Evidence of the Possibility to Contract the Lower Trapezius, Relaxing the Upper Trapezius, and Implications on Posture through the Use of an Innovative Mechanical Device for Physical Training

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1 OBJECTIVES

Often, in the execution of movements involving the shoulder and the back, the predominant activity is carried out by the Upper Trapezius (UT) muscle, and in many cases this may be a risk factor for the integrity of the cervical-dorsal structures. Shoulder and neck pain could be caused by repeated and sustained work of posture muscle including Upper Trapezius (Buckle et al, 2002). Since, from previous literature, the physical exercises proposed for making the Lower Trapezius (LT) muscle to train, make the UT to work more than LT (Bandy, 2001), there was the need to create an apparatus that would involve synergistically the cervical-dorsal muscles, emphasizing in particular the activity of the LT and going to relaxing the UT, to reduce consequences of faulty posture. With the device "Angel's Wings", thanks to a simple distribution of vectors of forces, it is possible to isolate the LT activity from the UT. The device "Angel's Wings", designed and build by Eng. Luca Valerio Messa, is patented, and acts mainly on the axial muscles of the cervical-dorsal rachis, so it can correct posture of this tract. We used Surface Electromyography (Richard, 2003), Echography (Hashimoto, 1999) and Magnetic Resonance (Dziubai, 2010) to assess the activity carried out by Trapezius and the resulting benefits in a group of volunteers. The "Angel's Wings" is already used in some physical therapy centres and gyms, and it is also used by international class swimmers of the Italian Swimming Federation. These findings are important because it was believed that the UT would have to contract higher than the LT in every physical performance or exercise. Since the use of this device is simple, the "Angel's Wings" appears to be a useful method to reduce the problems resulting from an excessive activation of the UT and to improve the postural control.

2 METHODS

The aim of the Angel's Wings device (Fig.1) is the distension of the cervical-dorsal spine, with contemporary rehabilitation of the shoulder joint position in its natural seat, rather than rotated forward.

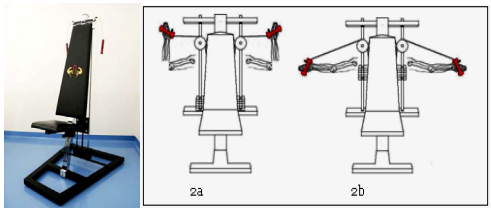

Figure 1: Angel's Wings; Fig.2: Schematic front view of the apparatus with the representation of the motory task respectively to the starting position (2a) and distension (2b).

The execution of the task is outlined in Figures 2a and 2b: starting from a seated position (2a) each of the participants were required to extend the arms (2b), keeping elbows at shoulder height, to lift a weight through the cables of the equipment. The weight lifted was in a range between 6 and 8 kg.

Thus, in the dynamic phase, were examined with sEMG of Trapezius muscle 9 healthy volunteers (6 M, 3 F, 22-64 y) using electromyography Medelec Sapphyre 1P. Subsequently, 6 healthy volunteers

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were examined (3 M, 3 F, 29-67 y), with sEMG of Trapezius muscle by EMG TruTrace. No differences in the signal of the performance between the two EMG used have been found. Then, 3 healthy volunteers (2 M, 29 and 67 y, and 1 F of 39 y) were examined with ultrasound echography to Trapezius muscle, during dynamic exercise with Angel's Wings, by ultrasound MyLab ™ One (ESAOTE, Genova, Italy). In order to perform the ultrasound echography, an Angel's Wings device has been suitably modified in its structure without altering the method of use (Fig.3).

Figure 3: Angel's Wings with modified structure and unchanged method of use.

Finally, 3 subjects (3 M, 56-67 y), in the group that participated in the study, were evaluated with MRI (Avanto 1,5 T; A.G. SIEMENS, Erlangen, Germany), at the beginning and at the end of a training period with Angel's Wings. The Motory Task was of 2 + 2 minutes of performance duration with a recovery interval of 2 minutes. The 3 subjects who underwent MRI, performed the motory task daily (morning and evening) for 30 days. The electromyography and the ultrasound echography scans were performed to determine the activity of the Trapezius muscle, in the Upper and Lower portions, during the 4 phases of the Motory Task: Start position (1), Contraction during lifting (2), Return phase (3), Final phase of rest (4). The MRI was performed to highlight the effects induced by physical exercise performed with Angel's Wings in a training period of 30 days.

3 RESULTS

The graph in Figure 4 shows the variation of the mean of UT activity and of the mean of LT activity, expressed in mV, during the 4 phases (n=15).

The Table 1 summarizes, in mV, the mean and the SD of the maximum amplitudes of EMG on UT and LT, during the 4 phases of the task, and furthermore shows the relative statistically differences, for each phases, between the two portions of the Trapezius muscle, using the "t" Test and the F Test.

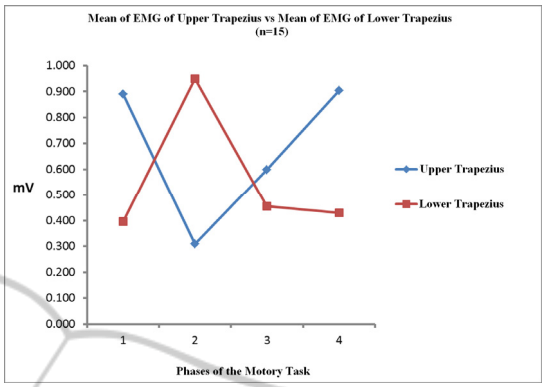


Figure 4: Variation of the mean of UT activity vs Variation of the mean of LT activity during the 4 phases (n=15).

Table 1: Mean and SD (n=15) for UT and LT for the 4 phases of the Motory Task and relative "t" Test and F Test.

Phase	Right Upper Trapezius	Right Lower Trapezius	"t" Test	F Test
1	0,890 ± 0,275	0,397 ± 0,188	p < 0,001 ***	ns
2	0,309 ± 0,095	0,949 ± 0,366	p < 0,001 ***	p < 0,01 **
3	0,611 ± 0,289	0,456 ± 0,176	ns	ns
4	0,904 ± 0,320	0,431 ± 0,431	p < 0,01 **	ns

A statistically significant difference using both "t" Test and F Test, in phase 2 (Contraction during lifting), was found.

Then, the graph in Figure 5 shows, for both portions, the mean (n=3) of the percentages variation of the Trapezius muscle section (contraction and relaxation), monitored by ultrasound echography, during the muscle workload for each phases of the Motory Task, considering the phase 1 = 0 for both UT and LT.

Finally, the Figures 6 to 9 show the MRI results of one of the 3 subjects (M, 64 y) who were trained for 30 days with Angel's Wings. The measurements to highlight the morphological changes were performed with the software built into the MR system (Syngo 8.4 version, A.G. SIEMENS, Erlangen, Germany).

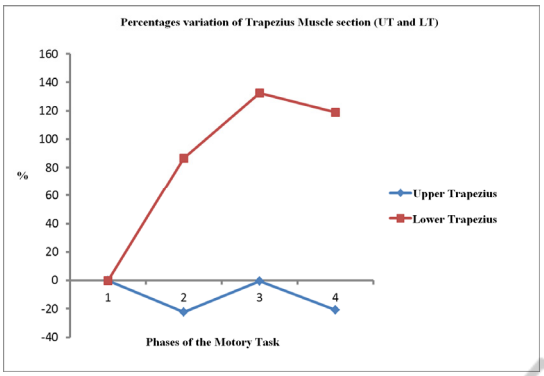
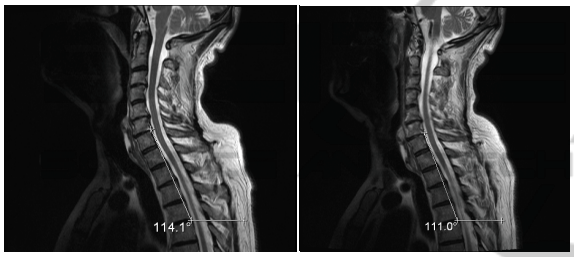
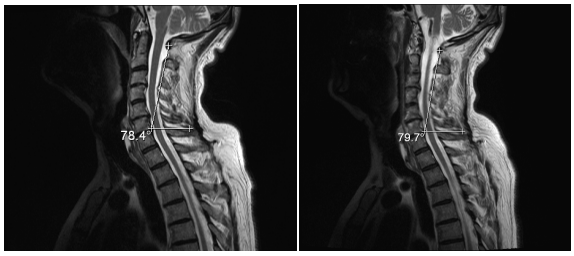


Figure 5: Mean (n=3) of Percentages variation of the Trapezius muscle (UT and LT) during the muscle workload for each phases of the Motory Task, considering the phase 1 = 0.



Figures 6 (left) and 7 (right): respectively the Pre-training and the Post-training with Angel's Wings.



Figures 8 (left) and 9 (right): respectively the Pre-training and the Post-training with Angel's Wings.

4 DISCUSSION

Figure 4 shows that, during this type of physical performance, the activity of the Upper Trapezius is nearly specular to that of the Lower Trapezius.

The most important phase of the Motory Task with Angel's Wings is the phase 2, the Contraction during lifting. The sEMG results clearly show that during Phase 2, to a sharp contraction of the Lower Trapezius corresponds a large relaxation of the Upper Trapezius. This is important because it allows us to think about being the first to propose a physical performance, performed with the proposed apparatus, that allows contracting significantly the Lower Trapezius, inducing at the same time a relaxation of the Upper Trapezius, whereas available equipment always make to contract the Upper Trapezius higher than the Lower Trapezius. Figure 5 confirms the sEMG results, especially in the same phase 2, where at a thickening of the LT section (contraction) corresponds a thinning of the UT section (relaxation). Figures 6 to 9 show a realignment of the cervico-dorsal column, between the Pre and the Post training, due to a variation of a few degrees in its curvatures, and clearly show an improvement in posture because also the gibbus, caused by a kyphotic posture, appears blunt. This data is important, considering the fact that the training period was of 30 days of duration, relatively short period of time. Moreover, the fact that, regardless of gender, age, level of training, the weight was lifted within a range between 6 and 8 kilograms, is indicative that the stimulated muscles in this performance by the proposed apparatus, have almost the same degree of training in all persons, because even the best trained people of the group could not lift a greater weight in the appointed time.

Today many people, including several categories of workers, have "postural defects" characterized mainly by altered distribution of muscle mass (Arts 2010). All of this becomes a tendency to assume a crouched position forward, characterized by shoulders moved forward.

This data, although obtained in a limited series, suggest the use of the proposed equipment to correct postural defects, as also kyphosis, of the cervico-dorsal column.

REFERENCES

Buckle P. W., Devereux J. J. "The nature of work-related neck and upper limb musculoskeletal disorders". *Appl Ergon.* 2002; 33(3):207-217.

Bandy W. D., Sanders B., 2001, Therapeutic Exercises: Techniques for Intervention. Baltimore, MD: *Lippincott Williams and Wilkins.*

Richard A. et al, 2003, Surface Electromyographic Analysis of Exercises for the Trapezius and Serratus Anterior Muscles. *J Orthop Sports Phys Ther*, 33(5): 247-258.

Hashimoto B.E. et al, 1999, Application of musculo-skeletal sonography. *J Clin Ultrasound*, 27: 293-299.

A. Dziubai et al, 2010, Magnetic resonance imaging (MRI) for assessment of differences in geometrical parameters in muscles stabilizing vertebral column in young and older persons. *Case study. Acta of Bioengineering and Biomechanics*, Vol.12, No.2:41-51.

Arts I. M. et al, 2010, Normal values for quantitative muscle ultrasonography in adults. Muscle Nerve, 41: 32-41.