

## **DEVELOPMENT OF A MEASUREMENT CHAIN TO EVALUATE MUSCULAR INTERVENTION IN ARCHERY PERFORMED BY PHYSICALLY DISABLED**

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The complexity of the motor activity in archery, and, the participation of physically handicapped persons in highest level competitions, gave rise to the development of a measurement chain that allows to analyze shooting technique recording simultaneously the posture adopted by subjects and the activity of the main involved muscles. The measurement chain consists in an EMG and a synchronized ELGoniometric system. Obtained data and the calculated standard parameters in the time and frequency domain allow to gain insight into the most convenient individual solutions that archers adopt, according to their motor capabilities, and, on the other hand, to clarify the intervention of archers' main muscular groups. Finally it is possible to establish a real-time feedback loop concerning bow's strain during the draw phase.

**KEY WORDS:** biomechanics, archery, disabled, electromyography, electrogoniometry

**INTRODUCTION:** During World War II Sir L. Guttmann introduced archery as part of the rehabilitation treatment of paraplegics and tetraplegics (Guttmann and Mehra, 1973). This sport activity proved to be ideal for training those muscle groups above the level of the spinal cord lesion, in particular the muscles mainly used in archery, namely, the arm, shoulder and trunk muscles. Also, the training of the trunk muscles, enabled paraplegic athletes to restore and maintain the upright posture without the aid of artificial and uncomfortable corsets. While they felt satisfied by accomplishing everything by his own strength capability given that the "weight" of the bow varies between 36 and 42 lbs. for men and 25 and 38 lbs. for women. Nowadays, disabled athletes compete under FITA's rules, in the context of ISMWSE (paraplegics and tetraplegics) or ISOD (amputees, polio, etc.) in the modalities FITA Round, Shoot Metric Round and Indoor FITA Round. Also, it is well known that Archery is a sport event, in which paraplegic can compete on terms of equality with able-bodied, even in the highest level of competition. Besides of these considerations, it is well known that archery is a very complex motor task that depends on the archer's capability to get highly reproducible release of the arrows. Therefore, postural consistency during the bow holding action, drawing, full draw, aiming, release and follow through, influence on the performance. In this way the main purposes of sport technique is to regulate the number of degrees of freedom in the joints, in spite of the influence of gravity and the mechanical properties of locomotor system and especially of the viscoelastic properties of muscles. In fact, archers attempt to transfer, during aiming, all mechanical loads across the passive structures and elements avoiding the intervention of the muscles that control the joints. Most scientific studies, in the last years, were respect to the analysis and evaluation of able-bodied archers technique, using biomechanical parameters obtained by means of a variety of measurement chains. That is, optoelectronic systems (Stuart and Atha, 1990; Squadrone and Rodano, 1994), force plates (Mason and Pelgrim, 1990), EMG (Nishizono et al. 1987; Clarys et al., 1990; Leroyer et al. 1993; Squadrone et al. 1994), accelerometers (Gallozi et al. 1986), etc. However it seems to be worthwhile the study of the archery technique of handicapped people gaining insight into the biomechanical solutions that they adopt, according to their functional motor capabilities and clarifying the intervention of the main muscular groups involved in the different phases of archery. Thus the main purpose of this study is to describe the development of a measurement chain integrated by an EMG system synchronized with an ELGoniometric system that allows to record the muscular activity respect to the archer's adopted posture and the force applied on the string during drawing and aiming.

**METHODS:** The measurement chain consists of an EMG system synchronized with an ELGoniometric (Biometrics) system, used to detect the postural adjustments of the subject as well as the strain of the bow during the drawing of the string (Fig.1) using surface active electrodes (Ag/AgCl) of 0.5cm diameter.



**Figure 1 - Set up of the measurement chain and detail of the bow.**

The myoelectric signals are transmitted to a differential amplifier (input impedance 100 Mohm) of variable gain (10 – 10000), with CMRR 90 dB, and frequency response of 10 to 2000 Hz. The data “filtering” is accomplished by “high - pass filters” (10 or 100 Hz), “low – pass filter” (300, 1000 and 2000 Hz), and “notch filter” to filter out the 50 Hz power line noise. The resulting EMG signal is recorded and stored for further digital processing in a PC using a 12-bit acquisition card (DI-200/PGH). The sampling rate of the system is 50 KHz allowing the use of 16 channels where eight are dedicated to EMG signals and four to ELG signals. Goniometers and torsimeters are lightweight and flexible strain gauge transducers, ideal for quick and accurate external measurements of the joint’s movement in multiple planes. Their accuracy is 1.5 over 90 degrees from neutral position and precision is better than 1.0 degree. ELG system has infinite analogue output resolution, the bandwidth of its amplifier is 50 Hz and its analogue output sensitivity is 1.0 V / 90°.

**RESULTS:** The processing of EMG and ELG signals and the calculation and graphical representation of all parameters take place in the MATLAB environment where data are exported in ASCII files. Thus, after the rectification and envelope detection of raw EMG signals (Fig. 2) the mean rectified value (MRV) and other parameters in time domain are calculated, namely, root – mean – square (RMS), moving average (MA), and integrated EMG (iEMG). To compare EMG signals normalisation can be achieved normalising the MRV or RMS with respect to some maximal measurable value for the particular experimental procedure (maximal voluntary contraction or the “weight of the bow”). Processing EMG in the frequency domain involves determining the frequency spectrum via FFT and then obtaining the power density spectrum (PDS) which may be affected by recruitment, firing rate, fatigue, and filtering. However, the calculated median frequency (AF), mean frequency (MF) and bandwidth of the signal can be very useful parameters for EMG evaluation. As far as ELG is concerned it is possible to obtain information respect to the drawing technique by means of a series of parameters expressing the bow’s strain because of the applied force during the drawing of the string (reactivity coefficient, force gradient, etc) (Fig. 3).

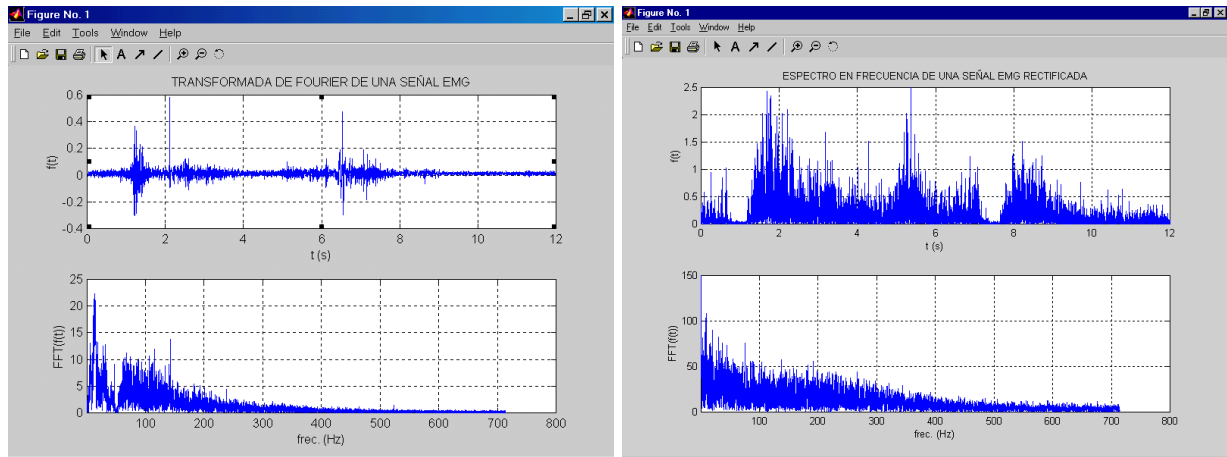


Figure 2 - Representations of raw EMG signals and their spectra after rectification.

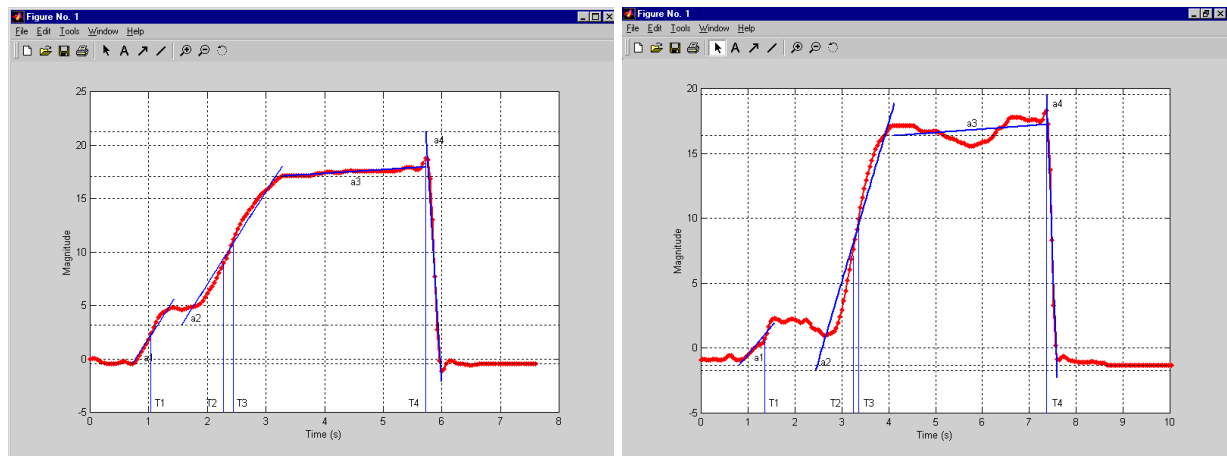


Figure 3 - Representations of the bow strain during the drawing of the string.

Finally it is obvious that ELGoniometric recordings allow information to be obtained respect to all parameters related to the joints' movement (range of movement, posture, etc.). On the other hand, it is possible to parameterize the drawing technique (Fig.3) and to provide the subject with real - time feedback concerning the bow's strain when the string drawing is taking place. Additionally the measurement chain enables the study of the "biomechanical disadvantage" condition that takes place as consequence of the muscular strength deficit in the "full draw". This is because when the archer has drawn the arrow and "full draw" has been reached there is a difference between the "bow weight" and the muscular tension that would cause injuries over time. Finally, the measurement chain could be completed using a sonic digitizer (kinematics), and a strain - gauge force plate (postural sway), facilitating detailed biomechanical analysis in different shooting activities (Gianikellis et al., 1994).

**CONCLUSION:** The developed measurement chain integrated by EMG and ELG systems seems to be a very useful tool for the biomechanical analysis in archery or other shooting activities and the identification of the technical solutions that disabled people adopt during the practice of such a type sport activities.

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