The effect of Lower Extremities Muscle for Normal Adults According to the Type of Chair and Posture During Sit-to-stand Motion

SungHyoun Cho¹, Haewon Byeon²

¹ Department of Physical Therapy, Nambu University, Gwangju, South Korea, geriatricpt1@naver.com
² Department of Speech Language Pathology & Audiology, Nambu University, Gwangju, South Korea, byeon@nambu.ac.kr

Abstract. The purpose of this study is to investigate the effect of sit to stand motion on the muscle activity of lower extremities muscles by the different type of chair and posture. Total 52 healthy adult between 19 and 26 were selected as subject for the study. The muscle activities of vastus lateralis, rectus femoris, vastus medialis, tibialis anterior and gastrocnemius by the different types of chair during sit to stand movement were measured by using surface electromyography WEMG. Sit to stand motion was performed by the different types of chair. For both fixed and wheeled chairs, rectus femoris and vastus lateralis showed a statistically significant difference (p<.05) when standing, while vastus medialis, rectus femoris, and vastus lateralis showed a statistically significant difference when sitting (p<.05). Comparison of standing and sitting positions revealed that all muscle types except gastrocnemius showed a statistically significant difference.

Keywords: Sit to stand motion, Lower extremity muscle, Chair, Posture

1 Introduction

The sit-to-stand (STS) motion is the most fundamental condition for other motions, as all motions, such as transferring from one position to another, walking, spinning, and climbing stairs, are possible only when someone is able to maintain a standing position [1]. Moreover, STS is a useful tool for evaluating muscle strength and the functional conditions of lower limbs without using special training or a device [2].

Position control during STS is related to dynamic balancing [3] and a balancing function is required to prevent falling that can be caused by a drastic change in the basal plane and acceleration of the center of the body [4]. During the STS motion, the center of gravity moves forward and the lower limbs extend, which causes the center of gravity to deviate from a stable condition. Schenkman et al. [5] classified STS motions into four stages. The first stage is the flexion-moment stage, wherein the

* Corresponding author
weight is moved to form an early moment. The second stage is the moment-
movement stage, wherein the person detaches the hip from the chair. The foot flexion
of the ankle joint becomes maximal in this stage. The third stage is the extension
stage, wherein the person stands up straight by completely extending the hip and knee
joints. Finally, the fourth stage is the stabilizing stage, wherein the hip and knee joints
are completely extended. This kind of classification has been widely used to describe
motion analyses [6-8]. Standing from a sitting position requires a physical change in
the horizontal and vertical directions. Here, important external conditions that can
affect standing include foot location, early trunk location, motion speed, chair height,
use of the arms, gender, age, etc. [9].

In evaluating the STS motion, the center of body speed and lower limb joint
moments are important factors, which are used to measure how the angular motion of
a joint in a given direction during all STS phases affects the entire body’s linear
movement [10].

Using the upper limbs during STS merely helps to maintain balance, rather than
decrease the load on the lower limb joints [11]. Among the factors that interrupt STS
motion, chair height has the most critical impact [12].

Studies on the STS motion can be largely divided into three categories: the motion
analysis approach using a kinematic system, the muscle activation pattern analysis
approach using an electromyogram signal analysis system, and the simultaneous
approach of a kinetic analysis using a force plate. As of now, studies on the evaluation
of standing up from a chair are insufficient. Hence, this study attempts to examine
how the STS motion according to chair type affects the muscle activity of the lower
limbs.

2 Methods

2.1 Subjects

For analyzing the muscle activity of the five lower limb muscles, i.e., the vastus
lateralis (VL), rectus femoris (RF), vastus medialis (VM), anterior tibialis (AT), and
gastrocnemius muscle (GM), students in their 20s enrolled at University N located in
Metropolitan City G in Korea were selected as research subjects. The subjects
included 52 healthy adults in their 20s (26 men and 26 women) who have no
anomalies in muscle strength and joint range of motion, so the experiment can be
sufficiently applied.

Among 52 adults who participated in this study, 26 were men and 26 were women.
The men’s average age was 21.10 ± 1.86 years, average height was 174.96 ± 4.34 cm,
average weight was 69.23 ± 10.11 kg, and BMI was 22.61 ± 3.15 kg/m². The
women’s average age was 20.54 ± 1.27 years, average height was 163.77 ± 3.86 cm,
average weight was 57.46 ± 8.09 kg, and BMI was 21.39 ± 2.63 kg/m² (p>0.05).This
study analyzed a total of 4,134 elderly people (1,754 males and 2,380 females) over
the age of 65 who participated in 2011 Korean Longitudinal Survey of Aging.
2.2 Measurement

An electromyogram is a bio signal that shows the invisible movement of the muscle during motion and an electromyogram device measures the electronic signal generated in the muscle during motion [13]. To measure the muscle activity of the VL, RF, VM, AT, and GM, a surface electromyogram WEMG-8 (LXM5308, Laxtha Inc., Korea) was used. In total, 11 electrodes of 2,223 H were used. The sample collection rate of the signal was set at 1,024 Hz and a 60-Hz notch filter was used. The real-time analysis program TeleScan (LAXTHA Inc., Korea) was used for the signal storage and signal process of the electromyogram (Table 1) (Fig. 1).

Table 1. Electrode placement for detection of muscle activation

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Electrode placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vastus medialis</td>
<td>The distance along a line from the superior internal side of the patella to the</td>
</tr>
<tr>
<td></td>
<td>anterior medial iliac spine, starting from the patella</td>
</tr>
<tr>
<td>Rectus femoris</td>
<td>The distance along a line from the superior medial side of the patella to the</td>
</tr>
<tr>
<td></td>
<td>anterior inferior iliac spine, starting from the patella</td>
</tr>
<tr>
<td>Vastus lateralis</td>
<td>The distance along a line from the superior lateral side of the patella to the</td>
</tr>
<tr>
<td></td>
<td>anterior superior iliac spine, starting from the patella</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>The percentage distance from the medial side of the popliteus cavity to the</td>
</tr>
<tr>
<td></td>
<td>medial side of the achilles tendon insertion, starting from the tuberosity of</td>
</tr>
<tr>
<td></td>
<td>tibia</td>
</tr>
<tr>
<td>Tibialis anterior</td>
<td>The percentage distance from the tuberosity of tibia to the medial malleolus</td>
</tr>
<tr>
<td></td>
<td>line, starting from the tuberosity of tibia</td>
</tr>
</tbody>
</table>

Fig. 1. Each channel in EMG signal
2.3 Statistical analysis

The average and standard deviation were computed for the physical characteristics of each group and the measurement results of each variable. For the data treatment of the study results, the statistics program SPSS ver. 18.0 was used. An independent t-test was performed for the verification of differences according to chair type and gender. A paired t-test was performed for the verification of a difference between the standing and sitting groups. The statistical significance level $\alpha$ was set at 0.05.

3 Results

3.1 Socio-demographic variables of the research subjects

There was an even number of research samples for each gender, i.e., 26 men and 26 women. As for age, 20-years-olds were the majority, representing 55.8% of the sample, and as many as 78.8% of the research subjects regarded their health condition as healthy. As for smoking habit, non-smokers were dominant, representing 75.0% of the entire sample. The primarily used foot was the right foot, representing 92.3% of the sample, and the rate of alcohol consumption was mostly once or twice a week, representing 69.2% of the sample. Regarding family members, the combination of the participant and his/her parents was most common, representing 76.9% of the sample. As for monthly income, more than 300,000 KRW was the most common rate, representing 48.0% of the sample.

3.2 Comparison of muscle activity according to chair type

The muscle strength of the lower limbs increases more in the case of a small STS motion value according to chair type. There was no significant difference in a comparison of different chair types ($p>.05$). As for the VM, RF, and VL, the muscle activity increased more in the case of a fixed chair than a wheeled chair in both groups. The muscle activity of the GC and AT increased more in the case of a wheeled chair in both the standing and sitting groups and in the standing group, respectively, while the muscle activity of the AT increased more in the case of a fixed chair in the sitting group (Fig. 2).
3.3 Comparison of muscle activity according to chair type

The muscle activity of the VM increased more in the case of a standing position than a sitting position. The RF and VL also showed greater increases in muscle activity in a standing position than a sitting position. On the contrary, the GC and AT showed greater decreases in muscle activity in a standing position than a sitting position (Fig. 3).

4 Discussion

The STS motion is a functional task that is most commonly required in daily life. Moreover, the STS motion is an important motion that precedes functional activities, such as walking [14]. It is also a practical evaluation method frequently used in technical research and rehabilitation studies [15].
This study limited the ankle joint at 90 degrees; hence, it differs from previous literature that investigated the STS motion’s impact on the muscle activity of the lower limb muscles according to the changing location of the feet. When stand-to-sit and STS motions were performed with the knee joints at 90 degrees, the GM and RF did not show significant differences (p>.05), while the VM, VL, and AT showed significant differences (p<.05).

Cheng et al. [16] argued the AT is activated most often before lifting the hip during the STS motion, and it is a crucial factor for maintaining ankle stability. Lomaglio et al. [11] reported the RF, VL, and VM are among the muscles that are activated most during the STS motion.

As for the stand-to-sit motion, depending on the chair type, the VM, RF, VL, GM, and AT showed no significant differences in lower limb muscle activity during the stand-to-sit motion between a fixed chair and a wheeled chair (p>.05).

Cahill et al. [17] reported that the dynamic stability of the quadriceps muscle, GM, and soleus muscle is important for the STS motion, as they play a critical role in controlling motion speed. Moreover, Eriksrud et al. [19] reported the RF achieves knee stabilization prior to hip joint flexion and knee extension during the STS motion.

In this study, there was no significant difference between a fixed chair and a wheeled chair when the STS motion was performed on a stable, supportive surface. However, if the controlled condition that makes a supportive surface unstable, as well as diverse dependent variables are included in future studies, it can be useful for providing fundamental data regarding the muscle activation of lower limbs according to chair type. In future studies, it will be necessary to build a strong power of verification that can conform to the purpose of the study by using a greater number of research subjects and various evaluation tools.

5 Conclusion

From the study results, differences in lower limb muscle activation according to standing and sitting were confirmed, despite no significant difference among lower limb muscles between a fixed chair and a wheeled chair. In future studies, it will be necessary to build a strong power of verification that can conform to the purpose of kinematic analysis research related to the STS motion.

References