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COMPARISON OF ISOMETRIC PLANTAR FLEXION TORQUE SHARING PATTERNS BETWEEN ELDERLY AND YOUNG PEOPLE

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SUMMARY
The influences of aging in muscle recruitment are still unclear. We used an isometric contraction protocol and an EMG–driven muscle model to estimate the contribution of each component of *triceps surae* muscle to ankle torque, in both young adults and elderly. Six subjects were enrolled in the study, 3 young and 3 elderly. The experimental protocol consists in two sustained contractions of 20% and 60% of maximum voluntary isometric contraction (MVIC) torque. Raw EMG and torque measured by an isokinetic dynamometer were synchronously collected. EMG signals were filtered, rectified, normalized and input into a Hill-type EMG-driven muscle model. Data were compared between sex, muscles contribution, peak of MVIC, tests and groups. Only peak of MVIC torque was statistically different between groups. No other data have shown differences reveled by the Wilcoxon test ($p>0.05$). The percentage of force contribution follows the decrescent sequence of *soleus*, *gastrocnemius medialis* and *gastrocnemius lateralis*.

INTRODUCTION
The effects of age in muscle behavior are unclear [1]. With the age, muscle fibers total numbers decrease, depending on the muscle group [1]. In addition, timing and velocity of the muscle twitch are modified [2]. According to Hashizume and Kanda [3], the proportion between slow and fast-twitch fibers in *gastrocnemius medialis* (GM) increase in old rats, compared with middle-aged. Such a reduction in the type II fibers participation in the muscle cross-sectional area can be related to strength loss [1] and possibly to changes in muscle recruitment patterns. For the ankle, it could be hypothesized an increase of *soleus* participation, due to its muscle fiber composition.

EMG-driven models are widely used to predict muscle force [4]. This approach is able to reveal the contribution of each muscle in the total joint torque. Essentially, EMG-driven models uses a Hill-type formulation of muscle dynamics, which is integrated using electromyography data as the input [4], [5].

The aim of this run test is to identify the torque sharing of each *triceps surae* component in plantar flexion torque, for young and elderly groups, performing isometric sustained contractions. For estimating muscle force, a Hill-type EMG-Driven model is used.

METHODS
The subjects were divided into two groups separated by age and sex. Individuals aged 65 and over made up the group of elderly (G1), and those aged between 25 and 30 years the young group (G2). Each group was composed of 3 individuals. Each subject performed the protocol twice with at least 2 days apart.

The ankle joint torque and electromyography signals of each component of the TS muscle were acquired synchronously. The instrumentation consisted of an isokinetic dynamometer Biodex™ System 4 Pro® (Biodex Medical Systems Inc., Shirley, NY, USA) and a multichannel electromyography (sEMG) OT Biolettronica (Torino, TO-Itália), with CMRR > 96 dB.

The individuals sat on the isokinetic dynamometer with the right knee extended (avoiding hyperextension) and with the right foot firmly fixed to the platform (ankle in neutral position). The protocol consisted of two tests: plantar flexion torques at maximum voluntary isometric contraction (MVIC), by a series of two replications and the submaximal 20% and 60% MVC tests. This test was conducted with visual biofeedback in torques steps at 20 and 60% MVC. Each step lasted to 10 seconds with 10 seconds interval.

EMG data was collected with differential electrodes (Ag–AgCl pre-gelled), positioned on *gastrocnemius medialis* (GM), *gastrocnemius lateralis* (GL) and *soleus* (SOL) muscles. Reference electrode was positioned on the right lateral malleolus. The tissue preparation and placement of electrodes followed the recommendations of SENIAN [6].

Raw EMG signal was initially band-pass filtered (15–350 Hz) to remove movement artifacts. Signals were then rectified and low-pass filtered with a 2nd order Butterworth filter (2 Hz cut-off frequency). Input excitation signal u (t) for the EMG-driven model was found by normalizing the processed EMG (of the step test) by MVC EMG. Only the last five seconds of each step were used for analysis.

The Wilcoxon test was applied to extract statistic information, processed on Statistical Analysis Software (SAS, 9.2.SAS Institute, 2011).

RESULTS AND DISCUSSION

The MVIC peak torque presented statistical significance ($p<0.0001$) when tested between groups (mean of groups G2=103.41Nm, G1=64.8Nm), following the findings of Christou and Carlton (2001) [2]. The muscle predicted torques did not show differences between groups ($p > 0.05$).

Figure 1 presents the relative torque contribution among muscles. GL and SOL at 60% of MVIC were statistically different ($p<0.001$ and $p=0.001$, respectively), and this difference remained when the comparison was taken between the two-day tests and the two groups (young and old). In this analysis, GL and SOL at 60% step, presented different torques contributions to the total plantar flexion torque ($p=0.0002$; $p=0.0045$ respectively).

To standardize the subjects, the measured value was divided by the standard deviation of own group. Data presented only a trend to a difference between the torque sharing, at 20% step, in GL ($p=0.1916$) and SOL ($p=0.1604$), and also at 60% step in GM ($p= 0.127$).

A similar study, only with young subjects, with the same approach showed similar torque sharing pattern among triceps surae muscles[5].

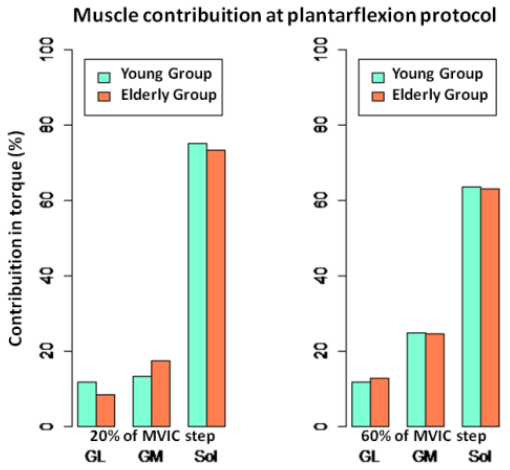

Figure 1: Percentage of muscle torque sharing to the total estimated torque by EMG-driven model at 20% of MVIC step (left) and 60% of MVIC step (right).GL (*gastrocnemius* lateralis); GM (*gastrocnemius medialis*); SOL (*soleus*).

CONCLUSIONS

Thos study showed a greater contribution of SOL muscle to the total plantar flexion torque, following the sequence (SOL, GM and GL), for both groups. No differences of muscle sharing patterns were found between elderly and young. More conclusive studies will be held with a greater number of subjects.

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