Very fast muscle activations during adjustment of tripping responses

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BACKGROUND AND AIM: Tripping over obstacles is one of the main causes of falls [1] in the elderly, who are often unable to take an appropriate recovery step [2, 3]. Therefore, recovery step adjustments might be beneficial for fall prevention. We have previously shown that young adults (YA) manage to adjust foot landing position to avoid stepping on an unwanted surface, even under very challenging conditions (such as after tripping) [4]. It is essential to study how one accomplishes these step adjustments and how fast one can alter the muscle activations.

METHODS: Sixteen YA walked at their comfortable speed over a walkway equipped with hidden obstacles that could unexpectedly appear to perturb the subject in mid-swing and elicit an elevating strategy [4]. Participants were tripped 10 times in between a random number of normal walking trials; 5 trips included a projection of a forbidden landing zone (FZ, 30x50 cm) at the subject's preferred foot landing position. Participants were instructed to land their recovery foot outside the FZ, if it was shown. For seven subjects (21-30 years, 1 female) who successfully shortened their steps to avoid the FZ in all trials, electromyographic activity of the tripped leg muscles tibialis anterior (TA), rectus femoris (RF), gastrocnemius (GM) and biceps femoris (BF) was analyzed. After subtracting average normal walking activity, a wavelet based functional ANOVA [5] was performed to compare 1) three trips performed at the start of the experiment to 2) five trips with a FZ and 3) two catch trips in between the FZ trips.

RESULTS: To successfully step outside the FZ, the distance from the center of the foot to the center of the FZ at landing was increased from 0.09 to 0.51 m during trips with a FZ. The adjustment of muscle activity started around 110 ms after trip onset as suppression of GM activity, followed by facilitation of TA activity around 150 ms after trip onset and longer latency changes in all muscles. Foot landing position was also adjusted during catch trips although no FZ was presented. In these trials, the distance from the center of the foot to the center of the FZ at landing was increased to 0.39 m. This coincided with significant changes in the activity of the fastest responding muscles (TA and GM), corresponding to changes shown during the FZ trials.

CONCLUSIONS: YA are able to adjust their foot trajectory during balance recovery following a trip by changing muscle activations at very short latencies, well below what would be expected on the basis of voluntary reaction times (<150 ms). Furthermore, subjects learn to apply these adjusted responses in anticipation and show similar fast muscle activity changes during normal trips presented as catch trials.

REFERENCES

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