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Original Research Article

IS THERE A CORRELATION OF MUSCLE STRENGTH WITH RESPECT TO ENERGY EXPENDITURE AND AMBULATORY CAPACITY IN PATIENTS WITH SPINAL CORD INJURY?

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ABSTRACT

Background: Following the Spinal Cord Injury, patient's ability for gait and endurance is been limited. Hence this further causes difficulty in managing activities of daily living and transfers. Thus reducing the ambulatory capacity and increasing patients dependability to be wheelchair bond and significantly affecting the use of lower limb muscle strength. This will eventually land in secondary complications. Muscle strengthening has been proved to be one of the important intervention. The purpose of this study is to quantify muscle strength with respect to its energy expenditure and later target those muscle group in improving their ambulatory capacity.

Materials and Methods: Seventeen incomplete spinal cord injury patients were recruited. Their initial pre-assessment was done. Muscle strength and Ambulatory capacity was graded using Manual Muscle Testing and Ambulatory Capacity grading. Energy expenditure was calculated using Physiological Cost Index. Initial heart rate at rest was taken. Later subject had to walk for six minutes and post heart rate and laps were taken. Using Mac-Gregor equation energy expenditure was calculated.

Results: The results interpreted that muscle strength to physiological cost index is negative correlation and to ambulatory capacity it is a positive correlation.

Conclusion: There is correlation of muscle strength with respect to energy expenditure and ambulatory capacity in an incomplete spinal cord injury.

KEY WORDS: Energy expenditure, Ambulatory Capacity, Muscle strength, Incomplete spinal cord injury.

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INTRODUCTION

In a incomplete spinal cord injury (ISCI), due to certain limitations like increase in effort of walking or due to the heavy weight of the orthosis, majority of the patients disregard the walking abilities and tend to be wheelchair bond [1,2]. Inability to walk and stand further compromises by increase in spasticity, joint contractures, pressure sores, osteoporosis and urinary tract infection. This further affects their ability to perform daily activities of living and thus further affecting their ambulatory capacity.

Researchers have proved that 95% of these subjects usually suffer from at least one secondary complication, and 58% have three or more complications. In order to improve the physiological and psychological well-being of such patients, they are encouraged to resume their ability to stand or walk in some way. Physiologically, standing and walking can prevent the

associated complication.

Muscle strengthening is one of the principal interventions following ISCI aimed at improving functional abilities such as walking [3,4]. Early recovery of muscle strength post ISCI has been identified as a useful predictor of ambulatory capacity. For example, Waters et al reported that lower extremity motor recovery 1-month post-injury was a good predictor of whether an individual became a community ambulator at 1-year follow-up [5].

Moreover, Crozier et al. found that persons who recovered a greater than grade 3 strength in their less affected quadriceps by 2 months following ISCI had an excellent prognosis for ambulation [6].

"Energy cost of ambulation has also been proved useful in gait research" Information about gait efficiency provides clinicians with objective data on treatment progress, ambulatory aids assessment and treatment strategies effectiveness [7].

In 1977 Astrand and Rodahl stated that heart rate (HR) and oxygen consumption have a linear relationship during submaximal workloads. A more practical and valid method of measuring energy expenditure has been investigated by MacGregor in 1979. He developed the physiological cost index (PHYSIOLOGICAL COST INDEX) which incorporated HR and speed of walking to measure energy expenditure in ambulation [8].

Orthosis used in ambulation of spinal cord injury is directly linked to the energy expenditure [9]. In this research there is the use of push knee brace as it has less energy expenditure compared to other orthosis.

MATERIALS AND METHODS

Study design: This study was observational analytical study completed over the period of September 2018-January 2019. Subjects were recruited from GB school of Neuro Rehab, Pune and Sancheti and Sion Hospital.

Subjects: Purposive sampling was done to recruit the subjects. Inclusion criteria included subject with sub-acute and chronic spinal cord injury , below T6 level of injury with incomplete spinal cord injury, able to walk for 6 min with knee ankle foot orthosis and the walker and subject between 20-40 years of age. Exclusion criteria included any recent Fracture of Lower extremity and individual having any cardiac and pulmonary disease. Initially twenty one patients were recruited, however four patients were not able to walk for six minutes. Hence the sample size was only seventeen. The mean of age of the sample was 34.5 and mean time since post injury was 2.48 years. The subject were evaluated on the basis of Manual Muscle Test, Ambulatory capacity and Physiological cost index.Spearman's Rho test was used as statistical analysis.

Procedure: The subject's participation consent was taken. The participants were assessed for their muscle strength, energy expenditure and ambulatory capacity using Manual Muscle Testing, Physiological Cost Index and Ambulatory Capacity.

The Physiological Cost Index was done as follows:

Patient was completely rested to measure the heart rate at rest. Then patient was asked to walk with the orthosis and with help of the walker for 6 minutes on the marked pathway. After 6 minutes the post heart rate and laps completed during that period was calculated. With the distance walked the speed was calculated using the formula:

Speed= Distance/ Time

Later the data calculated was added in MacGregor's equation as follows:

Physiological Cost Index= (walking heart rate - resting heart rate)bpm / walking speed)meters/min. (MacGregor 1979).

RESULTS

Descriptive Analysis: The average age of the sample size was 34.5. The average time of injury was 2.48. Mean of Physiological Cost Index was 10.87, Ambulatory capacity was 1.125, more affected side was 2.89 and less affected side was 3.27. The strongest group of muscles where from the more affected side were the Hip flexors, Hip abductors and Knee extensors and from the weakest side were the Hip extensors. The weakest group of muscles were the Dorsi flexors and Plantar Flexors.

Table 1: Characteristics of the subject.

Variable	Mean	SD
Age	34.5	5.573748
Time Since Injury	2.4875	1.31497782
Physiological cost index	10.8773	5.749239
Ambulatory Capacity	1.125	0.341565026
More affected side	2.897959	0.366211
Less affected side	3.27551	0.195304

Table 2: (left) More affected side and (right) Less affected side.

Muscle Group	Mean	S.D	Muscle Group	Mean	S.D
Hip Flexion	1.4375	1.28938	Hip Flexion	1.5	1.251666
Hip Abduction	1.21875	1.390069	Hip Abduction	1.25	1.47196
Hip Adduction	0.84375	1.274346	Hip Adduction	0.96875	1.371966
Hip Extension	0.84375	1.399032	Hip Extension	1.3125	1.400893
Knee Flexion	0.78125	1.264499	Knee Flexion	0.9375	1.459166
Knee Extension	1.28125	1.353622	Knee Extension	1.34375	1.399032
Dorsiflexion	0.0625	0.170783	Dorsiflexion	0.09375	0.271953
Plantarflexion	0.25	0.57735	Plantarflexion	0.25	0.57735

Statistical Analysis: According to Spearman's Rho, Muscle Strength to Physiological Cost Index is negative correlation and to Ambulatory capacity it is a positive correlation.

Table 3: Correlation analysis of Muscle Strength with PCI and AC. (*left*) More affected side and (*right*) Less affected side.

Left Side					Right Side				
Muscle Group	**PCI**	**P Value**	**AC**	**P Value**	**Muscle Group**	**PCI**	**P value**	**AC**	**P value**
Hip Flx	-0.724	0.002	0.634	0.008	Hip Flx	-0.837	0	0.601	0.014
Hip Abd	-0.748	0.001	0.595	0.015	Hip Abd	-0.808	0	0.593	0.016
Hip Add	-0.724	0.002	0.634	0.008	Hip Add	-0.663	0.005	0.594	0.015
Hip Ext	-0.6	0.014	0.636	0.008	Hip Ext	-0.817	0	0.593	0.016
Knee Flx	-0.69	0.003	0.635	0.008	Knee Flx	-0.761	0.001	0.619	0.011
Knee Ext	-0.727	0.001	0.587	0.017	Knee Ext	-0.781	0	0.583	0.018
Df	-0.369	0.16	0.429	0.098	Df	-0.373	0.154	0.392	0.133
Pf	-0.557	0.025	0.813	0	Pf	-0.557	0.025	0.813	0

DISCUSSION

The study results showed that the strongest correlation were produced by Muscle strength to Physiological Cost Index were by the Hip flexors, Hip abductors, Hip adductors and Knee extensors. The hip flexors play an important role during the initial swing phase of gait to pull the swinging limb forward [10]. The hip abductors and hip adductors are important for stability during stance phase of the gait cycle and they also control medio lateral balance [11]. The knee extensors are much effective during the swing phase of the gait cycle. With knee extension, there is an increase in the next heel strike moving forward to increase the stride length and consequently increase gait speed [12]. In case of hip extension, it is limited by the Y ligaments at hip joint ,hence it works on stability thus reducing the energy expenditure [13].

Looking from the kinetic sequences of the lower limb, as per link segment model which includes the foot segment, lower leg segment, thigh segment and ½ Head, arms and trunk segments also affects with respect to energy expenditure during ambulation [14].

In relation with Muscle strength to Ambulatory capacity, the strength of the more affected limb, seems more important in determining the level of Ambulatory Capacity. Which concludes that more the muscle strengthening protocol is targeted the better is the outcome for the ambulation. The least amount of correlation shown by Muscle strength with respect to Physiological Cost Index was by Plantar flexors, which

will be the result of distal group of muscle affection and also due to the orthosis the plantar flexors are passively supported, so the energy expenditure by these muscles is less. The least amount shown of correlation with respect to ambulatory capacity was by knee extensors. Dorsi flexors didn't show significant amount of correlation to both Physiological Cost Index and Ambulatory Capacity. To summarize more the muscle strength less is the energy expenditure and more the ambulatory capacity.

CONCLUSION

Based upon the above interpretations it can be concluded that there is a correlation of Muscle strength with respect to Energy Expenditure and Ambulatory Capacity in a Spinal Cord Injury Patients.

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Conflicts of interest: **None**

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