A Comparitive Study on Stair Walk and Stepper Strengthening Exercise Influence on the Thigh Muscle Activation of University Students

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Abstract

The purpose of this study was to evaluate the muscle activity patterns of the rectus femoris, tensor fascia latae and adductor longus activity during stepper strengthening exercise and stair walking. As a result, about the muscle activity of stair walking, the activity of rectus femoris, tensor fascia latae and adductor longus were higher than the muscle activity of stepper strengthening exercise. And the result shows significant difference that in the stepper strengthening group and stair walking group. In conclusion, this study demonstrated that stair walking has identical effects from stepper strengthening exercise of muscle strength improvement.

Keywords: Adductor Longus, Rectus Femoris, Stair, Stepper, Tensor Fascia Latae

1. Introduction

With the development of science and technology, people in today's society can enjoy comfortable and sufficient lifestyle. On the other hand, the development also brought intake of over-nutrition and decrease in physical activities. Therefore, people's body fat has increased and human beings are easily exposed to illnesses like diabetes which causes not only personal but also social problems. To prevent such cases, more and more try to have exercising as part of their daily lives. Among diverse working out methods, aerobic exercises like walking and running can be done by anyone at anywhere so it's less burdensome, accelerates oxidation of fat, improves cardiovascular functions, and prevents diseases like obesity, diabetes, and high blood pressure.

Sporting equipments for aerobic exercises include treadmills, cycle ergometer, and stepper. Among them, treadmill, which is very easy to access, is to have a belt on the bottom turn so a person on the belt can work out accordingly to the speed of the belt moving. Also, it is used not only for general exercising but also walking research. A researcher can analyze more natural walking on the ground but there are many limits. On the other hand, he can control the conditions on treadmills. Treadmills are used much in researches because the researchers can also change the slope to exactly control the exercise load or add the identical amount of load.

Cycle ergometer allows one to control the exercise load by changing the force to pedal and the number of wheel's rotations. The equipment improves gripping power when holding the handle and leg muscles to rotate the pedal. The amount of physical activity increases naturally. Cycle ergometer related researches include: Morries & Floelicher where they used the equipment for exercise load research, Neptune & Kautz where they used it to prove that the cycle ergometer is more safe for the patients with degenerative arthritis on knees and semilunar valve cartilage damage by decreasing the pressure on tibia-thigh.

Stair walking, like level walking on the ground, happens often in daily life. It is similar to level walking in a sense that the legs cross and both feet are on the ground. However, one needs to manage the physical
balance and combine horizontal movement and vertical climbing which requires more energy and muscle than normal walking\textsuperscript{12,13}. Also, when compared to level walking, stairs walking goes against the gravity and lifts the bottom of the body, how the muscle activation is different\textsuperscript{14}. Like the above, there are diverse researches on the aerobic equipments, especially treadmill and cycle ergometer. However, there aren't many, if not none, on stepper. The physical movement when using the equipment is very similar to that of stair walking. The paper is to explain what kind of differences there are on the activation of thigh muscle.

Therefore, the purpose of the research is to compare the activation of thigh muscle during stair walking and stepper strengthening exercising and find out which one is more effective. Additionally, the research will show whether there is a difference in the degree of activated muscle.

2. Materials and Methods

2.1 Subjects
23 healthy physical therapy major college students at S university, Asan, Chungnam participated in this research. All the participants did not have any orthopedical or neurosurgical damages within recent 6 months and muscular skeletal disease. All of them have heard the explanations on the research and agreed to participate. In addition, according to the regulations of the Institutional Review Board (IRB), we collected the written agreements. The participants were randomly positioned to stair walking group (11 persons) and stepper strengthening exercise group (12 persons). The physical features of the participants are recorded in the following (Table 1).

| Table 1. General characteristics of the subjects |
|---------------|----------------|----------------|
| characteristic | stair walking (n=11) | stepper strengthening exercise (n=12) |
| Gender        | 4/7              | 5/7            |
| (male/female) |                  |                |
| Age           | 020.7 ± 2.4      | 019.8 ± 1.3\textsuperscript{a} |
| Height(cm)    | 165.0 ± 7.2      | 164.8 ± 6.4\textsuperscript{a} |
| Weight(kg)    | 058.9 ± 9.1      | 060.6 ± 8.7\textsuperscript{a} |

\textsuperscript{a} All variable are mean ± standard deviation

2.2 Protocol
In the research, stairs with its each step's height of 15cm and length of 26cm and walking analyzer (Stepper, X-1S, Korea) were used. Before the experiment, we checked whether the electromyogram is operated well on Rectus Femoris (RF), Tensor Fascia Latae (TFL), and Adductor Longus (ADL) of the right thigh. To have natural movement, all the participants had sufficient practices. The experiment was done for 5 times and selected 2 which were most natural. The research in whole is explained below.

2.2.1 Stair Walking
Stair walking group was executed on the selected stairs. We asked to have the right foot step first and take 6 steps (Figure 1).

**Figure 1.** Stair walking.

2.2.2 Stepper Strengthening Exercise
Stepper strengthening exercise counted every step of the stepper as one step. Like stair walking, we asked to have the right foot step first and take 6 steps (Figure 2).

**Figure 2.** Stepper strengthening exercise.

2.3 Electromyography
To measure the activation of RF, TFL, and ADL, OQUS100
(Zero WIRE EMG, Italy) electromyogram machine was used during stair walking and stepper strengthening exercise.

We removed the hair and cleaned with medical alcohol for more accurate measurement. RF was attached between Anterior Superior Iliac Spine (ASIS) and knee muscle, TFL was 2 cm below the ASIS, and ADL was diagonally inside of pubis to measure the muscle activation. The electromyogram frequency band-pass filter was set to 5~500Hz, frequency with 30Hz or higher was removed using low-pass filter. Then, AC was changed to DC using the rectification.

2.4 Statistical Analysis
The collected data was statistically processed by SPSS 18.0 program (SPSS Inc, Chicago, IL, USA) for Windows. We compared the muscle activation measures of RF, TFL, and ADL when executing the stair walking and stepper strengthening exercise. The analysis method was independent t-test and the level of significance was set to \( p < .05 \).

3. Result
When the muscle activation degree was checked during stair walking and stepper strengthening exercise, there was statistical differences on RF, TFL, and ADL \( (p < .05) \) (Figure 3, Table 2).

|               | stair walking | stepper | p   |
|---------------|--------------|---------|-----|
| RF            | 046.28 ± 27.99 | 15.47 ± 8.82 | .01 |
| TFL           | 025.63 ± 14.20 | 09.17 ± 1.86 | .00 |
| ADL           | 145.21 ± 125.28 | 14.76 ± 8.70 | .01 |

Figure 3. Comparison of muscle activation about stair walking and stepper.

4. Discussion
The purpose of the study was to measure the differences in thigh muscle activation during stair walking and stepper strengthening exercise. As a result, the muscle was more activated during stair walking than stepper strengthening exercise.

In many previous thesis, the focus was on RF during the research on stair walking. We decided to find more information on TFL and ADL additionally. Also, we used steppers, which aren’t popular among aerobic equipments used for research.

Riley (2011) studied the muscle activation pattern and leg joint angle when changing from ground to stairs. There showed in total of 7 muscle activation, among them was RF and it was activated much more during stair walking than ground walking\(^2\). Anders (2006) studied Ground Reaction Force (GRF), muscle activation of legs, and simultaneous activation of muscles during stair walking. The thesis explained the activation of Vastus Lateralis (VL), Vastus Medialis (VM), RF, Biceps Femoris (BF), Semitendinosus (ST), Soleus (SOL), Gastrocnemius Lateralis (Gas L), and Tibialis Anterior (TA). All the muscle was actively used except SOL and Gas L. According to the studies explained above, we can find out RF is more used during stair walking\(^3\). Jinger (2011) mentioned TFL is highly activated during the first swing phase of up-stair walking. This was almost 2.5 times higher than the level walking. Also, the activity was 0.5 times higher in the first swing phase. ADL was similar to TFL during the swing phase. Also, first and last swing phases showed the highest activity\(^3\). The results of the previous researches support the fact that RF, TFL, and ADL activity was higher during stair walking than stepper strengthening exercise in this research.
According to the result of the research, general people can expect similar physical effects just by stepping up the stairs instead of using the actual equipment, stepper. However, since the study was applied only to normal, healthy college students in their 20s, it is difficult to generalize to every age. Also, handle was used during the stepper strengthening exercise which fails in uniformity among the groups. Additionally, the angle of the legs was different during stepper strengthening exercise and stair walking. In the later research, the angle will also have to be controlled for more specific, detailed result.

5. Conclusion

The research was performed to find differences in RF, TFL, ADL muscle activity during stair walking and stepper strengthening exercise with 23 physically healthy college students in 20s. In conclusion, the thigh muscle was more activated during stair walking than stepper strengthening exercise. Therefore, general people may use steppers to improve their muscle strength but simply walking up the stairs can bring the similar result.

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