INFLUENCE OF HANDRAIL USE ON STAIR WALKING STABILITY IN TRANS-TIBIAL AMPUТЕES

Goeran Fiedler, Dipl. Ing (FH), CPO-D, Brooke A. Slavens, PhD, and Roger O. Smith, PhD, OT
Department of Occupational Science and Technology Rehabilitation Research Design and Disability (R2D) Center

ABSTRACT: This paper presents preliminary findings on stair walking kinetics in trans-tibial amputees, as part of a larger, ongoing study of lower extremity kinetics of amputee gait.

INTRODUCTION: The ability to walk on stairs is an important skill, as stairs belong to the typical obstacles that can be widely found in most every environment. Various disabilities are known to reduce the stair walking efficiency in patients, which not only limits their range of mobility, but can also become a safety issue due to the high injury probability of stair accidents. Accordingly, the biomechanics of stair ascent and descent have been investigated to great extent [1]. Previous studies that were conducted on different populations, including elderly people [2], patients having undergone ACL reconstruction [3], and amputees [4-6] used force plates that were integrated in one or more steps of the stairs. This setup reduced the number of steps available for evaluation and limited information on step-to-step variability, a variable that indicates walking stability [2]. Artificial limbs offer the opportunity to install sensors to directly measure forces and moments in the weight bearing structure of the locomotor apparatus, which allows continuous data collection over entire flights of stairs.

METHODS: Ten subjects were recruited for this IRB approved study. Upon installation of the mobile sensor (IPIcs, College Park Industries, Fraser, MI) in their respective original prostheses, participants were asked to walk down and up a 13-step stair with handrails conveniently located on both sides. Walking speed and technique were self selected. Knee and ankle moments were compared within subjects over the intermediary 11 steps of their stair walk trials, separately for descent and ascent. Averages and standard deviations in stance duration, maximal longitudinal shin compression force, maximal ankle moment and maximal knee moment were compared between subjects who used no handrail, one handrail and both handrails.

RESULTS: Preliminary findings indicate that use of one handrail in stair descent reduces the body-weight normalized, maximal compressive force on the shin segment by almost 50% as compared to freehand walking. When the same person was using different handrails, the average peak force was increased slightly by 5% when using the non-preferred handrail down, but reduced by 2% upstairs. With both handrails, the force was reduced by 39% (down) and 8% (up). Variability between steps was considerable, with standard deviations of 10 to 20% for step time, maximal longitudinal force, and ankle flexion moments throughout. Stability, as expressed in deviation of peak force, step time, peak ankle moment, and peak knee moment was best with use of the preferred handrail, and worst with both handrails. However, step time decreased when both handrails were used.

DISCUSSION: Only two of the subjects elected not to use a handrail for normal speeds, and two others used both handrails. Of those who used one handrail, four preferred the one on the side opposite of the prosthesis, and two preferred the same sided handrail. Stability measures did not show big differences between subjects who preferred the handrail on the same side of the prosthesis and those who preferred the opposite side handrail. Given the fact, that the majority of subjects used the respective right handrail, it can be suspected that the preferred hand seems to be more important than the preferred leg. In absolute measures, preference of the opposite handrail seemed to decrease the stair climbing velocity, especially down stairs, and it clearly increased the measured knee and ankle flexion moments during up stairs climbing. Step-by-step variability within the selected kinetics parameters does not seem significantly influenced by the use of handrail(s); however, this finding may be attributed to the fact that subjects were free to decide which handrail to use. We suspect that other factors, such as prosthesis socket fit or the componentry design determine the level of stair walking stability in amputees.

REFERENCES:

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