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Effects of load carriage and fatigue on gait characteristics

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ABSTRACT

The objective of this study was to determine the main and interactive effects of load carriage and fatigue on gait characteristics. Twelve young male participants were recruited in this study. Fatiguing protocol involved a running exercise, and fatigue was considered to be induced when the participants first gave an RPE rating at or above 17. Gait data were collected when the participants walked on a medical treadmill at their self-selected comfortable speed, both before and right after the fatiguing exercise. Different back-carrying loads (i.e. 0, 7.5, and 15 kg) were applied separately to the participants during the walking trials. Gait variability measures and kinematic measures were used to quantify gait characteristics. The results showed that gait width variability, hip range of motion, and trunk range of motion increased with fatigue and with the application of the heavy load. These findings suggest that both fatigue and load carriage compromise gait. Findings from this study can help better understand how fatigue and load carriage affect gait, and further aid in developing interventions that are able to minimize fall risks especially with the application of fatigue and/or external load.

1. Introduction

Falls are a major health problem nowadays. In the year of 2002, over 12,900 adults in the US died as a result of falls, over 1,016,700 patients were treated in emergency departments for fall-related injuries and 388,000 were subsequently hospitalized (Stevens et al., 2006). Falls are serious not only for the general population, but also for military personnel. In the military, falls are costly due to time lost from duty and medical care (Schiffman et al., 2006). On average, falls among US military personnel led to a hospital stay of 6.4 days (Senier et al., 2002).

Almost all fall incidents occur during dynamic activities, particularly locomotion (Prince et al., 1997). Gait (walking) is the most common locomotion activities, and gait parameters have been reported to be critical determinant of fall risk (Dingwell and Cusumano, 2000). For example, it was reported that fallers tend to have higher gait variability compared to non-fallers (Hausdorff et al., 2001). Hence, in order to develop and assess fall prevention strategies, there is a need to better understand gait characteristics.

Falls are often multi-factorial. In general, the risk factors associated with falls can be classified as environmental factors, task-related factors, and personal factors (Hsiao and Simeonov, 2001). Interventions aimed at modifying fall-related risk factors have been suggested to be a possible solution to preventing falls (e.g. Arampatzis et al., 2011; Kim, 2009). However, in order to be effective, the development of these interventions should be based on good knowledge of how the risk factors affect gait characteristics.

Load carriage and fatigue have been identified as two major task-related risk factors that have effects on gait (Hsiao and Simeonov, 2001), especially for military personnel. The carrying of load by troops is necessary and important for military training and combat. Soldiers must be able to carry heavy load while maintaining battlefield performance. However, overloading and poorly designed load carriage systems can lead to excessive fatigue which significantly impairs the soldiers' ability to combat and at the same time also results in many health problems for soldiers (e.g. falls) (Knapik et al., 2004).

The effects of military load carriage on gait have been reported previously (Attwells et al., 2006; Birrelll and Haslam, 2009; Martin and Nelson, 1986). For example, Attwells et al. (2006) examined the changes in soldiers' walking gait caused by four load levels (i.e. 8, 16, 40, and 50 kg). Joint angles and spatiotemporal parameters were measured during gait at a self-selected speed. Results showed that stride remained the same but the range of motion of some joint angles (e.g. knee and craniovertebral angles) significantly changed with back-carrying load. Most recently, Birrell and Haslam (2009) have studied the lower limb kinematics with the application of military back-carrying load. They found that the range of motion of flexion/extension of the knee and pelvic rotation significantly decreased when the load was applied. A common limitation of these studies is that they did not investigate the possible effects of fatigue on gait, while military operations with load carriage could often be associated

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