

# STATIC, DYNAMIC STANDING TRAINING BY USING THE SEGWAY AND SPASTICITY:A PILOT STUDY

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## INTRODUCTION

Spasticity is a common consequence after spinal cord injury (SCI) that affects 53-78 % of individuals with SCI (Maynard, Karunas, & Waring, 1990). Spasticity is defined as increased tonic stretch reflexes and exaggerated tendon jerks (Lance, 1980). Rehabilitation modalities, pharmacologic intervention and surgery are three main therapeutic techniques for spasticity management (Adams & Hicks, 2005). Physical therapy techniques are essential components of spasticity management that are useful and beneficial during and after pharmacologic and surgical strategies (Adams & Hicks, 2005). Standing trainings have been used as spasticity management techniques in individuals with SCI (Newman & Barker, 2012). The Segway is a standing transportation mobility device with spasticity reduction effects in individuals with SCI (Boutilier, Sawatzky, Grant, Wiefelspuett, & Finlayson, 2012). The main purpose of this study was to evaluate the effects of static and dynamic standing trainings by using the Segway on spasticity in individuals with SCI.

## METHODS

This study was a pilot single-blinded cross-over study. A total number of 10 individuals with SCI were participated in the study. To be considered in the study the participants had to have the following inclusion criteria:

- Between the ages of 18 and 65 years
- Spinal cord injury more than 1 year
- Spasticity of lower extremities (MAS  $\geq$  1) for at least 1 month before participating in the study
- Have the ability to rise from sitting to standing with no more than moderate assistance from one person or using long leg braces
- Without the experience of autonomic dysreflexia

Each participant was randomly assigned to participate in two different training sessions: static standing, and dynamic standing in two different days. The static and dynamic standing trainings were 20 min. Dynamic training session was done through a defined pathway in the lab by using the Segway. For the static training session, the participants stood on the fixed Segway. Spasticity outcome measures were done before, after, and one hour later of either static or

dynamic standing training. Spasticity was measured by three different spasticity outcome measures as listed below:

Visual Analogue Scale (VAS), Modified Ashworth Scale (MAS), and Electromyography (EMG). The following muscle groups were assessed by the spasticity outcome measures: rectus femoris, biceps femoris, and gastrocnemius muscles. The EMG was recorded during the MAS assessment. Ankle and knee goniometers were used to assess the start and stop of the movements.

The recorded EMG was analyzed by removing the offset, rectifying the EMG, notch filtered at 60 Hz. The rectified notch filtered EMG was further low pass filtered at 10 Hz. The baseline EMG was recorded for 30 sec and the calculated root mean square (RMS) of the baseline EMG was used as the reference. The passive movements EMG/baseline EMG was calculated for each movement and used for further analysis. The analysis of variance (ANOVA) was used to analyze the EMG and VAS changes before, after, and one hour later after static and dynamic movements. A 2x3 repeated measures of ANOVA were used for either VAS or EMG analysis. The MAS is a nonparametric spasticity outcome measure and the related-samples Friedman two-way analysis of variance by ranks statistical analysis method was used to analyze the MAS scores. Statistical significance was evaluated at an alpha level of 0.05.

## RESULTS

Ten individuals with SCI including nine male and one female with the level of injury between C3- T6 were volunteered to participate in the study. The average age of the SCI groups were  $40.4 \pm 11.15$ . There was no significant difference between static and dynamic standing trainings VAS outcome measure for quadriceps, hamstrings, and calf muscle groups. There was a decreasing trend during the time (before, after, and one hour later) for all tested muscle groups in dynamic standing training. For static standing training, the spasticity measured by VAS had a decreasing trend during the time for quadriceps muscle groups. In total, the decreasing trend of VAS measurement for all tested muscles were more prominent in dynamic standing compare to static standing.

There was no significant difference between static and dynamic standing trainings MAS outcome measure for

ankle dorsiflexion ( $P=0.571$ ), knee flexion ( $P=0.243$ ), knee extension ( $P=0.60$ ). The MAS was significantly decreased ( $P<0.05$ ) for knee extension (biceps femori muscle) during the time (before, after, and one hour later) MAS measures for dynamic standing training. There was no significant difference for ankle dorsiflexion ( $P=0.267$ ) and knee flexion ( $P=0.08$ ) during the time (before, after, and one hour later) MAS measures for dynamic standing training. There was no significant difference for ankle dorsiflexion ( $P=0.595$ ), knee flexion ( $P=0.276$ ), and knee extension ( $P=0.422$ ) during the time (before, after, and one hour later) MAS measures for static standing training.

Two-way ANOVA analysis showed a significant difference ( $P<0.05$ ) for gastrocnemius muscle EMG (ankle movement) through the time (before, after, and one hour later). The applied post-hoc test revealed a significant difference ( $P<0.05$ ) between before and one hour later gastrocnemius muscle EMG (ankle movement) for the dynamic standing training. Two standing trainings were significantly different ( $P<0.05$ ) for biceps femoris muscle during the knee movement.

## DISCUSSION

The main purpose of this study was to explore how two different standing conditions including dynamic standing on the Segway and static standing are effective to decrease spasticity in individuals with SCI who experience spasticity. The quadriceps, hamstrings, and calf muscle had a decreasing trend after both dynamic and static trainings with a more prominent reduction after dynamic standing training compare to the static standing training. In general, SCI participants found the dynamic standing more helpful to change their level of spasticity and muscle tone with a remaining effect one hour later. Adams and Hicks studied two different standing trainings (12 sessions) including stand with tilt-table and a body-weight support treadmill training setting and assessed spasticity changes by two self-assessment spasticity outcome measures including the SCI\_SET and PSFS (Adams & Hicks, 2011). The self-assessments showed a decrease in spasticity from the baseline measurements to post-activity measurements after multiple sessions with a more reduction after body-weight support treadmill training setting (Adams & Hicks, 2011).

The clinical spasticity outcome measure by MAS showed a significant decrease of knee extension (biceps femoris muscle) immediately and one hour later after dynamic standing training in individuals with SCI. The ankle dorsiflexion (gastrocnemius muscle) and knee flexion (rectus femoris muscle) decreased after both static and dynamic standing trainings with a more prominent decrease after dynamic standing training. Adams and Hicks showed a decreased after single session of body weight support treadmill training setting for sum of MAS (hip flexors, hip extensors, adductors, knee flexors, and knee extensors)

without any change during multiple sessions or tilt-table standing (Adams & Hicks, 2011). Boutilier et al. dynamic standing training on the Segway resulted in an immediate significant lower extremity spasticity reduction (Boutilier, Sawatzky, Grant, Wiefelspuett, & Finlayson, 2012).

Gastrocnemius and biceps femoris muscle activities had a decreasing pattern after the dynamic and static standing training during the ankle and knee passive movements respectively. Spasticity reduction measured by EMG was significantly different after dynamic standing training. Adams and Hicks neurophysiologic spasticity outcome measure by H-reflex after either body weight support treadmill training setting or tilt-table training revealed no change in H/ M ratio post-activity after a single or multiple sessions (Adams & Hicks, 2011). To our knowledge, there were no more studies that reported the surface EMG changes as spasticity outcome measure after dynamic standing trainings in individuals with SCI.

In conclusion, the dynamic standing training revealed more promising results versus the static standing training for spasticity reduction measured by three different outcome measures including self-assessment (VAS), clinical (MAS), and electrophysiologic (EMG) measures. All the tested muscles groups except the rectus femoris measured EMG showed a remained decreasing trend after dynamic standing training for all spasticity outcome measurements used in the study.

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