ISSN: 2651-4451 • e-ISSN: 2651-446X

Türk Fizyoterapi ve Rehabilitasyon Dergisi

2019 30(2)112-118

Ferruh TAŞPINAR, PhD, PT[1]
Hakan AKKAN, PT[2]
İsmail SARAÇOĞLU, PhD, PT[2]
Betül TAŞPINAR, PhD, PT[1]
Suat EREL, PhD, PT[3]

1 *İzmir Democracy University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İzmir, Turkey.*
2 *Kütahya Health Sciences University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Kütahya, Turkey.*
3 *Pamukkale University, Vocational School of Physical Therapy and Rehabilitation, Denizli, Turkey.*

İletişim (Correspondence):

Ferruh TAŞPINAR, PhD, PT
İzmir Democracy University,
Faculty of Health Sciences,
Department of Physiotherapy and Rehabilitation,
35140 Karabağlar, İzmir, Turkey.
Phone: +90-232-2601001
E-mail: fztferruh@hotmail.com
ORCID: 0000-0002-5084-2949

Hakan AKKAN
E-mail: hakan.akkan@dpu.edu.tr
ORCID: 0000-0001-7920-1128

İsmail SARAÇOGLU
E-mail: ismail.saracoglu@dpu.edu.tr
ORCID: 0000-0002-2621-2357

Betül TAŞPINAR
E-mail: ptbetul@gmail.com
ORCID: 0000-0002-3106-2285

Suat EREL
E-mail: fzterel@gmail.com
ORCID: 0000-0001-7076-7651

Geliş Tarihi: *21.03.2018 (Received)*
Kabul Tarihi: *12.10.2018 (Accepted)*

IMMEDIATE EFFECTS OF POSTERIOR CAPSULE STRETCHING EXERCISE IN INDIVIDUALS WITH TOTAL ARC OF MOTION DEFICIT

ORIGINAL ARTICLE

ABSTRACT

Purpose: Total arc of motion deficit (TAMD) is a pathologic process contributing to shoulder injury. The purpose of the study was to examine the immediate effect on joint position sense and range of motion of posterior capsule stretching exercise, which is recommended for TAMD that can be seen in healthy individuals.

Methods: The study included 28 healthy individuals who were diagnosed with TAMD via goniometric measurements. The shoulder with TAMD was accepted as the study group. The non-deficit shoulder was accepted as the control. In order to measure the joint position sense, the angle repetition test was performed using a laser pointer, and the range of motion (ROM) of the shoulder joints was measured using goniometer. After the measurements in both shoulders were completed, the posterior capsule stretching exercise was demonstrated for the shoulder with TAMD. After the exercise was completed, the measurements were repeated for both shoulders.

Results: While no immediate change was found in joint position sense in the study group (p=0.280). Immediate significant changes were determined in internal rotation (p<0.001), external rotation (p=0.021), and horizontal adduction ranges (p=0.003).

Conclusion: The TAMD is a condition that can be observed in healthy individuals. It was found that posterior capsule stretching exercise immediately decreased the TAMD but did not affect the joint position sense. The long-term effects could be examined in further studies.

Key Words: Muscle Stretching Exercise; Proprioception; Range of Motion; Shoulder Joint.

POSTERİOR KAPSÜL GERME EGZERSİZİNİN TOTAL ARK HAREKET DEFİSİTİ OLAN BİREYLERDE ANLIK ETKİLERİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Total hareket ark defisiti (THAD), omuz yaralanmasına katkıda bulunan patolojik bir süreçtir. Bu çalışmanın amacı, sağlıklı bireylerde de görülebilecek THAD için verilen posterior kapsül germe egzersizinin eklem pozisyon hissine ve hareket açıklığına olan anlık etkisini incelemekti.

Yöntem: Çalışmaya gonyometrik ölçümler sonucunda THAD olduğu belirlenen 28 sağlıklı birey dahil edildi. THAD olan omuz çalışma grubu olarak kabul edildi. Defisit olmayan omuz ise kontrol olarak kabul edildi. Eklem pozisyon hissinin ölçümü için lazer pointer kullanılarak açı tekrarlama testi yapıldı ve omuz ekleminin hareket açıklıkları gonyometre ile ölçüldü. Her iki omuz ekleminde de ölçümler yapıldıktan sonra THAD olan omuz için posterior kapsül germe egzersizi gösterildi. Egzersiz tamamlandıktan sonra ölçümler her iki omuz ekleminde de tekrarlandı.

Sonuçlar: Çalışma grubunda eklem pozisyon hissinde anlık olarak değişiklik bulunmadı (p=0,280). Internal rotasyon (p<0,001), eksternal rotasyon (p=0,021) ve horizontal adduksiyon (p=0,003) hareket açıklıklarında anlık olarak anlamlı değişiklikler bulundu.

Tartışma: THAD sağlıklı bireylerde de görülebilen bir durumdur. Posterior kapsül germe egzersizinin anlık olarak THAD'ı azalttığı ancak eklem pozisyon hissine etki etmediği bulundu. Gelecek çalışmalarda, uzun dönem etkilerine de bakılabilir.

Anahtar Kelimeler: Kas Germe Egzersizleri; Propriyosepsiyon; Hareket Açıklığı; Omuz Eklemi.

INTRODUCTION

In overhead activities, abnormal movements of the glenohumeral joint narrow the sub-acromial range. The decrease in distance between the humeral head and acromion leads to the compression of the tissues in this region. It has been reported to be related to the limitation of shoulder flexion, internal rotation, and horizontal adduction (1). The glenohumeral joint plays a role in both stabilization and mobilization. In this joint, the structures providing mobility are the muscles while the structures responsible for stability are capsules and ligamentous structures. Moreover, these structures contribute to the joint position sense. These structures are essential for the control of the joint and play an active role in the protection mechanism of the joint. The neural structures obtain feedback through the mechanoreceptors in the capsules and ligaments in this region. The feedback mechanism of this afferent sense is defined as the proprioception. Therefore, pathologies that might develop in capsules and ligaments may deteriorate the joint position sense. The proprioceptive deficit may occur as a result of micro-trauma such as impingement syndrome and repetitive instabilities (2).

In athletes performing overhead activities, an asymmetrical glenohumeral joint range of motion (ROM) range has been detected. This condition has been reported to have the potential to leave athletes vulnerable to injuries (3). It has been revealed that there is a difference between the dominant and non-dominant extremities of athletes who perform overhead activities regarding internal and external rotation ROM. Glenohumeral internal rotation deficit (GIRD) is a side-to-side difference in internal rotation, and similarly, total arc of motion deficit (TAMD) which is defined by Wilk et al. is the side-to-side difference the sum of internal and external rotation ROM. The threshold for TAMD is five-degree side-to-side difference and athletes who have TAMD grater five-degrees tend to develop shoulder injury 2.5 times (4).

The soft tissue tightness in the posteroinferior joint capsule is believed to play a role in the development of TAMD. To prevent shoulder injury, stretching posterior joint capsule is one of the most recommended treatment option (5). Although there is clear evidence that shows the relationship between shoulder injury and TAMD in baseball pitchers, there is no study about the effectiveness of exercise on TAMD (4,6). Besides the athletes performing overhead activities, a few researchers have investigated the effectiveness of posterior shoulder stretching in nonathletic people with GIRD (7,8). However, we could not any study investigating the effectiveness of posterior capsule stretching exercise in people with TAMD. Therefore, this study was planned to determine the immediate effect of posterior capsule stretching exercise on joint position sense and ROM in individuals with TAMD.

METHODS

This study was conducted at Kütahya Health Sciences University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation between January 2016 and December 2016. A total of 28 healthy individuals (12 females and 16 males) with a mean age of 26.67±6.83 years were included in the study. Approval for the study was granted by the Ethics Committee of Pamukkale University Denizli, Turkey (Number: 60116787-020/8823). Before the study, to determine the size effect (0.80), it was calculated that 80% (5% Type I error level) and 26 subjects should be included in the study. Our study was performed with 28 subjects.

The study included individuals who signed the consent form and had at least five-degree side-to-side difference between the sum of internal and external rotation ROM in the glenohumeral joint, with no systemic disorder or neurological problem. Those individuals with a history of glenohumeral joint and/or spine surgery, with a diagnosis of shoulder pathology within the previous year, or a history of bone fracture in the shoulder girdle were excluded.

The demographic data of the participants such as age, height, weight, personal history of the medical condition, family medical history, and dominant extremity were recorded on a form in a face-to-face interview. The ROM was measured using a digital goniometer (Baseline Evaluation Instrument®, Fabrication Enterprises, Inc., White Plains, NY, USA), and the subjects with no difference between the extremities regarding ROM were excluded. The ex-

tremity with the lower degrees of ROM value was included in the study group while the other extremity was assigned to the control group. Then, the position sense in both glenohumeral joints of the participants was examined. While no intervention was given to the extremities in the control group, the study group was given posterior capsule stretching exercise. After the exercise was completed, the joint position sense and goniometric measurements were repeated by the same physiotherapist in the same room using the same device.

Goniometric Measurements

Using a Baseline® digital goniometer (Fabrication Enterprises, Inc., White Plains, NY, USA), the ROM of horizontal adduction, internal and external rotation of the shoulder joints were passively measured without overpressure. Since it ensures body and scapula stabilization, the supine position was preferred.

In order to determine TAMD, the internal and external rotation ROM were measured separately. During the measurements while a physiotherapist moved the shoulder passively to internal and external rotation with one hand, the other hand was placed on the coracoid process and the motion was continued to the point where the scapula moved, and was ended at this point. The measurements were performed bilaterally and by adding the internal and external rotation ROM values, the TAMD of the glenohumeral joint was calculated. The subjects with a difference of >5˚ of arc of motion between the glenohumeral joints were selected. The shoulder joint with the lower ROM comparing with the other extremity was considered to have TAMD (4,9).

Joint Position Sense

In order to evaluate the joint position sense of the individuals, the Microsoft Windows 7 Paint software® (Redmond, Washington, USA) and laser pointer (Logitech Legamaster LX-1, Lausanne, Switzerland) were used. The gridlines were selected and made apparent, then projected onto the wall via the projection device. The zoom of the software was set to 300%. Then the laser pointer was fixed directly on to the elbow joint with Velcro® (Manchester, USA). The shoulder joint was adjusted to a position of 30˚ abduction and 90˚ flexion in the scapular plane. In this position, the point that the laser pointer showed on the wall was marked as a black point in the paint software reflected on the wall. That point was determined as the target angle. The subject was fixed in this position with the eyes open and was allowed to repeat it three times for three seconds. Then, with the eyes closed, the subject was asked to reach the target angle and stay there for three seconds. The measurement was repeated three times, with a three-second resting period between each measurement. Each

Table 1: Demographic Data of the Subjects.

Variables	Subjects (n=28)	
	Mean±SD	Min-Max
Age (years)	26.67±6.83	20-50
Height (cm)	172.89±0.08	153-188
Weight (kg)	69.92±13.36	49-103
BMI (kg/m²)	23.57±3.61	17.36-31.79
Variables	**n**	**%**
Gender		
Female	12	43
Male	16	57
Dominant Side		
Right	25	89
Left	3	11
TAMD Affected Side		
Right	18	64
Left	10	35

BMI: Body Mass Index, TAMD: Total Arc of Motion Deficit.

Table 2: The Range of Motion of the Shoulder with Deficit and Non-Deficit at Baseline.

Range of Motion	Shoulder with Deficit (n=28)	Non-deficit (n=28)	p
	Mean±SD	Mean±SD	
Internal Rotation (°)	71.92±12.72	80.50±9.72	**<0.001***
External Rotation (°)	84.17±9.42	86.71±5.42	0.074
Horizontal Adduction (°)	59.42±13.64	64.78±13.12	0.196
Total arc of motion (°)	156.10±14.56	167.21±10.51	**<0.001***

*p<0.05.

of the measurement points was marked, and the projection points of the distances to the targeted point in x and y planes were determined. The x and y values of all three measurements were totaled separately, and the coordinates of the resultant vector were determined. From these coordinates, the length of the resultant vector was calculated using the formula: $\sqrt{x^2+y^2}$ (10-12).

Posterior Capsule Stretching

In order to stretch the posterior capsule, the cross-body stretch exercise was demonstrated in the standing position without scapular stabilization. The individuals were then asked to pull the extremity where the deficit was detected, passively to the opposite arm crossing the body. The exercise was repeated five times, each with a 30-second duration (8,13). A physiotherapist conducted all applications.

Statistical Analysis

For statistical analysis, the SPSS (Statistical Package for the Social Sciences) Statistics 20.0 (SPSS Inc, Chicago, IL, USA) package software was used. The demographic data were stated as the minimum, maximum, mean and standard deviation values. The Mann-Whitney-U test Wilcoxon test was used, as appropriate the pre-and post-exercise values. A value of p<0.05 was accepted as statistically significant.

RESULTS

Totally 50 participants were examined for TAMD. Twenty-eight participants meeting the inclusion criteria were included in the study. The demographic data of the individuals are presented in Table 1. Before the exercise, the ROM of both shoulder joints was measured. While the difference between the internal rotation ROM and TAMD of shoulder joint was found to be statistically significant (p<0.05), no difference was observed between other ROM (p>0.05) (Table 2).

When the ROM of the glenohumeral joint was examined after exercise, no difference was found between the the shoulder wtih deficit and without deficit (p>0.05). The data regarding these findings are presented in Table 3.

No statistically significant difference was found between the mean lengths of resultant vectors, indicating no difference in the post-exercise joint position sense after posterior capsule stretching exercise in the non-deficit and the study group (p>0.05). While no difference was found in internal rotation, external rotation, horizontal adduction ROM, and TAMD in the control group (p>0.05), statistically significant differences were found in shoulder with deficit (p<0.05) (Table 4).

Table 3: Range of Motion of the Shoulder with Deficit and Non-deficit at Post-Exercise.

Range of Motion	Shoulder with Deficit (n=28)	Non-Deficit (n=28)	p
	Mean±SD	Mean±SD	
Internal Rotation (°)	81.53±9.04	81.85±8.39	0.516
External Rotation (°)	87.57±4.36	87.14±3.98	0.084
Horizontal Adduction (°)	67.02±13.04	66.28±12.41	0.775
Total Arc of Motion (°)	169.11±10.66	168.28±11.32	0.153

Table 4: Joint Position Sense and Range of Motion of the Shoulder Pre- and Post-Exercise.

Shoulder Side		Pre-Exercise (n=28)	Post-Exercise (n=28)	p
		Mean±SD	Mean±SD	
Deficit	**Joint Position Sense**	17.95±7.74	16.18±8.61	0.282
	Range of Motion			
	Internal Rotation (°)	71.92±12.72	81.53±9.04	**0.001***
	External Rotation (°)	84.17±9.42	87.57±4.36	**0.021***
	Horizontal Adduction (°)	59.42±13.64	67.02±13.04	**0.001***
	Total Arc of Motion (°)	156.10±14.56	169.11±10.66	**0.001***
Non-Deficit	**Joint Position Sense**	19.81±6.78	19.38±5.41	0.100
	Range of Motion			
	Internal Rotation (°)	80.50±9.72	81.85±8.39	0.200
	External Rotation (°)	86.71±5.42	87.14±3.98	0.491
	Horizontal Adduction (°)	64.78±13.12	66.28±12.41	0.073
	Total Arc of Motion (°)	167.21±10.51	168.28±11.32	0.281

*p<0.05.

DISCUSSION

The results of this study showed that posterior capsule stretching exercise increases shoulder internal rotation, external rotation and horizontal adduction ROM in individuals with TAMD, whereas it does not affect joint position sense.

The TAMD, which can be seen in healthy individuals, may not be noticed since it does not cause pain or limitations in daily life activities. Hence, these individuals may not feel the need to consult a healthcare facility. Warner et al. reported that the passive internal rotation range was less in individuals with impingement syndrome in comparison with healthy people and that the stiffness of the posterior capsule caused the limitation. In this regard, the rotational joint motion ranges of 50 individuals were examined, and GIRD was found in 56% (14).

The ROM plays an essential role in diagnosis, treatment, the progression of glenohumeral joint pathologies and examining the level of alteration of motion. In the current study, the individuals found to have deficit were given a posterior capsule stretching exercise to increase the ROM. In the literature, many researchers have investigated the effects of stretching exercises on ROM. McClure et al. reported that cross-body stretching exercises increased the internal rotation range and that the increase was higher than that of the sleeper's stretch exercise (8). Manske et al. reported that a four-week program of posterior capsule stretching (cross-body stretch) exercise increased the internal rotation range and the addition of the posterior joint gliding exercise to the posterior stretching exercise led to a greater increase in ROM (13). Similarly, in the present study, posterior capsule stretching exercise was found to immediately significantly increase the shoulder joint internal rotation, external rotation, and horizontal adduction and to decrease the ROM variation causing the deficit.

Although cross-body stretch exercise has been determined to increase the shoulder ROM, there is no study in the literature which has examined its effect on joint position sense. The angle repetition test, which is performed using a laser pointer, is a common method used to examine the sense of joint position. In the first study to utilize this method by Revel et al., cervicocephalic kinesthesis in individuals with chronic cervical pain was examined (15). Balke et al., placed the laser pointer on the wrist to apply the angle repetition test and reported that the results might be affected by the wrist and elbow movements (12). Duzgun et al., in a study on the sense of shoulder joint position, used the angle repetition test and placed the laser pointer on the elbow joint to prevent the effects of wrist and elbow movements (10). Vafadar et al. and Balke et al. reported that the use of the laser pointer is a reliable and valid method for examining the joint position sense in the shoulder joint (11,12). In the current study, the joint position sense was examined using the angle repetition test with the laser pointer positioned on the elbow joint because of the low cost and practicality of this test.

As a result of damage in soft tissues around the glenohumeral joint, the excitability of the alpha

and gamma motor neurons decreases and a loss of proprioceptive sense occurs. In physiotherapy and rehabilitation clinics, proprioceptive training plays a significant role. During the exercise, there is correctly increasing stimulation of mechanoreceptors and muscle spindles (16). After the capsule stretching exercises that were applied for this purpose in our study, a decrease was observed in deviation values in the angle repetition test, but the difference was not found to be statistically significant. Vafadar et al. reported that the activity of musculotendinous receptors increased because of higher muscle activity in moving the glenohumeral joint to a moderate level of 90 ± 10^0. It was concluded that the errors in re-positioning the joint at those degrees were less than at other degrees (17). In our study, the mid-level motion ranges specified by Vafadar et al. were used as this position stimulates the musculotendinous mechanoreceptors more and does not lead to any change in joint position sense. Moreover, it is mostly the mechanoreceptors in the capsule and ligaments that are stimulated during the capsule stretching exercise. Beside that stimulation of the mechanoreceptors in muscles and tendons at mid-range is thought to result in no difference being observed in the joint position sense. In addition, individuals may have memorized this point as a specific angle is used, not as Vafadar et al.'s (17). Therefore, changes in the sense of the actual shoulder joint position cannot be identified and the influence of the visual memory may not be excluded.

Not using the full range of shoulder joint movements in daily life activities may lead to limitations in the ROM of the glenohumeral joint. There is little information in the literature about TAMD in healthy individuals. Therefore, this study can be considered to contribute to literature, because it draws attention to the limitation of the ROM in the glenohumeral joint of healthy individuals and highlights the deficit. It is also of value as it indicates the prevalence of the deficit and determines the effects of capsule stretching exercises on the deficit. The TAMD may cause shoulder injury, maybe even seen in healthy individuals in addition to athletes and if we identify and treat people with TAMD, we can prevent shoulder injury caused by TAMD. Our study showed that posterior capsule stretching exercise increased ROM of the shoulder joint. Thus, the use of posterior capsule stretching exercise will help prevent TAMD.

As only the immediate effect of capsule stretching exercise was examined in this study, further studies with a higher number of subjects and using measurement devices of greater accuracy are required to evaluate the long-term effects.

This study has several limitations including that the extremity with the deficit was determined but dominance was ignored, the laser pointer was fixed with Velcro® rather than using a fixed apparatus, and the eyes were kept closed while repeating the angle repetition tests rather than keeping them open. The use of the apparatus to keep the laser pointer in a fixed position is thought to decrease measurement-related errors. The angle repetition test was performed with closed eyes after the target point was shown once to the subject, but it has been reported that in subsequent measurements, the level of perception may change (10). Therefore, we believe that showing the target point to the subject before each repetition may change the results. The use of a specific angle may have prevented the measurement of the actual sense of shoulder position.

In conclusion, the TAMD is a condition that can be seen even in healthy individuals. Posterior capsule stretching exercise immediately decreases the TAMD, but it does not affect the joint position sense. With the consideration that the capsule stretching exercise immediately decreased the deficit, it can be predicted that regular shoulder capsule stretching exercises may contribute to the prevention of potential shoulder problems.

Sources of Support: None declared.

Conflict of Interest: None declared.

Ethical Approval: This study was approved by the Ethics Committee of Pamukkale University, School of Medicine (Protocol No: 60116787-020/8823).

Informed Consent: Written informed consent was obtained from all study participants.

Acknowledgements: None.

REFERENCES

1. Warner JJ, Allen AA, Marks PH, Wong P. Arthroscopic release of postoperative capsular contracture of the shoulder. J Bone Joint Surg Am. 1997;79(8):1151-8.
2. Aydin T, Yildiz Y, Yanmis İ, Yildiz C, Kalyon T. Shoulder proprioception: a comparison between the shoulder joint in healthy and surgically repaired shoulders. Arch Orthop Trauma Surg. 2001;121(7):422-5.
3. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Glenohumeral range of motion deficits and posterior shoulder tightness in throwers with pathologic internal impingement. Am J Sport Med. 2006;34(3):385-91.
4. Wilk KE, Macrina LC, Fleisig GS, Porterfield R, Simpson CD, Harker P, et al. Correlation of glenohumeral internal rotation deficit and total rotational motion to shoulder injuries in professional baseball pitchers. Am J Sport Med. 2011;39(2):329-35.
5. Lintner D, Mayol M, Uzodinma O, Jones R, Labossiere D. Glenohumeral internal rotation deficits in professional pitchers enrolled in an internal rotation stretching program. Am J Sports Med. 2007;35(4):617-21.
6. Amin NH, Ryan J, Fening SD, Soloff L, Schickendantz MS, Jones M. The relationship between glenohumeral internal rotational deficits, total range of motion, and shoulder strength in professional baseball pitchers. J Am Acad Orthop Surg. 2015:23(12):789-96.
7. Guney H, Karabicak GO, Pekyavas NO, Teker B, Gunaydin O, Balci P, et al. Which stretching technique is effective in decreasing glenohumeral internal rotation deficit? Med Sport. 2015;68(2):291-302.
8. McClure P, Balaicuis J, Heiland D, Broersma ME, Thorndike CK, Wood A. A randomized controlled comparison of stretching procedures for posterior shoulder tightness. J Orthop Sports Phys Ther. 2007;37(3):108-14.
9. Kibler WB, Sciascia A, Thomas SJ. Glenohumeral internal rotation deficit: pathogenesis and response to acute throwing. Sports Med Arthrosc Rev. 2012;20(1):34-8.
10. Duzgun I, Simsek IE, Yakut Y, Baltaci G, Uygur F. Assessing shoulder position sense using angle reproduction test in healthy individuals: a pilot study. Fizyoter Rehabil. 2011;22(3): 240-4.
11. Vafadar AK, Côté JN, Archambault PS. Interrater and intrarater reliability and validity of 3 measurement methods for shoulder-position sense. J Sport Rehabil. 2016;25(1):2014-309.
12. Balke M, Liem D, Dedy N, Thorwesten L, Balke M, Poetzl W, et al. The laser-pointer assisted angle reproduction test for evaluation of proprioceptive shoulder function in patients with instability. Arch Orthop Trauma Surg. 2011;131(8):1077-84.
13. Manske RC, Meschke M, Porter A, Smith B, Reiman M. A randomized controlled single-blinded comparison of stretching versus stretching and joint mobilization for posterior shoulder tightness measured by internal rotation motion loss. Sports Health. 2010;2(2):94-100.
14. Warner JJ, Micheli LJ, Arslanian LE, Kennedy J, Kennedy R. Patterns of flexibility, laxity, and strength in normal shoulders and shoulders with instability and impingement. Am J Sport Med. 1990;18(4):366-75.
15. Revel M, Andre-Deshays C, Minguet M. Cervicocephalic kinesthetic sensibility in patients with cervical pain. Arch Phys Med Rehab. 1991;72(5):288-91.
16. Baltacı G. Rehabilitation in shoulder injuries. 1st ed. Ankara: Pelikan Yayınevi; 2015.
17. Vafadar AK, Côté JN, Archambault PS. Sex differences in the shoulder joint position sense acuity: a cross-sectional study. BMC Musculoskelet Disord. 2015;16(1):273.