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MODULATION OF ACTIVITY IN THE TIBIALIS ANTERIOR MUSCLE CHANGES WITH UPRIGHT STANCE WIDTH

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SUMMARY

In this study we investigate whether the amount of modulation of activity in the tibialis anterior (TA) muscle is associated to changes in feet position during standing. Surface EMGs were collected from 10 subjects who were asked to stand at three different stances: feet apart, together and in tandem stance. The amount of modulation in TA activity depends on standing condition, been markedly associated to postural sway in the narrower stances. These results suggest the TA muscle might contribute substantially to compensation of sways when postural stability is challenged in the frontal plane.

INTRODUCTION

During human upright stance, current knowledge suggests the tibialis anterior (TA) muscle remains silent or is activated at levels slightly above those observed at rest [1,2]. However, theoretical and empirical evidence suggests an active, postural contribution of TA when subjects stand over a reduced base of support [3,4]. Considering that the TA contribution to torque in the frontal plane depends on the degree of ankle inversion/eversion [5], we hypothesize the active modulation of TA would depend not only on lateral body sway but also on the relative feet position. In this study, therefore, we investigate whether the amount of modulation in TA activity is associated to relative changes in feet position while standing.

METHODS

Ten subjects (6 females; 19-32 years) were asked to stand 30 s at three different feet positions: i) feet apart at the hip level; ii) feet closely together and; iii) tandem (feet aligned, with right leg behind). Three trials were applied for each feet position. Subjects provided written informed consent prior to participation in the study.

Bipolar, surface EMGs from the TA muscle in the right leg were amplified by 2000 times and then digitized at 2000 Hz. EMG envelopes were then calculated by low-pass filtering (2nd order Butterworth filter; 4 Hz cutoff) the full-wave rectified EMGs. Centre of pressure (COP) coordinates were calculated from the ground reaction forces collected synchronously with EMGs.

Variations in the amount of active modulation in TA muscle were evaluated in terms of the coefficient of variation (COV) of EMG envelopes. COV values are not affected by non-physiological (i.e., detection system and muscle anatomy) factors typically leading to differences in EMG amplitude between subjects. To ascertain whether fluctuations in TA activity were associated to bodily sways, the cross-correlation function (CC) was computed between EMG envelopes and COP displacement in the frontal plane (resampled to 2 kHz). The absolute maximum value obtained for the CC function indicates how strongly TA EMGs and ankle torque were associated. Moreover, analysis of variance and regression analysis between CC and COV were considered to compare postural sways and the degree of modulation in TA activity across stances.

RESULTS AND DISCUSSION

Different standing conditions resulted in marked changes in bodily sways and TA activation. Consider for example the COP displacement and the corresponding TA activity shown for a representative subject in Figure 1; traces are shown separately for each standing condition. By challenging the standing posture, a marked increase in the degree of fluctuation in TA activity was observed in association to a more pronounced lateral sway (compare traces between feet apart, feet together and tandem conditions; Figure 1a,b,c). When considering all participants, COV mean value obtained for both feet together and tandem stance was statistically higher than that observed during feet apart (Table 1; ANOVA, $p < 0.01$). Statistical difference was also verified for COV values between feet together and tandem. Although COV values increased in more challenging standing conditions, their variability also markedly increased (see standard deviations in Table 1). Such a large variability across subjects suggests that they might have relied upon distinct recruitment strategies to compensate for lateral sway. These strategies presumably reflect changes in TA inversion/eversion role [5] and on differing hip/ankle mechanical coupling in distinct feet position [3,6].

The relationship between CC coefficient and COV was investigated to understand whether pronounced modulations in TA activity were more strongly related to the postural sways. In this case, subjects showing greater COV values were expected to show higher CC coefficients. Such prediction was confirmed in feet apart and feet together conditions, with significant R^2 coefficient of 0.14 (p = 0.05) and 0.16 (p = 0.037), respectively (see Figure 1d, left and central panel), implying that significant modulation of TA activity was related to postural sway in the frontal plane.

For tandem position the R^2 coefficient showed small, non significant value of 0.09 (p = 0.1), that could be explained by the markedly bimodal distribution of COV (Figure 1d, right panel). Separate regression analyses demonstrate that while in one subset of subjects (COV range of 8-47%) the pronounced modulation in TA activity is indeed related to postural sway in frontal plane (R^2 = 0.26, p = 0.025), in the other subset (COV range of 77-126%) this is not the case (R^2 = 0.12, p = 0.3). For the later group of subjects, among other possible explanations, the marked modulation of TA activity could be more strongly associated to changes in joint stiffness than to the lateral postural sways.

CONCLUSIONS

The amount of modulation in TA activity depended significantly on the standing condition. Such modulation was markedly more associated to postural sways when subject stood over narrower lateral stances. These results suggest a substantial, active contribution of the TA muscle for the compensation of postural sways when stability is challenged in the frontal plane.

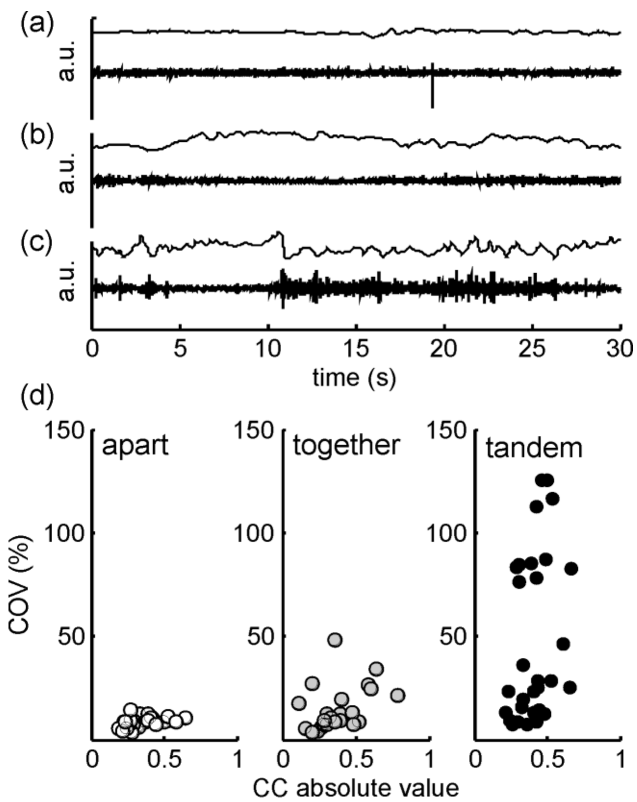

Figure 1. COP displacement in frontal plane and raw EMG data from a representative subject in feet apart (a), feet together (b) and tandem (c) positions. The relationship between absolute values of CC coefficient and COV were depicted in (d). a.u., arbitrary units.

Table 1: Results from tibialis anterior (TA) coefficient of variation (COV) of EMG envelopes, expressed as mean ± SD.

Feet position	**TA COV (%)**
Feet apart	9.28 ± 2.38
Feet together	15.83 ± 10.21*
Tandem	48.07 ± 40.24**

* Different from feet apart, p<0.05;
** Different from feet apart and feet together, p<0.01

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REFERENCES

1. Joseph J, et al., *J Physiol (Lond)* **127** :617-625, 1955.
2. Di Guilio I, et al., *J Physiol (Lond)* **587**:2399-2416, 2009.
3. Day BL, et al., *J Physiol (Lond)* **469**:479-499, 1993.
4. Sozzi S, et al., *Clin Neurophysiol* http://dx.doi.org/10.1016/j.clinph.2012.12.001, 2013.
5. Lee SS, Piazza SJ, *J Biomech* **41**:3366-3370, 2008.
6. Winter DA, et al., *J Neurophysiol* **75**:2334-2343, 1996.