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To Evaluatethe Correlation Between Trunk Length and Sitting Balance in Complete Paraplegic Patients

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Abstract

Objectives: Spinal Cord Injury (SCI) refers the injury to the cord resulting in impairment of Neuro-muscular function below the level of lesion; motor, sensory, bladder and bowel functions are affected and the functional independence depends primarily on the level and completeness of injury, trunk length and sitting balance in complete paraplegics: a correlational study. *Methods:* A sample of 30 subjects (26 males & 4 females) from SSSMC and jai physiotherapy and dental clinic, Meerut, were included in the study. The subjects were measured for their trunk length and then asked to perform the task of sitting functional reach (both forward and lateral). The reach values (cm) and the trunk length (cm) of the subjects were documented. *Results:* The data revealed the mean scores of forward reach values of 14.87, lateral reach values of 11.90, trunk length with a mean values of 62.6 cm. A non-significant negative correlation with r value of – 0.145 (NS) was found when values of forward reach of the sample were compared with the trunk length in group 1. A significant negative correlation with r value of – 0.561* & - 0.899* was found when values of forward reach of the sample were compared with the trunk length in group 2 & group 3. A significant negative correlation with r value of – 0.561* & - 0.72* was found when values of lateral reach of the sample were compared with the trunk length in group 1 & group 2. A non-significant negative correlation with r value of –0.901* was found when values of lateral reach of the sample were compared with the trunk length in group 3. *Conclusions:* The results of this study indicates that there exists a significant negative correlation between Trunk length and Sitting Balance in Complete Paraplegics.

Keywords: Complete Paraplegics, trunk length.

Introduction

Spinal Cord Injury (SCI) refers the injury to the cord resulting in impairment of Neuro-muscular function below the level of lesion; motor, sensory, bladder and bowel functions are affected and the functional independence depends primarily on the level and completeness of injury.[1]

Due to loss of motor power in the lower limbs, the locomotion of the injured person is mostly affected. Because of the difficulties in walking and increased energy expenditure in their locomotion, 70–80% of them are dependent on wheelchair for their mobility needs. Therefore, wheelchairs have been vital for spinal cord injury patients to lead an active, independent and productive life.[2] Once the patient is on wheelchair bound, sitting becomes the most fundamental position of interaction with the environment. The challenge to convert these patients from functional dependency to

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functional independency falls under the domain of physiotherapy.

Dynamic sitting balance involves the ability to maintain seated posture without falling while performing a variety of self initiated actions.[3] Reaching in sitting is a self initiated movement, which sufficiently challenges the body's postural control mechanism to control and coordinate the trunk and extremities to maintain the centre of gravity over the base of support. The system would be maximally recruited when the demand is also maximal. Any attempt beyond which will throw the centre of gravity outside the base of support and may result in a fall.

Hence any information provided by a detailed assessment of sitting position and sitting balance may play an important role in bringing a correlation between the sitting balance and functional independency of the patient which in turn will help in planning an effective rehabilitation for the patients with spinal cord injury.

Several factors such level of motor innervations, voluntary trunk control, endurance of postural muscles, spasticity and other variables such as type of sitting, pelvic tilt, are useful in predicting the sitting balance in spinal cord injury patients.[4] From mechanical perspective for a given level of injury, people of different height can have different position of centre of gravity, which in turn can affect their stability during any dynamic task.[5,6] Understanding the factors influencing sitting balance will help therapist to set appropriate goals and devise strategies for functional rehabilitation. Hence this study was planned to study the effect of trunk length, influencing dynamic sitting balance in spinal cord injured patients.

Since Modified Functional Reach Test is a well established and valid tool in assessing dynamic sitting balance, and the task of reaching used in this test is one of the most perfectly adapted activity of daily living in spinal cord injury patients, we believe that an assessment of reaching balance by using MFRT will detect the dynamic sitting balance in spinal cord injured patients.[7]

Objectives of the Study

Statement of study: Is there any correlation between trunk length and sitting balance in complete paraplegics?

Hypothesis

Alternate Hypothesis: There will be a negative significant correlation between trunk length and sitting balance in complete paraplegics.

Null Hypothesis: There will be a positive significant correlation between trunk length and sitting balance in complete paraplegics.

Operational Definitions

Sitting Balance[7]*:* "The ability to maintain control over upright posture in sitting during forward reaching without stabilization."

Sitting Functional Reach[7]: "The maximum distance one can reach beyond arm's length in the horizontal plane while maintaining a fixed base of support in a sitting position."

Trunk Length[5]: "Measurement from C7 spine to coccyx in sitting."

Paraplegia[8]*:* "The term refers to impairment or loss of motor or sensory function in the thoracic, lumbar or sacral (but not cervical) segments of the spinal cord secondary to the damage to neutral elements within the spinal canal."

Incomplete Injury[8]*:* "If partial preservation of motor or sensory functions is found below the neurological level and includes the lowest sacral segment, the injury is defined as incomplete."

Complete Injury[8]: "The term is used when there is an absence of motor or sensory functions in the lowest sacral segment."[12]

Limitation of Study: The movement strategy used for reaching in sitting was self selected by the individuals. No control for the strategy adopted by the subject to reach forward was predetermined which may easily influence the maximal distance reached. Sample size was small for studying this correlation with various anatomical levels of spinal cord injury patients.

Materials and Methods

Design: This study is a correlation study design which intends to find out if there is any correlation between trunk length and the sitting balance in complete paraplegics within the sample.

Sample: A sample of 30 subjects (26 males & 4 females) from SSSMC, Dehradun and jai physiotherapy and dental clinic, Meerut, were included in the study. All the subjects were assessed for inclusion and exclusion criteria of the study.

A baseline assessment of clinical and functional status was assessed before the subjects were assigned to do the task.

Following this, the subject's trunk length was

measured in sitting position and were asked to perform the sitting functional reach.

Inclusion Criteria

- Volunteers between age group of 18–35 years.
- Functionally independent in wheelchair transfer (FIM Score 7).
- Complete paraplegia (ASIA A and B) ranging from T2-T12.
- Spasticity (Modified Ashworth Scale Below 1+).
- History of one or more than one year duration since SCI.

Exclusion Criteria

- An active or terminal illness that may interfere with the participation.
- Spinal deformity like kyphosis, scoliosis.
- Pressure sores.
- Any history recent pain in the shoulder.
- Contractures.
- Any other complications like hetrotrophic ossicification.

Instrumentation

1. A standardized wheelchair recommended for paraplegics.
2. One standardized 2.5 cm x 116 cm measurement scale (yard stick) mounted horizontally on the wall at the level of the acromion process of right shoulder of a subject seated in the wheelchair.
3. A standardized measuring tape.

Protocol: The subjects were introduced to the study, followed by signing of the consent form. General baseline assessment regarding their clinical history and functional independence was performed. The subjects were measured for their trunk length and then asked to perform the task of sitting functional reach (both forward and lateral). The reach values (cm) and trunk length (cm) of the subjects were documented. For the entire data collection procedure the subjects were referred to by subject number and not by name to maintain the confidentiality of the subject.

Procedure: The procedure for collection of data closely followed those described by Lieng Chen and Lynch in their study.[5,7]

Preliminary measurement was taken prior to the beginning of the reaching task included the measurement of one of the body parameters.

Trunk length: Subjects in a sitting instructed to sit as erect as possible and measurement from C7 vertebrae to coccyx by a standard inch tape was taken.

Forward reach: The subject was allowed to sit comfortably against the backrest in the standard wheelchair given to the patient. However care was taken to maintain 90 degree bent at knee and ankle joints. Feet supported on the footrest (which can be adjusted).

A clearance of 2.5 inches was maintained between the popliteal fossa and the seat edge. A yardstick was positioned horizontally on the wall at the level of acromion process of the dominant GH joint. A pointer (pencil) was attached at the ulnar styloid process.

The following instructions were given to the subjects. "Raise your arm from the shoulder to horizontal position in front, Make a fist and hold it." Care was taken not to allow trunk rotation/ shoulder protraction by keeping both the shoulders in the same horizontal plane while taking the initial and final measurement. The readings were four feet away from the anterolateral side of non-dominant limb. Initial reach was measured at the landmark of ulnar styloid process. Care was also taken here to keep wrist in neutral, elbow straight and arm in horizontal position to the trunk.

Then the patient was given the following instruction "Now reach forward along the yardstick as far as you can without losing balance or raising from the buttocks and footrest". Freedom was given regarding the strategies used to task. The subject moved parallel to the yardstick in the frontal direction.

The final position was noted as the pointer on the ulnar styloid along the yardstick on the farthest value reached. The patient is asked not to touch the wall and the ruler. No weight bearing or holding was allowed on the non-reaching upper extremity. Two practice trials were allowed followed by three measurement trials.

Lateral reach: The initial position was in an armless chair with the backrest placed against the wall. The sitting posture of the subject and the procedure remain the same as above. However the following instruction was given. "Raise your arm

from the shoulder to horizontal position on the side, make a fist and hold it." Initial reading was taken as above. Then the patient was given the following instruction "Now reach sideways along the yardstick as far as you can without loosing balance or raising from the buttocks and footrest". Freedom was given regarding the strategies used to the task. The subject moved parallel to the yardstick in the lateral direction. The final position was noted as the pointer on the ulnar styloid along the yardstick on the farthest value reached. The patient was asked not to touch the wall and ruler. No weight or holding was allowed on the non-reaching upper extremity. Two practice trails wee allowed followed by three measurement trials.

The subjects were guarded during the reach task. Subjects were encouraged to use any reach strategy except use of non reach arm for support, raising from the buttocks or moving lower legs backward.

Variables

Modified Functional Reach (Forward)

Sitting Initial Reach (cm): Each subject sitting straight at right angle to the horizontal plane, with an upper extremity flexed forward to 90 degree. The anatomical landmark was ulnar styloid.

Sitting Final Reach (cm): The same subject on reaching forward in the horizontal plane as far as possible without loosing the balance. The final measurement was the ulnar styloid process on maximum forward reach position.

Sitting Functional Reach (cm): The average of the difference between the final and initial reach distances of the three trials.

Modified Functional Reach (Lateral)

Sitting Initial Reach (cm): Each subject sitting straight at right angle to the horizontal plane, with an upper extremity flexed sideways to 90 degree. The anatomical landmark was ulnar styloid.

Sitting Final Reach (cm): The same subject on reaching laterally as far as possible without loosing the balance. The final measurement was the ulnar styloid process on maximum lateral reach position.

Sitting Functional Reach (cm): The average of the difference between the final and initial reach distances of the three trials.

Trunk Length[5]

The length of the trunk was measured from the C7 vertebrae to the coccyx in sitting position.

Data Analysis: Data analysis was performed by using the SPSS version 10 for windows software descriptive statistics was used to analyze mean age, level of lesion and gender. Karl Pearson's correlation test was used to find the correlation between the trunk lengths and reach values. In all cases significance was set at $p<0.05$. Appendix G gives a sample table of calculation done.

Results

A total of 30 subjects were included in the study for studding the correlation between Trunk Length and Functional Reach Values (forward and lateral both) in sitting as a measure of dynamic sitting balance in complete paraplegics. The subjects were divided into three groups with respect to the level of lesion.

Demographic Information of the subjects – thirty subjects (26 males and 4 females) in the age group of 19-32 years with the mean (standard deviation) age of 27.26 (3.39) years (Table 1). All the subjects were grade A on ASIA scale.

Table 1: Demographic details of the samples

Age (years) Mean (SD)	27.26 ± 3.39
Males	26
Females	4
Samples	30

Demographic information of the groups

Group 1 with total number of subjects 13 in the age group of 19-32 years with the mean (Standard Deviation) age of 27.38 (3.40) years (Table 2)

Group 2 with total number of subjects 9 in the age group of 22-32 years with the mean (Standard Deviation) age of 26.78 (3.80) years (Table 2)

Group 3 with total number of subjects 8 in the age group of 22-31 years with the mean (Standard Deviation) age of 27.62 (3.29) years (Table 2)

Table 2: Demographic details of the groups

Group	Cases	Mean ± SD
1	13	27.38 ± 3.40
2	9	26.78 ± 3.80
3	8	27.62 ± 3.29

Sitting Reach Values

The data revealed the mean (standard deviation) scores of forward reach values of 14.87 (4.90), (Table 2).

The data revealed the mean (standard deviation) scores of lateral reach values of 11.90 (4.86), (Table 2).

Trunk Length

The distribution of trunk length of the subjects shows the trunk length from 55–75.1 cm with the mean value (standard deviation) of 62.6 (5.89) cm, (Table 3).

Table 5.3: Mean (SD) values for Modified Functional Reach (forward and lateral) and Trunk Length

	Trunk Length	Forward Reach	Lateral Reach
Total Sample	62.66 ± 5.89	14.87 ± 4.90	11.90 ± 4.86
Group 1	62.68 ± 4.31	13.00 ± 3.27	10.21 ± 3.53
Group 2	60.63 ± 6.44	16.42 ± 3.98	12.81 ± 4.32
Group 3	64.91 ± 7.30	16.18 ± 7.18	13.60 ± 6.74

Correlation of Modified Functional Reach (Forward Reach) with Trunk Length – A significant negative correlation with r – value of -0.614** was found when values of forward reach of the sample were compared with the trunk length. (Table 4).

Correlation of Modified Functional Reach (Lateral Reach) with Trunk Length – A significant negative correlation with r – value of -0.674** was found when values of lateral reach of the sample were compared with the trunk length. (Table 4)

Correlation of Modified Functional Reach (Forward Reach) with Trunk Length in Group 1 – A non - significant negative correlation with r – value of -0.145$^{(NS)}$ was found when values of forward reach of the sample were compared with the trunk length. (Table 4)

Correlation of Modified Functional Reach (Forward Reach) with Trunk Length in Group 2 – A significant negative correlation with r – value of -0.561* was found when values of forward reach of the sample were compared with the trunk length. (Table 4)

Correlation of Modified Functional Reach (Forward Reach) with Trunk Length in Group 3 – A significant negative correlation with r – value of -0.899* was found when values of forward reach of the sample were compared with the trunk length. (Table 4)

Correlation of Modified Functional Reach (Lateral Reach) with Trunk Length in Group 1 – A significant negative correlation with r – value of -0.561* was found when values of lateral reach of the sample were compared with the trunk length. (Table 4)

Correlation of Modified Functional Reach (Lateral Reach) with Trunk Length in Group 2 – A significant negative correlation with r – value of -0.72* was found when values of lateral reach of the sample were compared with the trunk length. (Table 4)

Correlation of Modified Functional Reach (Lateral Reach) with Trunk Length in Group 3 – A significant negative correlation with r – value of -0.901* was found when values of lateral reach of the sample were compared with the trunk length. (Table 4)

Table 4: Correlation between Modified Functional Reach (forward and lateral) with Trunk Length.

Trunk Length	N	Sitting Forward Reach (r)	Sitting Lateral Reach (r)
Sample	30	–0.614**	–0.674**
Group 1	13	–0.145(NS)	–0.561*
Group 2	9	–0.753*	–0.720*
Group 3	8	–0.899*	–0.901*

*Significant at 0.05, ** Significant at 0.01, ^{NS} Non – significant, r Correlation Coefficient.

Discussion

The sitting problems of the neurological ill are not new. Impaired sitting stability in people with spinal cord injury seems to be related to defective motor performance. Functional Reach, a measurement of margin of stability is biomechanically analogues to centre of pressure excursion. Duncan et al who designed the test, reported that age and height are the most significant factors that influence functional reach test. The taller the subject, the greater the distance of functional reach but this is not applicable in sitting, as Dural et al reported that the COG was higher by 5% of the body length in the paraplegics then the normal subjects. This upward displacement of COG reflects a disproportional loss of body weight. Such a change in COG must lead to loss of sitting stability and may continue to change in persons limits of stability.[6] Therefore we hypothesized that a subject with long trunk length may have a higher COG and may have a lesser extent of stability limit, supported by Chiung et al in his study where he used amplitude of weight transferred as the balance measure.[5]

Our results ended up showing a negative correlation between trunk length and sitting balance as measured by modified forward reach values (forward and lateral both) in sitting. The negative correlation established was longer the trunk length poorer the dynamic balance in sitting and vice-versa. The correlation was significant for both the forward and lateral reach values in the samples.

Forward Reach

There was a significant negative correlation between trunk length and forward reach (r= -0.614, p = 0.0001),. This is consistent with the results of the previous study by Chieung et al who explained that the patient who had a longer trunk length will have a lesser forward reach values in sitting. Thus, my hypothesis was well supported with the concepts forward reach being biomechanically analogues to center of pressure excursion in sitting.

Lateral Reach

The negative correlation between lateral reach and trunk length was more significant than the forward reach (r = -0.674, p = 0.0001) in sitting. Thus may be due to the reason that the perimeter for center of pressure excursion within the base of support was comparatively smaller than the forward reach.

Outcomes Based on Level of Lesion

Further when we classified the sample with respect to various level of lesion i.e. Group 1 (T2 – T6), Group 2 (T7 – T9), and Group 3 (T10 – T12). We found the negative correlation for the Group 2, Group 3 between trunk length and reach (forward and lateral) in sitting. But the correlation was not found in Group 1 where we had higher level thorasic paraplegics. This may be due to the reason that the mean of modified forward reach values in Group 1 was comparatively lesser than the other two Groups (Group 2 and Group 3). The loss of strength in major trunk muscles in Group 1 would have been a reason in Group 1 is not bringing a correlation between trunk length and sitting balance as compared to the other two Groups. However further studies are needed to see the correlation within different groups levels (hiog and low thorasic paraplegia) with more number of sample in each group.

In normal population the centre of gravity in erect sitting passes in front of the eleventh thorasic vertebrae and through the ischial tuboricities and a person with the longer trunk length this COG is assumed to be shifted slightly higher. So, in patients like paraplegics in whom the COG is generally higher by 5% of the body length as compared to normal individuals, a longer trunk length would further shift the COG higher. Moreover these patients with complete spinal cord injury who lack muscular control will face more challenges to maintain balance during the task of reaching. Thus, this negative correlation between trunk length and sitting balance was more significant in this Group of patients leading to a better understanding of management of balance deficits. So therefore trunk length is a valuable indicator of sitting balance in patients with complete paraplegia.

Relevance to Clinical Practice

The purpose this study was to find out the correlation between the sitting balance as measured by modified functional reach test and trunk length. The sitting functional reach would act as a measure to explore the outermost limits of the stability and mobility in sitting position of the patients with spinal cord injury.

Reliable sitting assessment increases accountability in developing individualized prescription. In this study, the negative correlation showing larger the trunk length poorer the sitting balance will have a direct application in goal setting of spinal cord injury patients prior to physical rehabilitation.

There are several additional factors like injury level, base of support in sitting, motor and sensory innervations spread which play a key role in predicting patients static and dynamic sitting balance. From my study trunk length will also br added to the predictive factor, thereby helping the physiotherapists further to modify their rehabilitation protocol for the respective patients with complete spinal cord injury.

Future Research

The Co-relation between trunk length and sitting balance in complete paraplegics can be studied in an environment where the patient on the wheelchair is not at rest.

Similar studies can be repeated by using more sensitive measures of balance with a larger samples with various levels of lesion.

Conclusion

The following conclusions were drawn from the data and results obtained.

The results of my study indicates that there exists a significant negative correlation between trunk length and sitting balance in paraplegics.

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