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Foot placement and arm position affect the five times sit-to-stand test time of individuals with chronic stroke

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Abstract
Objectives: To find out effect of two foot placements (normal and posterior placement) and three arm positions (hands on thighs, arms crossed over chest and augmented arm position with elbow fully extended) on the FTSTS times of individuals with chronic stroke.
Methods: Cross Sectional Study design assigned by Simple random sampling with 60 Subjects in each group.
Outcome Measure: Five times sit to stand
Results: The average FTSTS TIMES with the different foot placement and arm position. The mean FTSTS times for the 6 condition ranged from 14.4 to 20.8seconds.
Conclusion: There is significance of the observed relationship 2 foot placements and 3 arm positions on the FTSTS times of individuals with chronic stroke. Posterior foot placement and augmented arm position were found to associate with shorter FTSTS times for individuals with chronic stroke.

Keywords: sit to stand, five times sit to stand test, stroke

1. Introduction

In order to stand up, individuals with post-stroke hemiparesis often showed a lack of coordination between hip and knee displacements and hence, completed knee extension at the end of STS while their hips were still extending [6]. Unlike healthy subjects, who presented an almost neutral trunk position in the frontal plane, individual post-stroke showed trunk tilt towards the less affected side during STS when they rose from a chair using spontaneous [3, 7] or symmetrical foot positions [2]. This trunk displacement was observed, even before seat-off [23] and was estimated at 12.1˚ ± 6.1 compared to 2.4˚ in healthy individuals [2]. During the chronic phase of stroke, an impairment of lower limb muscle activity was observed in the paretic lower limb when compared with the less affected side especially for tibialis anterior, soleus and quadriceps [8]. In contrast with healthy subjects, the soleus muscle was activated before seat-off, which could be related to the spasticity and weakness of this muscle [9].

Along the same line, hemiparetic subjects who had experienced one or more falls had significantly increased CoP sway in both mediolateral and anteroposterior directions when compared to those who had never fallen [1]. To avoid this risk of falling, they have therefore adopted compensatory strategy such as exaggerating (3 cm more than healthy subjects) the anterior projection of CoM before rising [1]. This strategy allowed closer position of CoM to CoP and might thus induce less anterior movement during the rising phase and better postural stability [16]. The mean loading on the paretic limb was 37% of body weight according to Engardt [45]. A similar value was observed by Brunt *et al*. [5], with 16% excess on the less affected limb. However, they were able to perform more symmetrically with the use of auditory or visual feedback [4, 5] or by modifying the foot positions [2, 4],

The five times sit-to-stand (FTSTS) test was designed by Csuka and McCarty in 1985 [12]. It is used to assess the functional muscle strength of the lower limbs, especially with older adults. The test has been shown to have excellent intra-rater reliability (intra-class correlation coefficient [ICC3, 1] = 0.970 − 0.976), interrater reliability (ICC3, 2 = 0.999), and test-retest reliability (ICC2, 1 =0.994 − 1.000) in individuals with chronic stroke [13].

The time for performing the FTSTS has also been found to be negatively correlated with knee flexor strength in both the affected leg ($\rho = -0.753$) and the unaffected leg ($\rho = -0.830$) in individuals with chronic stroke [13]. Initial foot placement would affect the distance travelled by the body's centre of gravity (CoG) and leverage in rising from a seat [19–21].

Kawagoe *et al*. [20] demonstrated that forward displacement of CoG during standing up was significantly longer in normal foot placement when compared to posterior foot placement, which was referred to 10 cm behind the normal position. In some published studies, the arm position was not even mentioned [14, 15, 16, 17, 18]. Augmented arm position was referred to as the position of two hands gripping together with the shoulders flexed at 90ºand the elbows fully extended. Although augmented arm position was commonly used in clinical setting to facilitate sit-to-stand movement in subject with stroke [22], the effect of different arm positions including augmented arm position on FTST times has not yet been investigated.

2. Materials and methodology

2.1 Study design: Cross Sectional Study

2.2 Study setting: Department of Physiotherapy, SHREE B. G. Patel College of Physiotherapy, Anand

2.3 Sample size: 60 Subjects in each group

2.4 Subjects: Male and Female diagnosed with stroke

2.5 Inclusion criteria
1. Were age 50 years or above,
2. Had experienced a single stroke at least 1 year before the study, and
3. Were able to stand up from a chair without any external support.

2.6 Exclusion criteria
1. Were unable to follow commands properly,
2. Had an Abbreviated Mental Test score below 6
3. Were medically unstable, or
4. We're suffering from other neurological or musculoskeletal which could affect sit-to-stand performance.

2.6 Materials used in study: Measure tape, Pencil, Papers, Assessment charts

2.7 Apparatus used in study: Height Adjustable Chair, Digital Stop Watch

2.8 Outcome measures: 5 Times Sit To Stand Test (FTSTS)

2.9 Procedure
Subjects are selected on the basis of inclusion and exclusion criteria. Detailed assessment of patients with diagnostic tests for stroke was done. Informed consent was obtained from all patients.

A height-adjustable chair was used in this study to ensure subjects' hip was in 90˚ flexion when seated. The subjects were instructed to stand up and sit down from a height-adjustable chair 5 times as quickly as they could [12, 26].

The standardized instruction given for each trial was "on the count of 3, please stand up and sit down 5 times as fast as you can." The timing started when the subject's back left the back rest and ended when their back touched the back rest after the 5th repetition. The time was recorded by hand using a digital stop watch [12, 26].

The effects of normal and posterior foot placement together with hands on thighs, arms crossed over chest, an augmented arm position on FTSTS times were investigated in this study. Seat height was adjusted according to their lower leg length in all trials. The lower leg length was defined as the perpendicular distance between the fibular head and the floor, when the subject sat on the chair with the knees in 90˚of flexion and the ankles in the neutral position.

This sitting position was also defined as the normal foot placement Posterior foot placement was defined as having both heel positioned 10 cm backward from the normal foot placement [12, 26].

Each subject was required to perform the FTSTS under 6 experimental conditions in a random sequence by drawing lots [26].

Two trials were performed under each condition, with a 2-minute rest between each trial to avoid fatigue.

The experimental conditions were as follows
- **Condition 1:** Normal foot placement and hands on the thighs;
- **Condition 2:** Normal foot placement and arms crossed over chest;
- **Condition 3:** Normal foot placement and augmented arm
- **Condition 4:** Posterior foot placement and hands on the thigh
- **Condition 5:** posterior foot placement and arms crossed over chest
- **Condition 6:** posterior foot placement and augmented arm.

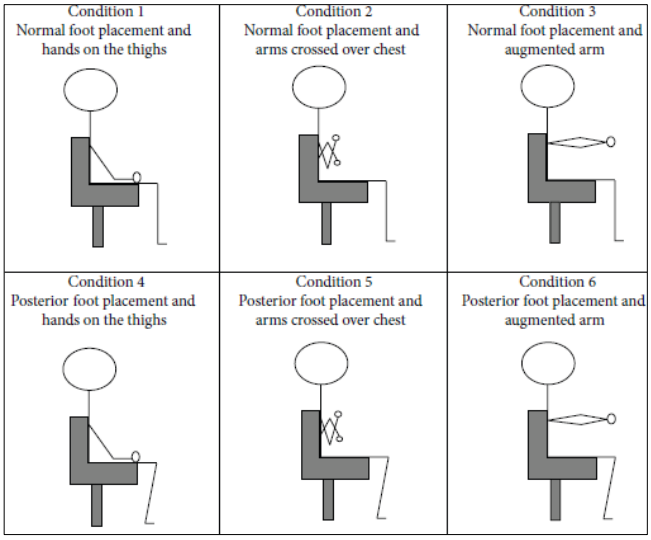

Fig 1: figure shows various foot placements and arm positions.

2.10 Statistical data analysis
Two-way repeated measures ANOVA were conducted to examine the significance of the observed relationship between 2 foot placements and 3 arm positions with FTSTS times.

If the main effects of arm position were statistically significant, post hoc multiple comparison test with Bonferroni adjustment would be used to evaluate the differences of FTSTS times between the 3 arm positions. Null hypothesis will be rejected if $P< 0.05$. All the statistical analysis was conducted with the help of version 16.0 of the SPSS.

3. Result
All the descriptive characteristics of the subjects and their variables are analyzed.

Total 60 patients were taken so according each variables distribution and differences is seen.

Table 1: Demographic variability in the population

Gender		Side of hemiplegia		Cause of Stroke	
Male	Female	Right	Left	ischemic	hemorrhagic
33	27	35	25	27	33

Table 2: Variables with its mean and standard deviation.

Variables	Mean ± SD
Age (Y)	57.63333 ± 4.83
Height (CM)	160.4 ± 8.39
Body Weight (KG)	62.33333 ± 7.44
BMI(kgm-2)	24.35233 ± 3.55
Years of Poststroke (Y)	3.665 ± 1.79

Table 3: Result of Five Times Sit-to-Stand Test Times (sec.) with various positions and its comparison

Arm position	Normal foot placement	Posterior foot placement	Compression and result	
Arms on the thighs	19.3 ±3.3	16.5± 3.2	P value	(59,118)
Augmented arm position	16.7 ± 3.2	14.4 ± 2.6	< 0.0001	= 8.1,
Arm crossed on the chest	20.8 ± 3.1	18.4 ± 2.8		P < 0.0001
Compression and result	F (1, 2) = 247.7, P =0.0040			

Here two way ANOVA repeated measures test is used. Table no. 3 the average FTSTS TIMES with the different foot placement and arm position. The mean FTSTS times for the 6 condition ranged from 14.4 to 20.8seconds.

Two way repeated measures ANOVA revealed the significant interaction between foot placement and arm position on the FTSTS times [F(59,118) = 1.553, P = 0.0220]. Both the main effect of foot placement and arm position were statistically significant with [F (1, 2) = 247.7, P =0.0040], and [F(59,118) = 8.1, P < 0.0001], respectively.

The significant main effect of foot placement indicated that the normal foot placement led to a significant longer FTSTS time than posterior foot placement.

Post hoc test showed that the hands on thigh position led to significant longer FTSTS times than the augmented arm position (P < 0.0001).

4. Discussion

This study was intended to investigate relationship between foot placement and arm position and the FTSTS times of individuals with chronic stroke. Our results showed that both the foot placement and arm position could affect FTSTS times.

Posterior foot placement in combination with augmented arm position associated with faster FTSTS times in individuals with chronic stroke.

The average FTSTS times for the 6 conditions ranged from 14.4 to 20.8 seconds. These averages were comparable to those observed in previous studies that reported individuals with chronic stroke [13, 17].

Weiss and colleagues reported FTSTS times of 19.3 ± 2.4 seconds in individuals with chronic stroke [16,] but that study included only 7 subjects with a mean age of 70 ± 2.4 years, who were twenty years older than our subjects.

Bohannon had published a meta-analysis which demonstrated that the normal FTSTS time for healthy individuals aged between 60 and 69 years was 11.4 seconds [23].

It was expected that our subjects with chronic stroke would take longer duration to complete the FTSTS. It might probably be due to stroke-specific impairments such as muscle weakness, poor weight bearing on paretic limb [71], impaired balance [24], and fear of falling [25].

Foot Placement

Consistent with the results of healthy adults that posterior foot placement could increase the speed of sit-to-stand [20], our study also showed that posterior foot placement led to shorter FTSTS times with all 3 arm positions.

Kawagoe *et al*, [20] showed that placing the feet at 10 cm behind the normal foot placement was associated with significantly less anterior and abrupt displacement of the CoG, as well as shorter distance between CoG and point of application (PoA) at lift off.

The smaller hip flexion angle implied a shorter distance that the trunk or upper body segment has to move forward to initiate the action of rising from a chair. Reduced muscular effort required during rising from the seat when the feet are placed posteriorly could also explain shorter FTSTS times taken in posterior foot placement. Reduced tibialis anterior muscle activation during standing up had been found in posterior foot placement when compared with those of normal foot placement [20].

In our study average, FTSTS completion with posterior foot placement was 2.42 seconds shorter when compared with normal foot placement. Therefore, the change in FTSTS times was unlikely due to measuring error and PatrickW. H. Kwong, *et al*., in that average, FTSTS completion with posterior foot placement was 1.14 seconds shorter when compared with normal foot placement so in that comparison is greater shorter duration is suggested.

Arm Position

The present results revealed significantly shorter FTSTS times with the augmented arm position than the hands on the thighs position. There was significant interaction between foot placement and arm position.

In Patrick W. H. Kwong [26] *et al*. same study done but their suggest minimal change of duration so there was no significant interaction between foot placement and arm position so their result is opposite the my study result so in that factor influences may be age, post stroke duration. in their study mean age was and average post stroke duration of 7.1 ± 2.9 years but in my study mean age was 57.6 ± 4.83 years, and average post stroke duration of 3.6 ± 1.7 year.

The augmented arm position might help to shift the CoG forward more efficiently, which could explain its association with faster FTSTS times.

5. Conclusion

There is significance of the observed relationship 2 foot placements (normal and posterior placement) and 3 arm positions (hands on thighs, arms crossed over chest and augmented arm position with elbow fully extended) on the FTSTS times of individuals with chronic stroke.

Posterior foot placement and augmented arm position werefound to associate with shorter FTSTS times for individuals with chronic stroke.

6. Clinical implication

Sit to stand done in various foot position and arm position in which mainly posterior foot placement and augmented arm is useful and makes independent sit to stand activity easy.

The FTSTS time's average range is 14.4 to 20.8 second for chronic stroke patients gives diagnostic or normalcy value for patients.

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