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Correlation Between Cardiopulmonary Metabolic Energy Cost and Lower Limb Muscle Activity During Inclined Treadmill Gait in the Elderly

Jihye Kim, Su-Hyun Lee, Jungsoo Lee, Seyoung Shin, Won Hyuk Chang, and Yun-Hee Kim

***Abstract*— The purpose of this study was to investigate the changes in lower limb muscle activities and cardiopulmonary metabolic energy cost during treadmill walking with different inclination grades and a correlation between these two measures in older adults. Twenty-four healthy older adults participated, simultaneous measurements of lower-limb muscle activity and cardiopulmonary metabolic energy cost during inclined treadmill walking were collected.**

***Clinical Relevance*— The key muscles showing a significant relationship with increased net cardiopulmonary metabolic energy cost during inclined treadmill gait were the SOL, GCM, and VM muscles. These results can be used as basic data for various gait training programs and also as an indicator for the development of assistive algorithms of wearable walking robots for older adults.**

I. Introduction

Inclined walking requires more cardiopulmonary metabolic energy and muscle strength than flat-level walking. This study sought to investigate changes in lower-limb muscle activity and cardiopulmonary metabolic energy cost during treadmill walking with different inclination grades and to discern any correlation between these two measures in older adults.

II. Methods

Twenty-four healthy older adults (n = 11 males; mean age: 75.3 ± 4.0 years) participated. All participants walked on a treadmill that was randomly inclined at 0% (condition 1), 10% (condition 2), and 16% (condition 3) for five minutes each. Simultaneous measurements of lower-limb muscle activity and cardiopulmonary metabolic energy cost during inclined treadmill walking were collected. Measured muscles included the rectus abdominis (RA), erector spinae (ES), rectus femoris (RF), biceps femoris (BF), vastus medialis (VM), tibialis anterior (TA), medial head of the gastrocnemius (GCM), and soleus (SOL) muscles on the right side. The relationship between cardiopulmonary metabolic energy cost and each lower limb muscle activity also was analyzed using a linear regression analysis.

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Jihye Kim, Su-Hyun Lee, Jungsoo Lee, Seyoung Shin, Won Hyuk Chang, and Yun-Hee Kim are with the Department of Physical and Rehabilitation Medicine, Center for Prevention & Rehabilitation, Heart Vascular Stroke, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea (Corresponding author: Yun-Hee Kim, e-mail; yunkim@skku.edu, phone; +82-2-3410-2824, fax; +82-2-3410-0388)

III. Results

As compared with 0% inclined treadmill gait, the 10% inclined treadmill gait increased the net cardiopulmonary metabolic energy cost by 22.9%, while the 16% inclined treadmill gait increased the net cardiopulmonary metabolic energy cost by 44.2% (p<.05). In the stance phase, as the slope increased, activity was significantly increased in the RA, RF, VM, BF, GCM, and SOL muscles (p<.05). In the swing phase, As the slope increased activity was significantly increased in the RA, RF, VM, BF, and TA muscles (p<.05). SOL muscle activity was most relevant to the change in cardiopulmonary metabolic energy cost in the stance phase of inclined treadmill walking (p<.05). The relationship between the increase in cardiopulmonary metabolic energy cost and changes in muscle activity was also significant in the VM, GCM, and RF (p<.05).

IV. Discussion & Conclusion

Cardiopulmonary metabolic energy cost is an important variable in daily life and has been studied extensively. Also, the cardiopulmonary metabolic energy cost has become an important clinical tool for evaluating human exercise capacity and for predicting outcomes [1]. Muscular efficiency is one of the key determinants of the net cardiopulmonary metabolic energy cost of walking [2]. This study demonstrated that changes in SOL, VM, GCM, and RA muscle activity had a significant relationship with cardiopulmonary metabolic energy cost increment during inclined treadmill walking. These results can be used as basic data for various gait-training programs and as an indicator in the development of assistive algorithms of wearable walking robots for older adults.

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