A BIOMECHANICAL STUDY OF SHOULDER PAIN IN ELITE GYMNASTS

Giuliano Cerulli, Auro Caraffa, Fabrizio Ragusa, Marco Pannacci,
Università di Perugia and "Let people move" Laboratorio di Biomeccanica, Perugia, Italy

INTRODUCTION: Very few scientific studies have dealt with shoulder problems in gymnasts. A review of the pertinent literature up to 1987 (9) found only one study (12) which reported shoulder problems in gymnasts. In other sports with overhead activities shoulder injuries are very common (1,6). A few recent case reports deal with shoulder problems in gymnasts (4,5,13). In our unit we have recently treated five competitive gymnasts with severe shoulder problems. They were all found to have so called SLAP-lesions (Superior Labrum Anterior Posterior) or other labral pathologies of the shoulder when examined with arthroscopy (2), even though they had never dislocated their shoulders. Since four of them became aware of their acute shoulder problems during ring exercises in suspension, we decided to make an EMG study of the shoulder musculature during exercises on the parallel bars and rings.

METHODS: Three 19-year-old Italian elite gymnasts without any shoulder problems volunteered to participate in an EMG study on parallel bars and rings exercises. Surface electrodes (Blue Sensors, Meditest DN, type 55-00) were applied over the following six muscles: Pectoralis Major, Deltoid, Biceps Brachii, Triceps Brachii, Trapezius, and Latissimus Dorsi. Prior to applying the surface EMG electrodes on the appropriate positions of the muscles, the skin was shaved and cleaned with alcohol. Six of the 16 channel telemetric bio-amplifiers (Telemyo 16, Noraxon, OY Finland) were used to transmit the EMG signal to a PC Pentium-based data acquisition system (Myosoft Research Software, Noraxon Inc. Arizona USA). The low-noise raw EMG signals were acquired at 1000 samples/s, converted and saved on the hard disk of the computer for later processing.
The EMG data were RMS-converted with a time constant of 20 ms. From the RMS EMG data, the peak activity (###V) were recorded for different phases of the exercises.

RESULTS: The EMG recordings showed that pectoralis major, biceps brachii and deltoid showed the highest and longest activity during the exercises when the athletes were pushing with their arms. When the athletes were performing the so-called "giant swing," that is letting their bodies fall from an upside down standing position in the rings until hanging in their outstretched arms, we found that the EMG activity of the studied muscles, which was high during the beginning of the fall, dropped to low values (about 10% of their max. activity) towards the latter part of the fall. The load on the shoulder at the moment the athletes reached the lowest point and their arms were stretched out must, however, have been very large. The EMG activity then rapidly rose to high levels– peak value (see Table 1).

Table 1 Average EMG values (in ###V) from the shoulder muscles of the three normal competitive gymnasts during the last part of the "giant swing" (peak) and from the "critical phase" just before reaching vertical hanging position.

	Peak activity during giant swing	Critical phase just before reaching vertical position
Pectoralis major	763 ###V	74 ###V
Biceps brachii	698###V	67###V
Triceps brachii	520###V	53###V
Deltoid	702###V	70###V
Trapezius	713 ###V	72###V
Latissimus dorsi	465 ###V	41 ###V

DISCUSSION: It is easy to understand why the high angular velocities in sports like baseball can lead to shoulder problems. In gymnastics the angular velocities are not as high, but the shoulder can be exposed to considerable loads, especially during the giant swing. In a study of Italian elite gymnasts we found a 46% incidence of shoulder problems. They all reported pain during the ring exercises. Of the five gymnasts with labral pathology, four had SLAP-lesions. This is interesting, since none of them had had any shoulder dislocations or were found to be lax. The high loads, 6.5-9.2 times body weight (3) on the arms at the end of the giant swing and the fact that the muscles seem to be "unprepared" for a load of many times body weight can explain why the long biceps tendon pulled out its insertion into and of the superior labrum from the glenoid and caused a SLAP-lesion. Further biomechanical studies are planned to explain and if possible to prevent this injury. It should also be pointed out that since we only used surface electrodes, we could not record the activities in, i.e., the rotator cuff muscles.
We have also talked with advanced gymnastic trainers about modifications of the rings in order to make them somewhat more elastic. This might be able to prevent SLAP-lesions. Another possibility might be proprioceptive training. We demonstrated earlier (10) that the labrum has free and corpusculated nerve fibers. Others (7,8) have also stressed the importance of proprioception for the stability and normal function of the shoulder. A proprioceptive training program for the shoulders might therefore be another way of trying to prevent SLAP lesions in elite gymnasts.

REFERENCES:

1. Andrews, J. R., Alexander, E. J. (1995). Rotator Cuff Injury in Throwing and Racquet Sports. *Sports Med. Arthroscop. Rev.* **3**, 30-38.

2. Bonivento, G., Cerulli, G., Buompadre, V. (1993). Valutazione e trattamento artroscopico delle lussazioni gleno-ornerali acute. *Artroscopia Ginocchio* **1**, 33-35.
3. Brüggemann, G.-P. (1987). Biomechanics in Gymnastics. *Med. Sports Sci.* **25**, 142-176.
4. Caine, D., Cochrane, B., Caine, C., Zemper, E. (1989). An Epidemiologic Investigation of Injuries Affecting Young Competitive Female Gymnasts. *Am. J. Sports Med.* **17**, 811-820.
5. Dalldorf, P. G., Bryan, W. J. (1994). Displaced Salter-Harris Type I Injury in a Gymnast. A Slipped Capital Humerus Epiphysis? *Orthop. Rev.* **23**, 538-541.
6. Fleisig, G. S., Andrews, J. R., Dillman, J., Escamilla, R. F. (1995). Kinetics of Baseball Pitching with Implications about Injury Mechanisms. *Am. J. Sports Med.* **23**, 233-239.
7. Jerosch, J., Steinbeck, J., Clahsen, M., Schmitz-Narath, M., Grosse-Hackmann, A. (1993). Function of the Glenohumeral Ligaments in Active Stabilization of the Shoulder Joint. *Knee Surg. Sports Traumatol. Arthroscopy* **1**, 152-158.
8. Lephart, S. M., Warner, J. P., Borsa, P. A., Fu, F. H. (1994). Proprioception of the Shoulder Joint in Healthy Unstable and Surgically Repaired Shoulders. *J. Shoulder Elbow Surg*., 371-380.
9. McAuley, E., Hudash, G., Shileds, K., Aibright, J., Garrick, J., Requa, R., Wallace, R. (1987). Injuries in Women's Gymnastics. The State of the Art. *Am. J. Sports Med*. **16** [Suppl 1], 124-131.
10. Patel, D., Cerulli, G. (1988). Neuromorphologic Stucture and Arthroscopic Anatomy of the Anterior Stabilizer Structures of the Shoulder. Presented at the Third ESKA Congress, Amsterdam, 16-20 May 1988.
11. Reeves, B. (1968). Experiments on the Tensile Strength of the Anterior Capsular Structures of the Shoulder in Man. *J. Bone Joint Surg.* **50**, 858-865.
12. Silvij, S., Nocini, S. (1982). Clinical and Radiological Aspects of Gymnast's Shoulder. *J. Sports Med. Phys. Fitness* **22**, 49-53.
13. Wadley, G. H., Albright, J. P. (1993). Women's Intercollegiate Gymnastics. Injury Patterns and "Permanent" Medical Disability. *Am. J. Sports Med*. **21**, 314-320.