Mechanical work as a tool for the assessment of muscle synergism

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OBJECTIVE

The objective of this study was to quantify muscle synergism (MS) during maintenance of posture control using total mechanical work (W*tot*) obtained from body segments after motor and visual disturbance.

METHODS

Sample

Our sample consisted of 10 male, healthy adult volunteers, average age 25,6 (± 2,26), stature 1,69 (±0,25) and weight 68,22 kg (± 0,25). Participation of these volunteers in our study was approved by the Committee on Ethics of the University of Mogi das Cruzes (Process CEP nº 110/06 and CAAE: 0111.0.237.000-06) and of IMREA-HC-FMUSP (Research protocol nº. 0069/08 - 17/03/2008).

Task

Initial position is trunk flexion to approximately 90º (parallel to the ground). After an initial sound command subjects performed trunk extension to upright position at their top speed in order to induce motor self-disturbance. They remained in upright position for 8s – period signalized by another beep. Each subject performed the task under two conditions: (1) firstly with temporary deprivation of vision with eyes covered by goggles filled with cotton wool and covered with black tape, and (2) with preserved vision, performed with open eyes. Therefore, this task allowed subjects to undergo motor and visual disturbances.

Material

This study was performed at IMREA-HC-FMUSP's Laboratory of Movement Analysis, in collaboration with UMC's Laboratory of Motor Control. This laboratory used *Hawk Digital System by Motion Analysis Corporation (Santa Rosa, Califórnia*, USA) to collect data. The image system consists of 8 video cameras with frame rate of 200 Hz, connected to the hardware system (Fig. 1). By capturing motion data from spherical reflective markers attached to the volunteers' body, this system allows the creation of a tridimensional model of human body in motion, besides providing the position of the CM of each segment based on Dempster's anthropometric model (1955) [1] (Fig. 2).

Fig. 1. Volunteer in Laboratory of Movement Analysis

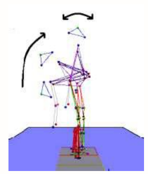

Fig. 2. Tridimensional model of the task

$$W_{tot} = \int_{T_D}^{T_O} \left|\dot{E}_{Tot}\right| \cdot dt \qquad [2]$$

$$E_{tot} = \sum_{i=1}^{N} E_i = \sum_{i=1}^{N} \left(1/2 m_i v_i^2 + 1/2 \omega_i I_i \omega_i + m_i g h_i\right)$$

Where: *Wtot*: Total mechanical work; *Etot*: Total energy of model to 12 segments; *N*: Number of segments, N=12; *i* indicates each segment: head, trunk, and left and right arms, forearms, legs, thighs, and feet; *Ei*: Total energy of each segment, *m*: Mass of each segment; *v*: Velocity vector component in direction *x, y, z*, in relation to the COM of each segment; ω: Angular velocity vector of each segment; *I*: Inertia tensor of each segment; *g*: acceleration gravity; *h*: height of COM for each segment.

Data analysis

Using MATLAB programming environment 2008a (Version 7.6) it was possible, by the method developed by Costa et al. (2008) [2] to separate the task in three intervals (before, during and after self-disturbance) and to calculate Wtot for self-disturbance. Data were analysed by a 6th order low pass Butterworth filter with a cutoff frequency of 10Hz. Data was compared for the using paired Student-T test.

RESULTS

There was a significant difference (p < 0,05) for legs at 0.60ms and for thighs at 0.100 ms when both conditions were compared. The legs twitched first of the thighs, possibly due to MS.

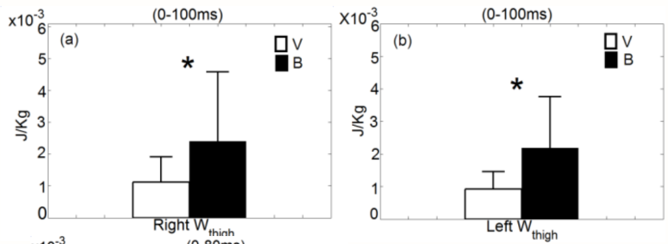

Figure 3. Mean and standard deviation *Wthigh* (J / kg) for both visual conditions during [0,100] ms post-perturbation interval (p <0.05). (a) Right *Wthigh* (b) Left *Wthigh*. V(with-visibility) and B (Bblindfolded).

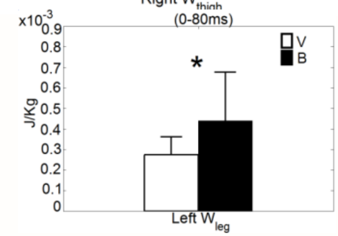

Fig 4. Mean and standard deviation of the left *Wleg* (J / kg) for 10 volunteers under conditions V (with-visibility) and B (Bblindfolded) during post-perturbation in the latency interval from 0 to 80 ms. Statistical significance p < 0.05.

DISCUSSIONS / CONCLUSION

These differences may be related to somato-sensory mechanisms promoted by MS [3], therefore suggesting that *Wtot* may be an invaluable tool to evaluate patients in physical rehabilitation programs.

The calculation of W turns into a valuable tool to evaluate patients undergoing conventional and / or robotic therapies, such as the gait training with robot for example.

REFERENCES

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