# EFFECT OF A STRETCHING PROGRAM ON OVERHEAD ATHLETES WITH A STIFF AND PAINFUL SHOULDER

**Cédric Schwartz[1], Jean-Louis Croisier[1,2], Olivier Brüls[1,3], Vincent Denoël[1,4], Bénédicte Forthomme[1,2]**

**Laboratory of Human Motion Analysis, University of Liège, Liège, Belgium[1]**
**Department of Sciences and Motor Skills, University of Liège, Liège, Belgium[2]**
**Department of Architecture, Geology, Environment and Constructions, University of Liège, Liège, Belgium[3]**
**Department of Aerospace and Mechanical Engineering, University of Liège, Liège, Belgium[4]**

Overhead athletes are more at risk of suffering shoulder injuries or/and developing shoulder pain. Stretching programs have been shown to successfully reduce pain for this population. However no study has provided a global overview of the effects of stretching. The present study evaluated the evolution of the pain, the strength of the shoulder muscles, potential instabilities or lesion of the shoulder as well as the 3D scapular kinematics of 10 overhead athletes having a painful and stiff dominant shoulder. Our results show a significant decrease of the pain and of the positive impingement syndrome tests. The kinematics of the scapula reveals a more upward rotation of the scapula after the stretching, which may reduce the risk of sub-acromial conflicts. The strength of the internal and external rotators of the shoulder is not modified by the program.

**KEY WORDS:** 3D, kinematics, volley, handball, upper limbs, isokinetics

**INTRODUCTION:** Athletes involved in overhead activities are more at risk of suffering shoulder injuries or/and developing shoulder pain (Forthomme, Wieczorek, Frisch, Crielaard, & Croisier, 2013). For micro-traumatic shoulder lesions, symptoms may appear progressively and if detected in time, rehabilitation programs may prevent injuries. Throwing athletes usually develop a significant decrease of the internal rotation for the dominant arm in comparison with the non-dominant one (Myers, Laudner, Pasquale, Bradley, & Lephart, 2006). This modification is frequently linked to a tightness of the posterior capsule. The tightness of the posterior capsule may be associated to various pathologies including sub-acromial conflict, internal conflict, SLAP (Superior Labrum from Anterior to Posterior) lesions (Myers et al., 2006). Studies have already shown that stretching programs help to increase the joint mobility (Maenhout, Van Eessel, Van Dyck, Vanraes, & Cools, 2012; McClure et al., 2007; Tyler, Nicholas, Lee, Mullaney, & McHugh, 2010) as well as the acromiohumeral distance (Maenhout et al., 2012). Cools (Cools, Johansson, Cagnie, Cambier, & Witvrouw, 2012) has also shown improvement in the pain assessment scores after a program of stretching of the posterior shoulder structures. However, in some cases, stretching programs could also lead to a decrease of the maximal muscle strength (McHugh & Cosgrave, 2010). The purpose of this study was to evaluate the effect of a stretching program on athletes having a painful stiff shoulder. Our hypothesis is that such a program would decrease the pain without modifying significantly the strength of the rotator muscles of the shoulder.

**METHODS:** Ten overhead athletes (24.8 ± 4.0 years, 1.84 ± 0.05 meters) were recruited from handball and volleyball clubs. They should present, on their dominant side, a glenohumeral internal rotation deficit (GIRD) and a horizontal adduction deficit. The stiffness of the shoulder was evaluated using both the sleeper stretch (Forthomme, Crielaard, & Croisier, 2006) and the cross body arm (Myers et al., 2007). Finally, they had to report a painful shoulder during training and competition at the beginning of the study. A score of at least 3 on Visual Analog Scale (VAS) of 10 (0: no pain, 10: severe pain) was required.

The subjects performed daily two kinds of stretching (cross body arm and sleeper stretch) at the dominant side for 4 weeks (5 repetitions of 30 seconds with 30 seconds pause between each). The pain (during training and competition) was evaluated using a VAS. Clinical tests of the shoulder were divided into two parts: detecting impingement syndrome (Neer's, Hawkins', and Yocum's tests), detecting a rotator cuff lesion (Jobe's test, Patte's test, lift-off test, and palm-up test).
An isokinetic evaluation of the shoulder rotator strength (internal/external rotation) was performed (Forthomme, Dvir, Crielaard, & Croisier, 2011). The protocol consisted of concentric (5 repetitions at 60°/s and 240°/s) and eccentric (4 repetitions at 60°/s) exertions.
The 3D position and orientation of the subjects' thorax and dominant scapula and humerus were expressed using the recommendations of the International Society of Biomechanics (ISB) (Wu et al., 2005). The subjects performed an arm elevation of their dominant side. As the accuracy of measurements based on skin markers rapidly decreases after 120° of humeral elevation (Karduna, McClure, Michener, & Sennett, 2001), the kinematics is only shown up to 120° of humerus elevation.

**RESULTS AND DISCUSSION:** The stretching program used in the present study was, in terms of protocol (duration, repetitions, …) in the average of those present in the literature (Cools et al., 2012; Maenhout et al., 2012; McClure et al., 2007). The originality of the study is to consider simultaneously the following parameters: the evolution of the pain, the evolution of the rotator muscles strength and the evolution of the shoulder kinematics.
In addition to a significant decrease of the shoulder stiffness (Table 1), a significant reduction of the pain reported by the subjects during their physical activities was observed (Table 2) and thus confirms previous results (Cools et al., 2012). We also observed a significant decrease of the number of impingement tests (Table 2).

**Table 1**
**Evaluation of the shoulder stiffness**

| | **Pre-test** *mean ± std* | **Post-test** *mean ± std* | **Statistical test** *p-value* |
|---|---|---|---|
| **Sleeper stretch (cm)** | 22.8 ± 2.4 | 14.5 ± 2.5 | **<0.001** |
| **Cross body arm (°)** | 14.3 ± 3.8 | 21.7 ± 3.8 | **0.005** |
| **Internal rotation (°)** | 36.6 ± 10.6 | 42 ± 7.0 | 0.055 |
| **External rotation (°)** | 96.7 ± 7.0 | 97.8 ± 4.3 | 0.476 |

**Table 2**
**Clinical evaluation of the shoulder and reported pain**

| | **Pre-test** *median [Q1-Q2]* | **Post-test** *median [Q1-Q2]* | **Statistical test** *p-value* |
|---|---|---|---|
| **Impingement syndrome tests** *positive tests (among 3)* | 1 [1 - 2] | 0.5 [0 - 1] | **0.04** |
| **Rotator cuff lesion tests** *positive tests (among 4)* | 1 [0 - 2] | 0 [0 - 1] | 0.06 |
| **Pain** *VAS (from 0 to 10)* | 5 [4 - 5] | 2.5 [2 - 4] | **0.02** |

This result may be partially explained by the more upward position of the scapula observed both at rest and during flexion at 120° of arm elevation (Table 3). Indeed, it has been reported that an increase of the upward rotation could reduce the risk of sub-acromial conflicts (Bedi, 2011). Our results also corroborate the increase of the sub-acromial space observed by Maenhout (Maenhout et al., 2012) after stretching. This more upward rotation of the scapula has also been reported to be a kinematic adaptation of non symptomatic throwers (Myers, 2005).

**Table 3**
**Upward rotation of the scapula relatively to the thorax at rest and during the flexion of the arm**

| | Downward(-)/upward(+) rotation (°) | | |
|---|---|---|---|
| | *Pre-test* | *Post-test* | *p-value* |
| **Arm elevation** | | ***Posture at rest*** | |
| **0°** | 4.8 ± 3.8 | 7.0 ± 5.5 | *0.053* |
| **Arm elevation** | | ***Arm flexion*** | |
| **30°** | 3.3 ± 1.8 | 3.0 ± 1.5 | *0.686* |
| **60°** | 10.9 ± 3.0 | 10.5 ± 2.7 | *0.803* |
| **90°** | 21.0 ± 3.1 | 21.1 ± 3.1 | *0.646* |
| **120°** | 29.2 ± 2.3 | 31.1 ± 3.2 | ***0.048*** |

According to Wang and Cochrane (Wang & Cochrane, 2001), muscle imbalance may play a key role in shoulder injuries. The stretching did not have a significant effect on this parameter as no significant modification of the conventional concentric ratio was observed (Table 4). Finally, for high level athletes, it is of formost importance that the stretching program does not lead to lower performance. Indeed McHugh (McHugh & Cosgrave, 2010) have reported that in some conditions, a stretching program could induce a decrease of the maximal muscle strength. It has been previously shown that the peak torque of the internal rotators is correlated to the ball velocity in volleyball (Forthomme, Croisier, Ciccarone, Crielaard, & Cloes, 2005). As our results show no significant decrease of the internal rotators of the shoulder (Table 4), no decrease of performance is expected after the rehabilitation program.

**Table 4**
**Isokinetic evaluation of the shoulder strength**

| | | **Pre-test** *mean ± std* | **Post-test** *mean ± std* | **Statistical test** *p-value* |
|---|---|---|---|---|
| **Internal rotation (IR)** | ***c60*** | 0,63 ± 0,08 | 0,6 ± 0,11 | 0.198 |
| | ***e60*** | 0,73 ± 0,11 | 0,76 ± 0,12 | 0.260 |
| **External rotation (ER)** | ***c60*** | 0,45 ± 0,08 | 0,44 ± 0,06 | 0.517 |
| | ***e60*** | 0,61 ± 0,12 | 0,56 ± 0,05 | 0.153 |
| **Ratio** | ***ER c60 / IR c60*** | 0,73 ± 0,13 | 0,76 ± 0,14 | 0.233 |

Because of the large relative motion between the skin and the bone (Matsui, Shimada, & Andrew, 2006), the motion of the scapula can only be accurately estimated for humeral elevation inferior to 120° (Karduna et al., 2001). Our own measurements in the sagittal plane are therefore only presented up to 120° of humeral elevation. More significant modifications of the scapula kinematics due to the stretching program may have appeared at larger humeral elevation and should also be evaluated in the future.

**CONCLUSION:** The stretching program reduced the stiffness of the shoulder both at the glenohumeral joint and at scapula-thoracic one. These gains, which may explain the reduction of positive impingement tests, were completed by a significant reduction of the pain. The stretching did not modify the agonist/antagonist muscles equilibrium at the shoulder and is therefore not increasing the injury risk. The absence of modifications of the rotators strength tends to demonstrate that this program should not modify performance.

**REFERENCES:**

Bedi, G. (2011). Shoulder injury in athletes. *Journal of Clinical Orthopaedics and Trauma*, *2*(2), 85–92.

Cools, A. M., Johansson, F. R., Cagnie, B., Cambier, D. C., & Witvrouw, E. E. (2012). Stretching the posterior shoulder structures in subjects with internal rotation deficit: comparison of two stretching techniques. *Shoulder & Elbow*, *4*(1), 56–63.

Forthomme, B., Crielaard, J.-M., & Croisier, J.-L. (2006). Rééducation de l'épaule du sportif : Proposition d'une fiche d'évaluation fonctionnelle. *Journal de Traumatologie Du Sport*, *23*(3), 193–202.

Forthomme, B., Croisier, J.-L., Ciccarone, G., Crielaard, J.-M., & Cloes, M. (2005). Factors correlated with volleyball spike velocity. *The American Journal of Sports Medicine*, *33*(10), 1513–9.

Forthomme, B., Dvir, Z., Crielaard, J. M., & Croisier, J. L. (2011). Isokinetic assessment of the shoulder rotators: a study of optimal test position. *Clinical Physiology and Functional Imaging*, *31*(3), 227–32.

Forthomme, B., Wieczorek, V., Frisch, A., Crielaard, J.-M., & Croisier, J.-L. (2013). Shoulder pain among high-level volleyball players and preseason features. *Medicine and Science in Sports and Exercise*, *45*(10), 1852–60.

Karduna, A. R., McClure, P. W., Michener, L. a., & Sennett, B. (2001). Dynamic Measurements of Three-Dimensional Scapular Kinematics: A Validation Study. *Journal of Biomechanical Engineering*, *123*(2), 184.

Maenhout, A., Van Eessel, V., Van Dyck, L., Vanraes, A., & Cools, A. (2012). Quantifying acromiohumeral distance in overhead athletes with glenohumeral internal rotation loss and the influence of a stretching program. *The American Journal of Sports Medicine*, *40*(9), 2105–12.

Matsui, K., Shimada, K., & Andrew, P. D. (2006). Deviation of skin marker from bone target during movement of the scapula. *Journal of Orthopaedic Science : Official Journal of the Japanese Orthopaedic Association*, *11*(2), 180–4.

McClure, P., Balaicuis, J., Heiland, D., Broersma, M. E., Thorndike, C. K., & Wood, A. (2007). A randomized controlled comparison of stretching procedures for posterior shoulder tightness. *The Journal of Orthopaedic and Sports Physical Therapy*, *37*(3), 108–14.

McHugh, M. P., & Cosgrave, C. H. (2010). To stretch or not to stretch: the role of stretching in injury prevention and performance. *Scandinavian Journal of Medicine & Science in Sports*, *20*(2), 169–81.

Myers, J. B. (2005). Scapular Position and Orientation in Throwing Athletes. *The American Journal of Sports Medicine*, *33*(2), 263–271.

Myers, J. B., Laudner, K. G., Pasquale, M. R., Bradley, J. P., & Lephart, S. M. (2006). Glenohumeral range of motion deficits and posterior shoulder tightness in throwers with pathologic internal impingement. *The American Journal of Sports Medicine*, *34*(3), 385–91.

Myers, J. B., Oyama, S., Wassinger, C. a, Ricci, R. D., Abt, J. P., Conley, K. M., & Lephart, S. M. (2007). Reliability, precision, accuracy, and validity of posterior shoulder tightness assessment in overhead athletes. *The American Journal of Sports Medicine*, *35*(11), 1922–30.

Tyler, T. F., Nicholas, S. J., Lee, S. J., Mullaney, M., & McHugh, M. P. (2010). Correction of posterior shoulder tightness is associated with symptom resolution in patients with internal impingement. *The American Journal of Sports Medicine*, *38*(1), 114–9.

Wang, H., & Cochrane, T. (2001). Mobility impairment, muscle imbalance, muscle weakness, scapular asymmetry and shoulder injury in elite volleyball athletes. *Journal of Sports Medicine and Physical Fitness*.

Wu, G., Vanderhelm, F., Dirkjanveeger, H., Makhsous, M., Vanroy, P., Anglin, C., … Wang, X. (2005). ISB recommendation on definitions of joint coordinate systems of various joints for the reporting of human joint motion - Part II: shoulder, elbow, wrist and hand. *Journal of Biomechanics*, *38*(5), 981–992.

*Acknowledgement*

The authors wish to thank the Wallonia-Brussels Federation for its support.