EVIDENCE OF MOVEMENT CONTROL ADAPTATION IN A LOWER EXTREMITY MOTOR TASK

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INTRODUCTION

Movement control adaptation (MCA) is designed to optimize dynamical characteristics of movement (such as effort, power, joint torque, or muscle force) in response to a change in the physical demands of movement. [1-3]. Results from previous studies on movement adaptation for upper extremities suggest that a delay in the onset or poor execution of movements in response to environmental change would form the basis of impaired MCA. The purpose of this study was to develop a method for measuring MCA in a more complex, functional lower extremity motor task. We hypothesized that MCA will begin in the motor preparatory phase and continue in the motor execution phase.

METHODS

Data from one healthy young subject are presented. The tests consisted of training an individual to react to a light cue by stepping forward as fast as possible to the light target, a distance equaling to 30% of maximal step length (MSL). Following the training period, an MCA trial (60%) was inserted into a series of trained step trials (30%) by shining the light cue at 60% of MSL.

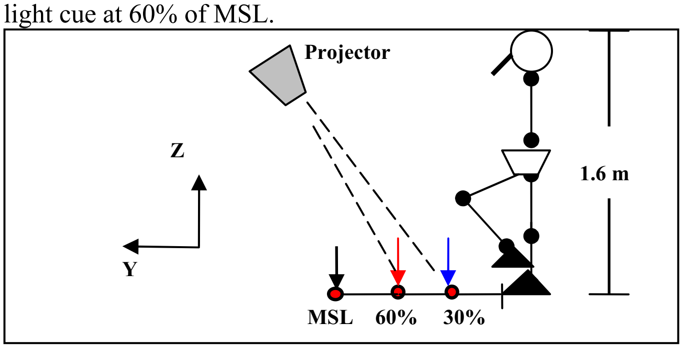

Figure 1: Stepping Test. MSL: maximal step length (1.06 m)

Force plates were used to measure kinetic data during stepping tests (Figure 1). Movement analyses were divided into three phases of forward stepping: Reaction time phase (RTP)- defined as time period from onset of light-cue stimulus to onset of step initiation. Motor preparatory phase (MPP)- defined as time period from onset of step initiation to toe-off of swing foot, and motor execution phase (MEP)- defined as time period from toe-off of swing foot to toe-off of stance leg.

RESULTS AND DISCUSSION

The results from a single subject showed there is no observed delay in reaction time at 60% of MSL (253 and 254ms at 30% and 60% of MSL, respectively). This finding indicated the subject has approached the motor tasks the same way as previously trained tasks via a feedforward control mechanism, which means the motor program has been processed prior stimulus. The evidence of identical motor programming is indicated by generation of similar slope of anterior/posterior (A/P) force in the early stage of MPP, and later modified the ongoing motor program, which has been shown in this study as the timing of departure in slopes at 30 and 60%, defined as onset of MCA (Figure 2). The finding in this study showed the onset of MCA occurred at 40% of a step cycle (500ms after onset of stimulus). The capability of developing MCA is very important for humans to overcome unexpected environmental challenges and achieve an optimal motor control. On the other hand, a delay of MCA would result in poor motor execution in the later phase.

In addition, MCA also was demonstrated by relatively higher peak force (60 vs. 47 N) and impulse in the A/P direction (14523 vs. 8218 N*ms) at 60% compared to 30% of MSL (figure 2) in swing leg. A longer period for weight transfer (Tw) was observed at 60% of MSL (369 vs. 290 ms). During MEP, the stance leg in the late phase of MEP showed relatively higher second peak A/P force at 60% compared to 30% of MSL (53 vs. 39 N). Increasing Tw in MPP indicated further generation of propulsion force for the swing leg. Occurrence of a second Peak A/P force in stance leg at 60% of MSL indicated MCA existed in stance leg. In summary, occurrence of MCA coexisting in swing and stance legs is governed by highly coordinated motor programs.

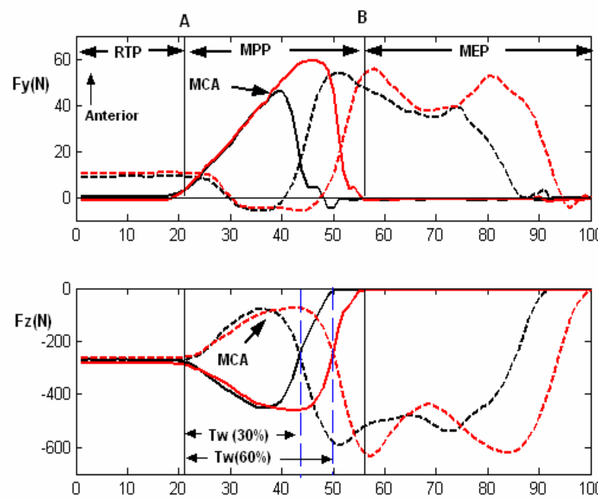

Figure 2: Ground reaction forces in A/P direction (Fy) and in vertical direction (Fz) for 30% (black lines) and 60% (red lines) of MSL (upper and lower figures, respectively). Time is normalized by 100%. Solid lines represent force measures of the swing leg. Dash lines represent force measures of the stance leg. The time point at 0 represents onset of the stimulus (light cue) and time point at 100 represents toe-off of stance leg. A: onset of stepping; B: toe-off of swing leg.

CONCLUSIONS

This study demonstrated the feasibility of measuring the onset and characteristics of MCA in a complex, lower-extremity motor task, and provided insight into understanding underlying control mechanisms of human locomotion.

REFERENCES

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