

BIOMECHANICS OF STAIR ASCENDING EXERCISES

Sami F. Almashaqbeh¹, Wan Abu Bakar Wan Abas¹ and Noor Azuan Abu Osman¹

¹Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

Email: faris.sami@gmail.com web: <http://biomedical.eng.um.edu.my/>

INTRODUCTION

Exercises provide many of important health benefits to people. It is strongly recommended to all people to be engaged in minimum 30 minutes of moderate intensity physical activity on most of the days of the week, if not all [1,2]. One of the important benefits of regular physical activity that it helps build and maintain healthy bones, muscles, and joints [1,2]. Stair climbing provides a useful model of daily physical activity that should be promoted to public [3]. Furthermore, staircases are available everywhere in home, work, malls, etc. These facts encourage trainers all over the world to propose some exercises that can be done on staircase such as walking up stairs holding dumbbells (HDUM) or walking in cross step manner (CSF) (figure 1). The purpose of this paper is to study the kinematic and kinetic differences of these exercises compared to regular stair climbing.

METHODS

Seven healthy young male subjects, ranging in age 20 to 26. Mean age 23.29 years (SD 1.8), mean height 170.38 cm (SD 3.5), and mean weight 66 Kg (SD 7.24). The experimental staircase consisted of four steps (step height 21.5cm, tread length 25 cm). Kinematic and kinetic recordings were collected from 6-cameras, three-dimensional motion analysis system (Vicon MX3, Oxford Metrics Ltd, UK) and force platform (Kistler, model 9281CA) positioned in the second stair step. 16 reflective markers were placed on specific location on the lower extremity according to plug-in gait marker placement. Subjects were asked to perform three trials of regular stair ascending, holding dumbbells, and cross step ascending. The stride cycle was defined as right foot contact on the second step and ended at the same foot contact on the fourth step [4]. Joints moment was calculated using the link segment method and expressed as external moment. Vicon polygon software was used for normalization, averaging and visualization of the model outputs. Dependent t-test was used to compare the exercises to regular stair climbing.

RESULTS AND DISCUSSION

At the hip, compared to regular stair ascending, CSF shows significantly higher flexion angle ($p < .05$), flexion moment ($p < .01$), flexion impulse ($p < .05$), adduction moment ($p < .001$), and adduction impulse ($p < .001$). No significant differences in power and work was obtained. HDUM shows significantly higher adduction moment ($p < .01$) and adduction impulse ($p < .01$). No significant difference was observed in flexion angle, flexion moment, flexion impulse, power, and work.

At the knee, the CSF shows significantly higher adduction moment ($p < .01$) and adduction impulse ($p < .05$) but significantly lower flexion moment ($p < .001$), power

($p < .01$), and work ($p < .01$). No significant difference in flexion angle and flexion impulse was observed. The HDUM shows significantly higher Flexion moment ($p < .01$), flexion impulse ($P < .05$), adduction moment ($P < .001$), and adduction impulse ($P < .001$). No significant difference in flexion angle, power, and work was observed.

At the ankle, only the CSF shows significantly lower dorsiflexion moment ($p < .05$), power ($p < .01$), and work ($p < .01$).



Figure 1: Staircase exercises A) Holding dumbbells. B) Cross step forward.

In the sagittal plane, the results show that, when compared to regular stair climbing, the CSF places greater demand on the hip extensors with higher flexion angle, flexion moment, and impulse. On the other hand, the HDUM places greater demand on the knee extensor with higher flexion moment and impulse. Furthermore, CSF decreases the load on the knee extensors and ankle plantarflexors, producing lower work, moment, and power.

In the frontal plane, the CSF places greater demand on the hip abductor with higher adduction moment and impulse. On the other hand, the HDUM places greater demand on the knee abductor with higher adduction moment and impulse.

REFERENCES

1. Bauman, et al., National Public Health Partnership, Melbourne, Australia, 2002.
2. U.S. Department of Health and Human services, U.S.A, 1996.
3. Eves, et al. *OBESITY*. **14**:2210-2216, 2006.
4. Protopapadaki et al., *Clinical Biomechanics*. **22**: 203-210, 2007.