Muscle Fatigue Evaluation in Ascending and Descending on Functional and Non-functional Stairs

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ABSTRACT

Objective: This study was to quantitatively assess the effect of ascending and descending on muscle fatigue in two different structured stairs. **Background:** Stair gait (ascending and descending) is a basic body movement required for performing the normal activity of daily living. The muscle activity and motor control aspect involved in ascending and descending stairs on human locomotion. The muscle activities are useful information while designing private and public stairs. **Method:** Sixteen healthy subjects participated. Two climbing stairs namely proposed (functional stairs with cushion plate) and traditional (non-functional stairs) stairs were tested. All the subjects ascended and descended on two stairs as they normally would in their daily activities of living for a 1 hour period. Surface electromyography has been used to assess the muscle activation before and after the experiment. The muscle activities have been measured from eight different muscles from the left and right side: vastus medialis oblique, tibialis anterior, vastus lateralis, rectus femoris, biceps femoris, and lateral gastrocnemius. LT medial gastrocnemius and LT semitendinosus. **Results:** Rectus femoris muscle activity while gait in the functional stairs was lower than the traditional stairs. It showed that at normal walking speed, rectus femoris muscle was active only during the stance-to-swing transition. In addition, subjective discomfort result that while gait in functional stairs was more comfortable in the body part (knee, ankle, and overall body). **Conclusion:** The stance-to-swing transition, that could be attributed to rapid hip extension and thereby a rapid stretch of rectus femoris. Therefore, a gait with functional stair is more comfortable than the traditional stairs. **Application:** The proposed type of functional stairs can be used for comfortable gait.

Keywords: Stairs, muscle fatigue, functional stairs

1. Introduction

The ascending and descending stair is an normal activity of daily living for people despite elderly people can have a hard activity than young people. Healthy people climb stairs quite easily, this movement task is quite demanding when motor function are reduced, particularly elderly people, obsess people, pregnancy people and people injured (muscle and joint diseases). The muscle activity and motor control aspect involved in ascending and descending stair on human locomotion. It is useful in the design of private and public stair and climbing stairs (Riener et al. 2002).

In the intact knee joint, activation of the agonist quadriceps muscle generates an anterior shear force on the tibia relative to the femur and activation of the antagonistic hamstring muscle group counteracts this force, producing joint stability (Bernardi et al., 1997; Ebenbichler et al., 1998). The purpose of this study was to quantitatively assess the effect of stair gait on muscle fatigue and subjective discomfort.

2. Method

2.1 Subjects

In this study, sixteen healthy subjects participated and their anthropometric details are height (167.67±5.28 cm),

weight (64.83±10.83 kg), and BMI (22.95±2.79 kg/m^2).

2.2 Materials

Two climbing stairs namely proposed (functional stair) and traditional (Non-functional stair) were tested. The functional stair (Fig. 1.a) is different in structure from the non-functional stair (Fig. 1.b)

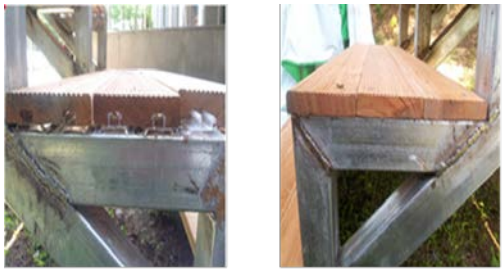

Figure 1. Two climbing stairs type

2.3 Muscle selection

Surface electromyography (EMG) has been used to assess the muscle activation before and after climbing on the stairs. The muscle activities have been measured from eight different muscles: left (LT) and right side (RT): LT vastus medialis oblique (VMO), RT tibialis anterior (TIB. ANT), RT vastus lateralis (VLO), RT rectus femoris (RECTUS FEM.), RT biceps femoris (BICEPS FEM.), RT lateral gastrocnemius (LAT. GASTRO.), LT medial gastrocnemius (MED. GASTRO.), and LT semitendinosus (SEMITEND).

2.4 Procedure

Data collected in one-hour session in alternative days. Subjects ascended and descended on a custom-built four-step wooden stairway. During ascent and decent, subjects synchronized their foot contact with the beat of a metronome that was set at 70 beats per minute for considering subjects feeling. As a warm-up, subjects walked up and down the four-step stairway for 30 minutes. The muscle activities were recorded before and after the task from the subjects using the Noraxon EMG system. The median frequency (MF) was calculated from the EMG measurement to evaluate the muscle fatigue. In addition, subjective discomfort evaluation performed after completing gait task. A t-test was employed to determine the statistical difference.

3. Results

3.1 Muscle fatigue

T-test results revealed significantly greater muscle fatigue while ascended and descended on the non-functional stair, particularly at the rectus femoris muscle ($p<0.01$)

3.2 Subjective evaluation

The subjective evaluation revealed significantly greater discomfort while ascended and descended on the non-functional stair. In particular, at the knee ($p<0.01$), ankle ($p<0.01$) and overall ($p<0.01$).

4. Discussion

This study was to investigate the muscle fatigue and subjective discomfort when gait on two different stairs for 1 hour. The result showed that muscle fatigue was lower only at rectus femoris muscle. It showed that at normal walking speed, rectus femoris was active only during the stance-to-swing transition. According to muscle alive book (Basmajian, 1985), the rectus femoris muscle is attached to the hip and helps to extend or raise the knee. This muscle is also used to flex the thigh. The rectus femoris is the only muscle that can flex the hip. So that at faster speeds, increased levels of rectus femoris activity were seen during the same transition period. At the fastest speed, there was some activity during terminal stance, in addition to that at stance-to-swing transition, that could be attributed to rapid hip extension and thereby a rapid stretch of rectus femoris (Nene et al., 2004). Therefore, gait at functional stair is more comfortable. In addition, subjective discomfort evaluation revealed that gait at functional stair was more comfortable in the part of the knee, ankle, and overall body.

4. Conclusion

This study assessed the effect of stair gait on muscle fatigue in two kind of stairs. The functional stair significantly reduced the muscle fatigue and increased the subjective comfort. This result can be used to make a comfortable stairs.

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