ADJUSTMENT OF MUSCLE ACTIVATION PATTERNS TO INITIAL CENTER OF PRESSURE LOCATION IN SQUAT JUMPING

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INTRODUCTION

It has recently been shown that humans adjust their control to initial squat depth by adapting the muscle activation patterns of the plantarflexors to the height of the body's center of mass (CM) in the initial posture: the lower the CM was in the initial posture, the later the onset of plantarflexor activity occurred [1]. The purpose of the present study is to examine if variations in the initial location of the center of pressure (CoP) relative to the toes in the equilibrium starting position also cause subjects to adapt their muscle activation patterns in squat jumping.

METHODS

A group of 6 male physically active subjects (age, 24.4 ± 2.4 yr, height, 1.83 ± 0.1 m and body mass, 77.3 ± 7.6 kg) participated in this study. Subjects performed three jumps from each of three different starting positions P1-P3 in random order. P2 was the subjects' preferred position for maximum-height squat jumping, in P1 CoP was at the heels, and in P3 CoP was at the toes (Figure 1). Ground reaction forces were measured with a Kistler force platform and sampled at 200 Hz, simultaneously with sagittal-plane positional data of six anatomic landmarks monitored with three electronically shuttered cameras (Optotrak 3020, Northern Digital). The heights of CM at the start of the jump ($z_{CMstart}$) at the lowest position (z_{CMmin}), at takeoff (z_{CMto}) and at the apex of the jump (z_{CMapex}) relative to standing upright were calculated from the positional data.

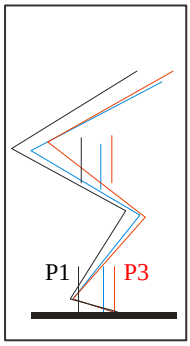

Figure 1: Average stick diagrams (n = 6) showing the three different starting positions P2 (blue line), P1 (black line) and P3 (red line).

EMGs were recorded from six muscles of the left lower extremity: soleus (Sol), gastrocnemius (caput mediale) (Gas), vastus lateralis (Vas), rectus femoris (Rec), gluteus maximus (Glu) and biceps femoris (Ham). The EMG signals were amplified and sampled at 1000 Hz (Porti-17t, Twente Medical Systems). Off-line, they were high-pass filtered (7 Hz) to remove any possible movement artefacts, full-wave rectified, and smoothed using a bidirectional digital low-pass Butterworth filter with a 7-Hz cutoff frequency, to yield smoothed rectified EMG (SREMG). For each SREMG signal, the onset was determined by fitting a line to two points on the ascending slope of the SREMG time history and extrapolating it backwards in time to where the SREMG level equalled the level observed while the subject was in his starting position [1]. To compare SREMG-onset patterns among starting positions, all onsets were expressed relative to the SREMG onset of Glu. A repeated-measures ANOVA (Condition (3) x Trial (3)) was used to test for possible differences among starting positions in selected kinematic variables of the jumps and SREMG onsets ($P<0.05$).

RESULTS AND DISCUSSION

Results are presented as the mean over the three jumps because neither a main effect nor an interaction effect was found for the factor trial. Subjects were able to perform well-coordinated squat jumps from P1 and P3; in jumps from these positions z_{CMto} and z_{CMapex} were not statistically significantly different from those in jumps from the preferred position P2 (Table 1). Initial CoP location had a significant ($P<0.05$) main effect on the SREMG onsets of the plantarflexors (Table 1); onset of Sol occurred later in P1 than in P2 ($P<0.05$) and later in P2 than in P3 ($P<0.05$), while SREMG-onset of Gas occurred later in P1 than in P2 and P3 ($P<0.05$).

Table 1: Selected variables (mean±SE) describing squat jumps and the SREMG onsets in squat jumps performed by subjects from different starting positions P1-P3. P2 was the preferred starting position.

Variable	P1	P2	P3	*F*-Ratio
$z_{CM,\ start}$ (m)	0.75±0.05	0.72±0.06	0.75±0.05	1.7
$z_{CM,\ min}$ (m)	0.73±0.05	0.71±0.06	0.74±0.05	1.7
$z_{CM,\ to}$ (m)	1.12±0.03	1.14±0.03	1.14±0.03	5.5
$z_{CM,\ apex}$ (m)	1.41±0.04	1.45±0.03	1.44±0.03	3.8
Sol (ms)	84±21	8±16	-52±25	13.1*
Gas (ms)	78±33	21±31	-41±33	11.6*
Vas (ms)	38±32	4±10	4±11	0.7
Rec (ms)	68±12	77±13	64±24	0.4
Ham (ms)	-31±39	7±20	13±14	1.2

*Main effect of starting position occurred ($P < 0.05$).

The finding that the plantarflexors become activated later as CoP is more backwards, suggests that subjects are trying to jump as vertically upwards as possible. Taking into account neural loop times, it seems impossible that the variations in onset times among P1-P3 are based on feedback generated during the ongoing push-off. Therefore, our findings indicate that subjects are able to prospectively map variations in initial CoP location to variations in muscle activation onsets.

CONCLUSIONS

This study provided evidence that in preprogramming their muscle activation patterns for vertical squat jumping, subjects take into account the initial location of CoP.

REFERENCES

1. Bobbert MF, et al., *J Appl Physiol.* **105**:1428-1440, 2008.