J Shoulder Elbow Surg (2012) 21, 709-714

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

SHOULDER

Does scapular dyskinesis affect top rugby players during a game season?

Takayuki Kawasaki, MD, PhD*, Jun Yamakawa, MD, Takefumi Kaketa, MD, Hideo Kobayashi, MD, Kazuo Kaneko, MD

Department of Orthopaedic Surgery, Juntendo University Faculty of Medicine, Bunkyo, Tokyo, Japan

Background: Scapular dyskinesis represents a considerable risk of shoulder injury to overhead athletes; however, there is a shortage of detailed epidemiologic information about scapular dyskinesis among the participants in collision sports.

Purpose: To describe the incidence and relationship of scapular dyskinesis to shoulder discomfort and variables related to the shoulder in top rugby players.

Methods: One hundred twenty top rugby football players in Japan were evaluated by means of questionnaires, physical examinations, and a video analysis during their preseason. Data were assessed by a logistic regression analysis calculating odds ratios. The primary outcome was processed to assess the relationship between scapular dyskinesis and other variables at the preseason. The secondary outcome was processed to assess an influence of scapular dyskinesis to shoulder discomfort during their regular season that were reassigned by second questionnaires.

Results: Scapular dyskinesis was identified in 33 (32%) shoulders, and type III was prominent. Scapular dyskinesis was significantly associated with shoulder discomfort (OR [odds ratio] = 4.4), and was also associated with variables of the affected shoulder. In addition, the players with asymptomatic scapular dyskinesis at the preseason would have high incident with shoulder discomfort during their regular season (OR = 3.6).

Conclusions: Scapular dyskinesis was associated significantly with both subjective and objective symptoms of the affected shoulder. These appearances may be of particular relevance in the early screening of chronic shoulder disorders in the rugby population. Further study to investigate and evaluate its reliability is needed to characterize its impact on the participants in collision sports.

Level of evidence: Level I, Prospective Design, Prognostic Study.

Keywords: Scapular dyskinesis; rugby; collision sports; shoulder; longitudinal study; prevention

Rugby is a major collision sport and the players are exposed to various injuries during a game season. The incidence of injuries was reported to be 91 per 1000 playing hours, which is higher than in most of other sports.[4,5] Of these injuries, 10% appeared in shoulders, for which possible preventive measures should be investigated. If one is able to predict shoulder injuries before the games, some

Ethics approval: Ethics approval for the study was received from the Juntendo University School of Medicine Research Ethics Committee (No. 21067).

*Reprint requests: Takayuki Kawasaki, MD, PhD, Department of Orthopaedic Surgery, Juntendo University Faculty of Medicine, 2-1-1 Hongo, Bunkyo, Tokyo 113-8421, Japan.

E-mail address: k-saki@luck.ocn.ne.jp (T. Kawasaki).

1058-2746/$ - see front matter © 2012 Journal of Shoulder and Elbow Surgery Board of Trustees.
doi:10.1016/j.jse.2011.11.032

injuries can be avoided. There are reports[16,25] dealing with the pre-seasonal conditions of rugby players and the incidence of injuries; namely, the ones with poor conditions in their pre-season are much more prone to injuries in the following game season in general; but whether it can be applied to the shoulder is not certain.

Scapular dyskinesis (SD) is a kinematic abnormality of the scapula often associated with pathological conditions such as impingement, instability, and injury of the acromioclavicular joint.[1,2,11,17] Overhead throwing athletes frequently present SD. Burkhart et al[6] mentioned that SD had something to do with the occurrence of shoulder problems in throwing players, and suggested that SD would be a possible indicator of shoulder at risk of injury. McClure et al[22] and Tate et al[29] examined 142 baseball pitchers to reveal its effective reliability and validity of visually 2-dimentional (2-D) evaluation. However, precise implication of SD remains to be seen. Various types of SD are seen in rugby players; but their characteristics and association with shoulder injuries have not been proven. This prompted us to carry out this study, in order to know SD and its clinical implications. Additionally, we studied whether pre-seasonal presence of SD affects shoulder conditions during the game season.

Materials and methods

Subjects

In 2009, one hundred twenty male roster players for top-league rugby teams in Japan, playing nearly 30 games during a regular season, were enrolled in this study. Twelve of them had participated in international games. Those who had shoulder or elbow surgeries in the past and those with a time-loss injury to shoulder or elbow in the previous 3 months were excluded. Examinations were conducted on both shoulders of each subject.

Demographics of the subjects

Demographic data were collected on all the subjects, using a questionnaire form before the regular season started. The data included: age; years of experience in rugby; height; body weight; position, such as forwards (FW) or backs (BK); side of dominant hand; side of shoulder frequently used for collision; subjective discomforts (ie, pain, apprehension, or fatigue) of the shoulder, if any, persisting more than 2 weeks; and shoulder trauma requiring off-game more than 7 days. Newly developed shoulder discomfort persisting for more than 2 weeks during the regular season was also questioned, and recorded at the end of the 2009 game season.

Physical examination

Both shoulders were examined in the same manner and consisted of the following tests: detection of impingement signs as evaluated by Neer and Hawkins maneuvers[12,24]; detection of instability of the glenohumeral joint through the multi-directional apprehension test[3,27]; and muscle weakness of the rotator cuff muscles and the shoulder girdle—the former being tested by manual testing of abduction force in the scapular plane[13] as well as external rotation force with the arm at the side of the shoulder, and the latter by scapular assistance test[6] which is positive when it gives relief of symptoms of impingement, clicking, or rotator cuff weakness. The muscle weakness was evaluated as positive or negative, comparing with that of the opposite side when the respective evaluations of the subjects and examiners were in accordance. Another test was conducted for tenderness over the acromioclavicular joint. None of the examiners (TK, JY, and TK) were notified of the subjects' demographic data prior to the examination to make it a blind fashion.

Definition of scapular dyskinesis

Detailed description of SD has been provided by Kibler et al.[15,30] Type I dyskinesis is characterized by prominence of the inferior medial scapular angle and associated with excessive anterior tilting of the scapula. Type II is characterized by prominence of the entire medial border and associated with excessive scapular internal rotation. Type III is characterized by prominence of the superior scapular border and associated with excessive upward translation of the scapula. When clinicians observed asymmetry in multiple planes of motion, they were instructed to choose the single most prominent type. Type IV is characterized as "normal," indicating no asymmetries or nonprominence of the medial or superior border of the scapula. All subjects performed 5 repetitions of bilateral, active movements of shoulders with 3-kg handheld load in anterior elevation and lowering, as well as abduction and lowering in the scapular plane. At the time of final lowering, arms were kept horizontally. The distance between the inferior angle of scapula to the thoracic spinous process were then measured bilaterally to elucidate their side-to-side differences. Each of these activities was video recorded and rated by 2 of the authors (KT and JY). The percentage of agreement for inter-rater reliability and the kappa coefficient in the evaluation of scapular dyskinesis were explored (Figure).

Statistical analysis

In order to maintain independency of the samples to explore the following analysis, 1 shoulder was chosen from each subject[28] on the basis of the following priority order: the presence of SD, frequent side of the shoulder for collision, and the dominancy of the shoulders.

Age, body mass index (BMI), and years of rugby experience were quantitative data; however, other variables such as the results of physical examinations and the presence of past trauma were qualitative ones, so that they were simply defined as being positive or negative. The variables of physical examinations, including more than 2 tests, were considered positive if at least 1 of these tests was positive. The difference in proportion of the types of SD was assessed using Fisher's exact test. Intergroup differences of the distance between the inferior angle of scapula and spinous process were also assessed by the Kruskal-Wallis H test, followed by the Mann-Whitney's U test for post hoc analysis.

The primary analysis was focused on the relationship between the presence of SD (types I- III) and each of the variables. Data were assessed by a logistic regression analysis calculating odds ratio (OR). The secondary analysis was performed on the same

Figure Classification of scapular dyskinesis. Superimposed photos represent high, middle, and lowered arm position during the task. *Dotted lines* and *arrows* represent characteristics of each type. (**A**) Type I dyskinesis characterized by prominence of the inferior medial scapular angle and associated with excessive anterior tilting of the scapula. (**B**) Type II characterized by prominence of the entire medial border and associated with excessive scapular internal rotation. (**C**) Type III characterized by prominence of the superior scapular border and associated with excessive upward translation of the scapula.

subjects to assess the relationship between the presence of pre-seasonal SD and the shoulder disorders during the game season obtained from the second questionnaire. To find whether the pre-existed SD had anything to do with the development of the shoulder disorders, analysis was performed on the group of subjects who presented no shoulder complaints in the pre-season but developed shoulder disorders during the game season. In all the analyses, not only was the simple presence of SD taken into consideration, but so was the type. $P < .05$ was considered to be significant, and all the tests were 2-sided. Data analyses were conducted using the SPSS software package for Windows, version 19.0 (SPSS, Chicago, IL, USA).

Results

The percentage of agreement representing inter-rater reliability in our evaluation of SD was 85.8% (103/120) and the kappa coefficient was .76. They correlated closely with the results reported by Kibler et al.[15] Only the subjects

Table I Summary of the subjects' demographic data (total number = 103)

Demographics	Mean ± standard deviation (95% CI)	
Age (y.o.)	24.6 ± 3.3 (18.2, 31.0)	
BMI (kg/m2)	28.9 ± 3.6 (24.0, 35.5)	
Experience (year)	12.7 ± 4.8 (4.2, 20.0)	
	Proportion	$P^{\dagger}$
Position (forward:backward)	61:42	.08
Dominant side of the shoulder (right:left)	99:4	.00*
Frequent side for collision (right:equal:left)	65:30:8	.00*

CI, confidence interval.
* Significant.
† Fisher's exact test.

Table II Summary of the subjects' characteristics (total number = 103)

Variables	Number (%)
Examined side (right:left)	85:18
Players' complaints	
Shoulder discomfort/total	33 (32.0)
Subgroup/pain	24 (23.3)
Subgroup/apprehension	6 (5.8)
Subgroup/Fatigue	6 (5.8)
Variables in the affected shoulder	**Number (%)**
Past shoulder injury	42 (40.8)
Positive impingement sign	24 (23.3)
Positive apprehension test	15 (14.6)
Motor weakness	29 (28.2)
Tenderness over the ACJ	8 (7.8)

ACJ, acromioclavicular joint.

Table III Characteristics of SD (total number = 103)

SD classification by Kibler et al[15]	Number (% total)	Δdistance (mean ± standard deviation)	$P^{\dagger}$
Type I	6 (4.9)	.5 ± .4	.63
Type II	4 (3.9)	−1.4 ± .4	.047*
Type III	23 (22.3)	1.2 ± .3	.00*
Types I-III	33 (32.0)	.7 ± .9	.00*
Type IV (as normal)	70 (68.0)	.1 ± .4	- (*reference*)

SD, scapular dyskinesis.
Δ distance: side-to-side difference in the distance between thoracic spinous process and inferior angle of scapula. Positive value represents that the distance of the affected side is longer than that of the opposite.
* Significant.
† Mann-Whitney's *U* test for post hoc analysis.

whose ratings were in accordance by both raters were used for the final assessment. Consequently, 103 players were subjected to the primary analysis. In the population, SD was observed in 22 right shoulders (21.4%) and 13 (12.6%) left. The right shoulder was often found to be the side of dominancy, as well as the side used for collision. Finally, 85 right shoulders and 18 left were subjected to the analysis (Table I). There were 33 shoulders with discomfort, 42 with past shoulder injury, and 24 with impingement (Table II). Of these, type III SD (23/33 = 59.1%) was predominant than types I and II ($P = .043$). There were significant side-to-side differences regarding the distance between the inferior angle of scapula and spinous process between the players with or without SD (Table III).

The results of the univariate logistic regression model with these variables are summarized in Table IV. SD as the dependent variable had: a relationship to shoulder discomfort (OR = 4.4, 95% CI = 1.8-10.7, $P = .001$); a past history of shoulder injury (OR = 2.3, 95% CI = 1.0-5.4, $P = .04$); positive impingement sign (OR = 4.4, 95% CI = 1.7-11.6, $P = .002$); positive apprehension test (OR = 4.0, 95% CI = 1.3-12.4, $P = .02$); and motor weakness (OR = 3.3, 95% CI = 1.4-8.2, $P = .01$). These results were consistent with those obtained solely from type III scapular dyskinesis.

At the end of the regular season, a second questionnaire was given to the 70 players who had no shoulder discomfort before the season started; 8 of whom were either retired or unable to participate in actual games during the season because of injuries to other than the shoulder. Therefore, only 62 players, including 14 SD, were subjected to the second analysis. From the secondary analysis (Table V), 25 players had shoulder discomfort persisting at least 2 weeks during the season; 14 (56.0%) of whom had apparent causes such as tackling. The presence of asymptomatic SD (N = 14) during the preseason was found to be associated with newly developed shoulder discomfort during the season (OR = 3.6, 95%CI = 1.0-12.5, $P = .04$). These results were consistent with those subjects with type III SD alone (N = 9, OR = 7.0, 95%CI = 1.3-37.0, $P = .02$), while the number of the subjects belonging to other SD types was insufficient for significant analysis.

Discussion

The present study is the first preliminary one dealing with epidemiology of SD in rugby players. Of the top rugby players subjected to the study, SD was evident in 21.4% in the right shoulders and 12.6% in the left. The etiology and pathophysiology of SD would be different between collision sports (ie, rugby) and throwing sports (ie, baseball).[14] SD itself can be considered to be an adaptation of the shoulder to the mechanical stress or injury.[7,23] The shoulders of rugby players are more prone to direct injuries than of baseball pitchers. In collisions such as tackling in rugby,

Table IV Cross-sectional association of SD with variables N = 103

Variables (%total)	SD type I (N = 6)	SD type II (N = 4)	SD type III (N = 23)	SD types I-III (N = 33)
Age	.9 (.7, 1.2), .45	1.2 (.9, 1.5), .32	1.0 (.9, 1.1), .88	1.0 (.9, 1.1), .92
Experience	1.1 (.9 1.3), .37	1.1 (.9 1.3), .53	1.0 (.9 1.1), .57	1.0 (1.0, 1.1), .32
BMI	.9 (.7 1.2), .63	.9 (.6 1.2), .46	1.0 (.9 1.1), .84	1.0 (.9, 1.1), .56
Shoulder discomfort	3.7 (.7, 20.1), .14	3.7 (.5, 28.2), .22	4.8 (1.7, 13.0), .002*	4.4 (1.8, 10.7), .001*
Past shoulder injury	3.8 (.7, 22.5), .13	1.9 (.3, 14.5), .44	2.1 (.8, 5.4), .10	2.3 (1.0, 5.4), .04*
Positive impingement sign	3.0 (.5, 18.6), .24	2.0 (.2, 21.2), .48	5.5 (1.9, 15.8), .002*	4.4 (1.7, 11.6), .002*
Positive apprehension test	5.3 (.8, 35.4), .12	3.6 (.3, 39.7), .33	3.8 (1.1, 13.2), .04*	4.0 (1.3, 12.4), .02*
Motor weakness	2.0 (.3, 12.0), .37	1.3 (.1, 13.8), .60	4.4 (1.6, 11.9), .004*	3.3 (1.4, 8.2), .01*
Tenderness over the ACJ	1.1 (1.0, 1.2), .61	4.4 (.4, 47.8), .28	2.1 (.2, 18.2), .43	1.5 (.3, 7.6), .50

SD, scapular dyskinesis; *ACJ*, acromioclavicular joint.
Numbers in the fields represent odds ratio, 95% confidential interval in parentheses, and probability calculated from logistic regression analysis, respectively.
* Significant.

Table V Longitudinal association of asymptomatic SD detected in the preseason with shoulder discomfort during the season

Preseasonal SD	Shoulder discomfort during the season (N = 62‡)		Odds ratio (95% CI)	*P*†
	(+)	(−)		
Type I	1	2	1.0 (.1, 11.9)	.71
Type II	1	1	2.0 (.1, 34.5)	.57
Type III	7	2	7.0 (1.3, 37.0)	.02*
Types I-III	9	5	3.6 (1.0, 12.5)	.04*
Type IV	16	32	1.0 (reference)	-

SD, scapular dyskinesis.
* Significant.
† Logistic regression analysis.
‡ The players who had no shoulder discomfort in the preseason.

the upper extremities often come in contact with the opponents or the ground. Under these circumstances, the superficial long thoracic nerve and/or the accessory nerve, as well as the shoulder joint itself, can be damaged by repetitive traction or direct contusion.[26] The logistic regression analysis of the variables disclosed SD of being significantly associated with several pathological conditions of the shoulder (ie, impingement, instability, and muscle weakness). This finding is similar to the ones reported by other investigators[2,11,17,31] and is quite plausible, as rugby players often suffer from conditions such as impingement, glenohumeral/acroclavicular instability, and cuff dysfunction during regular games.[4,5]

Various classifications of SD have been presented in the past. Kibler et al[15] divided SD into 4 subcategories from type I to IV, on the basis of presence or absence of prominence of the medial and superior border of the scapula. There were 22 shoulders with type III SD among 103 players. Type III was consistent with shoulder discomfort, as well as other shoulder symptoms such as impingement (Table IV). These findings are similar to the ones reported by others.[19,21] The other 2 types of SD (types I and II), which were indicated in past studies as being caused by weakness of the serratus anterior and/or lower part of the trapezius,[8-10,18,20,32] were also present in rugby players. However, types I and II are not statistically significant based on the small number of subjects (total number of types I and II = 10).

In the second longitudinal analysis, the population without any discomfort during the preseason (N = 62) demonstrated that ones with asymptomatic SD can develop into symptomatic during regular season (OR = 3.6). These findings were also proved in type III SD (OR = 7.0). In this study, we also addressed neck, hip, knee, and low back pain, as well as shoulder pain, which could affect scapular kinematics; however, no relationship was revealed with shoulder discomfort (data not shown). Many works have been done; but, whether SD is an etiological factor or a result of shoulder pathology is still a matter of question. Our study suggests that the presence of SD before the regular season can be a predictable factor for shoulder symptoms to occur during the season, and that certain shoulder problems could be prevented by appropriate measures such as muscle and/or range of motion exercises.

A limitation of this study is the lack of a critical method to evaluate SD in the present 2-D setting. It is possible that other critical methods such as 3-D analysis of scapular kinematics could detect minimal abnormalities and association to the specific pathophysiology in the affected shoulder; although these methods are not readily available for use in the screening to detect shoulder problem.

As SD is only a kinematic alteration, it may never be associated with a specific anatomic lesion but may place the shoulder at increased injury risk; the exact pathology determined more by the loads and forces experienced in the individual joint. SD may provide for a more stable articulation within the kinetic chain so it can develop and control the sport or task specific forces and loads.

Conclusion

In conclusion, SD before and after a regular season was studied in a group of top-grade rugby players. The presence of SD, even asymptomatic before the season, was proved to be an alarming sign for shoulder problems. Therefore, SD should be further studied for prevention of various "rugby shoulders."

Acknowledgments

The authors thank Makoto Urushibara, MD, Daisuke Kubota, MD, Yuji Takazawa, MD, Atsushi Kuwata, AT, Shigeru Ooka, AT, Chihiro Ota, AT, Mototsugu Matsui, Shingo Urayama, Koji Nishimoto, and Saya Hirabayashi for their valuable help in the data collection.

Disclaimer

None of the other authors, their immediate families, and any research foundation with which they are affiliated received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Abbott Z, Richardson JK. Subacromial impingement syndrome as a consequence of botulinum therapy to the upper trapezii: a case report. Arch Phys Med Rehabil 2007;88:947-9. doi:10.1016/j.apmr.2007.04.006
2. Bagg SD, Forrest WJ. A biomechanical analysis of scapular rotation during arm abduction in the scapular plane. Am J Phys Med Rehabil 1988;67:238-45.
3. Bahk M, Keyurapan E, Tasaki A, Sauers EL, McFarland EG. Laxity testing of the shoulder: A review. Am J Sports Med 2007;35:131-44. doi:10.1177/0363546506294570
4. Brooks JH, Fuller CW, Kemp SP, Reddin DB. Epidemiology of injuries in English professional rugby union, part 1: match injuries. Br J Sports Med 2005;39:757-66. doi:10.1136/bjsm.2005.018135
5. Brooks JH, Fuller CW, Kemp SP, Reddin DB. Epidemiology of injuries in English professional rugby union, part 2: training injuries. Br J Sports Med 2005;39:767-75. doi:10.1136/bjsm.2005.018408
6. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology, part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. Arthroscopy 2003;19:641-61. doi:10.1016/S0749-8063(03)00389-X
7. Downar JM, Sauers EL. Clinical measures of shoulder mobility in the professional baseball player. J Athl Train 2005;40:23-9.
8. Fiddian NJ, King RJ. The winged scapula. Clin Orthop 1984;185:228-36.
9. Gozna ER, Harris WR. Traumatic winging of the scapula. J Bone Joint Surg Am 1979;61:1230-3.
10. Gregg JR, Labosky D, Harty M, Lotke P, Ecker M, DiStefano V, et al. Serratus anterior paralysis in the young athlete. J Bone Joint Surg Am 1979;61:825-32.
11. Gumina S, Carbone S, Postacchini F. Scapular dyskinesis and SICK scapula syndrome in patients with chronic type III acromioclavicular dislocation. Arthroscopy 2009;25:40-5. doi:10.1016/j.arthro.2008.08.019
12. Hawkins RJ, Kennedy JC. Impingement syndrome in athletes. Am J Sports Med 1980;8:151-8.
13. Jobe FW, Moynes DR. Delineation of diagnostic criteria and a rehabilitation program for rotator cuff injuries. Am J Sports Med 1982;10:336-9.
14. Kibler WB. The role of the scapula in athletic shoulder function. Am J Sports Med 1998;26:325-37.
15. Kibler WB, Uhl TL, Maddux JWQ, Brooks PV, Zeller B, McMullen J. Qualitative clinical evaluation of scapular dysfunction: a reliability study. J Shoulder Elbow Surg 2002;11:550-6. doi:10.1067/mse.2002.126766
16. Lee AJ, Garraway WM, Arneil DW. Influence of preseason training, fitness, and existing injury on subsequent rugby injury. Br J Sports Med 2001;35:412-7.
17. Ludewig PM, Cook TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys Ther 2000;80:276-91.
18. Ludewig PM, Cook TM, Nawoczenski D. Three-dimensional scapular orientation and muscle activity at selected positions of humeral elevation. J Ortho Sports Phys Ther 1996;24:57-65.
19. Lukasiewicz AC, McClure P, Michener L, Pratt N, Sennett B. Comparison of 3-dimensional scapular position and orientation between subjects with and without shoulder impingement. J Orthop Sports Phys Ther 1999;29:574-83.
20. Makin GJ, Brown WF, Ebers GC. C7 radiculopathy: Importance of scapular winging in clinical diagnosis. J Neurol Neurosurg Psych 1986;49:640-4.
21. McClure P, Michener LA, Karduna AR. Shoulder function and 3-dimensional scapular kinematics in people with and without shoulder impingement syndrome. Phys Ther 2006;86:1075-90.
22. McClure P, Tate AR, Kareha S, Irwin D, Zlupko E. A clinical method for identifying scapular dyskinesis, part 1: reliability. J Athl Train 2009;44:160-4. doi:10.4085/1062-6050-44.2.160
23. Myers JB, Laudner KG, Pasquale MR, Bradley JP, Lephart SM. Scapular position and orientation in throwing athletes. Am J Sports Med 2005;33:263-71. doi:10.1177/0363546504268138
24. Neer CS II. Impingement lesions. Clin Orthop Relat Res 1983;(173):70-7.
25. Quarrie KL, Alsop JC, Waller AE, Bird YN, Marshall SW, Chalmers DJ. The New Zealand rugby injury and performance project. VI. A prospective cohort study of risk factors for injury in rugby union football. Br J Sports Med 2001;35:157-66.
26. Safran MR. Nerve injury about the shoulder in athletes, part 2: long thoracic nerve, spinal accessory nerve, burners/stingers, thoracic outlet syndrome. Am J Sports Med 2004;32:1063-76. doi:10.1177/0363546504265193
27. Silliman JF, Hawkins RJ. Classification and physical diagnosis of instability of the shoulder. Clin Orthop 1993;291:7-19.
28. Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys Ther 2005;85:257-68.
29. Tate AR, McClure P, Kareha S, Irwin D, Barbe MF. A clinical method for identifying scapular dyskinesis, part 2: validity. J Athl Train 2009;44:165-73. doi:10.4085/1062-6050-44.2.165
30. Uhl TL, Kibler WB, Gecewich B, Tripp BL. Evaluation of clinical assessment methods for scapular dyskinesis. Arthroscopy 2009;25:1240-8. doi:10.1016/j.arthro.2009.06.007
31. Warner JJ, Micheli LJ, Arslanian LE, Kennedy J, Kennedy R. Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome: A study using Moire topographic analysis. Clin Orthop 1992;285:191-9.
32. Wright TA. Accessory spinal nerve injury. Clin Orthop 1975;108:15-8.