



# Investigation of motor strategies of sit to stand activity in elderly population

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## Research Article

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**Purpose:** The aim of the study was to identify the differences in motor strategies of elderly people compared to young people during sit to stand activity. **Material and methods:** Fifty-five healthy individuals who were over 75 years of age (35 females and 20 males) participated voluntarily. Age, gender, body weight, body height, body mass index and dominant lower extremity of participants were recorded. Sit to stand test was performed by using the Balance Master System. Weight transfer time, center of gravity sway velocity, rising to stand index, and weight bearing symmetry were measured. **Results:** Elderly people generated significantly lesser rising to stand index than young people ( $p<0.001$ ). Elderly people in our study preferred to bear weight on their right leg when compared to the left leg 98.41% to 1.59%, respectively. **Conclusion:** Elderly people chose different motor strategies compared with younger adults in terms of rising to stand index and weight bearing symmetry. Further study including muscular activation and kinematic assessments is needed to investigate how these different motor strategies occurred during sit to stand activity of elderly people. Better understanding of sit to stand activity in elderly will provide developing better assessment methods and therapeutic interventions to improve sit to stand activity of elderly people.

**Key words:** Elderly, Sit to stand, Weight-bearing, Activities of daily living.

## Yaşlılarda oturmadan ayağa kalkma aktivitesinin motor stratejilerinin incelenmesi

**Amaç:** Çalışmanın amacı, yaşlı bireylerin oturmadan ayağa kalkma aktivitesindeki motor stratejilerinin genç bireylerden farkını incelemektir. **Gereç ve yöntem:** Yetmiş beş yaş üzeri 55 sağlıklı yaşlı birey (35 Kadın ve 20 Erkek) çalışmaya katıldı. Yaş, cinsiyet, vücut ağırlığı, boy uzunluğu, beden kütle indeksi ve dominant ekstremitte bilgileri kaydedildi. Oturmadan ayağa kalkma testi Balance Master Sistemi ile değerlendirildi ve ağırlık aktarma süresi, ayağa kalkma indeksi, postural salınım derecesi, ağırlık taşıma simetrisi ölçüldü. **Sonuçlar:** Yaşlı ve genç bireylerin verileri karşılaştırıldığında yaşlı bireyler daha düşük ayağa kalkma indeksi gösterdiler ( $p<0.001$ ). Çalışmamızdaki yaşlı bireyler sağ bacağa % 98.41 ve sol bacağa % 1.59 oranında ağırlık aktarmayı tercih ettiler. **Tartışma:** Yaşlı bireyler gençlere göre ayağa kalkma indeksi ve ağırlık aktarma simetrisi açısından farklı motor stratejiler seçtiler. Bu farklı stratejilerin nasıl oluştuğunu değerlendirmek için kas aktivasyonları ve kinematik değerlendirmeleri içeren ileri çalışmalar gereklidir. Yaşlılarda oturmadan ayağa kalkma aktivitesinin daha iyi anlaşılması ve değerlendirmesi, doğru terapatik yaklaşımların geliştirilmesi ve yaşlılarda oturmadan ayağa kalkma aktivitesinin iyileştirilebilmesi için önemlidir.

**Anahtar kelimeler:** Yaşlı, Oturmadan ayağa kalkma, Ağırlık aktarma, Günlük yaşam aktiviteleri.

Ageing causes numerous declines in physical performance parameters which are related with changes in neuro-musculo-skeletal system of individuals.<sup>1-3</sup> The ability of an elderly person to live independently is upon their physical performance of important activities of daily living.<sup>4,5</sup>

Rising from a chair is an important basic task of daily living that depends on joint torques, coordination, and accurate balance control.<sup>6</sup> Disturbance of the ability to rise from a chair and to maintain balance at upright posture following rising constitutes a major source of disability with ageing. It accentuates the risk of falling, the dependence level in daily living activities and even risk of mortality.<sup>6,7</sup>

From neuromechanical perspective, sit to stand (STS) is one of the most commonly executed human movements. It is a complex motor task characterized by the transfer from one stabilized posture to another requiring the control of equilibrium during an important displacement of the body center of mass.<sup>8</sup> Researchers have found that STS movement requires greater muscle strength and a peak joint moment than other daily activities such as walking or stair climbing. Because of these mechanical demands, elderly people may experience difficulty when standing from a chair. Furthermore, STS function decline with ageing accentuates the risk of falls.<sup>9,10</sup>

Mobility disturbances such as STS activity are typically presents as early manifestations of disablement process.<sup>11</sup> Therefore, several studies have focused on STS activity, especially in the elderly population. Some determinants such as kinematics, executed forces during STS, have been clearly identified.<sup>12,13</sup> Although differences between elderly and young population have been revealed in these studies, there is no clear evidence.<sup>12</sup> Moreover, there is a lack of data about motor strategies for the achievement of this task in elderly people by means of musculoskeletal functions such as postural sway degree, weight transfer time, weight symmetry and the amount of the exerted force during rising phase. These parameters are important since the way these functions are combined in terms of timing,

weighting, maintaining postural balance together with the objectives that are pursued through their combination, pertain to the motor strategies. For this reason, the selected motor strategy and functional status of an individual are closely connected.<sup>12</sup>

In elderly, better knowledge of the motor strategies used in STS activity, along with better understanding of the limiting factors may lead better physiotherapy approaches of this critical task.<sup>6</sup> The aim of the study was to identify the differences in motor strategies of elderly people as compared to young individuals during STS activity.

## MATERIAL AND METHODS

### Subjects

Fifty-five healthy individuals (35 females and 20 males) living in Narlıdere Geriatric Home Care Center, İzmir, accepted to take part in this study. Each subject received information about the study and gave written consent to participate. The study was approved by the Local Ethical Committee.

Elderly adults who were 75 years old and over, had ability to perform self care activities of daily living without difficulties or need for help, able to walk independently without assistive device were included in the study. None had a chronic or acute illness leading to an inflammatory syndrome and pain at the occasion of the test. Others with impaired cognitive status (<24 on Mini Mental State Examination (MMSE) Score), psychiatric disorders requiring drug treatment, previous lower limb surgery and neurological disorders influencing postural balance control, visual disorders (not able to see distance closer than 4 m) were excluded from the study. They were all able to see adequately and follow instructions. The medical information (MMSE scores and diagnosis) were obtained from the medical reports of the Geriatric Home Care Center.

The normative values in Balance Master System which have been obtained from healthy young individuals were used as controls. The control group was consisted of 74 young individuals (43 females and 31 males) who were

aged between 20 and 39 years. They had no current or past medical diagnosis or injury affecting balance, no medications affecting the central nervous system or known to affect balance or coordination, no symptoms of dizziness or lightheadedness, no symptoms of vestibular or neurologic disorders, no psychological disorders, no history of two or more unexplained falls within the past 6 months. They had normal vision with or without glasses.<sup>14</sup>

Elderly subjects' characteristics recorded included; age, gender, body weight, height, body mass index and dominant lower extremity. Lower extremity dominance was determined by asking which leg they would prefer to hit a ball.

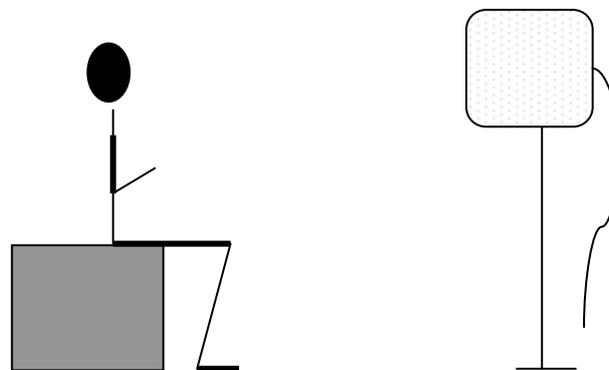
#### Testing procedure

To evaluate STS movement, a STS test was performed by using the Balance Master System Version 8 (Neurocom Inc., Glocams, USA). The system has a force platform connected to a computer which is capable of detecting center of gravity (COG) sway during different tasks. The equipment provides quantitative data through STS test that reproduce activities of daily living.

During the measurements subjects were positioned on the platform facing the monitor with barefoot (Figure 1). They performed STS movement from a seated surface. The starting position before each trial was standardized by placing knees at 90 degree flexion by adjusting foot placement. Subjects were allowed one practice trial for familiarization with the procedure of the test. Subjects were instructed to stand up as quickly as possible when start sign appear on the monitor. They were not allowed to use arms or hands to push off their legs or the seated surface. Following the STS movement subjects were also instructed to stand as still as possible for 5 seconds to measure COG sway. System requires the STS trial three times.

Important components of this task measured by the system include shifting the body's COG sway from initial position over the seat to a location centered over the base of support, followed by extension of the body to an erect standing position while maintaining the centered COG position. The measured parameters were

weight transfer time, rising index, sway velocity during rising phase and left-right symmetry (explanations of parameters are in Figure 2).



**Figure 1. Schematic representation of the initial posture and of the experimental set-up.**

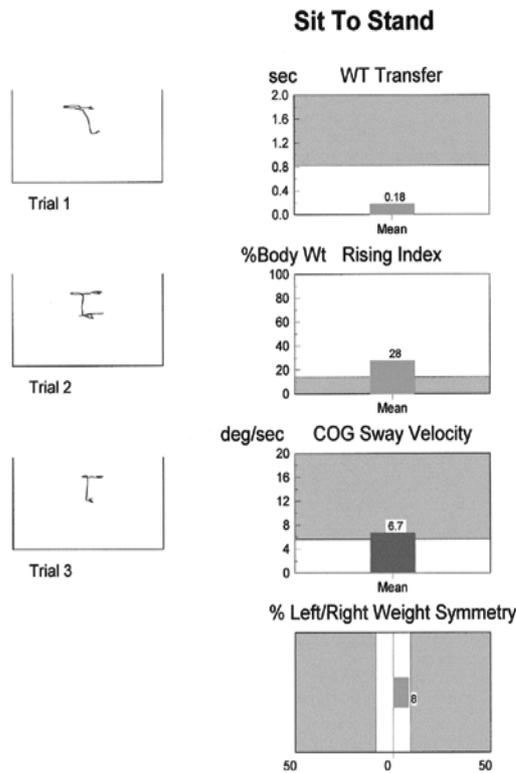
#### Statistical analysis:

All analyses were performed with SPSS version 11.0. The data were analyzed by using one sample t test and normative values of Balance Master System which have been obtained from healthy young individuals were used as controls. Statistical significance was set at  $p < 0.05$ .

## RESULTS

Data were analyzed for 53 healthy elderly individuals (35 females and 18 males) since two of them had incomplete data. Demographics of the participants are presented in Table 1. Data from sit to stand test include time to transfer weight over center of base of support, rising index, the amount of COG sway, left and right weight symmetry.

No significant difference was found for weight transfer time with regard to age although elderly people had higher transfer time than normative data of young people ( $p = 0.096$ ). Elderly people generated significantly lesser rising index, which is the amount of forces on the force platform, than data of young people ( $p < 0.001$ ). The COG sway degree was tended to be higher in elderly group by indicating no significance value ( $p = 0.082$ ) (Figure 3). Elderly people in our study



**Weight Transfer** is the time in seconds required to voluntarily shift COG forward beginning in the seated position and ending with full weight bearing on the feet

**Rising Index** is the amount of force exerted by the legs during the rising phase. The force is expressed as a percentage of the patient’s body weight.

**Cog Sway Velocity** documents control of the COG over the base of support during the rising phase and for 5 seconds thereafter. Sway is expressed in degrees per second.

**Left/Right Weight Symmetry** documents differences in the percentage of body weight borne by each leg during the active rising phase.

**Figure 2. An example of report of Sit to Stand Test, and explanations of measured parameters.**

preferred to weight bearing on their right leg and left leg by 98.41% and 1.59%, respectively.

**Table 1. Characteristics of the elderly subjects (N=55).**

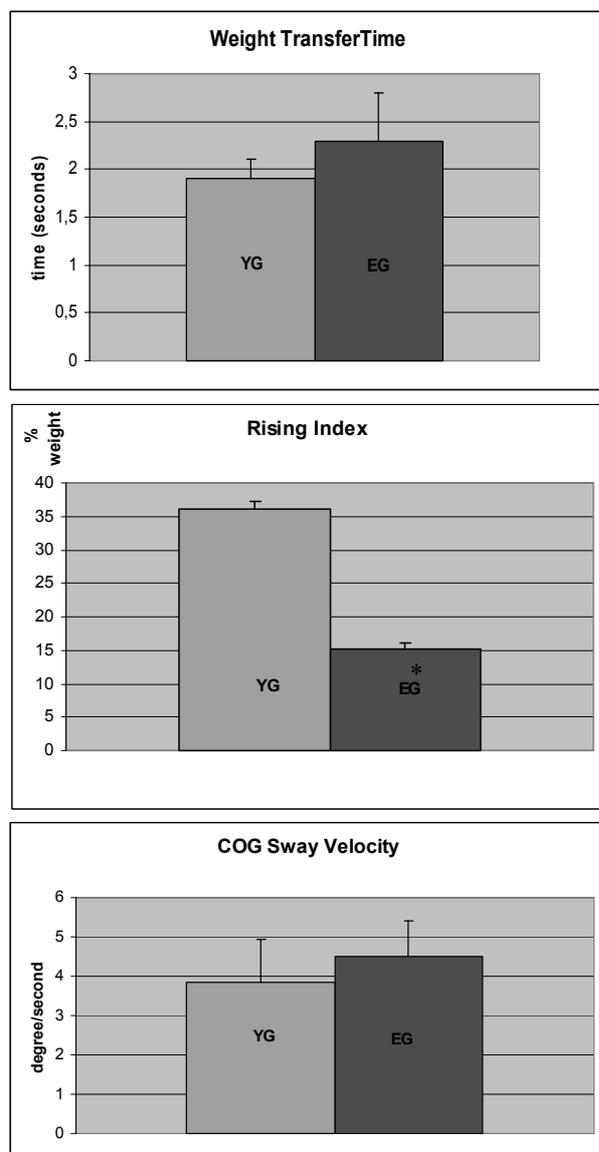
	Mean±SD
<b>Age</b> (years)	79.1±9.3
<b>Height</b> (cm)	161.0±15.5
<b>Body weight</b> (kg)	71.5±3.4

**DISCUSSION**

The purpose of this study was to identify the possible differences in motor strategies between healthy elderly people and young population during STS movement. We have measured the time to transfer weight over center of base of

support, the amount of COG sway, rising index, left and right weight symmetry.

Rising from a chair to a standing position is influenced by numerous factors including motor control and balance factors. Accurate control of COG position is critical to control the rise movement as well as to maintaining postural stability.<sup>1</sup> The weight transfer time, assessed in our study, is one of the indicators of controlled and successful rising. Increased times indicate decreased ability of moving COG forward.<sup>4</sup> Decreased reaction time and nerve conduction velocity by ageing may cause increased weight transfer time in elderly people.<sup>16</sup> The STS movement times reported in previous studies range from 1 to 6 seconds. Young people are generally can perform STS task less than 2 seconds, and those of elderly people needs more than 2 seconds.<sup>12</sup> In our study, the STS times of elderly subjects were 2.3 seconds. Since the findings of Yoshioka et al suggested that people



**Figure 3. Weight transfer time, rising index and COG sway velocity of young and elderly groups (YG represents NeuroCom data range of young group, EG represents elderly group). Error bars show the standard deviations (\* Significantly lesser,  $p < 0.05$  by one sample t-test).**

having minimal strength and coordination to stand up once, can stand up about 2.5 seconds, we may suggest that strength and coordination of elderly subjects in our study were enough to perform the task.<sup>9</sup> On the other hand, Nevitt et al, found that for people who could achieve the STS test in more

than 2 seconds. The risk of two or more falls in one year was 2.4 times the risk of one or no falls.<sup>17</sup> Therefore, our results suggested that elderly people in this study should be followed for fall risk.

Elderly people in our study also showed increased COG sway velocity. Since the increased COG sway velocity shows worse balance control, this result means that during the rising phase and for 5 seconds thereafter, elderly people had weaker balance control compared with the young population. This finding was parallel with the results of previous studies stating higher COG sway in elderly individuals than young individuals.<sup>18</sup>

Parallel to the previous studies, it was found that rising index of elderly group had lower values than young population.<sup>4</sup> Since the rising index is the amount of force exerted by the legs during the rising phase, it was expected to decline with increasing age. Rising index is considered to be an indicator of lower extremity extensor muscle strength. In rising phase, the legs must extend, push down against the surface to produce counterforce sufficient to raise the body to a standing position. The elderly group in our study performed lower rising index score than young population indicating lower extensor muscle strength of lower extremity.

One possible explanation of lower rising index score of elderly group could be initial trunk position of elderly people to start STS movement. Elderly people tend to flex their trunk more and at a higher velocity to gain a higher momentum than young individuals.<sup>19</sup> Muscular effort required to further rotating the body forward was lesser. Unfortunately, we did not check the subjects during STS task performance for their trunk positions. It should be taken in account in further studies on STS movement and elderly.

Another parameter that was tested by the system during STS was left/right weight symmetry. The relative amount of weight bearing by each leg during rise to stand and for 5 seconds after rise was measured and expressed as a percentage. Elderly people in our study preferred to bear weight on their right leg and left leg by

98.41% and 1.59%, respectively. Excessive loading was on their right leg. It is worth to note that all of the participants in our study reported their dominant extremity as right leg. The ideal percentage is 50% bearing on right and 50% bearing on left extremity. An individual with 60% of body weight on right leg and 40% on left are to be expected.<sup>14</sup> These excessive percentages on one side may reflect strength loss, sensory loss or joint restriction. We did not found any study reporting weight bearing asymmetry during STS movement in elderly population that we can compare our results with it.

The results of this study contributed the empirical studies by providing basic information to perform more advanced research in this subject. Papa et al also investigated differences between motor strategies of STS activity in elderly and young subjects but they have chosen a different method as telescopic inverted pendulum model.<sup>12</sup> Therefore, their selected motor strategy parameters were different than the parameters used in this study and more complicated to calculate in a clinical context. The method we used is a simpler assessment to apply and easier to interpret in a clinical environment.

To be able to interpret these results in a more detailed way, further studies should be performed by controlling kinematics of lower extremity and trunk movements for the same selected motor strategy parameters. Unfortunately, we did not observe muscle activation during tests which might further explain differences in rising index parameter and weight bearing asymmetry. Further study may include electromyography measurements. Besides absence of kinematic and electromyography data, another limitations of our study was sample size since we assessed healthy elderly individuals who met with our strict inclusion criteria. Further studies including more participants and above mentioned evaluation methods (electromyography, muscle strength, and kinematic assessments etc.) will provide deeper information on STS and elderly population.

In conclusion, this study showed that elderly people chose different motor strategy as compared to younger adults in terms of rising index and

weight bearing symmetry which may lead disequilibrium during performing of the task. Physiotherapists who are training STS activity in elderly individuals may pay attention for weight bearing asymmetry to prevent poor balance ability during the task. Understanding STS movement and utilization of the findings of STS studies will help to develop therapeutic intervention programs for elderly population.

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