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Published in:
20th annual Congress of the European College of Sport Science

2015

[Link to publication](#)

Citation for published version (APA):

Halder, A., Kuklane, K., Miller, M., Gao, C., Johan, N., Delin, M., Lundgren Kownacki, K., & Fridolf, K. (2015). Energy costs and leg muscle activities in ascending stairs. In *20th annual Congress of the European College of Sport Science*

Total number of authors:

8

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Submitted: 2015-01-01

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Citation for published version (APA):

Halder, A., Kuklane, K., Miller, M., Gao, C., Johan, N., Delin, M., ... Fridolf, K. (2015). Energy costs and leg muscle activities in ascending stairs. Abstract from 20th annual Congress of the European College of Sport Science, Malmö, Sweden.

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ENERGY COSTS AND LEG MUSCLE ACTIVITIES IN ASCENDING STAIRS

Halder, A. 1, Kuklane, K. 1, Miller, M. 1, Gao, C. 1, Noren, J. 2, Delin, M. 3, Lundgren, K.1, Fridolf, K. 1.

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Introduction

Repetitive movements and continuous force production through lower limb muscles are required to ascend many flights of stairs on demand especially in an emergency situation. The purpose of this study was to determine the relationship of muscle activity to the oxygen uptake (VO_2) and the development of leg muscle fatigue from real stair climbing activities.

Methods

A total of twelve healthy adults (8 men and 4 women) with mean age (\pm SD) 35.6 (\pm 9.7) volunteered in the study. Subjects were encouraged to climb 12 floors with 268 steps in their self-selected pace. Oxygen consumption, heart rate (HR) and surface electromyography (sEMG) of the thigh Vastus Lateralis (VL), Vastus Medialis (VM) and Gastrocnemius Lateralis (GL), Gastrocnemius Medialis (GM) from calf muscles as well as ascending speed were recorded.

Results

The average total time required about 162 (\pm 38.9) s to reach to the top 12th floor while VO_{2max} reached to about 3.0 (\pm 0.7) l/min corresponding to 40.5 (\pm 6.5) ml/kg/min. The average HR_{max} peaked to 170 beats/ min and max metabolic rate calculated about 553 W/m² from the participants. The main sEMG average root mean square (RMS) median amplitudes ($P < 0.05$) results from GL and RMS average as well as RMS area amplitudes of (both $P < 0.02$) GM muscles reduced significantly in one-way ANOVA test. Moreover, RMS amplitudes of both thigh and calf muscles showed anticipated progressive reduction at the end. The average climbing speed dropped gradually from .95 to .73 m/s. However, none of the leg muscles frequency analysis showed significance decrease.

Discussion

Thus, no indication of muscle fatigue observed in this self-controlled short duration repetitive activities. This may suggest that subjects tend to adopt some coping strategies that might have changed the sEMG signals (Bigland-Ritchie et al., 1981). The results also showed that sEMG amplitudes reduction might be related to the gradual speed reduction during climbing and to the decrease of leg muscles force production capabilities (Cifrek et al., 2009). Stair ascent is a physically challenging task in terms of leg muscle force production and cardiorespiratory capacities. This may be manageable for a shorter duration with tolerable amount of physical stress under self-controlled situations. Future studies with more number of floors and longer ascending duration to evaluate physical evacuation capacity and muscle fatigue are needed.

References

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