sports.

The flexibility results of our study showed that the flexibility of WBP was comparatively low as compared to AB-BP and the CG. This difference in flexibility may be due to the age difference. Flexibility is known to decrease with age. However, CG and AB-BP have a similar flexibility, and both groups have a significantly better flexibility than WBP. Although there is no age difference between WBP and CG, flexibility in CG is better than that of WBP, thereby suggesting that this difference may not be due to the age difference. In the literature, there was a study comparing WBP with another group in terms of flexibility. Feter et al. evaluated flexibility in WBP and found that Apley's test indicated a significant difference between WBP and sedentary individuals with disabilities.[13] WBPs are professional players of basketball however, their flexibility of upper limbs may have been reduced due to their disabilities. Inadequate flexibility prevents a specific activity from being carried out, or it hinders the effectiveness of performance. The flexibility deficits in the soft tissue surrounding the scapula can restrict the normal scapular movement during the daily and sport-specific activities. Flexibility problems can arise in the scapular muscles, especially in the pectoralis minor and levator scapulae or at the glenohumeral level. Particularly, stiffness and tightness occur in the posterior shoulder structures, capsule and glenohumeral ER muscles. These flexibility deficits can cause scapular malposition, particularly toward anterior tilting and downward rotation. These changes in the scapular position are similar to the scapular deviations detected in the patients with impingement symptoms.[17] This is a risk factor for WBP who commonly face shoulder pain and injuries. Wilroy et al. stated that a six-week strengthening and stretching intervention program may reduce the risk factors for shoulder injury in the WBP.[18] We believe that this study is important because it is the first-known study to compare WBPs with AB-BPs and healthy sedentary in terms of flexibility and reveal the difference in flexibility. Because flexibility is very important in terms of injury risk, exercises stretching shoulder ER and IR muscle should also be added in the training programs of WBPs.

There are many studies conducted in different populations who use a wheelchair to evaluate the strength of ER and IR muscles because of the significance in the wheelchair propulsion. Previous studies have observed two functional synergies throughout the wheelchair propulsion: push (anterior deltoid-pectoralis major-supraspinatus-infraspinatus-serratus anterior-biceps) and recovery (middle and posterior deltoid-supraspinatus-subscapularis-middle trapezius-triceps). Additionally, the spinal cord injury levels were shown to mostly affect pectoralis major muscle activity and rotator cuff muscles. The active propulsion movements during wheelchair use (extension-adduction-IR) are at least twice as large as the countermovements (flexion-abduction-ER) on the same axis.[19] This can lead to the rotator cuff muscle imbalance, which is identified as a risk factor for impingement.[20] Similar to our study, Kotajarvi and Basford found no difference in terms of ER and IR torque and ER/IR ratio in the wheelchair users and healthy subjects.[21] In a study that included tennis players with wheelchair and sedentary participants, Bernard et al. have also shown that there is no difference in shoulder ER and IR strength.[22] Unlike these studies, Burnham et al. found that the strength of ER and IR muscles in the wheelchair players was greater than the able-bodied athletes.[5]

Only a few studies have been found in the literature while looking at the ER and IR muscle isokinetic evaluations of WBP. There are some studies in the literature that have measured the shoulder ER and IR concentric strength of WBP, but only WBP have been evaluated in these studies and there was no comparison of WBP with AB-BP and CG. In addition, we did not find any study evaluating the eccentric strength of WBP. It is important to evaluate the eccentric strength because the deficiency of eccentric muscle strength of the ER is associated with the rate of shoulder injury.[23] This makes our study different from the other studies in literature. Considering the studies evaluating ER and IR muscle strength in WBPs, there is no control group in these studies. Nyland et al. found that the WBPs' ER and IR muscle strength were similar in both shoulders.[12] Basar et al. compared the shoulder rotator cuff muscle strength of national young and junior WBP.[7] These studies evaluated the ER and IR muscles of WBP; however, the comparison of this group with AB-BP and sedentary individuals is crucial in examining the effects of wheelchair and sports on the shoulder strength and flexibility. Thus, we determined the changes in the use of wheelchairs around the shoulders in athletes playing the same sport. In the literature, the control group was taken in a single study evaluating ER and IR muscle strength. In that study, paraplegic individuals who did not play sports were selected as the control group. Freitas et al. compared the rotator cuff muscle strength of WBP and non-athletic individuals with paraplegia to investigate the effect of sport on shoulder strength in individuals with paraplegia. They found that the rotator cuff muscle strength of WBP was higher than that of non-athletic individuals with paraplegia.[24] Their study showed that wheelchair basketball affects the shoulder musculature of individuals with traumatic spinal cord injury. We designed this study to examine the effect of wheelchair on the shoulder strength in basketball players; therefore, the concentric and eccentric strength of shoulder rotator cuff muscles of WBP and AB-BP was found to be similar. The reason WBP and AB-BP did not differ in terms of muscle strength may be due to the fact that both groups had a similar training program and that there was no statistically significant difference between the weekly training hours and the years of participation in sports. Our study found that concentric and eccentric strengths of shoulder rotator cuff muscles of WBPs and AB-BPs were higher than that of the CG. The reason why both basketball groups exhibit a higher muscle strength than the CG may be that regular training may affect the increase in muscle strength. Additionally, another reason is there was no difference in strength may be that 58.8% of wheelchair athletes participating in the study did not use wheelchair to provide mobility in daily life, even though they used wheelchair during the game. This factor may be important as the load on the shoulders of athletes who use wheelchair only during games and training is different from the athletes who use a wheelchair as the only form of mobilization in their daily lives. Additionally, the range of the classification scores of WBP may have resulted in the similar shoulder strength between WBP and AB-BP. There are five major functional classes: 1.0, 2.0, 3.0, 4.0, and 4.5 (a higher class denotes a higher level of functional abilities on the court) in the WBP classification. Players can be classified to either category A (functional classes: 1.0-2.5) or category B (3.0-4.5). The level of anaerobic performance demonstrated by athletes in the classification category A was significantly lower than that of category B. The fact that most of the WBPs (53%) included in our study were in category B may have caused them to show a similar strength as that of AB-BPs.

In literature, there are studies that compare WBP with AB-BP or CG, but these studies are focused on the shoulder and elbow flexors or extensors. Calmels et al. found that the elbow flexor and extensor muscle strength of the individuals with paraplegia was greater than that of the able-bodied athletes.[26] Unlike these studies, Uzun et al., found no difference in the elbow flexor torque between the WBP and AB-BP, but the torque of these two groups was shown to be higher than that of the CG.[27] Külünkoğlu and colleagues found WBPs to have a higher shoulder flexor and extensor muscle strength than the able-bodied individuals.[28] Although different muscle groups were evaluated, the studies performed by Uzun and Külünkoğlu show similar results to our study.

ER/IR ratio is one of the most important criteria in the evaluation of shoulder by using the isokinetic system. The differences in ER/IR ratio indicate the presence of muscular imbalance between ER and IR muscles. This can lead to many shoulder pathologies, especially impingement.[5] Many authors have stated that modifications to the ER/IR ratio might cause musculoskeletal problems in shoulder.[11] Although our study did not show a significant difference among the three groups in terms of ER/IR ratio, this ratio (ranging from 0.66 to 0.75 for healthy subjects) was found to be lower in WBP than the other two groups and normative values.[29] The normal shoulder function is believed to require the equal strength of ER and IR, and a ratio of less than 1 is believed to be associated with shoulder injury. However, some authors have proposed that the ER strength of at least two-thirds of IR strength is sufficient to provide the muscular balance.[30] The lower ratio is related to a greater IR strength without a concomitant increase in the ER strength. The greater IR strength may be caused by several factors such as most athletes doing strength training, with a greater focus on larger muscles such as the IRs, the latissimus dorsi, and the pectoralis major, and ignoring small external rotators.[31] The decrease in ER/IR ratio in WBP may be because of the muscular kinematics of wheelchair propulsion. Because of using a wheelchair for long years, muscles that are active during propulsion may become stronger.[7] This may be an additional factor in increasing the muscular imbalance among the rotator cuff muscles. Increasing the ER strength could effectively bias this ratio. It could also add a greater stability to the shoulder joint in the athletes performing overhead activities and possibly prevent shoulder injuries.[31] In sports such as basketball where repeated activities are performed intensively by the upper limbs, it is essential to evaluate the athletes in terms of muscular imbalance because of the increased risk of injury. WBP often encounter shoulder pain and muscular imbalance; therefore, ER strengthening exercises aiming to prevent or treat this imbalance must be added to the training programs.

Our study has several limitations. The fact that the WBPs included those who did not use a wheelchair to provide mobility in the daily life and low classification scores (functional class 1.0 and 2.5) were the limitations of our study. Additionally, the age difference between WBP and AB-BP group is one of the important limitations.

CONCLUSION

This study found that the flexibility of shoulder rotator cuff muscles of WBP was found to be less than that of AB-BP and the CG. The concentric and eccentric strength of the shoulder rotator cuff muscles of WBP and AB-BP were similar and higher than those of the CG. Concentric and eccentric ER/IR ratio was similar in three groups. However, the ER/IR ratio was lower in WBP than the other two groups and normative values. Considering these results, we revealed the importance of evaluating strength and flexibility, which are important parameters in terms of athletic performance and injury risk. Stretching exercises for shoulder ER and IR muscles should be added to WBP's training programs to decrease the inadequate flexibility. In addition, exercises to strengthen the ER muscles should be added to WBPs' training programs to bring the ER/IR ratio to normal values. For a more thorough understanding of the effects of trunk control, there is a need for additional studies should include WBP with lower classification scores and their comparison with AB-BP.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Nevin Atalay Güzel;* ***Design:*** *Nihan Kafa;* ***Control/Supervision:*** *Nevin Atalay Güzel;* ***Data Collection and/or Processing:*** *Gamze Çobanoglu, Sinem Suner-Keklik;* ***Analysis and/or Interpretation:*** *Barış Seven;* ***Literature Review:*** *Gamze Çobanoglu;* ***Writing the Article:*** *Gamze Çobanoglu;* ***Critical Review:*** *Sinem Suner-Keklik;* ***References and Fundings:*** *Seyfi Savaş.*

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