A PARAMETER TO DESCRIBE COORDINATION OF HIP AND KNEE FLEXION DURING OBSTRUCTED GAIT

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INTRODUCTION

During obstacle crossing, healthy adults increase toe-ground/obstacle clearance from an average of 3 cm during level walking to approximately 10-15 cm over an obstacle (Chen et al., 1991; Patla et al., 1996; Chou et al., 1997) to minimize the risk of tripping. The hip, knee and ankle joints of the swing limb are modulated for phase and amplitude of flexion to ensure appropriate elevation of the swing foot over the obstacle (Patla et al., 1996). Due to a different proximity of the swing foot at the time of toe-off with the location of the obstacle, strategies with emphasis on different joints are adopted to elevate the swing foot to clear the obstacle (McFayden and Winter, 1991; Patla et al., 1996; Chou et al., 1997). The purposes of this study was to define a parameter that could describe different coordination strategies of hip and knee flexion of the leading and trailing limbs during obstacle crossing and to examine its relationship with the obstacle height in healthy young adults.

METHODS

Six healthy young adults (mean age, 24.8 years) were recruited for this study. Whole body kinematic data were collected using a six-camera HiRes™ system (Motion Analysis Corp., Santa Rosa, CA) during unobstructed walking and when stepping over an obstacle of height corresponding to 2.5%, 5%, 10%, or 15% of the subject’s body height (BH). All trials were conducted at a comfortable self-selected walking speed while barefoot. The order of obstacle height was randomly selected. Flexion angles of the hip and knee joints were plotted one against the other, from toe-off to heel-strike for each limb. A coordination slope was then calculated to represent the overall trend of joint coordination for each limb (Fig. 1). Graphical midpoints were calculated between toe-off (LTO, TTO) and heel-strike (LHS, THS). For each limb, the slope of the line between the midpoint and the apex of the coordination curve represented the overall hip/knee coordination during the obstacle-crossing stride. A one-way ANOVA with repeated measures for obstacle height was used for each limb to test the effect of obstacle height on coordination of the hip and knee.

RESULTS AND DISCUSSION

During unobstructed walking, the coordination slope between knee and hip flexion had an average value of 0.181, which implies a favor of flexing knee joint to the swing foot with the floor. This can be explained from the aspect of energy efficiency. During obstacle crossing, the coordination slope of the leading limb demonstrated a value from 0.447 ± 0.09 for the lowest obstacle to a value of 0.602 ± 0.06 over the highest obstacle. A significant effect of obstacle height on the joint coordination slope of the leading limb was identified (p=0.001). These greater values of the coordination slope reflect that a relatively greater contribution from the hip flexion, as compared to the knee flexion, is required to safely step over a higher obstacle. The coordination slope of the trailing limb increased slightly from that of unobstructed walking to an average value of 0.247 ± 0.06 across all obstacle heights. This indicated that the joint coordination strategy of the trailing limb remains unchanged regardless of obstacle height, with foot elevation being achieved primarily through knee flexion.

SUMMARY

The joint coordination slope provides us information on the overall strategy adopted by the swing limb when walking on different terrains. Inability to coordinate motion of hip and knee joints may result in obstacle contact, increasing the risk of tripping and falls. Results of this study could potentially serve as a baseline for comparing the functional strategies adopted by patients with joint pathology, muscular strength deficits or post-surgical complications.

REFERENCES


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