



Biomechanical Factors Influencing the Elderly Ability to Sit-To-Stand Manoeuvre

Bernelee DD* and Terry JE

Department of Human Movement and Therapeutic Sciences, South Africa

***Corresponding author:** Bernelee Denize Doherty Department of Human Movement and Therapeutic Sciences, Tshwane University of Technology, South Africa, Email: bddoherty95@gmail.com

Editorial

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Editorial

The sit-to-stand manoeuvre (STSM) is one of the most challenging biomechanical tasks an individual performs on daily, which dramatically increases with advanced age [1]. The successful execution the STSM depends on the intricate synchronization of hip, knee and ankle joint kinetics, and postural co-ordination to effectively control the body's center of mass (COM) within its base of support.

Human biomechanists have divided the STSM into four distinct phases, each requiring a specific coordinated strategy (Figure 1). The elderly often change activities within each phase to compensate for age related physiological declines in order to successfully complete the STSM [2]. The phases include flexion momentum, momentum transfer, extension and stabilization.

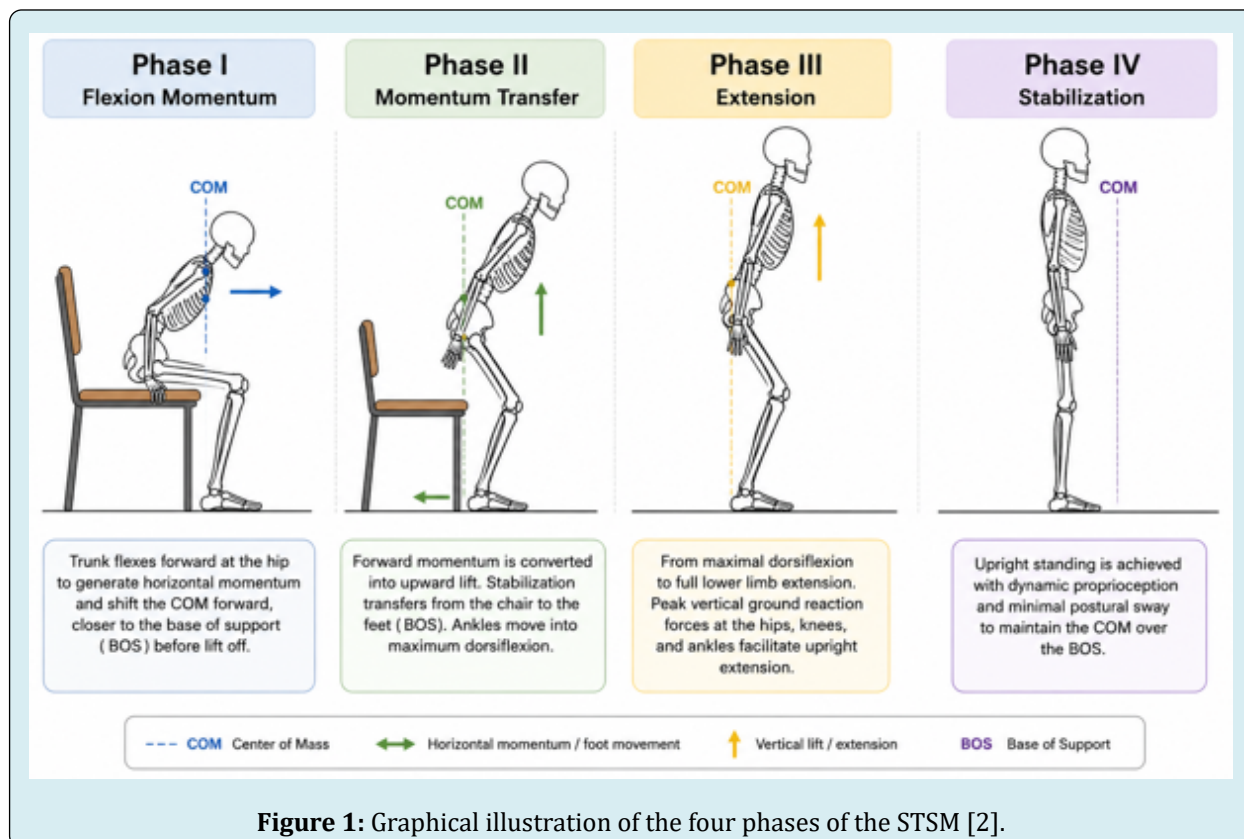


Figure 1: Graphical illustration of the four phases of the STSM [2].

Flexion momentum begins when the individual's upper body leans forward at the hip joint to generate horizontal momentum. The elderly frequently lean further forward as to generate a greater trunk flexion as to shift their COM closer to their base of support just before the engage in lifting off (Figure 1) [2]. This exaggerated biomechanical strategy reduces the demand placed on the knee extensors. People with large abdominal girth are placed at disadvantage, who often then must manipulate other environmental factors to successfully complete the STSM.

The momentum transfer phase is the important transition of converting the forward momentum produced by the greater trunk flexion into a vertical lift (Figure 1) [2]. This phase also involves the transfer of stabilization from the chair to base of support by the feet. The ankles move into maximum dorsiflexion. Therefore, many people will move their feet further under the chair. Limited ankle flexibility and strength limit this strategy.

The extension phase continues from maximal dorsiflexion to full lower limb extension. The extension phase is characterized by peak vertical ground reaction forces acting on the hips, knees, and ankles to facilitate upright lower limb extension (Figure 1) [2].

The stabilization phase is completed when the individual maintains their dynamic proprioception accompanied with minimal postural sway to achieve an upright standing position (Figure 1) [2].

The biomechanical factors influencing the elderly person's ability to successfully complete the STSM are categorized into internal physiological and external environmental. The internal factors include muscle torque generation at the knees, hip, and ankle.

Knee extensor torque is generated by the quadriceps femoris muscle, primary driver (agonist) of the extension phase. Sarcopenia associated with aging often decreases muscle strength of this muscle, which reduces its explosive power. If peak concentric quadriceps femoris torque falls below the threshold needed to vertically lift the body's mass, then the STSM fails [3].

The gluteus maximus and hamstrings (hip extensors) are essential for driving the trunk upward during the extension phase. Sarcopenia also reduces the vertical torque generation of the gluteus maximus muscles. The knee extensors and hip extensors synchronize their efforts to provide the explosive vertical lift in the STSM [4].

The tibialis anterior (dorsiflexor) and gastrocnemius and soleus (plantar flexors) synergistically coordinate their efforts to provide the much-needed torque during the lift-off

(momentum transfer and extension phases) to successfully complete the STSM. A significant biomechanical challenge among the elderly is the decreased passive ankle dorsiflexion range. If elderly person's the ankle cannot flex sufficiently (dorsi-flexion), the feet are unable to be placed far back under the chair. This enlarges the horizontal distance between the person's COM and their feet, which significantly increases the muscular effort needed at the hip and knee joints to achieve momentum transfer and vertical lift [5].

The external environmental factors include chair height, use of armrest of chair and foot placement. Manipulation of environmental factors assist the elderly to successfully complete the STSM, because their internal muscle generating torque decreases with aging.

Chair height plays a significant role in the successful execution of the STSM. Lower chair heights increase the need for greater knee and hip flexion, which subsequently increases the peak extension torques of quadriceps femoris and gluteal muscles to stand [1].

The use of armrest when rising from a chair, provides some of the needed extension torque to assist with the vertical lifting phase of the STSM, thereby reducing the knee and hip extension torques [1].

Foot placement also assists with the STSM. The greater posterior placement of the feet under the chair, produces greater dorsiflexion and planta flexion torque. This additional torque generated by the ankles further reduces the threshold torque of knees and hips to vertical lift the person [2].

Therapeutic Strategies to Help the Elderly Successful Sit-To-Stand

The elderly need to increase explosive muscle strength of their knee and hip extensors and triceps surae. Chair squat is recommended exercises to help a person successfully complete the STSM. The person should sit on a sturdy chair with their feet hip-width apart and lean forward to anteriorly rotate their pelvis. This will move their COM within their base of support of their legs. The person must push through their heels and stand up. This will ensure that the quadriceps, gluteus maximus and hamstrings maximally concentrically contract. To further assist the STSM the person can use the armrest of the chair, which reduces the vertical momentum threshold. One should initially start using a taller chair (a higher seat height), which further reduces the vertical threshold to complete the STSM.

Another exercise is gluteal contractions. The elderly person should practice squeezing their gluteal muscles when sitting. The stronger the squeeze or contraction, the more

explosive power they will generate to help them create a large vertical momentum to rise out of the chair.

Conclusion

The functional STSM becomes increasingly challenging as people age, therefore regular exercise and use of environmental biomechanical ergonomic strategies will help an elderly person successfully complete the task. Physiotherapists, occupational therapists and bio kineticists should prescribe explosive strengthening exercises for the gluteus maximus, quadriceps femoris and triceps surae.

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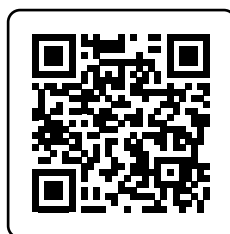
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