Analysis of Joint movements and muscle length during sit-to-stand at various sitting heights in the Korean elderly daily life

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Abstract— **In this study, we analyzed the elderly joint movements and changes in muscle length during STS at various sitting heights through the motion analysis and the musculoskeletal modeling. Five elderly and five young were participated in this experiment. Three heights of sitting posture which could represent typical sitting in Korean daily life were chosen as table seat (42cm), bath seat (21cm) and bottom (0cm). As the results, the elderly showed both smaller knee/hip flexion and larger trunk flexion relatively in comparison to the young during table seat STS. The elderly also showed larger dorsiflexion and smaller ROM of knee, hip, trunk compared to the young during bath seat STS. Additionally, the elderly showed larger plantarflexion, hip flexion, smaller knee flexion and trunk flexion during the first half of bottom STS and larger knee flexion, hip flexion and trunk flexion during the second half of bottom STS. In addition, we could know contraction and relaxation characters of major muscles in lower limb during various STS through the analysis of changes in muscle length by musculoskeltal modeling.**

Keywords— **Sit-to-stand, Joint movements, Muscle length, Korean elderly, Sitting heights**

I. Introduction

Sit to stand (STS) movement is one of the most common activities in daily life. Sit to stand movement is a complex activity: it requires an adequate postural control during the motor transfer from a stable 3-points base, the sitting position, to a 2-points base, the standing position[1]-[3].

With aging, the deterioration of the ability to rise from a chair contributes a major source of disability and handicap. It accentuates the risk of falling, the dependence level in daily living activities and can lead to institutionalization[4]-[6].

In addition, Korean traditionally stands up from various sitting heights in one's daily life compared to other foreigners. As Korea enter rapidly to the aging society, needs of the elderly independent life are increasing. Therefore the importance of research about the analysis of elderly activity in daily life is rapidly increasing. In this study, we analyzed joint movements and changes of muscle length during STS(sit-to-stand) at various sitting heights(table seat, bath seat, bottom) in the Korean elderly daily life by using the motion analysis and musculoskeletal modeling.

II. Materials and method

A. Subjects

Ten elderly (69.4±6.3years, 161.6±6.1cm, 60.9±4.7kg) and ten young (24.4±1.3years, 173.3±3.3cm, 65.5±5.9kg) were participated in this experiment(Table 1).

Table 1 Characters of subjects

	Elderly	Young
Age(yr)	69.4±6.3	24.4±1.3
Height(cm)	161.6±6.1	173.3±3.3
Weight(kg)	60.9±4.7	65.5±5.9

B. Motion analysis

Joint movements(ankle, knee and hip) in sagittal plane during STS were measured by using six infrared cameras (VICON, U.K.) and thirty nine reflective markers which were attached on the body as the plug-in gait marker set(Fig. 1).

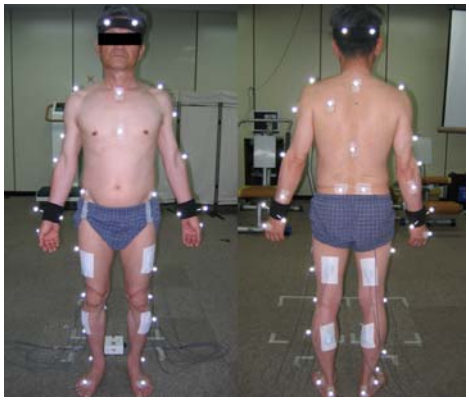

Fig. 1 Marker set for the motion analysis

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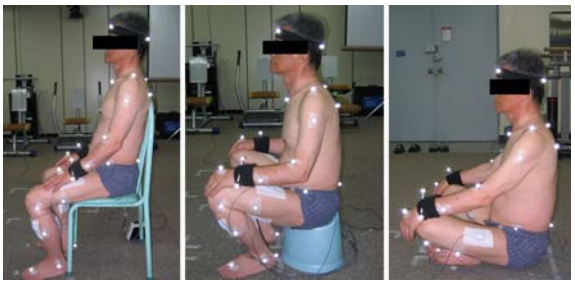
Three heights of sitting posture which could represent typical sitting in Korean daily life were chosen as table seat (height from bottom: 42cm), bath seat (21cm) and bottom (0cm) as shown in Fig. 2.



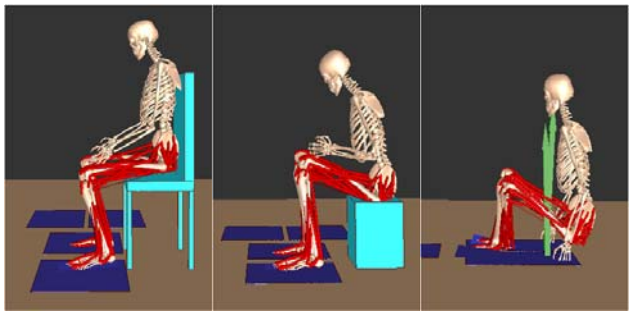
(a) TS STS (b) BS STS (c) Bottom STS

Fig. 2 Three heights of sitting posture for the experiment

All subjects were requested to keep the posture as close as possible to situations of their actual life. Every subject's feet were initially placed flat on the floor at a fixed location. The hands were also initially positioned on the knees. One cycle of STS was defined as from once the motion of standing started to when the motion of standing finished. In order to allow the assessment of trials consistency, subjects were asked to perform five trials with a break after each trial.

C. Musculoskeletal modeling & dynamic simulation

The musculoskeletal modeling and dynamic simulation were also performed to analysis changes of the length of major muscle in lower limb during STS using SIMM(Musculographics, U.S.A.) as shown in Fig. 3. Gastrocnemius, tibialis anterior, biceps femoris, rectus femoris, gluteus maximus and psoas were selected for major muscles of lower limb. We defend the muscle length in natural position as 100%, the muscle length was increased when the muscle relaxed and the muscle length was decreased when the muscle contracted.

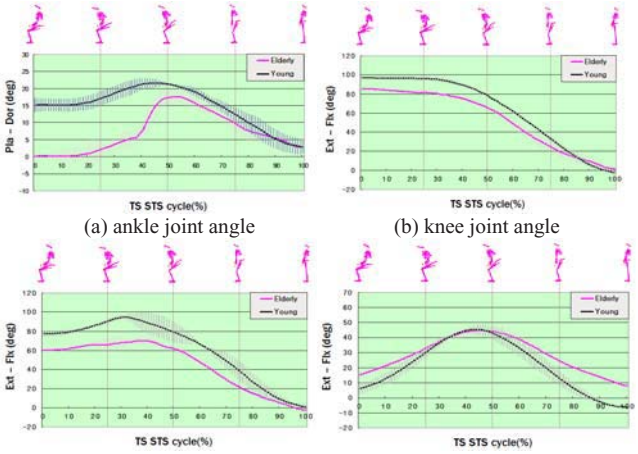


(a) TS STS (b) BS STS (c) Bottom STS

Fig. 3 Musculoskeletal modeling during STS

III. RESULTS & DISCUSSION

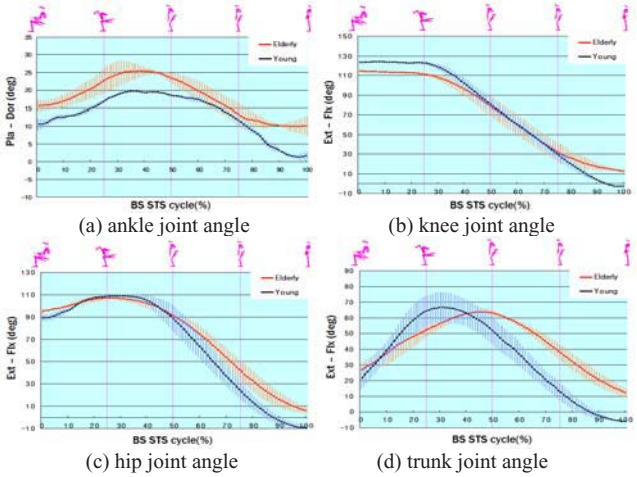
Fig. 4, Fig. 5 and Fig 6 were joint angles of during TS STS, BS STS and Bottom STS. The elderly showed both smaller knee/hip flexion and larger trunk flexion relatively in comparison to the young during table seat STS. The elderly also showed larger dorsiflexion and smaller ROM of knee, hip, trunk compared to the young during bath seat STS. Additionally, the elderly showed larger plantarflexion, hip flexion, smaller knee flexion and trunk flexion during the first half of bottom STS and larger knee flexion, hip flexion and trunk flexion during the second half of bottom STS. In addition, we could know contraction and relaxation characters of major muscles in lower limb during various STS through the analysis of changes in muscle length by musculoskeletal modeling(Fig. 7, Fig. 8).



(a) ankle joint angle (b) knee joint angle

(c) hip joint angle (d) trunk joint angle

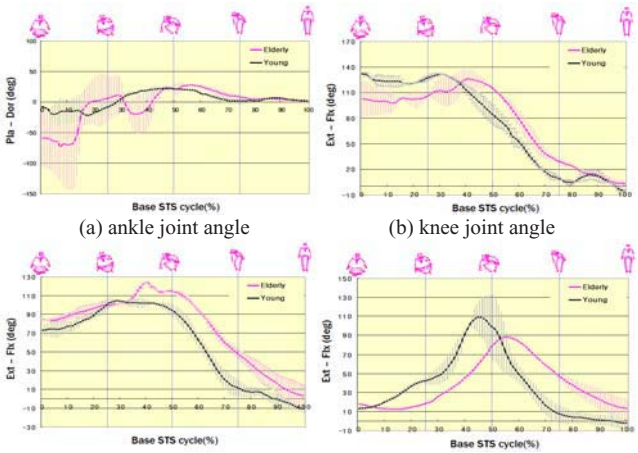
Fig. 4 Joint angles during table seat sit-to-stand(TS STS)



(a) ankle joint angle (b) knee joint angle

(c) hip joint angle (d) trunk joint angle

Fig. 5 Figure 5 Joint angles during bath seat sit-to-stand(BS STS)



(a) ankle joint angle (b) knee joint angle

(c) hip joint angle (d) trunk joint angle

Fig. 6 Joint angles during bottom sit-to-stand(Bottom STS)

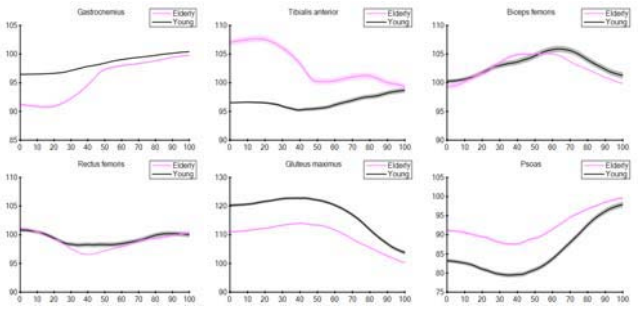


Fig. 7 Changes of the muscle length during TS STS

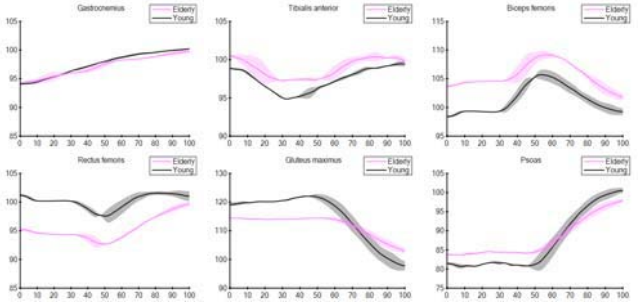


Fig. 8 Changes of the muscle length during BS STS

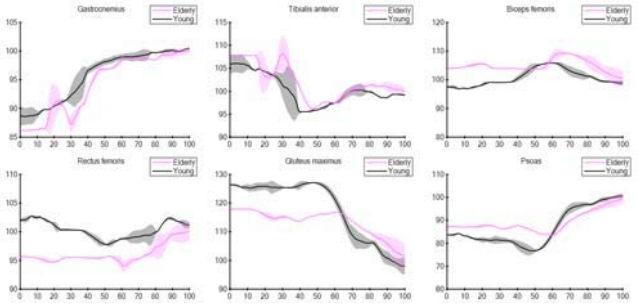


Fig. 9 Changes of the muscle length during Bottom STS

IV. CONCLUSIONS

Joint movements and changes of muscle length during STS(sit-to-stand) of various sitting heights(table seat, bath seat, bottom) in the Korean elderly daily life were analyzed by using the motion analysis and musculoskeletal modeling in this study. We expect results of this study could be useful information to design chairs for the elderly. In addtion, those also could be helpful to train and strengthen proper muscles for the sit-to-stand.

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