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CORRELATION BETWEEN TRUNK LENGTH AND SITTING BALANCE IN COMPLETE PARAPLEGICS

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Abstract:
A lesion that compromises the anatomical integrity of the spinal cord can result in spinal cord injury (SCI), a disorder with persistently debilitating clinical manifestations brought on by partial or complete impairment of spinal cord functions. SCI sequelae are regarded as a public health issue in Brazil and across the globe due to their severe functional and socioeconomic effects. Both men and women made up all of the subjects. The connection between Trunk Length and Functional Reach values (both forward and lateral) in sitting as a measure of dynamic sitting balance in full paraplegics involved a total of 30 patients. Based on the severity of the lesion, the sample was split into three groups. This section's main emphasis is on the steps for conducting sitting functional reach tests and measuring trunk length. The data collection process was strictly adhered to. Prior to starting the reaching exercise, a preliminary measurement was made, which comprised measuring one of the bodily parameters. As determined by modified forward reach values (both forward and lateral) while sitting, our findings ultimately revealed a negative connection between trunk length and sitting balance. The established negative connection showed that the dynamic balance when sitting was worse and longer trunk length was better. Both the forward and lateral reach values in the sample had a strong association.

Key words: Paraplegia, Sitting balance, Trunk muscle strength.

INTRODUCTION

A lesion that compromises the anatomical integrity of the spinal cord can result in spinal cord injury (SCI), a disorder with persistently debilitating clinical manifestations brought on by partial or complete impairment of spinal cord functions. SCI sequelae are regarded as a public health issue in Brazil and across the globe due to their severe functional and socioeconomic effects. According to recent data, this illness affects between 236 and 1,298 people per million worldwide, and approximately 180,000 people each year experience spinal cord damage [1]. An damage to the spinal cord can cause a partial or complete loss of motor and/or sensitive functions, endangering the reproductive, respiratory, circulatory, and urine systems and severely limiting movement. The causes of these disorders may include both non-traumatic conditions like tumours, infections, and congenital deformities as well as traumatic occurrences including car accidents, gunshot wounds, and scuba diving in shallow water [2, 3]. Tetraplegia and paraplegia are the two functional categories under which SCIs are categorised. While paraplegia is the partial or complete paralysis of the lower limbs and trunk brought on by thoracic, lumbar, or sacral lesions, tetraplegia is the partial or complete paralysis of the four limbs and trunk brought on by spinal cord injury [3].

In addition to the stability of the spinal column and pelvis, the sitting balance of patients with paraplegia is also based on a number of complex mechanisms, including muscle strength, the senses, the position of the head and upper extremities, and reflexes like righting reflexes and equilibrium reactions. There is debate regarding whether conservative or operational treatment should be chosen for spinal cord injuries in their early stages. The goal of treating early stages of spinal cord damage is to reconstruct a painless, robust, supporting, and moveable spinal column and prevent a wide range of problems, including decubitus, as there is now no radical therapy available for the treatment of injured spinal cords. [4, 5, 6]

Barnett et al., and Vernadakis et al., claim that the ability to manipulate objects in exercise games increases with the duration of play. Studies on the use of virtual games in wheelchair-bound patients are uncommon despite recent positive scientific data. In paraplegia patients, we assessed sitting balance and trunk muscle strength (which is closely connected to sitting balance). [7, 8]

METHODS

All the subjects were male and female. A sample of convenience of 30 adults (26 males and 4 females) took part in the study. The subjects for the study came from G. B. Pant Hospital. and L.N.J.P. Hospital., New Delhi. The volunteers between age group 18-35 years were considered for this work. A standardized wheelchair recommended for paraplegics. One standardized 2.5 cm* 116 cm measurement scale (yardstick) mounted horizontally on the wall at the level of the acromian process of right shoulder of a subject seated in the wheelchair in the above-mentioned form.

A standardized inch 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 the trunk length(cm) of the subjects were documented. For the entire data collection procedure the subjects were referred to by subject no. and not by name to maintain the confidentiality of the subject. Data was collected on a data collection form. [9]

Procedure: This section's main emphasis is on the steps for conducting sitting functional reach tests and measuring trunk length. The method used to acquire the data was very similar to that which Lieng Chen and Lynch detailed in their investigations. Before beginning the reaching task, preliminary measurements were collected, including the measurement of one of the bodily parameters. [10]

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

Three trials of Forward Reach: The standard permitted the subject to sit comfortably against the backrest. The patient is given a wheelchair. Care was taken to keep the knee and ankle joints bent 90 degrees, though. On the adjustable footrest, your feet are supported. The popliteal fossa was kept 2.5 inches away from the border of the seat. On the wall, a yardstick was placed horizontally at the level of the dominant GH joint's acromian. At the ulnar styloid process, a pointer (pencil) was connected. The subject received the directions listed below. Raise your arm up and out in front so that it is horizontal. Hold a fist in your hand. When taking the initial and final measurements, care was made to prevent trunk rotation and shoulder protraction by keeping both shoulders in the same horizontal plane. The distance between the readings and the anteromedial side of the non-dominant leg was four feet. The ulnar styloid process landmark served as the initial reach measurement point. Here, it was also important to keep the wrist neutral, the elbow straight, and the arm parallel to the ground. [11, 12]

The patient was then told to reach forward as far as they could along the yardstick without losing their balance or getting up from the footrest and buttocks. The methods employed to complete the objective were left up to the user. In a frontal direction, the subject moved parallel to the yardstick. The pointer on the ulnar styloid along the yardstick on the farthest value reached was recorded as the final position. The wall and ruler are off-limits to the sufferer. On the non-reaching upper extremity, no holding or weight bearing was permitted. Three measurement tries were allowed after two practise trials. [13, 14]

Three trials of Lateral Reach: The initial position was in an armless chair with the backrest against the wall (the same wheelchair but with the arms removed). The individual continued to sit in the same position as before, as did the procedure. However, the advice that follows was offered. "Raise your arm so that it is horizontal and pointing to the side. Hold your fist in place. Initial interpretation was as stated above. The patient was then instructed to "now reach sideways along the yardstick as far as you can without losing balance or rising from the buttocks and footrest". The methods employed to complete the objective were left up to the user. The object moved laterally on a line parallel to the yardstick. The pointer on the ulnar styloid along the yardstick on the farthest value reached was recorded as the final position. It was requested of the patient not to touch the wall or the ruler. On the non-reaching upper extremity, no holding or weight bearing was permitted. Three measurement tries were allowed after two practise trials. The reach assignment involved guarding the subjects. All reach techniques, with the exception of lifting one's buttocks or moving one's lower legs backward, were encouraged. [15, 16]

Fig. 1: Starting position for Modified Functional Reach

Fig. 2: Final position for Modified Functional Reach Test

Data Analysis: Analysis was performed by using SPSS version10 for windows software under the guidance of Dr. R. M. Pandey (Head of the Department, Department of Biostatistics, AIIMS, New Delhi) 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 trunk lengths and reach values. In all cases significance was set at p<0.05. Appendix G gives a sample table of calculation done. [17, 18]

RESULTS AND OBSERVATION

A total of 30 subjects were included in the study in studying about the correlation between Trunk Length and Functional Reach values (both forward and lateral) in sitting as a measure of dynamic sitting balance in complete paraplegics. The sample had been divided into three groups with respect to the level of lesion. The following section documents the observations and results obtained after statistical analysis. The results are also tabulated and graphically represented in later part of this section.

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.

All the subjects had grade A on ASIA scale.

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. **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. **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.

Sitting Reach Values: The data revealed the mean (standard deviation) scores of forward reach values of 14.87(4.90). The data revealed the mean (standard deviation) scores of lateral reach values of 11.90(4.86).

Trunk Length: The distribution of trunk length of the subjects shows the trunk length from 55-75.1 cm with a mean value (standard deviation) of 62.6 (5.89) cm.

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.

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.

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.

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.

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.

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.

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.

Correlation of Modified Functional Reach (Lateral Reach) with Trunk Length in Group 3: 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.

Table 1: Demographic details of the sample

Age (yrs) Mean (SD)	27.26 (3.39)
Males	26
Females	4
Sample	30

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)

Table 3: Mean (SD) values for Modified Functional Reach (Forward and Lateral) and Trunk Length

	Trunk Length(cm)	Forward Reach (cm)	Lateral Reach(cm)
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)

Table 4: Correlation between Modified Functional Reach (Forward and Lateral Reach) 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*

NS not significant
*significant at 0.05
** significant at 0.01
r Correlation Coefficient

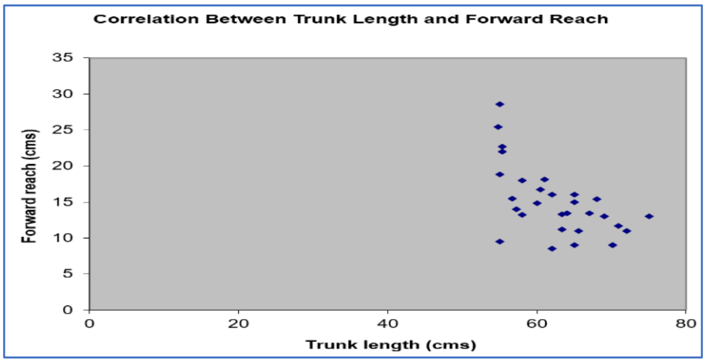

Fig. 3: Negative Correlation of Trunk Length with Forward Reach

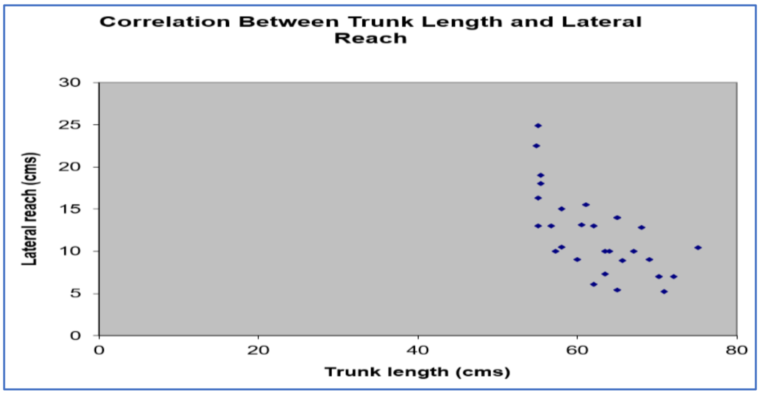

Fig. 4: Negative Correlation of Trunk Length with Lateral Reach

DISCUSSION

The neurologically ill's seating issues are not brand-new. People with spinal cord injuries appear to have less stable sitting postures, which may be connected to poor motor function. Centre of pressure excursion is biomechanically analogous to functional reach, a measure of margin of stability. According to Duncan et al., who developed the test, age and height had the most effects on functional reach. The distance of functional reach increases with height, although this is not true when seated, as Dural et al. found that the COG was 5% higher in paraplegics than in healthy participants. A disproportional reduction in body weight is reflected in this upward displacement of COG. Loss of sitting stability must result from such a shift in COG, and the limits of stability of the person may continue to vary. Therefore, based on Chiung et al.'s work, which employed amplitude of weight transferred as the balancing measure, we hypothesised that a person with a long trunk length may have a higher COG and may have a shorter extent of stability limit. [19, 20]

As determined by modified forward reach values (both forward and lateral) while sitting, our findings ultimately revealed a negative connection between trunk length and sitting balance. The established negative connection showed that the dynamic balance when sitting was worse and longer trunk length was better. The correlation was significant for both the forward and lateral reach values in the sample.

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, our hypothesis was well supported with the concepts forward reach being biomechanically analogus to centre of pressure excursion in sitting.

Lateral Reach: The negative correlation between lateral reach and trunk length was more significant than forward reach (r=-0.674, p=0.0001) in sitting. This 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. [21, 22, 23]

Outcomes Based on Level of Lesion: Further when we classified the sample with respect to various level of lesion i.e.; group1 (T2- T6), group2(T7-T9) and group3(T10- T12). We found the negative correlation for the groups 2(T7-T9), group3 (T10-T12) between trunk length and reach (forward and lateral) in sitting. But the co-relation was not found in group1 (T2-T6) where we had higher level thoracic paraplegics, this may be due to the reason that the mean of modified forward reach values in group1 was comparatively lesser than the other two groups (group2 and group3). The loss of strength in major trunk muscles in group 1 would have been a reason in group 1 in 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 group levels (high and low thoracic paraplegia) with a greater number of samples in each group.

The centre of gravity (COG) in upright sitting in the general population runs through the ischial tuberosities in front of the eleventh thoracic vertebrae, and it is considered that the COG is slightly higher in a person with a longer trunk. Therefore, a larger trunk length would push the COG even higher in patients like paraplegics, whose COG is typically 5% of body length higher than in healthy individuals. Additionally, it will be more difficult for these patients with total spinal cord injuries who lack muscle function to maintain equilibrium while doing a task like reaching. This increased significance of the negative connection between trunk length and sitting balance in this group of patients has helped to improve management of balance deficits. So therefore, trunk length is a valuable indicator of sitting balance in patients with complete paraplegia. [24-26]

Relevance to Clinical Practice: This study sought to determine the relationship between trunk length and sitting balance, as determined by the modified functional reach test. The seated functional reach would serve as a test to determine the patients with spinal cord injuries' highest levels of stability and movement. Developing individualised prescriptions requires a reliable sitting evaluation to promote accountability. Goal-setting for spinal cord injury patients before physical rehabilitation will directly benefit from the study's negative association revealing that the larger the trunk length, the worse the sitting balance.

In addition, there are several variables that are crucial in predicting patients' static and dynamic sitting balance, including injury severity, base of support while sitting, and spared motor and sensory innervation. Trunk length will be added to the prognostic factor from our study, assisting physiotherapists in further modifying their treatment plans for the corresponding patients with full spinal cord damage. [27]

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 sample with various levels of lesion.

CONCLUSION

The following conclusions were drawn from the data and results obtained. The result of this study indicates that there exists a significant negative correlation between Trunk length and Sitting Balance in Complete Paraplegics.

REFERENCES

1. Quadri SA, Farooqui M, Ikram A, Zafar A, Khan MA, Suriya SS. Recent update on basic mechanisms of spinal cord injury. Neurosurg Rev. 2020;43(2): 425-41.
2. Lee BB, Cripps RA, Fitzharris M, Wing PC. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. Spinal Cord. 2014; 52(2): 110-6.
3. Stokes M, Stack E. Physical management for neurological conditions. Amsterdam: Churchill Livingstone; 2013.
4. Flesch JR, et al: Harrington instrumentation and spine fusion for unstable fracture and fracture dislocation of the thoracic and lumbar spine. J Bone and Joint Surgery 1977; 59-A: 143–153.
5. Luque ER et al. Segmental spinal instrumentation in the treatment of fracture of the thoracolumbar spine. Spine 7: 312–317, 1982.
6. Bendix T et al. Posture of the trunk when sitting on forward inclining seats. Scand Jf Rehab Med 1983; 15: 197–203.
7. Yarkony GM, Roth EJ, Heinemann AW, Lovell L, Wu YC. Functional skills after spinal cord injury rehabilitation: three-year longitudinal follow-up. Arch Phys Med Rehabil 1988; 69: 111-4.
8. Yarkony GM, Roth EJ, Meyer PR, Lovell LL, Heinemann AW. Rehabilitation outcomes in patients with complete thoracic spinal cord injury. Am J Phys Med Rehabil 1990; 69: 23-7.

9. Waters RL, Yakura JS, Adkins RH, Sie I. Recovery following complete paraplegia. Arch Phys Med Rehabil 1992; 73: 784-9.
10. Daverat P, Petit H, Kemoun G, Dartigues JF, Barat M. The long term outcome in 149 patients with spinal cord injury. Paraplegia 1995; 33: 665-8.
11. Felici. Rehabilitation of walking for paraplegic patients by means of a treadmill. Spinal Cord 1997; 35: 383-385.
12. Protas EJ, Holmes SA. Supported treadmill ambulation training after spinal cord injury: a pilot study. Archives of Physical Medicine Rehabilitation 2001; 82: 825-31
13. Hornby TG, Zemon DH. Robotic-assisted, body-weight-supported treadmill training in individuals following motor incomplete spinal cord injury. Physical Therapy 2005; 85 :52-66.
14. Johnson TE. Implantable FES system for upright mobility and bladder and bowel function for individuals with spinal cord injury. Spinal cord 2005; 43:713-723
15. Carr JH, Shepherd RB. A motor relearning Programme for Stroke, Second edition, Oxford, 1992.
16. Carr JH, Shephard RB. Stroke Rehabilitation: Guidelines for Exercise and training to optimize motor skill, first edition, Butterworth Heinmann, 2003.
17. Rew M, Everett. Human movement, 3rd edition, Churchill living stone, New York USA, 1997.
18. Seelen HAM, Potten YJM. Postural motor programming in paraplegic patients during rehabilitation. Ergonomics 1998; 41:302-316
19. Potten YJM Seelen HAM. Postural muscle responses in the spinal cord injured persons during forward reaching. Ergonomics 1999; 42:1200-1215.
20. Robinson MW. Functional reach: Does it really measure dynamic balance? Archives of Physical Medicine and Rehabilitation 1999; 80: 262-269.
21. Madorsky JG, Kiley DP. Wheelchair mountaineering. Archives of Physical Medicine and Rehabilitation 1984; 65: 490-2.
22. Haas BM, Bergstrom E. The inter rater reliability of the original and of the Modified Ashworth's scale for the assessment of spasticity in patients with spinal cord injury. Spinal Cord. 1997; 35: 64.
23. Sullivan SO. Physical Rehabilitation, Assessments and Treatment. FA D avis company, Edition 4th, 2001.
24. Paolov. Tolerable exercise intensity in the early rehabilitation of paraplegic patient preliminary study. Spinal Cord 1996; 34: 684-690.
25. Brucker BS, Bulaeva NV. Biofeedback effect on electromyography responses in patients with spinal cord injury. Archives of Physical Medicine and Rehabilitation 1996; 77:133-7.
26. Yarkony GM. Rehabilitation outcomes in patients with complete thoracic spinal cord injury. American Journal Physical Medicine Rehabilitation 1990; 35: 266-274
27. Jackson AB, Dijkers M, De Vivo MJ. A demographic profile of new traumatic spinal cord injuries: change and stability over 30 years. Archives Physical Medicineand Rehabilitation 2004; 85: 1740-1748.