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Original Article

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Reference Values of Isometric Trunk Muscle Strength in School Age Children using a Hand Held Dynamometer: A cross- sectional study

Rahul S.Bisen, M.P.T*, Jaya Shanker Tedla, M.P.T., Ph.D, K. Vijaya Kumar, M.P.T.*****

Abstract

Aims: To establish isometric muscle strength reference values for trunk flexors, trunk extensors, trunk lateral flexors and trunk rotators by using a hand held dynamometer in 6 to 12 years of age children.

Methodology: In thiscross-sectional study a total number of 280 children in the age group of 6 to 12 years, with 140 from each gender, were recruited for measuring the trunk muscle strength values using a baseline hand-held dynamometer.

Major findings: The reference values of the trunk flexors, trunk extensors, trunk lateral flexors and trunk rotators were established. It was observed that the height and weight of the children proportionately increased from 6 to 12 years with a few exceptions between 10-12 years in both boys and girls.

Conclusion: The normal mean value of isometric trunk muscle strength using a hand-held dynamometer ranged from 23.53N to 137.58N, in children 6 to 12 years of age. In girls it ranged from 23.53N to 121.03N whereas in boys from 41.40N to 137.58N.

Keywords: Normative data; Typically developing; Muscle power; Pediatric population; Dynamometer.

Muscle strength is defined as the force exerted by a muscle or a group of muscles to overcome a resistance in one maximal effort.[1] Muscle strength is associated with functional performance, work productivity and the efficiency of the movement. The trunk forms an intermediate segment connecting the upper and the lower parts of the body and it is the place where the kinetic chains come together. The trunk is the foundation for posture, balance, and coordinated movement all of which areimportant for maintaining spinal stability. This ability to support the body is dependent upon appropriate trunk muscle strength.[2]

The trunk muscles are comprised of the flexors, extensors, lateral flexors and rotators. Thesemuscles are chiefly responsible for moving or controlling the trunk because of their mechanical arrangement and multiple segmental innervations. They have a peculiar property of contracting in part and not just as a whole, thus making possible the enormous variety of trunk movements and postures. The function of the trunk muscles is an essential factor for the balance, gait, transfers, and the wide range of activities performed in daily living.[2]

Skeletal muscle strength is a key feature of childhood and adolescenceand is a fundamental parameter of the motor system which is very often tested during neurological examination in children.[3] Muscle strength assessmentsprovide important clinical

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information about any weakness that may relate to functional limitations. Clinical decisions on the management of patients who have sustained musculoskeletal or neurological injuries or patients recovering from surgery are taken after assessing muscle strength.[4] It is therefore important to have a reliable method for the assessment of muscle strength. There are different methods by which trunk muscle strength can be measured. These include manual muscle testing and testing using Isokinetic dynamometer or a hand-held dynamometer. [4,5]

Manual muscle testing remains a conventional method of measuring muscle strength because it has some drawbacks. The shortcomings encountered by MMT can be overcome by using a hand-held dynamometer. The hand held dynamometer is a battery-operated device consisting of strain gauges that records the force in newton's/pounds/ kilograms.[5] It has gained popularity as a tool to measure muscle force production in clinical settings and these measurements have been found to co-relate with the isokinetic strength scores.[6]The isokinetic dynamometer measures muscle strength as well as torque throughout the range of motion. However, the length of time needed to perform the testing procedure, complicated use; high cost and decreased portability of the unit usually preclude its use in pediatric settings.[5,6]

Hand-held dynamometry seems to be a good alternative. Most clinically important muscle groups can be measured easily with a dynamometer. The Baseline™ digital hand-held dynamometer offers an objective, portable and relatively inexpensive method to quantify the muscle strength. Usually it weighs less than 2 pounds, requires no setup and can be used in many kind of environment. [6] It is a reliable and valid method of obtaining muscle force measurements in adults and children. [7]

Objective measurements of muscle strength can provide the therapist with information about muscle performance and are used when making a diagnosis, developing goals and treatment plans, assessing the effects of therapeutic and surgical interventions or assessing change in longitudinal studies and clinical trials. By measuring the strength accuratelyone can examine the effect of muscle weakness on function. This information may assist the therapist in early identification of loss of strength before functional failure is observed.[8]

To determine whether pathological muscle weakness is present or develops during the course of a disease reference values for maximum isometric muscle force are needed. Though there have been studies on the limb musculature strength in the adult as well as in the pediatric population using the hand-held dynamometer, there was no retrievable data for trunk muscle strength in the pediatric population.

To establish isometric muscle strength reference values fortrunk flexors, trunkextensors,trunk lateral flexors and trunkrotators by using the hand-held dynamometer in children betweensix and twelve years of age.

Methodology

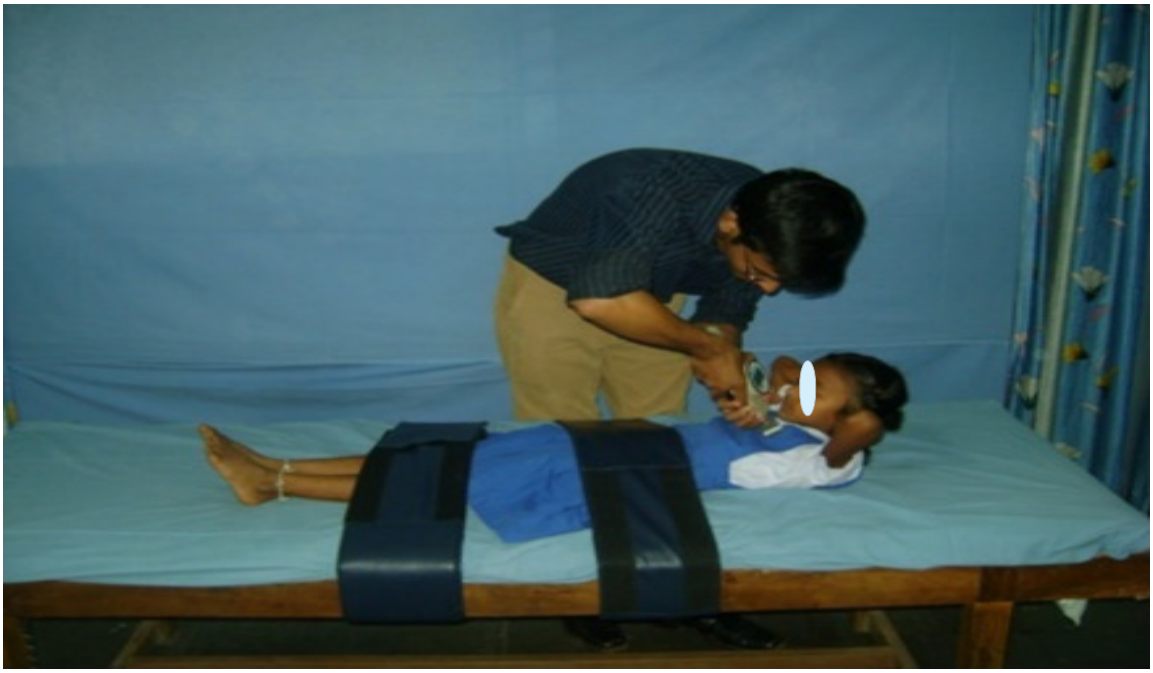
In thiscross-sectional studya total number of 280 children in the age group 6-12 years, 140 from each gender were recruited from two schools of Mangalore city.The children were grouped age wise: 6, 7, 8, 9, 10,11and12 years. 40 children constituted a sub group with equal representation from both genders. There were seven such subgroups.

Only children, 6-12 years of age possessing unrestricted ranges of motion at the thoracic as well as the lumbar spine, were included in the study.Children with following abnormalities were excluded from the study: a history of any neurological, musculoskeletal, cardiovascular and systemic problems; a history of injury to the spine and the pelvis.Any history of surgery confined to the thoracic, lumbar or abdominal region and children on medication like antiepileptics and muscle relaxants.

The tester is a qualified physical therapist and instruments used area baseline push-pull digital dynamometer.(Fig 1), measuring tape, a weighing machine, a couch, straps for stabilization and a sponge pad.

The children's age (in years) from the date of birth mentioned in the admission certificate/ school register; their weight in Kilograms (kg) using a weighing machine; and height, measured in centimeters (cm) using a height

Figure 1: Measurement of trunk flexors muscle strength



The protocol of the study was approved by the scientific committee and time-bound research ethics committee. Permission from the Block Education Officer (BEO) was taken and a list of schools was obtained.

From the list of schools available, two schools were selected by random sampling using a random number table. Permission was taken from the school authorities to carry out the study. The classes where the target population is located were identified and children were selected by random sampling using the lotterymethodand initial screening for inclusion andexclusion criteria was carried out. A health questionnaire, along with a consent and assent form,was given to the children for the approval of their parentsthe selected children were explained in brief regarding the study. After the children had given assent and theirparents' consent the whole test procedure and the purpose of the study was explained in detail to the children.

scale were carefully documented. Strength measurements were taken by a Baseline™ digital push-pull hand held dynamometer (Digital-LCD,Hydraulic, New York,500 lb. =2224.11N.) for trunk flexors, trunk extensors, trunk lateral flexors and trunk rotators.A detailed explanation of the muscle to be tested, the starting position, the placement of the dynamometer and the test procedure are given in table no .1

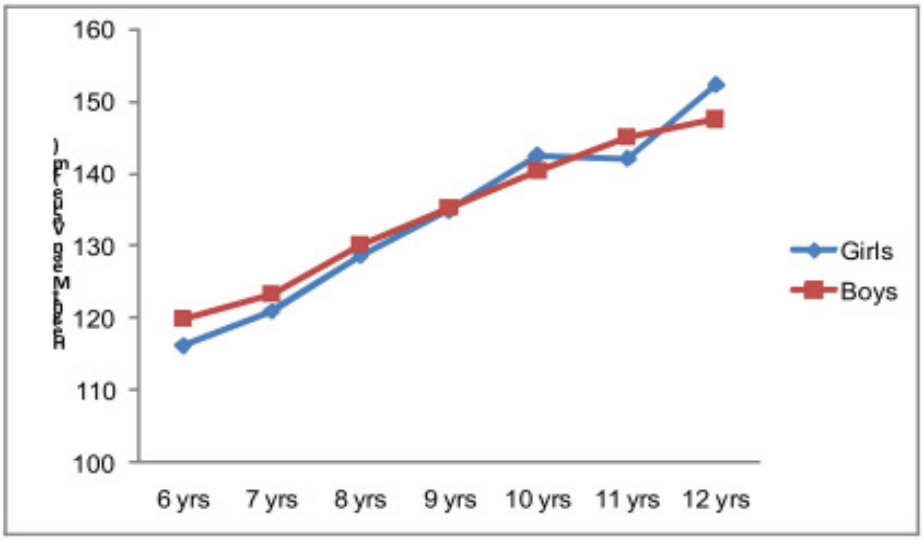
The muscle groups were tested in random and no specific sequence was followed. During the testing, verbal commands like "push as hard as you can" were given to the children in order to obtain a maximal effort.

The children were asked to do three trials for each group of trunk muscle and the mean of the three was taken into consideration. Five-second muscle contraction durations were used to allow the children to gradually achieve maximum force. A rest period of 1 minute was used in between the trials.

Table 1: Trunk muscle strength measurement

Muscle to be tested	Starting position	Placement of the dynamometer	Test procedure
Trunk flexors	Child was in supine lying position on the couch with his hands placed behind neck, with the hip and the knee joints extended.	Just below the sternomanubrialsymphysis.	The child performed trunk flexion and was asked to push the base of the dynamometer with maximum force and hold it for 5 seconds.
Trunk extensors	The child was in prone lying position with hands on the side of the couch.	Posteriorly at the T4 spinous process level.	The child performed trunk extension and was asked to push the base of the dynamometer with maximum force and hold it for 5 seconds.[10]
Trunk lateral flexors	Child was inside lying position on the couch.	Under the arm on the rib cage	The Child performed side flexion and was asked to push the base of the dynamometer with maximum force and hold it for 5 seconds.
Trunk rotators	Child was in supine lying position on the couch.	On the bulk of the Pectoralis major muscle	The child was asked to perform rotation and push the base of the dynamometer with maximum force and hold it for 5 seconds.

Figure 2: Gender wise comparision of mean values of height with age



Data Analysis

The Statistical Package for Social Science (SPSS) Version 16.0 was used for analysis.Descriptive statistics were obtained for normal values of trunk muscle strength for trunk flexors, trunk extensors, trunk lateral flexors and trunk rotators for all age groups with a 95% confidence interval established based on mean and standard deviation (SD).

Results

The aim of the current study was to establish isometric muscle strength normative data for trunk flexors, trunk extensors, trunk lateral flexors and trunk rotators by using a hand-held dynamometer. A total of 280 children, 140 boys and 140 girls from the age of 6 to 12 years were tested and the normative scores for both were obtained. The demographic data such as age, gender, height and weight were obtained. The mean and standard deviation of each gender and the total children are shown in Table 2.

Table 2: Demographic data with Mean and Standard Deviation of Height and Weight of both the Genders

AGE	GENDER	HEIGHT(cm) (MEAN±SD)	WEIGHT(kg) (MEAN±SD)
6	Girls-20	116.20 ± 4.37	20.47 ± 3.36
	Boys-20	119.00 ± 7.18	20.50 ± 4.86
	Total-40	118.00 ± 6.61	20.48 ± 4.12
7	Girls -20	120.90 ± 5.66	21.35 ± 3.97
	Boys -20	123.35 + 5.20	21.30 + 2.43
	Total-40	122.13 ± 5.51	21.32 ± 3.25
8	Girls-20	128.65 ± 4.66	25.90 ± 6.40
	Boys-20	130.20 ± 5.72	26.55 ± 5.47
	Total-40	129.43 ± 5.21	26.22 ± 5.89
9	Girls-20	135.00 ± 6.80	32.50 ± 9.28
	Boys-20	135.35 ± 6.63	29.95 ± 7.68
	Total-40	135.18 + 6.63	31.22 + 8.51
10	Girls-20	142.60 ± 7.05	33.65 ± 6.74
	Boys-20	14O.40 ± 4.33	37.00 ± 7.30
	Total-40	141.50 ± 5.88	35.32 ± 7.14
11	Girls-20	142.10 ± 6.60	32.80 ± 6.09
	Boys-20	145.15 + 5.65	33 .00 + 7.18
	Total-40	143.63 ± 6.26	32.90 ± 6.57
12	Girls-20	152.45 ± 6.68	42.35 ± 7.30
	Boys-20	147.60 ± 6.59	39.80 ± 9.43
	Total-40	150.03 ± 7.00	41.07 ± 8.42

Height and weight increases withage. In girls height seems to level off at the age of 10 and 11 years whereas in boys there is a linear increase in the height as the age advances until 12 years (Graph 1). There is a linear increase in the weight of both the genders except at the age of 11 years where there is decrease in the weight of both the genders(Graph 2) (Table 2).

The reference values of the trunk flexors, trunk extensors, trunk lateral flexors and trunk rotators were established. The mean, standard deviation and the range of these values are given in Table no. 3-5.The trunk muscle strength values ranged from 23.53N to 121.03N in girls, and 41.40N to 137.58N in boys.

Discussion

The purpose of the present study was to provide the isometric trunk muscle strength reference values for children 6-12 years of age using a hand-held dynamometer.These values can be used to quantify possible muscle weakness in children or to monitor the effects of therapy.[9]

According to our previous exposure of various dynamometers we found this base line digital hand held dynamometer was easier to handle, reliable and valid tool to measure the muscle strength. In our present study we found that children are more enthusiastic and competitive with the other children to know their muscle strength values. This was a positive factor to complete the study more easily.

Most of the previous studies have reported isometric strength values for upper limb and lower limb muscles using the hand-held dynamometer. [9-13]However, there are no studies retrieved on trunk muscles normative valuesusing the hand-held dynamometer. The present study gives reference values for the trunk muscle strength in 6-12 years age group for both the genders. This ranged from 23.53N to 121.03N in girls and 41.40N to 137.58N in boyswith a 95 % confidence interval. The upper extremity muscle strength values ranged from 67.96N to 171.96N in girls and 72.99N to 141.98N in boys whereas lower limb muscle strength values ranged from 84.96N to 264.98N in girls and 75.97N to 267.96N in boys.[9-13]

The previous studies done on upper limb and lower limb muscle strengths involved smaller sample size with arange between 41-131 children. Also the number of children in each gender (9-11) was reported to be less.[9-13]By contrast the presentstudy involves a

Figure 3: Gender wise comparision of mean values of weight with age.

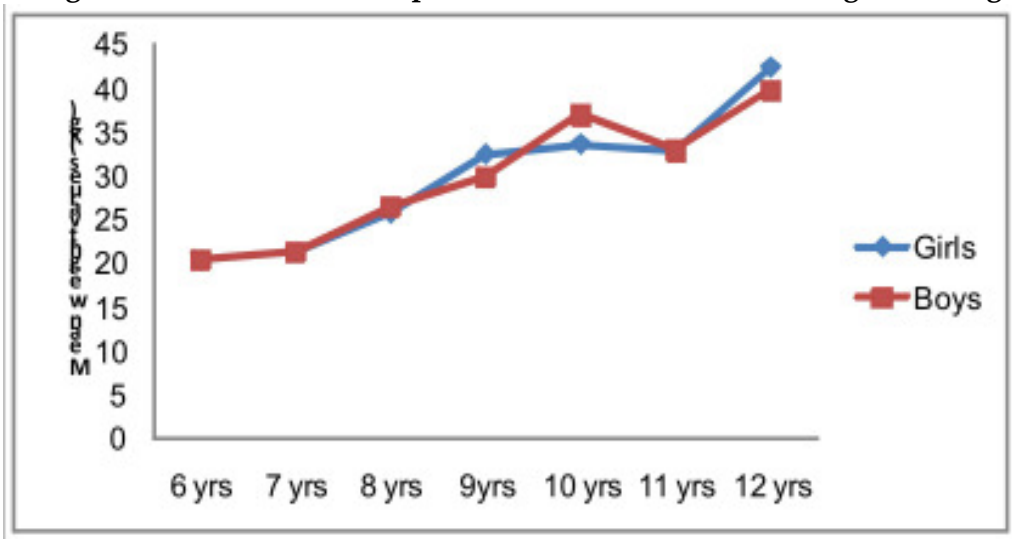


Table 3: Reference values of trunk flexors and extensorsmusclestrength in newtonswith Mean, SD and Range for both the Genders.

TM	Gender		AGE						
			6	7	8	9	10	11	12
T F	G	M± SD	26.24±7.56	40.92±6.67	52.49±9.34	68.50±10.68	91.19±13.79	95.64±18.68	81.85±29.36
		R	22.69-29.80	37.81-44.04	48.04-56.94	63.61-73.40	84.96-97.42	87.19-104.53	68.06-95.64
	B	M±SD	41.81+5.78	46.71+8.01	50.26+15.57	67.61+10.23	84.96+24.91	97.42+16.90	126.33+23.13
		R	39.14-44.04	43.15-50.71	43.15-57.38	63.16-72.51	73.40-96.53	89.85-105.87	115.65-137.01
	T	M± SD	33.81+10.23	44.04+7.56	51.60+12.90	68.06+10.23	88.52+20.02	96.97+17.35	104.09+34.70
		R	30.25-37.37	41.37-46.26	47.15-55.60	64.94-71.17	81.40-94.30	91.19-102.31	92.97-115.21
T E	G	M± SD	55.16±13.79	71.62±11.12	87.63±8.45	92.08±14.23	108.09±17.35	120.99±15.57	119.66±24.91
		R	48.49-61.39	65.83-76.51	83.18-91.19	84.96-98.75	99.64-116.10	113.43-128.11	108.09-131.22
	B	M± SD	66.28±8.45	73.40±10.68	82.74±16.01	99.64±12.90	104.98±26.69	120.55±20.91	137.45±131.22
		R	60.50-68.50	68.06-78.29	75.17-89.85	94.30-104.09	92.08-117.43	110.32-129.89	123.22-151.68
	T	M± SD	60.05+12.01	74.29+10.68	84.96+12.90	95.64+12.90	106.31+22.69	120.55+18.24	128.55+28.91
		R	56.05-63.61	68.50-75.62	80.51-88.96	91.63-99.64	99.20-113.43	114.76-126.33	119.21-134.34

Where, TM=Trunk Muscles, TF = Trunk Flexors, TE= Trunk Extensors, G=Girls, B=Boys, T = Total, M= Mean SD= Standard Deviation, R= Range.

sample size of 280 children and the number of children in each gender is 20 each. This large sample size gives strength to the present study.

As seen in the present study, boys were taller and heavier than the girls, except in some age groups. Girls are taller than the boys in the age group of 12 years whereas boys are heavier than the girls except at age 9 and 12 years. This earlier growth acceleration in girls is likely to be caused by the early onset of puberty.Timing of puberty has a wide variability. In girls from 8 to 12 years and in boys from 9 to 14 years. Girls attain puberty earlier as compared to boys. This leads to earlier increase in the growth parameters.[14] Therefore it is hypothesized to cause fluctuations in the height and weight in the 9-12 years age group.

The results of the present study showed that trunk strength increase with age. It was observed that in thegirls there was increase in the flexor and extensor muscle strength from 6-11 years age, but there was decrease in the strength in the 12 year age group. However for the trunk lateral flexors andtrunk rotators there was an increase in the muscle strength in the 6- 12 year age group. This may be because of the greater amount of fat deposition in the abdominal region as well as in the breast tissue leading to an increase in trunk weightwhich might have altered the trunk flexor and extensor strength measurements.[15]

In boys, trunk flexors and trunk extensors muscle strength was found to increase progressively from 6-12 years.But in the case of trunk lateral flexors and trunk rotatorsthe

Table 4: Reference values of trunk lateral flexors muscle strength in newtons with Mean, SD and Range for both the Genders.

TM	Gender		AGE						
			6	7	8	9	10	11	12
L F (RT)	G	M± SD	24.47±7.12	44.48±3.56	50.26±8.45	52.04±10.68	54.71±20.91	76.51±16.90	67.17±20.46
		R	20.91-27.58	43.15-46.26	46.26-54.27	47.15-56.94	45.82-64.05	68.50-84.52	57.38-76.51
	B	M± SD	42.26±4.00	46.26±7.56	47.15±14.68	59.61±7.56	55.16±19.57	72.51±26.24	92.52±24.91
		R	40.48-44.04	42.70-49.82	40.03-53.82	56.05-63.16	46.26-64.50	60.05-84.96	80.96-04.09
	T	M,± SD	33.36±10.68	45.37±5.78	48.49±12.01	56.05±9.79	55.16±19.13	74.73±21.80	79.62±25.80
		R	29.80-36.48	43.59-47.60	44.93-52.49	52.49-59.16	48.93-61.39	67.61-81.40	71.62-88.07
L F (LT)	G	M± SD	23.58±6.67	41.81±5.78	48.49±8.45	47.60±12.90	51.60±19.13	75.62±16.46	63.61±20.91
		R	20.46-26.24	39.14-44.48	44.93-52.93	41.81-57.38	42.70-60.94	68.06-83.18	93.86-73.40
	B	M± SD	37.37+3.11	41.81+8.90	44.48+12.90	55.16+8.90	50.71+20.02	66.72+21.80	87.63+25.35
		R	36.03-39.14	37.37-45.82	38.70-50.71	51.15-59.61	41.81-60.05	56.49-76.95	75.62-99.20
	T	M±, SD	30.69±8.45	41.81±7.56	46.71±11.12	51.60±11.57	51.15±19.13	71.17±19.57	75.17±25.80
		R	27.58-33.36	39.59-44.04	43.15-50.26	48.04-55.16	45.37-57.38	64.94-77.40	67.17-84.07

Where, TM=Trunk Muscles, LF = Lateral Flexors, Rt = Right,Lt = Left, G=Girls B=Boys, T = Total, M= Mean, SD= Standard Deviation, R= Ran

Table 5: Reference values of trunk rotators muscle strength in newtons with Mean, SD and Range for both the Genders

TM	Gender		AGE						
			6	7	8	9	10	11	12
ROT (RT)	G	M± SD	48.04±7.56	52.49±8.90	52.93±12.01	69.39±11.12	75.62±22.69	89.41±20.91	78.29±28.91
		R	44.48-51.60	48.49-56.94	47.60-58.72	64.05-74.73	65.39-86.30	79.18-99.20	65.39-92.08
	B	M± SD	48.49+9.79	52.93+11.57	57.38+15.12	70.28+11.57	81.85+20.46	93.86+25.80	110.76+28.47
		R	44.04-52.93	48.04-58.72	50.71-64.94	64.94-75.62	72.06-91.19	81.85-105.87	97.42-124.11
	T	M± SD	48.04+8.45	52.93+10.23	55.16+13.79	69.84+11.12	78.73+21.35	91.63+23.58	94.75+32.92
		R	45.37-51.15	49.82-56.49	51.15-59.61	66.28-73.40	72.06-85.85	84.07-98.75	84.07-105.42
R OT(LT)	G	M± SD	44.04±7.12	49.82±8.01	47.60±12.01	65.83±12.46	72.06±23.58	84.07±21.80	73.40±30.25
		R	40.92-47.60	46.26-53.82	41.81-52.93	60.05-71.17	61.39-83.18	74.29-94.30	59.61-87.63
	B	M ± SD	45.82±8.45	51.60±12.90	53.38±16.01	66.28±12.01	72.95±23.58	89.41±24.91	105.87±31.58
		R	41.81-49.82	45.82-57.38	46.26-60.94	60.94-72.06	61.83-84.07	77.84-100.97	91.19-120.55
	T	M± SD	44.93±8.01	50.71±10.68	50.71±14.23	65.83±12.01	72.51±23.58	86.74±23.13	89.85±34.70
		R	42.70-47.60	47.60-54.27	45.82-55.16	61.83-69.84	64.94-79.62	79.62-94.30	78.73-100.53

Where, ROT = Rotators, Rt = Right, Lt = Left, G=Girls B=Boys, T = Total, M= Mean SD= Standard Deviation, R= Range.

trunk strength increased from 6-11 years age but decreased in the 12 year age group. Normal developmental changes in ligament and musclefiber elasticity and increased resistance to the trunk motions may contribute to the increased stiffness of the soft tissues across these age groups. Skeletal maturationmilestones are achieved during the same time period. Primary ossification of the lumbar spine is completedbetween seven and nine years of age and mature lumbar facet orientation is achieved by approximately 11 years of age. Trunk lateral flexion and rotation are greater in younger children because of the frontal orientation of the facets, but as age advances the facets gradually achieve sagittal orientation constraining these movements of the trunk. This decreased range of motion and changes in the facet orientation might have decreased the child's performance at 12 years of age as observed during this study.[16]Boys were found to be stronger thangirls in all the age groups under study.

The clinical Implication of the study is that the normative data of the trunk muscle strength established can be used to quantify patterns of muscle weakness or to evaluate the possible effects of therapy in children suffering from any disease that affects the muscle strength.

The limitationsof the study include the following; children who participated in the study lived within similar geographic location; thetherapist was not blinded while reading the

measurements during the study due to manpower constraints; andthe present study determined muscle strength in terms of force values rather than torque values of the muscle strength.

This data will form the basis for future studies on trunk muscle strength in different geographical locations and it can be used as standard reference values in future studies performed on trunk muscle strength in affected children. Studies can be performed to establish reference values of trunk muscles strength in children using isokinetic dynamometers, with an independent observer.

Conclusion

The normal mean value of isometric trunk muscle strength using a hand-held dynamometer ranged from 23.53N to 137.58N, in children 6 to 12 years of age. In girls it ranged from 23.53N to 121.03N whereas in boys from 41.40N to 137.58N.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Original Article

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A Comparative Study between Elders with and without Knee Osteoarthritis on Quadriceps Strength, Prporioceptive Acuity and Balance

Monika Sultan*, Majumi Mohamad Noohu**

Abstract

Objective: The study was done to assess the balance function in elderly with knee osteoarthritis along with quadriceps strength and prprioceptive acuity (joint position sense).

Methods: The study was observational type with 30 subjects in group 1 with osteoarthritis knee and 30 subjects in group 2 without any known history of osteoarthritis of knee joint. The subjects were measured for quadriceps strength, prprioceptive acuity, static balance using mCTSIB and functional balance using timed Up and Go test. The test scores were compared using student's t test.

Results: The study showed a statistically significant difference for all the variables studied such as quadriceps strength, prpioceptive acuity (joint position sense), modified CTSIB score and TUG scores between the groups.

Conclusion: The elderly adults with knee osteoarthritis have deterioration in quadriceps strength, proprioceptive acuity, static balance and functional mobility.

Key Words: Osteoarthritis; Postural control; Ageing and functional mobility.

Introduction

Balance is a complex biologic function dependent upon sensory inputs through visual, tactile-proprioceptive, and vestibular system. Sensory input is processed within the nervous system eliciting a restorative response coordinated among extremity and axial muscles.[1]An inevitable accompaniment of the aging process for many adults is the restriction in their ability to move independently within the context of constantly changing task demands and environmental context.[2] Greater postural sway and an increased incidence of falls observed in elderly suggest that older individuals may be slower in detecting and correcting postural disturbances.[3]

Persons with knee osteoarthritis (OA) have been found more likely to report difficulty with physical functioning than persons without knee OA.[4] As the prevalence of OA increases with age and aging is associated with decreasing physiological functions, the combination has a major health implication.[5] It has been suggested that proprioception declines with age and is further impaired in elderly with knee OA. Poor proprioception may contribute to functional impairment in knee OA.[6] Those with OA and older adults with lower limb arthritis are at an increased risk of falling due to deficits in neuromuscular system.[7] This is particularly apparent at the knee joint, one of the most commonest sites to be affected.[5]

Pain had been documented to affect quadriceps function. Nociceptors and other receptors in and around the joint can have flexor excitatory and extensor inhibitory

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actions. At knee, these receptors are likely to excite hamstrings and inhibit quadriceps.[8] O' Reilly et al, demonstrated low quadriceps strength in individuals with knee pain than those without pain; and also reported decreased muscle activation.[5] Limited researches have evaluated the impact of knee osteoarthritis on balance in elderly. Few studies, all utilizing force platforms to measure postural sway have been undertaken in patient population, revealed deficits in postural control compared to asymptomatic subjects.[9, 10, 11]

So it is necessary to study the changes in muscle strength, proprioceptive function and balance performance in elderly with knee osteoarthritis as these changes may contribute to decline in function as well as other complications such as falls. In this study it was hypothesized that the elderly with knee osteoarthritis will display deterioration in quadriceps strength, proprioceptive acuity, static balance and functional mobility.

Methods

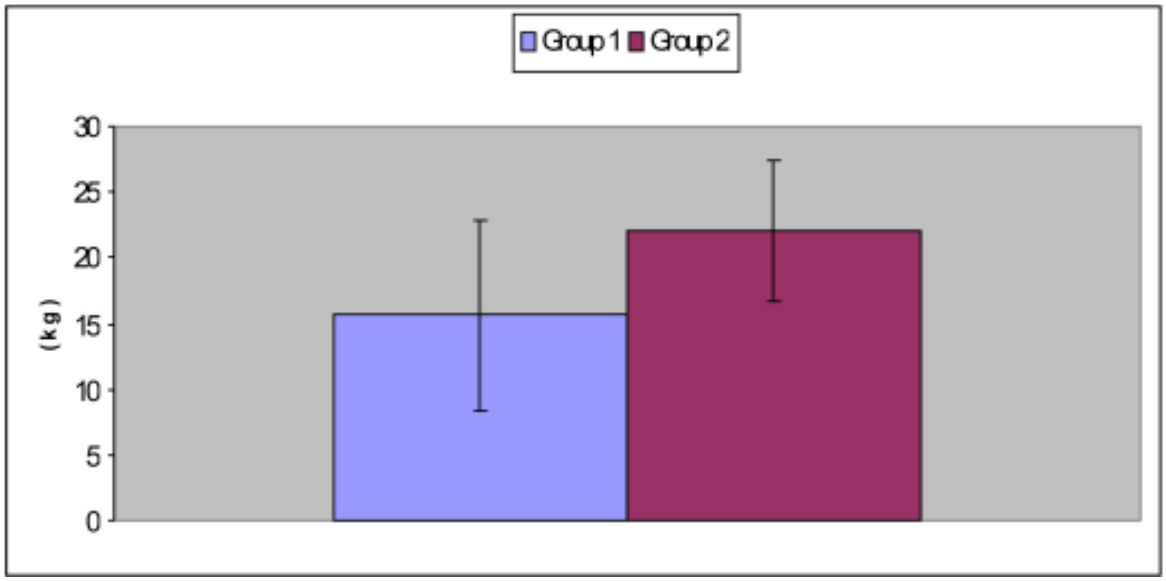
A sample of convenience of 60 community dwelling older adults, 60 to 70 years of age took part in the study. The sudy consisted of

Table 1: Comaprison of quadriceps strength, joint position sense, mCTSIB and TUG between group 1 and 2.

Variables	Group 1 (n=30)	Group 2 (n=30)	t-value	p-value
	Mean+ S.D	Mean+ S.D		
Quadriceps Strenght(kg)	15.64+ 7.22	22.05+ 5.31	3.91	0.05
JPS1(25⁰)(Absolute error)	7.61+ 0.55	2.95+ 0.22	7.71	0.01
JPS2(45⁰)(Absolute error)	8.05± 3.20	2.86± 1.02	8.45	0.01
JPS 3(60⁰) (Absolute error)	8.90+ 3.05	3.10 + 1.39	9.45	0.01
mCTSIB(seconds)	114.67+5.73	117.43 =3.22	2.29	0.05
TUG(seconds)	11.25+1.29	9.90+0.74	4.93	0.01

mCTSIB-Modified test for sensory integration of balance.
TUG-Timed Up and Go Test

Figure 1: Comaprison of quadriceps strength between group 1 and group 2

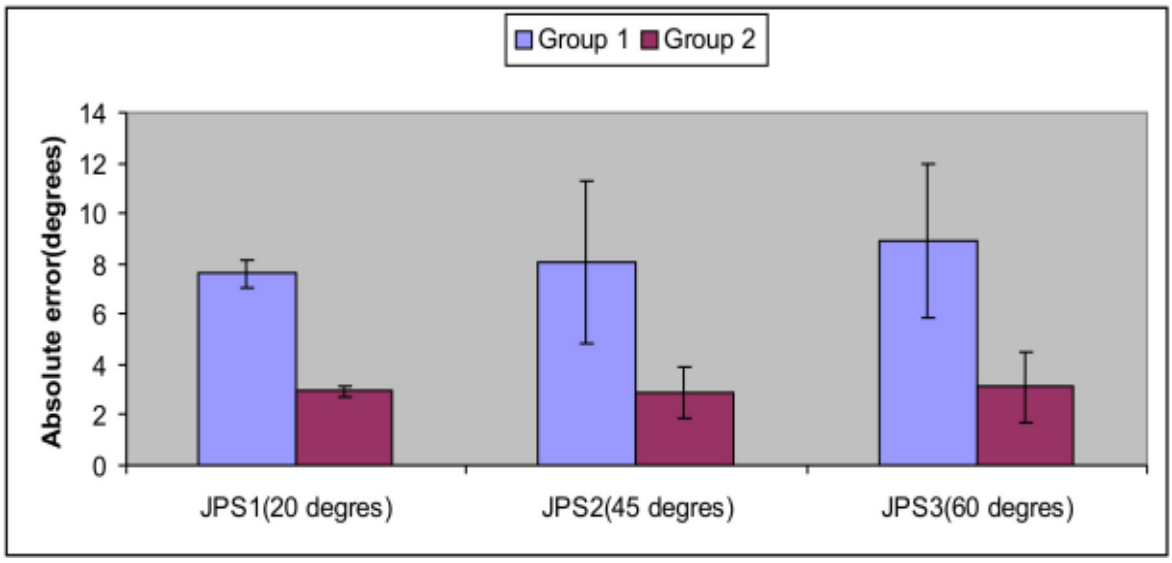


two groups , group 1 consisted of 30 elderly with OA of knee and group 2 consisted of 30 elderly without known history of OA of knee. The study design was observational type. The study was approved by research and ethical committee of ISIC Institute of Rehabilitation Sciences, New Delhi.

The subjects were recruited from OPD of Indian Spinal Injuries Centre,New Delhi and from the free geriatric health check-up camp organized at the ISIC Institute of Rehabilitation Sciences, New Delhi.Subjects were recruited on the following criteria ,age 60 years and above, able to follow commands, diagnosed with unilateral osteoarthritis of knee joint using clinical and radiological (ACR) criteria for diagnosis of knee osteoarthritis,[12]ndependent in ADL's and for group 2 subjects were without history of OA of knee. Subjects with intraarticular steroid injections, severe medical condition precluding safe testing, coexisting lower limb joint pathology, head trauma, neurological disease,visual impairment, limb or spinal fractures, persistent symptoms of vertigo, light headedness and unsteadiness, total knee arthroplasty, diaetes mellitus and history of falls were excluded.

Demographic data was collected from the subjects who met the inclusion criteria of the study after signing an informed consent. The study was explained in detail to the participants. Following this, the subjects were assessed on the first day of their visit, for the isometric strength of quadriceps, followed by proprioceptive acuity assessment of knee joint. The subjects were assessed for static balance and functional mobility on the second non-consecutive day to eliminate the confounding effects of fatigue. Data for the isometric quadriceps strength and proprioceptive acuity was obtained in the group 1 (OA group) from the arthritic limb and in the group 2 (control group) from the randomly chosen limb (by lottery method).Equipment used were, quadriceps table, strain guage, continuous passive motion (CPM) device, air splints for ankle and thigh, medium density polyfoam (52.5 cm x 52.5 cm x 10.6 cm)stop watch and goniometer (360°).

Figure 2: Comaprison of joint position sense between group 1 and 2

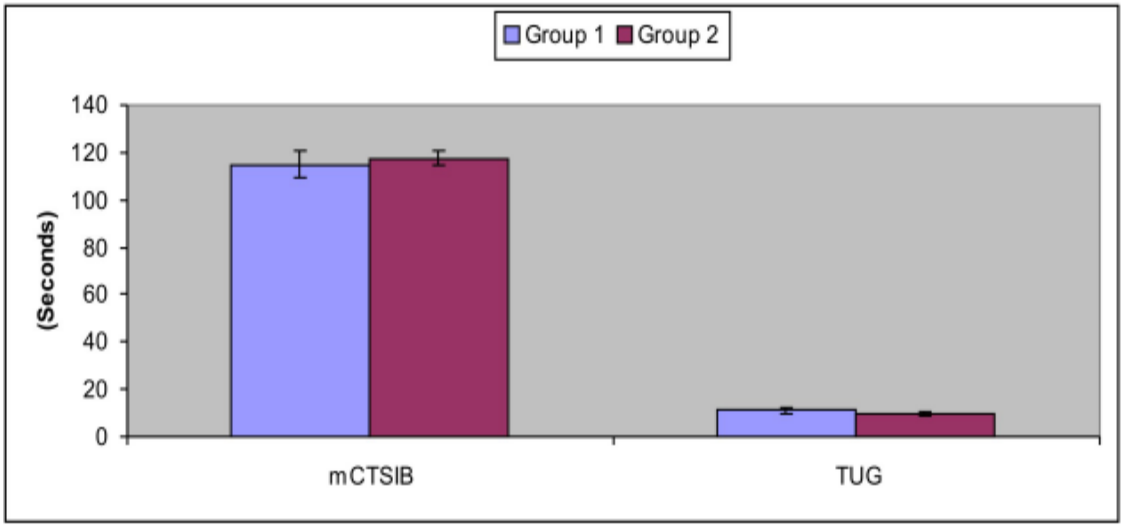


The method used in present study to measure muscle strength was proven for its reliability and validity by Edwards et al.[13] For isometric quadriceps strength measurement, the subject sat on the quadriceps chair, with hips and knees flexed to 90°.One end of the strain gauge was connected just above the ankle pad over the lever of quadriceps table and the other end of the strain guage was attached to the back unit of the chair giving a horizontal link of pull. Each subject was asked

to push as hard as possible against the ankle pad by the chosen limb to try to straighten the leg.Restaring straps were used at thigh,hip and trunk. Subjects were allowed to practice maximum contraction and were given sufficient rest before the actual strength testing trial.Three strength testing trials were administered for each patient, with 1 minute rest between them. During the rest intervals, subjects were instructed to breathe out to prevent Valsalva maneuver effects. The maximum voluntary contraction (MVC) was taken as the highest value of three trials.[14]In the present study, the measurement of proprioceptive acuity, has been determined by passive-passive method,[15] which is considered to be a pre-requisite for measuring joint position sense clinically.[16] Tsang et al have reported that passive knee repositioning test produces highly repeatable data, with ICC=0.90.[17] Proprioceptive acuity measurements were done with subjects in shorts , they were made to lie supine with the chosen limb on the CPM device.To neutralize the cutaneous sensations air splints were used in thigh and foot, and subjects were blind folded to prevent any visual input. After fixing straps, the CPM device was adjusted so that the axis of the device was in line with the subject's knee joint. The knee joint was passively moved from its starting position (0 degree of knee flexion) to one of the predetermined angles (JPS1-25°, JPS2-45°, JPS3-60°) at a speed of 2 degree per second. The knee joint was rested at the target angle for 10 seconds (same duration for all the trails) by the investigator, and the subjects was instructed to remember the position of the knee joint. This was considered to be the first practice trial. The knee was then brought back to different randomly assigned angle between 10°-15° from the original starting position and rested for 10 seconds. This was followed by bringing the knee again to the target angle (as in practice trial 1) and rested for 10 seconds. The subject was again asked to remember the knee position. This was considered to be the second practice trial.[18] Total 2 practice trials were given to the subjects prior to final assessment. After the completion of the practice trials, the knee was again flexed with subject instructed to stop the machine with hand held remote to identify the target angle. The absolute difference between the presented angle and the perceived angle was recorded as the absolute error for the predetermined angle. Three readings were taken, and absolute error was calculated for each trial, and then the average absolute error was computed for each predetermined angle for the subject's knee.[19]

On the second test session, the subjects were first assessed for static balance using modified CTSIB balance test. All subjects were tested for each of the four conditions in modified

Figure 3: Comparison of mCTSIB and TUG score between group 1 and 2



CTSIB balance test. All the tests were done barefoot. The trials were timed using a stopwatch. Time was stopped during a trial and recorded if: (a) subject deviated from the initial crossed arm position, (b) subject opened eyes during 'eye closed' trial condition, or (c) subject moved feet (took a step) or required manual assistance to prevent loss of balance. A trial was considered successful if the subject was able to maintain the starting position independently for a period of 30 seconds in each condition. A maximum of three trials were permitted for each condition, each lasting for 30 seconds. Trials were performed until the subjects either: (a) successfully maintained the starting position for an entire 30 seconds, or (b) completed three, 30 second trials to the best of their ability. The score was averaged for each condition for the number of trials performed; which gave the condition score, and the average of all the conditions was summated to obtain the total score for the test. Prior to testing in each condition, a demonstration was provided to the subjects. The test was administered with the conditions in same order each time. Subjects were told that each trial would last for 30 seconds.[20]After completion of the static balance assessment, the subjects were provided a period of 5 minutes of rest (if required). The subjects were assessed for functional mobility using 'timed up and go'(TUG) test which ia basic test for functional mobility test for elderly with an inter-rater reliability of ICC=0.99. The subjects were instructed to move from a seated position in a chair to a standing position, walk 3 meters (10ft) at a normal and safe pace, turn around, walk back to the chair, and sit down. The timed up and go test was measured with a stop watch. The subjects were given a practice trial, followed by 2 timed trials. The test began with each subject sitting, back against the chair, arms resting on the lap, and feet just behind the distance marker on the floor. Subjects were instructed as follows "on the word 'go' stand up, walk comfortably and safely upto the cone on the floor, walk around the cone, come back and sit all the way back into your chair". They were informed that the trial would be timed. Timing began on the word 'go' and ended when subject's back rested against the chair upon returning. A practice trial was performed, followed by 2 recorded trials. Data obtained during the 2 recorded trials were averaged for use in data analysis.[14]

All four tests took approximately 40 minutes time to administer. The quadriceps strength testing took 4 to 5 minutes, proprioceptive acuity testing took 20 minutes, static balance assessment took 5-6 minutes and timed up and go took 4 to 5 minutes for completion.Data analysis were performed using SPSS software. A student's t-test was used to compare isometric quadriceps strength, proprioceptive acuity, static balance and functional mobility between group 1 and group 2.The significance level was set at p d" 0.05.

Results

The mean+ s.d of age of group 1 was 64.20+ 2.71 years and for group 2 was 64.43+2.97 years. There was a statistically significant difference for all the variables studied such as quadriceps strength, prpioceptive acuity (joint position sense), modified CTSIB score and TUG scores between the groups(table 1). The mean+ s.d of quadriceps strength of group 1 was 15.64+7.22 kg and for group 2 was 22.05+5.31kg(table 1 and figure 1). The mean+ s.d f of JPS1-25^0,absolute error was 7.61+ 0.55^0, JPS2-45^0,absolute error was 8.05+ 3.20^0 JPS3-60^{0,} absolute error was 8.90+ 3.05^0 in group 1 and in group 2 the mean+ s.d of JPS1-25^0,absolute error was 2.95+ 0.22^0, JPS2-45^0-,absolute error was 2.86+ 1.02^0, JPS3-60^0,absolute error was 3.10 + 1.392^0(table 1 and figure 2). The mean+ s.d of mCTSIB in group 1 was 114.67+5.73 seconds and in group 2 it was 117.43 +3.22 seconds and the mean+ s.d of TUG for group 1 was 11.25+1.29 seconds and for group 2 was 9.90+0.74 seconds.(table 1 and figure 3)

Discussion

In this study, the group of elderly with knee OA has displayed decreased quadriceps strength, compared to the age matched controls this finding is in accordance with reporting from Hurley et al.[22] The possible factors contributing to the deficit could be inadequate activation of muscles, joint pain and effusion.It has been reported that the articular damage may stimulate articular mechanoreceptors, evoking abnormal sensory information, which decreases voluntary activation.[22] Pain is also known to affect quadriceps function.[5] According to the pain adaptation model, the activity of the agonist muscle has been found to be decreased by pain, even when it does not arise from the muscle itself; also there has been found to be a small increase in the level of activity of antagonist. As a consequence of these changes force production, the range and velocity of the movement of the affected part are often decreased.[23] Nociceptors and other receptors in and around the joint can have flexor facilitatory and extensor inhibitory actions. Thus at the knee, these receptors are likely to excite hamstrings and inhibit quadriceps muscle.[24] Quadriceps function is also believed to be affected by coexisting effusion. Knee effusion has been found to stretch the joint capsule[25], and increase the intrarticular volume.[26] Because of this increased volume, there is an increase in pressure, accompanied by distension of capsular structures. Type 1 mechanoreceptors are believed to be activated by such change in the joint and are considered to mediate inhibition by reflexively inhibiting lower motor-neurons supplying quadriceps muscle.[27]

This study compared the proprioceptive acuity between arthritic and control groups, and found significant difference between the groups. The arthritic group has shown larger errors when compared to normal healthy controls. Proprioceptive acuity has been found to be affected at all predetermind angles, chosen for the study. Some previous studies have given similar results.[22,28] The possible explanation for such results can be loss of mechanoreceptors around the joint.[29] Larger errors were however shown at 60^{o} angle of knee flexion. Eventhough there have been studies suggesting critical role of joint receptors in proprioception and motor control.[30, 31]

Age has been shown to affect the balance physiology.[32,33] On comparing the static balance scores, the arthritic group was found more unstable, which has been confirmed by previous studiy.[22]The study used mCTSIB for evaluating static balance because elderly have been demonstrated to have difficulty balancing, when sensory inputs contributing to balance are reduced, so that they have less redundancy of sensory information.[34] The challenging stance conditions offered by the test placed greater reliance on peripheral proprioceptors,[35] and since arthritic individuals have larger poprioceptive deficits as compared to the normal elderly controls,[22,36] they were found more unstable, while performing the test. On comparing the functional mobility in both the groups, the arthritic group demonstrated altered functional mobility, that is- they took significantly longer time to accomplish the task.Aging has been shown to affect quadriceps strength,[35,37] so does arthritis.[38,39] The altered function by the arthritic group could be because of the combined effects of aging and the pathology.

The study suggests screening for balance deficits in elderly with OA and providing balance re-education. Future studies are recommended, which include a bigger sample group,studies on genders separately, studying effect of balance training protocols on functional performance of subjects with OA knee.

Conclusion

The data obtained from this study shows that the elderly with knee osteoarthritis have decreased quadriceps strength, proprioceptive acuity, static balance and functional mobility,

when compared to healthy elderly controls. Hence the hypothesis that "elderly with knee osteoarthritis will display deterioration in quadriceps strength, proprioceptive acuity, static balance and functional mobility" holds true.

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Original Article

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Comparative Study of Neural Tissue Mobilization and Manual Traction in Patients with Cervical Spondylosis

Shipra Bhatia*, Neha Samvedi, Aparna Sarkar*****

Abstract

Objective: To compare the efficacy of Neural Tissue Mobilization and Manual Traction in patients with Cervical Spondylosis.

Study Design: Experimental design

Method: 30 subjects of cervical spondylosis, age group 50-65 yrs participated in the study and were divided into 3 groups (10 subjects in each group). Group A was treated with neural tissue mobilization, neck isometrics and hot pack; Group B was treated with cervical manual traction, neck isometrics and hot pack & Group C was treated with hot pack only. Then the results were compared on NDI scale, VAS scale and active ROM of cervical spine.

Result: This study showed significant results of cervical manual traction on all outcome measures. However, neural tissue mobilization was significant on NDI scale, cervical right rotation and left rotation.

Conclusion: The study concluded that in patients with cervical spondylosis, treatment with cervical manual traction, neck isometrics and hot pack helps in reducing the pain, increasing the range of motion of cervical spine and efficiency in activities of daily living, as seen by improvement in VAS scale, active ROM of cervical spine and NDI scale respectively. Cervical Manual Traction showed significantly better results on all outcome measures as compared to Neural Tissue Mobilization in patients with cervical spondylosis.

Keywords: Cervical Spondylosis, Cervical Manual Traction, Neural Tissue Mobilization.

Introduction

Cervical spondylosis is a generalized disease process affecting all levels of the cervical spine. Cervical spondylosis encompasses a sequence of degenerative changes in the intervertebral discs, osteophytes of the vertebral bodies, hypertrophy of the facets and laminal arches, and ligamentous and segmental instability. The natural history of cervical spondylosis is associated with the ageing process. Senescent and pathologic processes are thus morphologically indistinguishable (1).

The outcome of neck pain depends on the underlying cause, but acute neck pain usually resolves within days or weeks, although it can recur or become chronic. Aetiological factors are poorly understood and are usually multifactorial, including poor posture, anxiety, depression, neck strain, and sporting or occupational activities. When mechanical factors are prominent, the condition is often referred to as "cervical spondylosis," although the term is often applied to all non-specific neck pain. Mechanical and degenerative factors are more likely to be present in chronic neck pain (2). The most common cause of cervical radiculopathy is foraminal encroachment of the spinal nerve due to

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combination of factors, including decreased disc height and degenerative changes of the unco-vertebral joints anteriorly and zygapophyseal joints posteriorly (i.e., cervical spondylosis). In contrast to disorders of the lumbar spine, herniation of the nucleus pulposus is responsible for only 20 to 25 percent of cases (3).

Presenting features of cervical spondylosis are cervical pain aggravated by movement, referred pain (occiput, between the shoulder blades, upper limbs), retro-orbital or temporal pain (from C1 to C2), cervical stiffness-reversible or irreversible, vague numbness, tingling, or weakness in upper limbs, dizziness or vertigo, poor balance and rarely, syncope, triggers migraine, "pseudo-angina". Signs in patients with cervical spondylosis generally are poorly localized tenderness, limited range of motion and minor neurological changes like supinator jerk (2).

Radiculopathy (nerve root compression) due to cervical spondylosis usually occurs at the C5 to C7 levels, although higher levels can also be affected. Neurological features follow a segmental distribution in the upper limb, with sensory symptom (shooting pains, numbness, hyperaesthesia) being more common than weakness. Reflexes are usually diminished at the appropriate level (biceps (C5/6), supinator (C5/6), or triceps (C7)) (2).

Table 1: Comparison of mean NDI score in group A, B and C in Pre and Post condition

Group	Pre	Post	T-value	Level of significance	P-value
A	26.6	22.8	3.8	Significant	<0.01
B	27.9	21	6.44	Significant	<0.001
C	28.1	25.5	2.13	Insignificant	>0.05

Table 2: Comparison of VAS scale in group A, B and C in Pre and Post conditions.

Group	Pre	Post	T-value	Level of significance	Probability
A	6.75	5.65	2.03	Insignificant	>0.05
B	7.3	5.1	4.03	Significant	<0.01
C	6.85	6.15	1.11	Insignificant	>0.05

Exercise regimens-using proprioceptive, strengthening, endurance, or coordination exercises-are more effective than usual care (analgesics, non-steroidal anti-inflammatory drugs, or muscle relaxants) or stress management. Manual treatments (mobilization physiotherapy or manipulation) provide limited evidence that mobilization physiotherapy and manipulation are more effective for chronic neck pain than less active treatments (drug treatment, education, counselling). However, manipulation has occasionally been associated with serious neurological complications (2).

When neural mobilization is used for treatment of adverse neurodynamics, the primary theoretical objective is to attempt to restore the dynamic balance between the relative movement of neural tissues and surrounding mechanical interfaces, thereby allowing reduced intrinsic pressures on the neural tissue and thus promoting optimum physiologic function. The hypothesized benefits from such techniques include facilitation of nerve gliding, reduction of nerve

Table 3: Comparison of Cervical Active ROM in groups A, B and C in Pre and Post conditions

FLEXION ROM					
Group	Pre	Post	T-value	Level of significance	P-value
A	35.9	38.4	1.85	Insignificant	>0.05
B	33.4	38.9	3.95	Significant	<0.01
C	32.1	32.9	0.52	Insignificant	>0.05
EXTENSION ROM					
A	56.7	59.3	1.48	Insignificant	>0.05
B	60.4	65.7	4.95	Significant	<0.001
C	55.1	56	0.82	Insignificant	>0.05
RIGHT SIDE FLEXION ROM					
A	32.9	35.2	2.11	Insignificant	>0.05
B	31.6	36.4	4.03	Significant	<0.01
C	31.3	32.2	1.05	Insignificant	>0.05
LEFT SIDE FLEXION ROM					
A	36.2	38.6	1.69	Insignificant	>0.05
B	35.8	40.3	4.94	Significant	<0.001
C	36.5	37.5	1.96	Insignificant	>0.05
RIGHT ROTATION ROM					
A	57.2	59.7	2.97	Significant	<0.02
B	56.5	60.8	5.24	Significant	<0.001
C	55.2	56.4	1.76	Insignificant	>0.05
LEFT ROTATION ROM					
A	62.2	64.5	3.33	Significant	<0.01
B	62.1	66.5	4.65	Significant	<0.01
C	61.5	62.7	1.42	Insignificant	>0.05

adherence, dispersion of noxious fluids, increased neural vascularity, and improvement of axosplasmic flow (4).

Traction has also been reported to decrease pain by providing muscle relaxation, stimulation of mechanoreceptors and inhibition of reflex muscle guarding (5). Manual cervical traction is suggested to relieve pain and muscle spasm in the neck and upper quartile. Afferent input generated by these procedures may lower the excitability of á-motoneuron pools of upper limb muscles. While joint receptors are traditionally viewed as the receptor most likely to evoke responses to manual therapy, a review of the literature into possible mechanisms underlying manual cervical traction suggests stretch generated in cervical muscles and skin during the procedure has the potential to influence the excitability of á-motoneurons (6).

This study aims to compare the efficacy of neural tissue mobilization & cervical manual traction in patients having cervical spondylosis.

Materials and Method

Sample: 30 individuals with cervical spondylosis participated in study from RBTB hospital and residents in Ashok Nagar.

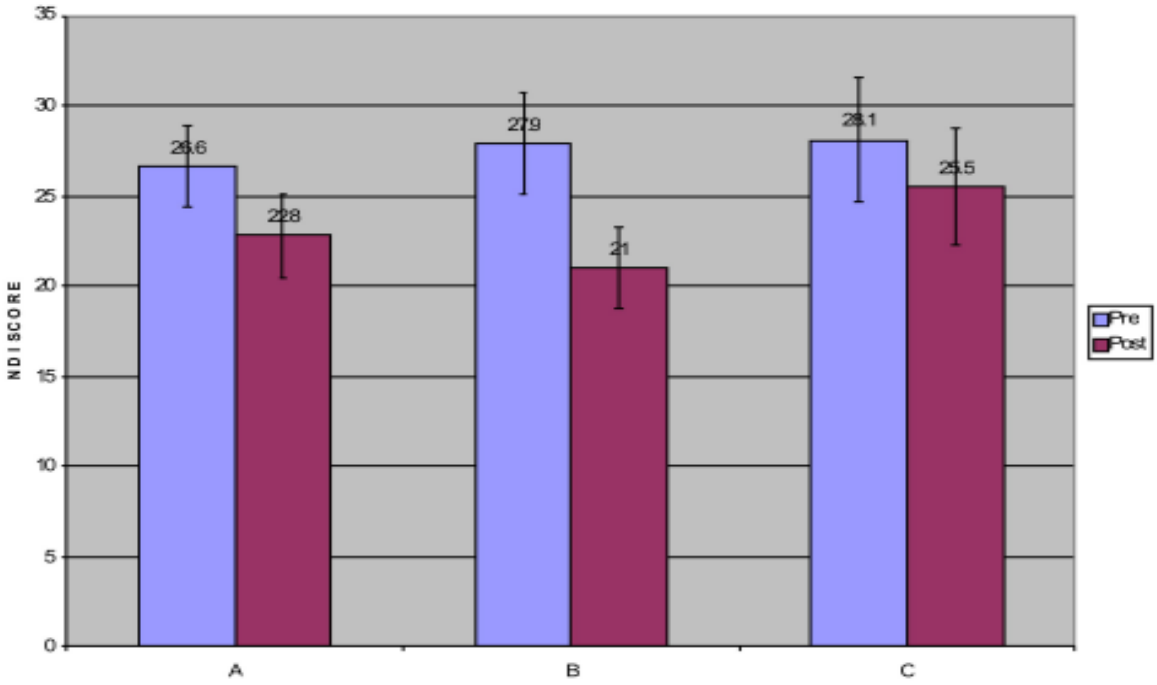
Inclusion criteria

1. Having cervical spondylosis since 10 or more years
2. Unilateral Radiculopathy
3. NDI score >24
4. ULTT1 positive
5. Ability to read English

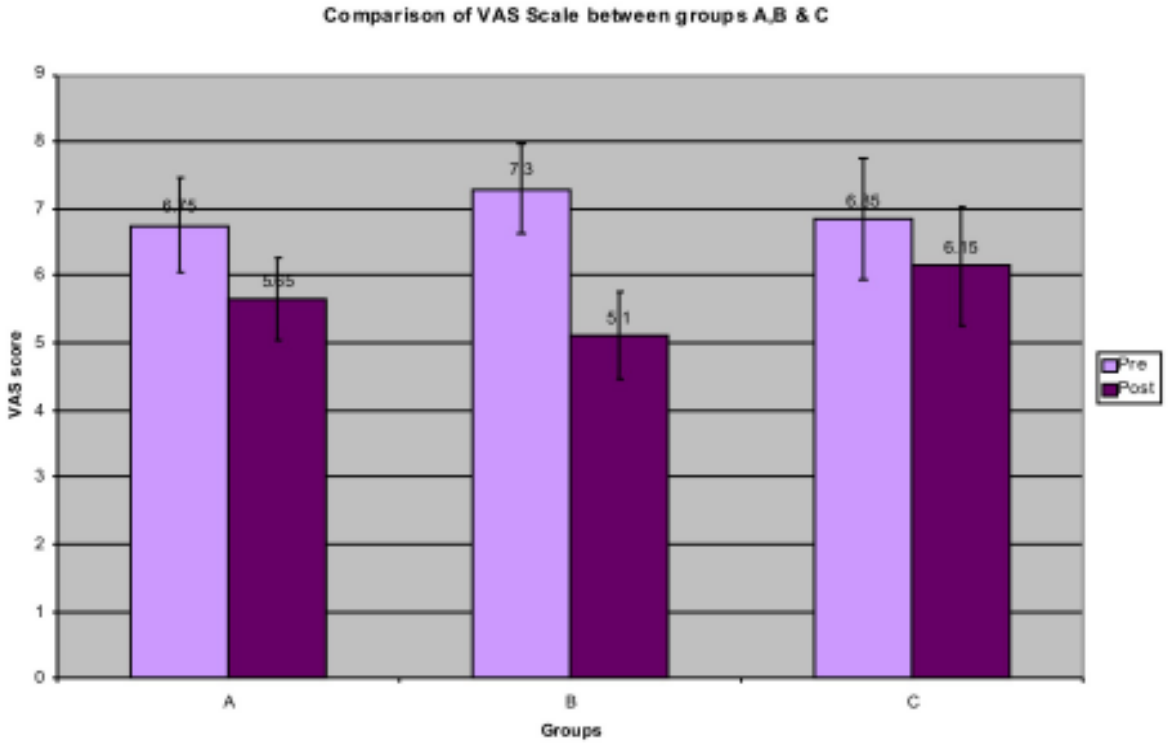
Exclusion criteria

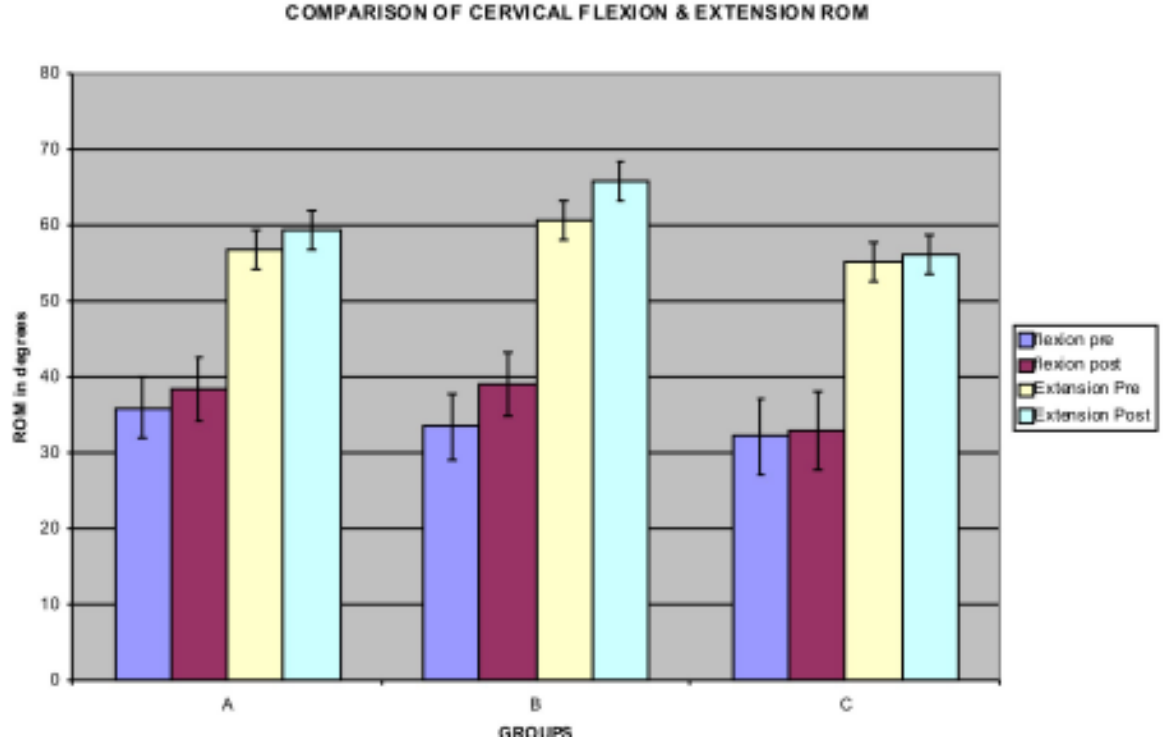
1. Contraindication to manual therapy techniques.
2. Cervical spine surgery.
3. Patients involved in compensation and/or ligament associated neck and/or upper limb pain.

Comparision of NDI Score between Groups



4. Soft tissue inflammatory condition like tendinitis, tenosynovitis, capsulitis & bursitis.
5. Tumors
6. Circulatory disturbances
7. Cervical myelopathy
8. Specific pathology due to trauma of the shoulder girdle complex, arm or hand on the affected side.





Procedure

30 individuals with cervical spondylosis were selected. They were assessed & randomly allocated to one to the three groups given below. Measurements of NDI scale, VAS scale and ROM of cervical spine were taken before and after the treatment to compare the effectiveness of the various treatments given.

Group A: Neural tissue mobilization (NTM), neck isometrics and hot pack;

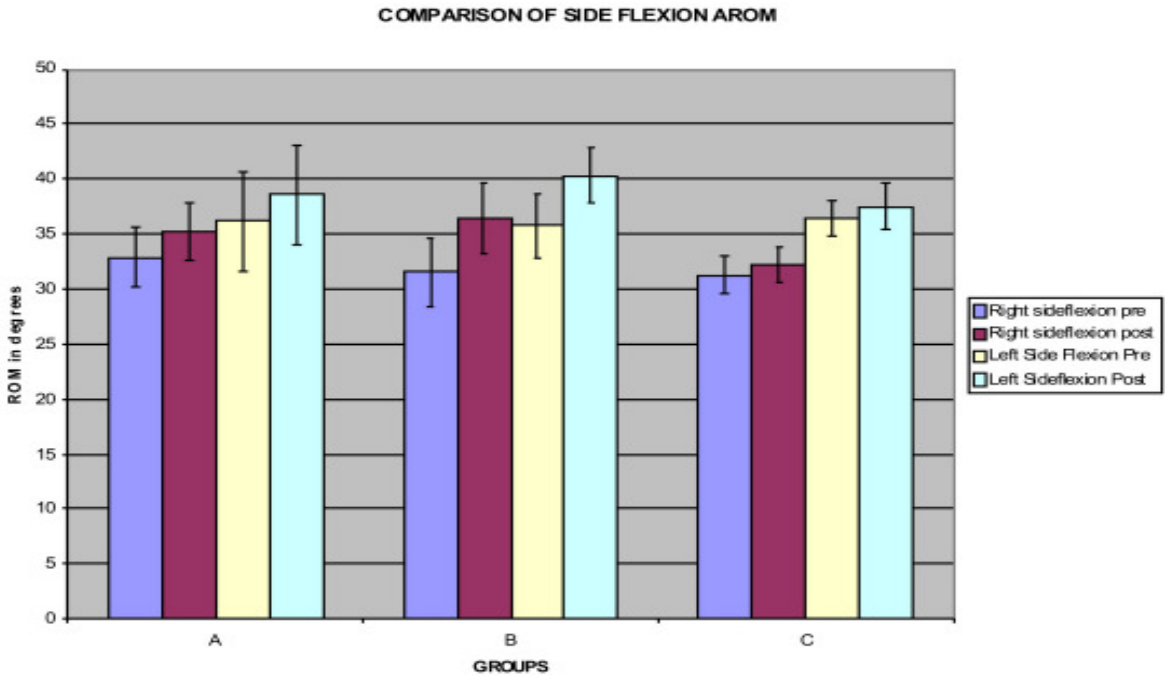
Group B: Cervical manual traction, neck isometrics and hot pack;

Group C: Hot pack only

Group A: NTM was given by the therapist on the ipsilateral side of the patients by positioning them in supine lying, slightly diagonal across the bed with affected side towards the open side of the couch and shoulder placed slightly out of the couch. The therapist was standing next to the head of the patient, facing towards his feet. Constant shoulder depression was maintained throughout the treatment session, once started, with pressure application from the thigh of the therapist. While the shoulder girdle is depressed, the glenohumeral joint is taken to the appropriate abduction position (90 deg.), elbow extended, forearm supinated, wrist extended, fingers & thumb extended and cervical spine side flexion of the contralateral side and neural tissue mobilization was then given by the therapist without any discontinuity in between the treatment. Dosage of mobilization was 2 sets of 30 repetitions each day, for 5 days. Following hot pack, neck isometric exercises to group A and B.

Group B: Manual cervical traction was given with patient in supine lying position and relaxed. The therapist stood at the head of the treatment table, suppoting the weight of the patient's head in the hands. Hand placement depends on comfort, vary the patient's head position in flexion, extension, side bending with rotation until the tissues to be stretched are taut, and then apply a traction force by assuming a table stance and leaning backward in a controlled manner. The force was usually applied intermittently with a smooth and gradual building and releasing of the traction force. Dosage of cervical traction was 15 repetitions, twice a day for 5 days.

Group C: The patients in this group were treated with hot pack under the cervical spine for 15 min for 5 days.



Outcome measures

1. NDI Scale
2. VAS Scale
3. Active ROM of Cervical Spine

Result

Baseline characteristics

The age of patients was between 50-65 years. Both males and females were included in the study and duration of cervical spondylosis symptoms were 10 years or more.

Both neural tissue mobilization and cervical manual traction were significantly effective with $p<0.001$ and Group C showed insignificant results with $p>0.05$.

Cervical manual traction was significantly effective with $P<0.01$; and neural tissue mobilization & application of hot pack showed insignificant results in cervical spondylosis patients on calculating T- values.

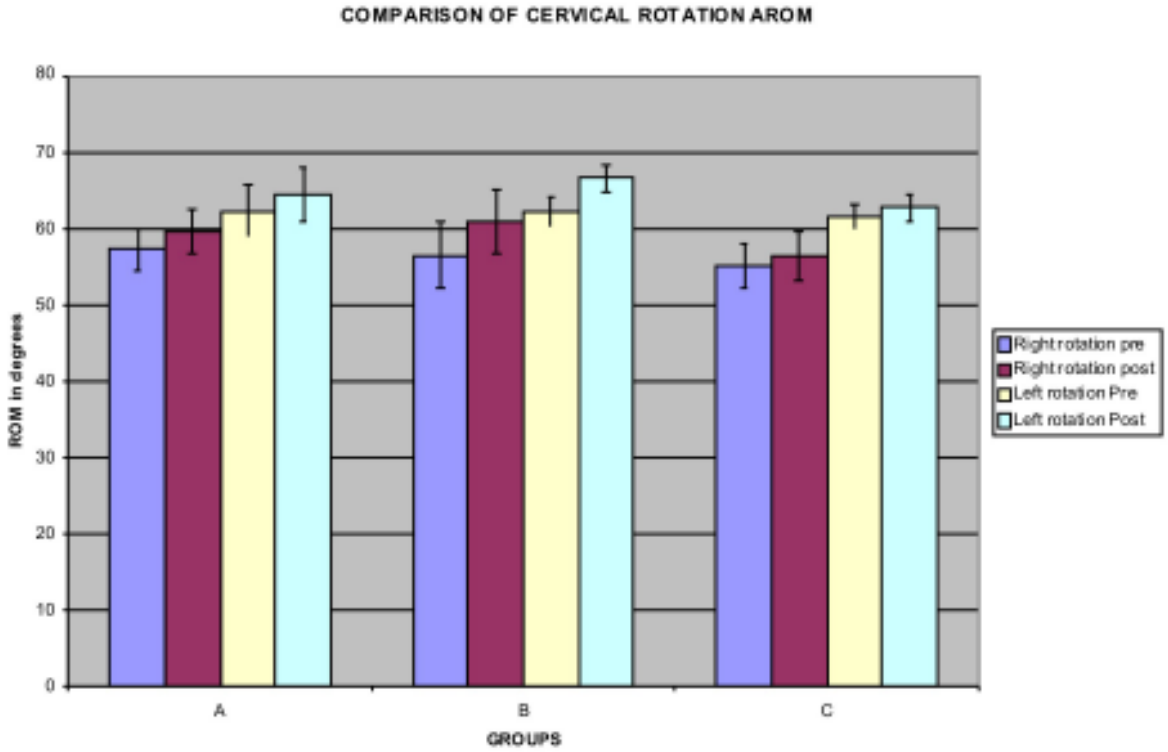
There was a significant improvement in active ROM of cervical spine with cervical manual traction. However, with neural tissue mobilization, only rotation showed significant results.

This is a comparison of NDI scale in group A, B and C in Pre and Post conditions. Both neural tissue mobilization and cervical manual traction were significantly effective with $P<0.01$ & $P<0.001$ respectively and application of hot pack was found insignificant on cervical spondylosis patients on calculating T- values.

Cervical manual traction was significantly effective with $p<0.01$ and neural tissue mobilization & application of hot pack was found insignificant on comparing VAS score.

Cervical manual traction was significantly more effective with $P<0.01$ and neural tissue mobilization & application of hot pack were found insignificant in cervical spondylosis patients on calculating T- values.

Cervical manual traction showed significant results with $P<0.01$ and neural tissue mobilization & application of hot pack was found insignificant on cervical spondylosis patients.



Both neural tissue mobilization and cervical manual traction were significantly effective with P<0.02 & P<0.001 respectively. However, the application of hot pack was found insignificant.

Discussion

The study compared the effect of Neural Tissue Mobilization and Manual Traction in patients with cervical spondylosis. The outcome measures neck disability index, active ROM of cervical spine and pain assessment on VAS scale. The result of the study supports the manual traction as it shows significant results on all the outcome measures. Neural tissue mobilization was found significantly effective only on NDI scale and cervical left and right rotation.

The subjects chosen for this study fulfilled the inclusion criteria for cervical spondylosis. The cause of subject's signs was postulated to be neurogenic because of the distribution and behavior of pain and the adverse response to neural tissue provocative tests.

The group to which manual traction, neck isometric exercises and hot pack was given showed significant improvement in cervical spondylosis. *Ktavich, Lynley* in his study of Neural Mechanisms Underlying Manual Cervical Traction found that Manual cervical traction is suggested to relieve pain and muscle spasm in the neck and upper quartile. Afferent input generated by these procedures may lower the excitability of motor neuron pools of upper limb muscles. While joint receptors are traditionally viewed as the receptor most likely to evoke responses to manual therapy, a review of the literature into possible mechanisms underlying manual cervical traction suggests stretch generated in cervical muscles and skin during the procedure has the potential to influence the excitability of motor neurons (6).

It was found from a randomised clinical trial on the effects of cervical traction (CT) and exercise on the patients with chronic cervical spondylosis. There was a marked improvement in both the groups treated with CT and NSAIDs (P<0.001). But there was nearly significant difference regarding improvement in treatment with CT plus exercise than with NSAID (P = 0.06). The results indicate that the improvement of the patients with chronic cervical spondylosis was more in CT plus exercise than analgesics. So, CT & neck muscle strengthening exercise may have some more beneficial effects than NSAIDs on chronic cervical spondylosis (7).

The group to which neural tissue mobilization, neck isometric exercises and hot pack were given, showed significant effects only on NDI scale and cervical rotation to both left and right sides, even Michael Shacklock also concluded in his study that Mobilization of the nervous system is an approach to physical treatment of pain. The method relies on influencing pain physiology *via* mechanical treatment of neural tissues and the non-neural structures surrounding the nervous system. Previous descriptions of this method have not clarified the relevant mechanics and physiology, including interactions between these two components. To address this, a concept of neurodynamics is described. The body presents the nervous system with a mechanical interface *via* the musculoskeletal system. With movement, the musculoskeletal system exerts non-uniform stresses and movement in neuraltissues, depending on the local anatomical and mechanical characteristics and the pattern of body movement. This activates an array of mechanical and physiological responses in neural tissues. These responses include neural sliding, pressurization, elongation, tension and changes in intra-neural microcirculation, axonal transport and impulse traffic (8).

The neural tissue mobilization could not show significant improvement on VAS scale, cervical flexion, and extension and side flexion. Also Mark T. Walsh studied and discussed about the basic science and the research that supports or refutes the efficacy of these techniques. There is sufficient biomechanical evidence that the peripheral nerve under tension undergoes strain and glides within its

interfacing tissue. Evidence supports that Upper Limb Neural Tension Test causes strain within the peripheral nervous system however; it is also evident that Upper Limb Neural Tension Test places strain on other multi-segmental tissues. Clinical investigation has examined intra-rater reliability and has begun to define the parameters of a positive test but there is lack of randomized controlled studies. There is limited evidence reporting favorable outcomes when using neural mobilization to treat specific patient populations, and the appropriate parameters of dosage (i.e., duration, frequency, and amplitude) remain to be confirmed. Clinical application of these techniques must be applied in a practical manner that relies on continual clinical reasoning (9).

Limitations of the Study

The size of the sample was small. Long-term follow-up could not be taken.

Conclusion

The study concluded that in patients with cervical spondylosis, a treatment combining cervical manual traction, neck isometrics and hot pack helps in reducing the pain, increasing the range of motion of cervical spine and efficiency in activities of daily living, as seen by improvement in VAS scale, active ROM of cervical spine and NDI scale respectively.

Cervical Manual Traction showed significantly better results on all outcome measures as compared to Neural Tissue Mobilization in patients with cervical spondylosis.

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Original Article

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Effectiveness of Sensory Motor and Behavior Therapy on Drooling in Children with Cerebral Palsy

Banumathe KR*, Sugi S., Guruprasad V.*****

Abstract

Aim: To determine the effectiveness of sensory motor and behavior therapy on drooling in children with cerebral palsy

Methodology: 20 children with drooling in cerebral palsy were selected for the study based on the screening tool. The assessment tools such as swab method, drooling quotient with activity and drooling quotient without activity were used for pre and post test scores. 10 children received conventional treatments who were control group and 10 children were given sensory motor and behavior therapy along with conventional treatment who were experimental group. Posttest was taken after 6 weeks of intervention for 10 min / session, 3 days a week and the scores were subjected to statistical analysis.

Results: The data were analyzed with Mann-Whitney U-test and Kruskal Wallis test using the SPSS version 16. Results showed statistical significant difference at $p<0.05$ levels of significance in post test scores of experimental when compared to control group. Constant droolers showed greater improvement than frequent droolers in swab method and drooling quotient with activity at $p<0.05$ levels of significance. The study also found that age and diagnosis do not have an effect on treatment outcome.

Conclusion: The study concluded that sensory motor and behavior therapy have a significant effect on reducing drooling in children with cerebral palsy.

Key Words: Cerebral palsy; Drooling; Sensory motor therapy; and Behavior therapy.

Introduction

Drooling is the unintentional loss of saliva from the mouth. Many children lose control of saliva and drool when they concentrate on gross and fine motor movements. Normal children develop the ability to perform most activities without drooling around 2 years of age. Persistent drooling is most commonly associated with neuromuscular disorders such as Cerebral Palsy which is the most common physical disability in early childhood. Those children frequently have lifelong problem with oral motor control that can present as drooling, eating and drinking difficulties and /or speech problems [2].

The pathophysiology of drooling seems to be the result of problems exist in sensory awareness or organisation and children may be unable to perceive the pressure cues in the mouth that would normally serve to trigger an automatic swallow and may be aggravated by inability to close the mouth[1].

Drooling can produce significant negative effects on physical health including irritated facial skin, unpleasant odor, increased oral and perioral infections, hygiene problems,

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dehydration, social isolation and affect the Quality of Life that can result in a loss of self-esteem. Thus drooling can lead to functional, social, psychological and clinical consequences for patients, families and caregivers.

Control of drooling requires developed oral sensory awareness provided by own secretions in order to swallow in a timely manner and to facilitate frequent swallowing, where sensory therapy is necessary [2].Significant correlations have been found between jaw control ability and adequate swallowing by creating intraoral suction pressure, which implies the need for jaw control techniques[3]. However, the above techniques alone need not facilitate swallowing. Habituation and generalization of swallowing is essential to reduce drooling even when the above techniques are not in use. This can be facilitated through the use of behaviour therapy techniques like positive reinforcement, prompting, cueing, modeling, shaping and prompt fading [4].

Thus there is a need for combination of behavior treatment methods along with sensory motor therapies to increase swallowing frequency, to facilitate mouth closure and thereby reducing drooling [5].

The current study attempts to find out the effectiveness of combinations of sensory, motor and behaviour therapy techniques to reduce drooling in children with cerebral palsy.

Methods

The study design was two group pretest-posttest quasi experimental designs in which the designed sensory motor and behavior therapy techniques were independent variable and drooling was the dependent variable. The study was conducted in KMCH Occupational therapy Department and Special schools in Coimbatore. 20 Children who have been diagnosed with Cerebral palsy, within the age group of 2 to 12 years of both genders, who were identified to have drooling based on screening tool who scored > 3 in frequency and severity, and who were not having any illness over the past week at the time of the assessment were included for the study and others who were under medications, or undergone any surgeries for drooling or having care givers with psychiatric morbidity were excluded.

Modified drooling measure form and questionnaire on drooling were used for screening, Drooling Quotient (with activity and without activity) and Swab Method used as a primary outcome tool. The drooling quotient is a validated, semi quantitative, direct observational method. The drooling is observed and the presence or absence of drooling is evaluated at every 15th sec interval over a 10 minutes period (40 observations) while the subject is awake and sitting erect. An episode of drooling is defined as new saliva leaving the chin. The drooling quotient expressed as

$$DQ(\%) = \frac{\text{No. of drooling episodes in 10 min}}{\text{40 observations in 10 minutes}} \times 100$$

The swab method is a highly reproducible method and can be used to evaluate salivary flow rates in drooling children in cerebral palsy during interventional studies under standardizes conditions. It was described by Rotteveel et al. after the mouth is dried with sterile gauze; the cotton roll is placed in the floor of the mouth for 2 minutes. The cotton roll should be weighed before and after the procedure using an electronic scale, which is sensitive to 0.01 gram. The increase in weight during the 2 minutes interval is calculated.

A written consent was taken from the head of the institution to conduct a study. The purpose of the study was explained and informed consent was obtained from the caregivers prior to the study. Modified drooling measure form and drooling questionnaire were given to caregivers of 23 children with cerebral palsy. Among them, 20 children were selected and 3 were excluded as they had mild, occasional drooling. The 20 children were divided into 2 groups: experimental and control, 10 in each. Pretest scores were taken using the swab method, drooling quotient without activity and drooling quotient with activities like listening to rhymes, stacking rings

and cups, and beads for both groups. The control group received conventional occupational therapy. The experimental group received conventional occupational therapy along with; Sensory stimulation by using lemon extract, jaw control techniques and behavior therapy techniques was used to facilitate mouth closure and to increase the frequency of swallowing. The behavior techniques were faded, as the child showed improvements. The intervention was given for 10 min/session for 3 days a week over a period of 6 weeks, after which the post test was done.

Results

The data was analyzed using SPSS version 16. Non-Parametric tests such as Mann-Whitney U test and Kruskal Wallis test were used. Table 1 and 2 shows that there were no significant differences at $p>0.05$ level among experimental and control groups in age, gender, and diagnosis, which can be compared. According to Table 3, there was significant difference between experimental and control group at $p<0.05$ level, which shows the significant reduction in drooling. Table 4 and 5 shows the age and diagnosis do not have an effect on treatment outcome. The constant droolers showed significant improvement at $p<0.05$ which was showed in table 6 that frequency have an effect on treatment outcome.

Discussion

The main implication for occupational therapists is that the assessment and treatment of drooling should address both the sensory and motor elements of oral function [7]. Hence this study attempted to find out the effectiveness of the above combinations.

Based on the screening tool, the following were also analyzed, which implies the need

Table 1: Baseline Characteristics

CHARACTERISTICS	Experimental Group (N=10)		Control Group (N=10)		u-TEST (Z)	P
	MEAN	SD	MEAN	SD		
AGE	62.4	37.22	75.6	33	-1.064	.287
GENDER	1.30	.48	1.40	.51	-.457	.648
DIAGNOSIS	1.40	.51	1.60	.51	-.292	.771

Table 2: Comparison of pretest data of experimental and control group

DROOLING ASSESSMENT	PRE TEST				u-TEST (Z)	P
	Experimental Group (N=10)		Control Group (N=10)			
	MEAN	SD	MEAN	SD		
SWAB	2.31	.70	1.91	.81	-.983	.326
Drooling Quotient with activity	45.75	22.67	42.25	14.74	-.341	.733
Drooling Quotient without activity	30.75	24.38	34.50	17.51	-.682	.495

Table 3: Comparison of post test data of experimental and control group

DROOLING ASSESSMENT	POST TEST				u-TEST (Z)	P
	Experimental Group (N=10)		Control Group (N=10)			
	MEAN	SD	MEAN	SD		
SWAB	1.03	.480	2.25	.717	-3.176	.001*
Drooling Quotient with activity	13.00	13.165	44.50	8.959	-3.536	.001*
Drooling Quotient without activity	6.25	9.736	32.50	10.671	-3.428	.001*

* significant at p<0.05 levels

Table 4: Effect of chronological age on treatment outcome in experimental group

DROOLING ASSESSMENT	< 5 YEARS		> 5 YEARS		u-TEST (Z)	P
	MEAN	SD	MEAN	SD		
SWAB	1.156	.283	1.460	.949	-1.066	.286
Drooling Quotient with activity	-26.25	16.336	-31.00	18.389	-.000	1.000
Drooling Quotient without activity	-19.166	21.369	-32.50	17.677	-1.183	.237

Table 5: Effect of diagnosis on treatment outcome in experimental group

DROOLING ASSESSMENT	CP QUADRIPLEGIA		CP DIPLEGIA		u-TEST (Z)	P
	MEAN	SD	MEAN	SD		
SWAB	1.128	.640	1.502	.561	-.853	.394
Drooling Quotient with activity	-27.916	15.765	-28.500	19.659	-.107	.915
Drooling Quotient without activity	-21.666	18.819	-28.750	24.195	-.323	.747

for therapy. Parental views on drooling 90 % of them extremely worried about their child's drooling and their effects on his/her life, 85 % of them needed wiping most of the time, 75 % were frequent droolers, 25 % were constant droolers, 90 % had moderate to severe drooling and 10% had profuse drooling. Percentages of degree of drooling in the following activities were moderate to very severe. 100 % in concentrated activity like fine activities, e.g. stringing beads, putting pegs in a hole etc. 95 % in prone position, 90 % in supported sit, while playing, while crying, 85 % in unsupported sit, 75 % during ill, 50 % while watching TV.

In 1987, Morris stated that the drooling can be reduced by improving sensory awareness or through improving the ability to perceive the pressure cues in the mouth which trigger swallow [8]. The alcohol based flavors may have served to heighten intra-oral sensory awareness in these children who displayed a diminished threshold to swallow. Using lemon

extract in the current study which consisted alcohol could trigger swallow by increasing intra-oral sensory awareness, participants learned to swallow more frequently and drooling diminished over time.

Children with cerebral palsy found to have significant positive correlations between drooling and reduced ability to voluntarily control the jaw [3]. So jaw control technique has been used in the present study which has the ability to facilitate mouth closure and helps in swallowing [9]. Behavior therapy techniques such as positive reinforcement, prompting, cueing can be used to learn new behavior or to increase the frequency of desired behavior [6].Therefore, in the current study, behavior therapy techniques have been used to increase the frequency of swallowing behavior to reduce drooling.

Nunn, 2000 suggested that combination of behavior therapy method and sensory motor therapy are the treatment approaches to be adopted to reduce drooling [5]. The current study findings also supported the above statement by showing the reduction in drooling through the use of sensory motor and behavior therapy in experimental group when compared to control group in all the 3 variables such as swab method, drooling quotient with activity and drooling quotient without activity.

Erasmus et al, 2009 had done a study on salivary flow rates in cerebral palsy of different ages and sex and concluded that no age related decline or increase in distribution of salivary flow in children from 3-19 years of age; age is not an important factor when measuring salivary flow rates till adolescence [10]. Similar findings were recorded in this study.

Heyring et al, 1980 found that there was no correlation between type of cerebral palsy and the incidence of drooling [3]. Likewise, the current study showed that the type of cerebral palsy has no effect on treatment outcome.

The constant droolers have higher improvement when compared to frequent droolers in both swab method and drooling quotient with activity. Generally the children with cerebral palsy have associated movements like opening mouth while concentrating on activities and movements. This may induce drooling. Intervention adopted in this study included sensory stimulation (which would cue a child to swallow saliva), jaw control (which would facilitate appropriate swallowing), positive reinforcement, shaping, prompting (which would increases swallowing frequency). This probably could have reduced drooling during activities.

Table 6: Effect of frequency of drooling on treatment outcome in experimental group

DROOLING ASSESSMENT	FREQUENT DROOLERS		CONSTANT DROOLERS		u-TEST (Z)	P
	MEAN	SD	MEAN	SD		
SWAB	1.007	.472	1.910	.371	-2.165	.030*
Drooling Quotient with activity	-25.00	15.275	-35.50	19.640	-.843	.054*
Drooling Quotient without activity	-17.50	20.00	-40.833	7.216	-1.720	.084

*significant at p<0.05 levels

During the study period, the investigator appreciated the following incidents.

One of the children in experimental group showed marked reduction in drooling which made the special educator to recommend the investigator to give therapy to other children as well. Another child was applauded by teachers and other children in morning assembly as his drooling was reduced.

A similar incident was noted in another child where the special educator said that

there is no need to bring hand kerchief to school as his drooling reduced gradually. Some parents also noticed the reduction in drooling and gave positive verbal feedback.

The subjects were not assigned randomly and sample size was too small to generalize the study results. Biological variations and emotional variations were not considered during the assessment. As drooling quotient method was direct observational method, chances for the investigator to miss out the drool while observing is high. If it was videotaped and assessed, it would have been more standardized. The investigator found difficulty in prompt fading and could not assess the generalization as the duration of therapy was short. Longitudinal study would be beneficial. Since this study is the preliminary study to find out the factors like age, diagnosis, frequency affecting the intervention outcome, further research in this area is recommended.

The results of this study favored the alternate hypothesis by showing a significant reduction in drooling after the intervention. The study confirm the implication of intervention should consider the combination of sensory, motor and behavior therapies and further confirm the role of Occupational therapist to intervene for subjects with drooling.

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Original Article

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Test Retest Reliability of 6 Minute Walk Test and 1 Minute Walk Test in Spastic Cerebral Palsy

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Abstract

Background and objectives: Timed walk tests over 1 and 6 minute intervals have been developed for use in evaluating patients with cerebral palsy but on a smaller sample size. Moreover it is important to establish its reliability according to their gross motor function classification system levels and in an age stratum for conclusive results.

Methods and materials: A total of 70 spastic cerebral palsy participants of age group 7 to 18 years took part in the study , who were classified according to GMFCS level .The walk tests were performed on the same day and retest was done after 7 days.

Results: The test retest reliability of 6 min walk test and 1 min walk test was obtained by cronbach alpha and the value was 0.99 and 0.97 respectively.

Conclusions & interpretations: The 6 min walk test and 1 min walk test has shown high test retest reliability across all gross motor function classification system levels.

Keywords: Cerebral Palsy; 6 minute walk test; 1 minute walk test.

Introduction

Cerebral palsy is defined as a persisting but not unchanging disorder of movement and posture, appearing in the early years of life and due to a non-progressive disorder of the brain, the result of interference during its development.[1] The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, behavior and by secondary musculoskeletal problems.[2] The prevalence of cerebral palsy is approximately 2.12-2.45 cases per 1000 live births, indicating a slight rise in recent years.[3] Improvements in neonatal nursing have helped reduce the number of babies, who develop cerebral palsy, but the survival of babies with very low birth weights has increased, and these babies are less likely to have cerebral palsy.[4],[5] [6] Walking is a complex functional activity; thus, many variables contribute to walking speed. [7,8,9] The ability of children with cerebral palsy to walk has been quantified in various ways, from the relatively simple measures of velocity, step length, and cadence to the more sophisticated measures of kinematics and kinetics, as provided by instrumented three-dimensional analysis but many children have difficulty in tolerating the equipment, particularly the face mask, for the sustained period required for testing indicating the need of some simple tests which are easily clinically applicable.[10,11] The walking time required to achieve steady state varies in the literature from 3 to 10 minutes consequently many children with more disabling forms of the condition are unable to complete this type of test.[12] Butland et al. investigated the possibility of using shorter walking times in patients with respiratory

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disease and found that 2 and 6 minute walks were as reproducible as a 12 minute walk.[13] . Timed walk tests are also now being used as measures of functional ability in clinical intervention trials that involve children with cerebral palsy.[14,15] The 6-minute walk test is a self-paced, sub maximal test that assesses functional capacity for walking a prolonged distance.[16,17] It may reflect exercise tolerance required for the performance of ADL,[16] and predict ability to walk in the community.[17,18] The 6MWT is increasingly used in the young children in whom performing cardiopulmonary exercise tests is especially problematic, requiring a high degree of cooperation, good coordination and motivation[19,20]. A new test i.e. 1 min walk test has been frequently used recently in children with cerebral palsy to measure functional abilities. 1 minute walk is considered as a potential measure of functional ability and walking endurance[21]. Testing a child at their maximum walking speed would be a greater discriminator of their functional ability for dynamic balance, muscle performance, and endurance than that recorded at a self-selected speed. The duration of 1 minute allow the testing of most children with ambulatory cerebral palsy. The distance covered on the fast 1MWT has a significant relationship with net oxygen cost,[22] a traditional measure of exercise capacity, and also correlates with the Gross Motor Function Measure-66, a global measure of functional ability score.[23] The gross motor function classification system (GMFCS) was developed to describe gross motor function in children with cerebral palsy and has its focus on self-initiated movements, in particular sitting and walking.[24] It is an age-related five-level system in which level I represents the least limitation and level V the most. The GMFCS has been internationally accepted and is widely used. [25,26,27] Although the reliability of 6 min walk test and 1 min walk test has been studied in the cerebral palsy population but it was done on a smaller

Figure 1: Sphygmmomanometer, Measuring Tape, Pulse Oximeter And Stop Watch

sample size. So there is a need to study it on a larger sample size as devised by Donner and Elaisziw for reliability study sample size calculation, there should be atleast 40 participants within a single GMFCS level or age stratum to be confident of reliability of 0.90. Also, the 1 min walk test being relatively new, its efficacy needs to be studied further in the above population.

Methodology

The data was collected from special schools in Delhi and NCR. A total of 70 children diagnosed with spastic cerebral palsy were included in the study within the age range of 7-18 years and were classified as per GMFCS Levels I, II and III as determined by their developmental pediatrician . The children included were able to walk independently without stopping for 6 minutes, with or without a walking aid and were also able to follow verbal instructions. Those who underwent Orthopaedic surgery within past 6 months, who took Botulinum toxin type A injection in the lower limb within past 6 months., who were Currently ill, or those who have any documented cardio respiratory comorbidity or any documented mental retardation or intellectual disability were excluded .Children who had scores less than 24 on mini mental state examination were also excluded. The materials included weighing machine, stadiometer, stop watch, measuring tape, pulse oximeter, syphygmomanometer, two small cones, telephone and a chair. (Fig 1)

Procedure

A written informed consent to participate in the study was obtained from a legal guardian of each participant. The height and weight were taken on the first day of visit. The walking course was set in the corridor. Children wore their own clothing and shoes, allowed to wore their splints and use their walking aids as appropriate. Instructions were given clearly to the participants before the procedure. The 6 minute walk test and 1 min walk test were performed on the same day. The 6 min walk test and 1 min walk test were randomly done with half an hour of seated rest. The retest was done after one week respectively for both tests.

6 minute walk test

The walking course was set in a quiet, rectangular corridor and marks were taped on the floor at 20-meter intervals. The turnaround points were marked with a cone. Children were instructed to walk as many laps as possible in 6 minutes without running. A demonstration was given to the children for one lap. The procedure was, the child was made to sit at rest in a chair, located near the starting position, for at least 10 minutes before the test started. During this time, the heart rate, blood pressure and oxygen saturation were recorded. The child was made to stand and their baseline dyspnea and overall fatigue using the Borg scale were recorded. The object of this test is to walk as far as possible for 6 minutes. The children walked back and forth in the ground. They were permitted to slow down, to stop and to rest as necessary if they get exhausted or breathe out. They may lean against the wall while resting, but resume walking as soon as they were able to. They were instructed to walk back and forth around the cones and pivot briskly around the cones and continue back the other way without hesitation. The child was positioned at the starting line. The therapist also stood near the starting line during the test. As soon as the child started to walk, the timer was started. They were not allowed to talk to anyone during the walk. An even tone of voice was kept when using the standard phrases of encouragement and the child was watched. After the first minute, the command given was: "You are doing well. You have 5 minutes to go." When the timer shows 4 minutes remaining, the child was instructed as the following: "Keep up the good work. You have 4 minutes to go." When the timer shows 3 minutes remaining, the child was told the following: "You are doing well.

Figure 2: The subject walking during the test

You are halfway done." When the timer shows 2 minutes remaining, the child was told the following: "Keep up the good work. You have only 2 minutes left." When the timer shows only 1 minute remaining, the child was told the following: "You are doing well. You have only 1 minute to go". When the timer ranged, the command was: "Stop!" The therapist then walked to the child and took the chair if they looked exhausted. The spot where they stopped was marked by placing a piece of tape on the floor. The post walk Borg dysponea and fatigue levels were recorded by asking the child. By using pulse oximetry, SpO2 and pulse rate were measured from the oximetry. The number of laps taken by the child and additional distance covered were recorded.

1 min walk test

It was done on the same track. They were instructed that whenever the instruction given to them to start they were to keep walking around the track as fast as possible for 1 minute. They were not allowed to run. Distance was calculated by the meter markings on the floor. The assessor explained the protocol to each subject before the test, demonstrated one lap of the track and gave the order to start and stop. The distance was calculated during the 1 minute. The heart rate, oxygen saturation, blood pressure and fatigue levels were taken before and after the test. (FIGURE 2)

Results

The data was collected from 70 subjects and it was statistically analyzed.

(Table 1),(table 2) , (table 3) , (table 4) , (table 5)

The result depicts the mean distance walked by these children. d1 represents the first day the walk tests were conducted and d7 represents the 7th day when the tests were reconducted.

The significant differences was present between males and females for 6 min walk test at level p<0.05. There was no significant difference present between males and females for 1 min walk test.

Table 1: Mean and standard deviation of 6MWD & 1 MWD

Walk Tests	N	MEAN(m)
6 min walk distance(d1)	70	426.19±74.9
6 min walk distance(d7)	70	434.20±76.71
1 min walk distance(d1)	70	71.79±13.38
1 min walk distance(d7)	70	73.97±14.82

Table 2: Test retest reliability values of 6 MWT AND 1 MWT

GMFCS LEVELS	N	Cronbach's alpha 6 min walk test	Cronbach's alpha 1 min walk test
All subjects	70	.99	.97
GMFCS-I	34	.84	.92
GMFCS-II	25	.96	.90
GMFCS-III	11	.98	.93

respectively. The results of this study are consistent with the results of Maher[28] who found out 448.7m and 449.5m respectively for test and retest at half an hour interval in the age group 11-17 years where as C Andersson[29] has reported that the mean distances walked by the subjects at the four tests were 316, 336, 341 and 345m within two week interval. This difference in results could be due to elderly age range *i.e.* 26-58 years, more number of subjects in GMFCS III and less sample size. There was no significant difference in the 6 min walk distance reached at two time points separated by a mean of 7 days. The test retest reliability of 6 min walk test was found to be high. This was consistent with the results of Maher[28] and Patricia Thompson[30] who found out ICC 0.98 in children with cerebral palsy whereas C Andersson[29] has stated ICC 0.99 in adults with cerebral palsy but all these studies have given their reliability values on a comparatively small sample size. The data regarding the mean distances walked across all gross motor function classification system levels has been collected to find out the affect of GMFCS levels on the distances walked. The results were consistent with the results of Maher et al[28] and Patricia Thompson et al[30] except for GMFCS III. These studies have stated the mean distance walked by these children in GMFCS III were 234.7m and 254.7m respectively. The reason behind this variability could be the severity of spasticity

Table 3: Effect of gender upon distance walked

	GROUP	N	Mean	Std. Deviation	SIG (2-tailed)
6 min walk test	Males	33	443.64	61.87	0.043
	Females	37	410.62	82.58	
1 min walk test	Males	33	73.85	12.92	0.158
	Females	37	69.95	13.69	

The positive correlation was found significant between the height and walk distances at p< 0.05 level.

The positive correlation was found significant of age with both walk distances at p< 0.05.

Table 4: Correlation between height and walk distance

		6 min walk distance	1 min walk distance
Height	Pearson Correlation	.432	.364
	Sig. (2-tailed)	.000	.002
	N	70	70

Discussion

70 subjects met the inclusion criteria of being in the age group of 7 years to 18 years and constituted the study sample in which 34 subjects were in GMFCS I, 25 in GMFCS II and 11 IN GMFCS III. The mean distances walked by all the subjects in 6 min walk test was 426.19m & 434.2 m at baseline and retest

Table 5: Correlation between age and walk distance

		6 min walk distance	1 min walk distance
Age	Pearson Correlation	.447	.411
	Sig. (2-tailed)	.000	.000
	N	70	70

and the duration of intervention taken by these children. The distance walked has decreased with the increased GMFCS levels. There was no significant difference found between test and retest within all GMFCS levels. The 6 min walk test across all GMFCS has showed good to high reliability values. In the present study the reliability value for GMFCS I differs from the study of Maher [29] and C Andersson[29] who found out ICC 0.93. This could be due to faster children in this group which had increased the retest distances. These children had perhaps more physical capability to speed up on the retest after perhaps realizing from their first attempt that they could have gone faster. Conversely, children in Level III with their greater physical restriction and associated limits to performance were most consistent in their distance covered as demonstrated within each of the 6MWT analyses.[30] The distance walked by children of age stratum 7-12 years was 245m-502m and the mean distance was 403.2m. It shows the average distance walked by the children of this age group. The major problem observed with cerebral palsy children in this study was 'spasticity' in their legs rather than cardiorespiratory problems and this was the main reason for their reduced walking distance. These findings were confirmed by the study of Andersson[29] who showed that there was no correlation between heart rate and perceived exertion/ heart rate and walking distance. These results are also confirmed to a certain extent by Bean et al. who found that the six-minute walk test was a useful measure of functional limitation among mobility-limited elders without cardiorespiratory or peripheral vascular distance. There was a strong correlation found between the height and 6 min walk distance. This can be attributed to the longer length of steps in taller individuals. The length of the step is one of the main determinants in gait velocity. Some studies like Troosters T et al[31] and Lammers AE[32] have shown a strong correlation of height with 6 min walk distance whereas only the study of Enright and Sherill[33] did not show a significant correlation. Age too had a significant influence on the 6MWD in several studies and in the present study also there was a strong correlation found between age and 6 min walk distance. In the studies involving children and adolescents[32] a positive correlation was seen whereas in the studies involving healthy adults and elderly individuals [33, 31] a negative correlation was observed. The correlation between age and 6MWD was not significant only in the study by Camarri et al[34] due to narrow age range assessed by the study. The shorter distance walked as age increases can be explained by the decrease in muscle mass and strength and the maximum oxygen consumption, inherent to the aging process. On the other hand, the positive correlation between the 6MWD and age < 20 years is the result of the higher degree of maturation among adolescents, as compared to children. In the present study there was a significant difference noticed in 6 min walk distance based on gender. Males were found to have greater 6 min walk distance than females possibly as a result of their greater muscle mass and the ability to achieve higher levels of physical activity. This was consistent with the results of Albert M. Li[35] in which the 6 min walk distance was higher in males than females. The same result is stated by A.M. Iwama[36] ,the difference being attributable to the greater absolute muscle strength, muscle mass and height of men compared to women. There was a weak correlation found between BMI and distances walked. This is supported by the study of Iwama[36] who said that 6MWD being shorter in subjects with greater body weight or higher BMI. Unlike the protocol for the original 6 min walk test as given by the American Thoracic Society, the practice trial was not included in this study. This decision was made on work by Van Loo[17] which demonstrated no significant learning effect

when adults with spasticity did the 6 min walk test trials. This same result has been supported by Maher[28] that the distance walked during the 6 min walk test varied by less than 1% between the two trials suggesting that a practice walk is not necessary. These findings are in contrast to those of Andersson and colleagues[29] whose study on adults with cerebral palsy reported an improvement of 7% between trials 1 and 2. It is difficult to tell whether the different findings in this study were due to inherent differences between the pediatric and adult cerebral palsy populations or methodological differences in the way the 6 min walk tests were conducted between studies. According to Fry DK[20] et al a practice trial was not given for this lengthy test because of concerns about the impact of associated fatigue. Sciurba[37] hypothesized that long corridors are more effective when compared to short corridors for the walk test because, in the long corridors, the number of turns is reduced and, therefore, the effort is smaller. Nevertheless, in this study, the walked distances in the long corridor were not statistically greater when compared to the shorter corridor. Therefore, the authors concluded that the length of the corridor during the test would not be relevant to its standardization. However, the corridor should not be shorter than 15.23 meters as stated by Scuirba[37], unlike the American Thoracic Society minimum standard of corridor length which is 30 meter. The study by Troosters T[31] had compared the 20 and 50-meter corridors for the test in adults and found no significant differences in the walked distance. Maher[28] has used a 10 m straight course which is considerably shorter than the 30m course recommended by the American Thoracic Society[16]. Although a 30m indoor course can often be found in hospital settings, in many cases young people with cerebral palsy are seen by health professionals in community settings where a 30m course may not feasible. The results indicated that 6 min walk distance can be achieved using a 10 m course for cerebral palsy population.[28] The results for 1 min walk test differed with the study B.C. McDowell[21] whose observations were 81.4m and 81.4m at baseline and retest respectively. The reason behind this could be due to a smaller sample size (17 subjects) in the above quoted study. The test retest reliability value of 1 min walk test was consistent with the study of B.C.McDowell[21] who found ICC 0.94 and the repeatibilty coefficient was 13.1. This coefficient suggests that for individual patient data, walking distance may vary by up to 13 m between test occasions. In practical terms, this means that a child with bilateral spastic cerebral palsy (GMFCS levels I–III) would need to demonstrate an improved walking distance of at least 13 m following an intervention before one could attribute the change as 'real'. The significant differences in 1 min walking distances were noticed between GMFCS levels. The mean distance walked by the cerebral palsy children may provide a quick guide to expected walking distances for GMFCS I to III. There seems to be significant difference in the distance walked between GMFCS I and II but not much difference between levels II and III. This result concurs with previous findings in studies done by Baker R.[10] which demonstrated a significant relationship between the 1 min walk test and functional ability(r=0.92). The distance walked by these children of age stratum 7-12 years was 39-93m and the mean distance was 67.54m±13.52m. Age and height was found to be significantly correlated with the 1 min walk distance.. There was not significant gender difference found in 1 min walk distance. A negative correlation was found between BMI and 1 min walk distance. The anthropometric values were correlated in the study for the first time. The test is shorter in duration to other well reported walk tests of 2, 6 and 12 min , and therefore likely to be a poorer discriminator of exercise tolerance which is a limitation. Alternatively, the 1-min protocol is likely to be more acceptable for the majority of ambulant children with CP, particularly those children in GMFCS level III that use walking aids and/or a wheelchair for mobility within the community. Furthermore, due to the short duration of the test, it is more feasible to be included within a battery of tests assessing gait in CP[21]. This study found that

the distances walked either in a fast-paced 1min walk test or a self-selected 6 min walk test were highly correlated both with each other and with the GMFCS, suggesting that in practical terms, both of these timed walk tests are measuring the same construct. Still a large number of data is required across each gross motor classification system level for more conclusive results. The effect of puberty on 6 min and 1 min walk distance can be seen in further studies. A study by Spadano[38] stated that absolute total energy expenditure and physical activity level increased after puberty. Hence further study can compare the children and adolescents. Similar assessment of the 6 min walk test and 1 min walk test would need to be repeated in other age groups of cerebral palsy to ascertain its reliability and validity as age, sex and height have all been shown to affect the distance walked.

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