ISSN 2706-6819 Vol.5, Issue 6: 85-88, DOI: 10.25236/IJFM.2023.050613

A Comparison of Sit to Stand Movement between Stroke Subjects and Healthy Subjects

Weiyi Zhan[1], Jia Liu[2,*], Zizhuo Xu[3], Lan Zhu[4]

[1]*School of Healthcare Sciences, Cardiff University, Cardiff, the United Kingdom, CF14 4XN*
[2]*Department of Obstetrical, Nanjing Maternity and Child Health Care Hospital, Nanjing, China, 210000*
[3]*School of Kinesiology Individual with Disability, University of Virginia, Charlottesville, the United States of America, 22904*
[4]*Department of Rehabilitation, the First Affiliated Hospital of Nanjing Medical University, Nanjing, China, 210000*
**Corresponding author*

Abstract: *The sit to stand (STS) movement is a vital part of the activities of daily living (ADL). Due to the influence of the decreasing balance ability, patients with stroke would have high risk of falling when conducting this common movement. This essay had explored and compared the difference of the STS movement between patients with stroke and healthy adults from angular displacements of the trunk and lower limbs, muscular activation, postural control, weight bearing distribution and time aspects in kinematics and kinetics views, which aims to provide reference on reducing the risk of falls and improve the motor function for stroke survivors.*

Keywords: *sit to stand, stroke, kinematics and kinetic*

1. Introduction

Sit to stand (STS) is an essential movement of daily life. It is considered as an excessive action of standing posture which is a basic component of activities of daily living (ADL)[1]. ADL focuses on the independence of people with disabilities [2]. Approximately 40% of stroke survivors suffer from decreased balance ability, including weight imbalance, postural instability and a reduction in the limits of stability[3]. These symptoms will increase the potential risk of falling during the STS process and decrease functional independence [4]. The aim of this article is to understand STS characteristics from the kinematics and kinetics aspect to improve motor function and reduce the risk of falls among stroke survivors. A literature review was conducted to compare the differences during STS process aspects between healthy subjects and subjects with stroke. Keywords including ‘stroke’, ‘sit to stand’ and ‘healthy subjects’ were combined with ‘and’. Articles were collected from different electronic databases: PubMed, Web of Science, MEDLINE, and Cochrane Library.

2. Main body

In trunk position aspect, Ohtsuru, Eto, Wada, Saotome and Furuichi [5] found that compared to normal, some stroke patients tend to exhibit a backward tilt in the sagittal plane in the beginning sitting phase of STS. Combined with the author's inference, this tilt was caused by lack of core muscle strength. Furthermore, the total time will increase when standing from this position since patients' bodies must have extra tilt forward, which can put too much load on the knees and ankles and make STS more difficult to finish [6]. Impairments for the generation and transfer of the trunk flexor momentum will also affect STS position [6]. In the frontal plane, post-stroke subjects' trunks would tilt to the less affected side when they stood up from the seat position, while healthy individuals showed a nearly neutral trunk position [7], since for healthy people in spontaneous or symmetrical foot positions, the feet gradually assumed the support of the body weight with the knee and hip in flexion position, the joint moments at the hip and knee reached the maximum, but for stroke patients’, decreased knee moment appeared on the paretic side, the paralytic limb cannot undertake the weight, which lead to asymmetry [7, 8]. A study showed that patients' hips were still extending when the knee completed extension at the end of STS [9], which could be attributed to post-stroke patients with hemiplegia usually lacking coordination between hip and knee displacements. Lecours, Nadeau, Gravel and Teixera-Salmela [10] found that stroke survivors' tilt angle

ISSN 2706-6819 Vol.5, Issue 6: 85-88, DOI: 10.25236/IJFM.2023.050613

of the trunk in the frontal plane (12.1°) was six times higher than the healthy person (2°). The authors considered the abnormal condition in the foot affected the absolute trunk translation, trunk flexion, the weight-bearing and moment asymmetry since the hemiplegic foot cannot be supported by the ground reaction, thus create this huge gap. A high number of studies also show the similar displacement, among them Hirschfeld, Thorsteinsdottir and Olsson [7] found this movement in post-stroke subjects even appeared before the seat-off phrase, the abnormal angular displacement of the trunk and hemiplegic limb are the source to create the angle differences in the STS, which exacerbates trunk instability. When requested to do an anterior trunk flexion in a sitting position, although with similar trunk motion amplitude, stroke patients had less center of pressure displacement than healthy subjects [11], and the explanation is that anterior flexion of the trunk is implemented mainly by flexion of the upper trunk while the pelvis occurred a slight anterior tilt, thus the decreased anterior pelvic tilt appears and affects the movement. However, placing the affected foot behind another foot can effectively narrow the gap of trunk asymmetry with healthy people by 30 % to 50 % for different muscles [12, 13]. It can be explained as this position can increase the paretic limb loading and joint angles of the dorsal knee and ankle. When in this position, patients' affected side's front loading increased for muscles of hip extensors, knee extensors and ankle plantar flexors, accordingly, increasing the knee and ankle joint moment, and eventually increasing the paretic lower limb muscle function [12].

Compared with healthy people, patients' muscle activity in the chronic phase decreased significantly. The impairment of lower limb muscle including tibialis anterior, soleus and quadriceps, was the main reason [14]. The average start time of muscle activity of post-stroke subjects accounted for 12.5 % of the total time for STS movement, nearly twice that of healthy subjects [15]. Combined with the analysis of the authors, the phase which activating tibialis anterior was delayed due to loss of muscle control caused by the stroke, which leads patients to fail to recruit the affected lower limb at the right moment to conduct STS. Unlike healthy people, patients usually activate the soleus muscle prior to seat-off phase, which is a potential result of muscle spasms [16]. Tibialis anterior, soleus muscles and quadriceps were observed with higher EMG activity and early hamstring activation in stroke patients when compared with healthy people, and this phenomenon occurred as compensation of the paretic lower limb and is associated with increased weight bearing on the less affected side [17].

For patients, the movement of the center of mass shifted laterally towards the less affected side by 78% and 50% more in the phases of before seat-off and after seat-off separately than healthy people [10, 18]. According to the author's inference, explanation could be the trunk having a wider range of movement in the mediolateral direction. Duclos, Nadeau and Lecours [18] measured the maximal time before the center of pressure (CoP) reaches the limit of the base of support in the mediolateral plane. The result showed a shorter time for stroke subjects than healthy subjects, indicating stroke subjects have poorer dynamic stability. Authors speculated the result was primarily associated with impaired motor function of the paretic limb, less related to the strength of trunk muscle and degree of spasticity.

Compared with the healthy person separate weight on two legs averagely, stroke patients' less affected leg need to bear approximately 15 % of the extra load during STS, and the distribution of weight bearing (WB) for stroke patients in the foot is also unbalanced in different foot position [7, 19]. A significant number of studies also showed similar results. Among the study, Briere, Lauziere, Gravel and Nadeau [20] analyzed that both WB asymmetry and errors of WB perception appeared in stroke patients during STS. Asymmetry of the knee extensor strength was the main factor of unbalanced distribution for WB. Briere, Nadeau, Lauziere, Gravel and Dehail [21] also attribute the reason for the perception problem to knee muscle strength impairment. However, the same authors improved the previous research method by testing the intraclass correlation coefficient in the subjects [22].In the study, perception and real distribution's scores were higher than that of the level of muscle effort for weight bearing, which reveals a more accurate result that stroke survivors decreasing ability to determine the perception of effort spent on the knee is more related to proprioceptive sense rather than the motor function of muscles. Compared with the healthy subjects, the distribution of weight bearing in the vertical angle was also observed for stroke survivors [23]. The damaged of perceptions of verticality, the haptic vertical and the postural vertical were reasons. If the right hemisphere of the brain is involved in the injury, the STS movement will also be affected since the injury of nerve function is manifested in the form of injury of motor function [24]. Extensors muscles' weakness in the affected limb may also interfere with the weight bearing distribution vertically [25].

A high number of studies illustrated that stroke survivors generally take more time than healthy subjects to perform STS, despite the specific values varying depending on the experimental design. Stroke patients' kinematic changes related to the declining ability to generate and transfer trunk flexor momentum, is one of the major results leading to an extension of the time to complete STS [26]. Lecours,

ISSN 2706-6819 Vol.5, Issue 6: 85-88, DOI: 10.25236/IJFM.2023.050613

Nadeau, Gravel and Teixera-Salmela [10] claim that the increased time was nearly equally distributed to trunk flexion before off-seat, and before hip and knee joints reached full extension. However, a similar experiment found the increased time from off-seat to the hip reaching the stable extension in standing position, was most obvious [6]. One explanation may be the average age difference between the stroke patients and healthy subjects in this study (59.78 Vs 59.67) was smaller than that in the above study (49.93 VS 56.1), thus the smaller age gap makes this study more reliable. These changes may be associated with decreased trunk control and muscle activation and it indicated that the later phase is the most likely stage to fall since patients spend the most time adjusting their body balance in an unstable state [6]. Time to reach maximum knee joint moment had a sharp delay than healthy subject since during abrupt transitory knee extension phase [12]. Combined with the authors' analysis, since the maximum knee joint moment for patients was sharply lower than healthy body, which requests patients spend more time to get balance and reach maximal extension, thus decreasing knee moment on the paretic side appear and create the reduction of time [26]. Cheng, Liaw, Wong, Tang, Lee and Lin [27] found subjects who fell before needing extra time to stabilize swing around the center of mass and took the longest time (4.32 s) to finish STS than healthy people (1.88 s) and stroke patients who never experienced falls (2.73 s), and this finding revealed the increased time during STS could be a significant indicator of the likelihood of falling due to altered activation patterns of important lower limb muscles on the affected side. For healthy people to make full use of the kinetic energy acquired during forwarding movement, the standing movement of seat-off to the end must follow the horizontal movement of beginning to seat-off at the fastest speed, however, stroke patients fail to perform this action coherently [6], since increasing the speed and the stability of STS performance are connected with the increased muscular needs of the trunk for the generation and control of the flexor momentum, and these are the abilities most stroke patients lack, which creates the different [25] .

3. Conclusion and implication

This essay compared the differences between stroke individuals and healthy subjects in STS movement from angular displacements of the trunk and lower limbs, muscular activation, postural control, weight bearing distribution and time aspects in kinematics and kinetics views. According to the essay, causes of motor dysfunction are varied but interrelated. The results of this paper also provide implications for clinical application. Stroke individuals can use adaptive policy to compensate for asymmetric deficit patterns related to hemiplegia, which makes the less affected side's compensation of patients more obvious when compared with normal people. Targeted clinical rehabilitation methods could be developed to improve motor function according to these deficiencies to improve performance in daily living for stroke patients. Clinically, training of muscle strength and training for range of joint motion are universally applicable solutions. Besides, auditory or visual feedback and adjustment for foot position were used as compensation for balance as they were the most appropriate compromise for the decrease of muscle activation, safety insurance and being effective during the STS process. Improving the position of the limbs to produce larger vertical force or undertake more bodyweight on the paralyzed limb can also improve motor function. Further study could focus on the design of appropriate treatment approaches and comparison of effectiveness for these methods.

References

[1] VAUGHAN-GRAHAM J(2019), PATTERSON K, BROOKS D, et al. Transitions sit to stand and stand to sit in persons post-stroke: Path of centre of mass, pelvic and limb loading - A pilot study [J]. Clin Biomech (Bristol, Avon), 61: 22-30.

[2] LAVERDURE P, BEISBIER S(2021). Occupation- and Activity-Based Interventions to Improve Performance of Activities of Daily Living, Play, and Leisure for Children and Youth Ages 5 to 21: A Systematic Review [J]. The American journal of occupational therapy, 75(1): 7501205050-p24.

[3] ISHO T, USUDA S(2016). Association of trunk control with mobility performance and accelerometry-based gait characteristics in hemiparetic patients with subacute stroke [J]. Gait Posture, 44: 89-93.

[4] POLLOCK A, GRAY C, CULHAM E, et al(2014). Interventions for improving sit-to-stand ability following stroke [J]. Cochrane database of systematic reviews, 5(5): CD007232-CD.

[5] OHTSURU I, ETO F, WADA N, et al(2001,). New reliable and valid motor assessment scale for stroke patients: Hemiplegic motor behavior tests [J]. Geriatrics & gerontology international, 1(1-2): 45-51.

[6] SILVA P F, QUINTINO L F, FRANCO J, et al(2017). Trunk kinematics related to generation and transfer of the trunk flexor momentum are associated with sit-to-stand performance in chronic stroke survivors [J]. NeuroRehabilitation, 40(1): 57-67.

ISSN 2706-6819 Vol.5, Issue 6: 85-88, DOI: 10.25236/IJFM.2023.050613

[7] HIRSCHFELD H, THORSTEINSDOTTIR M, OLSSON E(1999). Coordinated Ground Forces Exerted by Buttocks and Feet are Adequately Programmed for Weight Transfer During Sit-to-Stand [J]. Journal of Neurophysiology, 82(6): 3021-9.

[8] GALLI M, CIMOLIN V, CRIVELLINI M, et al(2008). Quantitative analysis of sit to stand movement: experimental set-up definition and application to healthy and hemiplegic adults [J]. Gait Posture, ,28(1): 80-5.

[9] ADA L, WESTWOOD P. A kinematic analysis of recovery of the ability to stand up following stroke [J]. Australian Journal of Physiotherapy, 1992, 38(2): 135-42.

[10] LECOURS J, NADEAU S, GRAVEL D, et al(2008). Interactions between foot placement, trunk frontal position, weight-bearing and knee moment asymmetry at seat-off during rising from a chair in healthy controls and persons with hemiparesis [J]. J Rehabil Med, 40(3): 200-7.

[11] MESSIER S, BOURBONNAIS D, DESROSIERS J, et al(2004,). Dynamic analysis of trunk flexion after stroke [J]. Archives of physical medicine and rehabilitation,85(10): 1619-24.

[12] MAO Y R, WU X Q, ZHAO J L, et al(2018). The Crucial Changes of Sit-to-Stand Phases in Subacute Stroke Survivors Identified by Movement Decomposition Analysis [J]. Front Neurol, 9: 185.

[13] BRUNT D, GREENBERG B, WANKADIA S, et al(2002,). The effect of foot placement on sit to stand in healthy young subjects and patients with hemiplegia [J]. Arch Phys Med Rehabil, 83(7): 924-9.

[14] ROLDAN-JIMENEZ C, BENNETT P, CUESTA-VARGAS A I(2015). Muscular Activity and Fatigue in Lower-Limb and Trunk Muscles during Different Sit-To-Stand Tests [J]. PLoS One,10(10): e0141675.

[15] SILVA A, SOUSA A S, PINHEIRO R, et al(2013). Activation timing of soleus and tibialis anterior muscles during sit-to-stand and stand-to-sit in post-stroke vs. healthy subjects [J]. Somatosens Mot Res, 30(1): 48-55.

[16] CAMARGOS A C, RODRIGUES-DE-PAULA-GOULART F, TEIXEIRA-SALMELA L F(2009). The effects of foot position on the performance of the sit-to-stand movement with chronic stroke subjects [J]. Arch Phys Med Rehabil, 90(2): 314-9.

[17] LEE T-H, CHOI J-D, LEE N-G(2015). Activation timing patterns of the abdominal and leg muscles during the sit-to-stand movement in individuals with chronic hemiparetic stroke [J]. Journal of physical therapy science, 27(11): 3593-5.

[18] DUCLOS C, NADEAU S, LECOURS J(2008). Lateral trunk displacement and stability during sit-to-stand transfer in relation to foot placement in patients with hemiparesis [J]. Neurorehabil Neural Repair,22(6): 715-22.

[19] ROY G, NADEAU S, GRAVEL D, et al(2007). Side difference in the hip and knee joint moments during sit-to-stand and stand-to-sit tasks in individuals with hemiparesis [J]. Clin Biomech (Bristol, Avon), 22(7): 795-804.

[20] BRIERE A, LAUZIERE S, GRAVEL D, et al(2010). Perception of weight-bearing distribution during sit-to-stand tasks in hemiparetic and healthy individuals [J]. Stroke,41(8): 1704-8.

[21] BRIERE A, NADEAU S, LAUZIERE S, et al(2013). Knee efforts and weight-bearing asymmetry during sit-to-stand tasks in individuals with hemiparesis and healthy controls [J]. J Electromyogr Kinesiol, 23(2): 508-15.

[22] BRIERE A, NADEAU S, LAUZIERE S, et al(2013). Perception of weight-bearing and effort distribution during sit-to-stand in individuals post-stroke [J]. Percept Mot Skills,, 117(1): 1208-23.

[23] BARRA J, MARQUER A, JOASSIN R, et al(2010). Humans use internal models to construct and update a sense of verticality [J]. Brain, 133(Pt 12): 3552-63.

[24] YELNIK A P, KASSOUHA A, BONAN I V, et al(2006). Postural visual dependence after recent stroke: assessment by optokinetic stimulation [J]. Gait Posture, 24(3): 262-9.

[25] FRANCO J, QUINTINO L F, FARIA C D C M(2021). Five-repetition sit-to-Stand test among patients post-stroke and healthy-matched controls: the use of different chair types and number of trials [J]. Physiotherapy theory and practice, ,37(12): 1419-28.

[26] VAN BLADEL A, ONURSAL KILINç Ö, DE RIDDER R, et al(2021). Trunk and lower extremity biomechanics during sit-to-stand activity after stroke: A systematic review [J]. Gait & Posture, 90.

[27] CHENG P-T, LIAW M-Y, WONG M-K, et al(1998). The sit-to-stand movement in stroke patients and its correlation with falling [J]. Archives of physical medicine and rehabilitation, 79(9): 1043-6.