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Effectiveness of Progressive Resisted Isometric Exercise on Gait Performance and Balance Training In Stroke

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Abstract

Neurological rehabilitation aims to reduce impairments and disabilities so that persons with serious stroke can return to participation in usual self care and daily activities as independently as feasible.

New strategies to enhance recovery draw from a growing understanding of how types of training progressive task related practice of skills,exercise for resisted isometric and fitness neurostimulation and drug and biological manipulation can induce adaptation and multiple level of the nervous system.

Keywords: *Balance training with waitcuff gait,cross transfer training, mobility limitation, resistance training, stroke.*

Introduction

Stroke is defined as an acute neurological dysfunction of vascular origin with sudden or at least rapid occurrence of symptoms or signs corresponding to involvement of focal areas of the brain (WHO)[1].Stroke is caused by a disruption of the blood supply to the brain, leading to damage of the brain tissue, as a result from either blockage i.e. infarct in 85%,a rupture of a blood vessel i.e. intracerebral hemorrhage in 10% or other causes.

Stroke accounts for 10% to 20% of all deaths in industrialized nations, with almost 90% of those deaths occurring in persons over 65years of age. The incidence of first stroke rises exponentially with age. In the 55-59 years old age group, the risk of stroke is about 5% per year, whereas in the 80-85 years old group the risk is almost 25% per year[2].

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Studies have shown that the major risk factors for stroke are hypertension, heart disease; diabetes and cigarette smoking [8].Others include alcohol consumption, high blood cholesterol levels, drug use and genetic or congenital conditions particularly vascular abnormalities.

Gender also plays a role in risk for stroke. Men have a higher risk for stroke, women are generally older when they have stroke & are more likely to die from it.

It has been shown that stroke can cause a number of disabilities which include paralysis or problems controlling movement, sensory disturbances including pain, problems in using or understanding language, problems with thinking & memory & emotional disturbances[104].Atleast ¼ of all patients experience language problems involving inability to speak, write & understand spoken & written language.

Motor impairments are the most prevalent of all the deficits after stroke. It has been reported[1] that the hemi paresis after stroke can dramatically reduce the muscle mass available for the contraction during physical activity

& the weakness in the lower limb affects mobility especially gait. In the non-paretic limb there is also a reduction in muscle strength, this muscle weakness affects mobility & balance, which in turn increases the risk of falls.

The treatment of stroke should aim at to get the patient out of bed & make him as independent as possible in his activities of daily living. Treatment should be systematically designed to prepare the affected side for functional use. It has been possible to improve gait & balance &the use of arm in many patients with longstanding residual hemiplegia.

In the past various techniques such as bobath, proprioceptive neuromuscular facilitation,brunnstrom technique,motor relearning programme[51] have been used in the rehabilitation of a stroke patient.

Cross education or cross transfer of strength is a neurophysiological phenomenon where an increase in strength in the untrained limb occurs following strength training in the opposite contra lateral limb. There are numerous sites of cross limb cortical interactions, which could contribute to contra lateral strength training, effect that could contribute to contra lateral strength training effect (cortical mechanism).Also, there is a complex networks of circuits in the spinal cord that influences motor output, both via reflex actions on motor neurons and by modulating descending commands (spinal cord mechanisms).

It has been documented that an unpracticed hand can be helped to acquire a motor task that has been practiced and acquired previously by the other hand. This is called intermanual transfer. Researchers have shown that the effects of intermanual transfer can be seen in both the improvement of strength and acquisition of motor skills of contra lateral extremity & may provide insight into more efficient treatment strategies for population with unilateral impairments such as hemiplegia, amputation or post fracture immobilization.

Studies have shown that following stroke, weakness occurs on the side contra lateral to the lesion as well as some weakness is seen on the side of the lesion also.

In rehab protocol, strengthening exercises for affected lower limb are used to improve strength & thus gait & balance, but exercises are generally not given in the unaffected limb.

In past, intermanual transfer has been used in cases of normal subjects. Also number of studies have shown that the transfer of strength occurs in both upper limb and lower limb via the intermanual transfer,but not much has been done to study or to support the idea that whether such a transfer takes place in the lower extremity in case of stroke patients.

Thus our aim of this study is to find out the effects of intermanual training using progressive resistive exercises in unaffected lower limb in improving gait & balance in the affected limb in stroke patients.

Gait and balance in Stroke: Following stroke, many people present with one or more clinically significant kinematic deviations from normal gait, as in decreased peak hip flexion, decreased peak knee flexion,decreased knee extension for heel strike & decreased ankle dorsiflexion throughout swing which is attributed to forces produced by the inappropriate activation & adaptive shortening of particular muscle groups

S. Onley, C.Richard investigated the characteristics of hemi paretic gait following stroke in 2009 & found reduced walking speed & longer stance phase which was greater on the unaffected side. Variations in joint excursions included several deviations at initial contact & decreased excursions during swing joint moment reports were variable but included high hip flexor moments in late stance, the muscle groups of the unaffected side performed about 60%of the work of walking.

Roth EJ, Meritzc, 1997 to studied the relationship between velocity & 18 other temporal gait parameters in patience with first hemispheric stroke & found that velocity was significantly correlated with cadence,mean cycle duration,mean cycle length hemispheric limb stance phase duration & percent non hemiplegic limb swing phase percent hemiplegic limb swing/stance phase ratio, non hemiplegic limb swing/stance phase,swing phase symmetry but not with hemiplegic limb stance phase percent hemiplegic limb phase duration stance phase symmetry ratio & overall symmetry ratio.

Sarah F. Tyson,Marie Hanley,Jay Chillala studied the frequency of balance disability, different levels of disability & concluded that the subjects with the most severe strokes,impairments & disabilities .Subject demographics,stroke paths visuospatial neglect were not associated with the balance disability.

DettmannMA,Linder MT,Sepic SB in 1987 investigated the relationships among walking performance, postural stability & functional assessments of the hemiplegic point & found that the hemiplegic gait was characterized by a lack of symmetry & slow speed. Their area of stability during weight shifting was dramatically smaller than for normal men & was located closer to the non paretic side.

Wandel A, Jorgensen HS, Nakayama H, Raaschou HO, Ulsen TS, in 2000, studied the walking function in stroke patients with initial lower extremity paralysis & found that hemi paresis after stroke can greatly reduce the muscle mass available for contraction during the physical activity & the weakness in the lower limb affects mobility especially the gait.

Strength Training In Stroke: To improve the post stroke weakness strength training as progressive resistive training has been used.PRT generally refers to training with progressively increasing resistive loads beginning at a minimum of 6o% of that load that can be lifted once (1RM).

The 1RM should be regularly tested at least every 2 weeks and resistive load is progressively increased to maintain a sufficiently intense training stimulus.

There is a positive relationship between the resistive load and degree of improvement.

Gloria Jt Miller & Kathyne E Light, 1997 studied whether the strength training should be avoided in spastic hemi paresis. In past, bobath avoided resistive exercises with post stroke individuals with spasticity suggesting that the use of effort would only increase co contraction and reduce coordination. Hence they wanted to test the clinical assumption that graded resistive exercises leads to loss force production and force modulation in spastic subjects in such a way that spasticity and co-contraction increases and force control is reduced. They found that resistive exercises appeared to have a beneficial effect on the performance of paretic muscle hence graded resistive exercises is not detrimental to post stroke spastic muscle & should be considered as a possible remediation for the deficits of muscle weakness & decreased function in post-stroke individuals.

Duncan et al in 2003,studied the effect of strength training on the muscle strength & muscle tone in cases of sub acute patients & they found significant gains in the intervention group for isometric knee extensor strength but no between group difference for ankle strength was found.

Weiss A,Suzuki T,Bean J, Fielding RA in 2000 evaluated the effects of PRT on changes in muscle strength, gait & balance in older individuals 1 year after the stroke & found that the strength training can profoundly increase strength & result in modest improvements in function late in the stroke recovery.

Isokinetic strength training has also been shown to improve the spasticity & function in stroke patients.

Shelley A, Sharp, Brenda J.Brouwer studied the effects of isokinetic training on the strength of hemi paretic knee musculative,functional mobility & physical activity &also on the spasticity & concluded gains in strength and gait velocity without concomitant increases in muscle tone.

In order to prescribe strength training by means of progressive resistive exercises,1-repitition maximum(1-RM), should be calculated for the individual patient.

Lex B,Verdijick,Luc Van,Loon Kenneth Meijer and Hans in 2008 used the following equation[58]:

1RM = load/(1.0278Xreps) to calculate 1 RM & they also concluded that though dynamometer is used to measure the muscle strength but 1RM can also be used as a reliable method for the assessment of muscle strength in both young and elderly in case of knee extension.

In the case of progressive resistive exercises, a fixed percentage of 1-RM should be used to decide the starting load for the exercises & then this can be gradually increased.

Teixera –salmela et al in 1999, 2001 studied the effects of PRE in chronic stroke patients using isometric, eccentric & concentric exercises starting with 50% 1-rm & gradually increased to 80 % by 2 wk & found 42.3% increase in strength of the paretic limb.

In rehab protocol, strengthening exercises for the affected lower-limb are used to improve strength & thus gait & balance, but strengthening exercises are generally not given in the unaffected limb.

Cross transfer Training: It is a phenomenon that occurs when an untrained limb receives some of the same benefits in performance from unilateral training that the contra lateral limb received.

Cross Tranfer & Strength Transfer: It is widely believed that unilateral strength training increases strength in the homologous muscle group of the contra lateral limb. The phenomenon whereby training one side of the body increases the strength of muscles on the other side of the body has become known as the contra lateral strength training effect.

Now over so many years, many studies have attempted to demonstrate contra lateral training effects. Most often the approach is as follows the strength of both right and left limbs is measured. Then, the right and left limbs of each subject are allocated to training and control conditions. Subjects perform a unilateral strength training program, after which strength of right and left limbs is re-measured. The increase in strength of the untrained limb is used to estimate the size of the contra lateral strength training effect.

Possible Mechanisms for the Contra lateral Strength Training Effect: There are two different classes of mechanism by which force generating capacity could increase in the untrained, opposite limb. First, unilateral strength training could cause a "spill-over" of neural drive to the untrained side that induces adaptations in the control system for the opposite limb, and second, unilateral strength training could cause neuromuscular adaptations in the control system for the trained limb that can be accessed by the opposite limb.

Methodology

Study design: The study was a pre post Experimental design.

Sample size: A sample of 30 stroke patients was taken.

Sampling: Thirty stroke patients were included on the basis of inclusion and exclusion criteria. The subjects were divided into two groups by multiple block randomization with 15 subjects in group A and 15 subjects in the group B.

Inclusion Criteria:

1. A diagnosis of first sub acute stroke resulting in hemiplegia within previous 30-150 days
2. Age group: 40-70yrs.
3. MMSE score of 24 or more than that.
4. Spasticity 1+ or less than 1+ on modified ash worth scale.
5. Ability to stand independently for 30sec &walk independently
6. Right lower limb dominance

Exclusion Criteria:

1. Neurological problem like multiple sclerosis, dementia, Parkinson's disease & cerebellar disorders.
2. Inability to understand instructions
3. Uncontrolled hypertension
4. Any orthopedic problem like fractures, dislocations affecting balance & gait.

Variables

1. Independent variable
2. Progressive resistive exercises.
3. Dependent variable
4. Balance
5. Walking speed
6. Cadence

Instruments and Materials:

1. Ankle Exerciser
2. Weight Cuffs
3. Stopwatch
4. 10 meter paper walkway
5. Measuring tape
6. Standard Chair

Fig. 1: Ankle Exerciser

Fig. 2: Weight Cuffs

Results

This chapter deals with the results obtained after statistical analysis. A total of 30 sub acute stroke patients were assigned to the experimental group (n=15) or control group (n=15).Experimental group received progressive resistive exercises in both lower limbs ie the affected and unaffected and the control group received Progressive resistive exercise only in the affected lower limb.

At baseline, there was no significant difference between the study groups.

Characteristics details: In Group A, there were 8 males and 7 females with the mean age of 53.93 + 6.36 years and MMSE mean of 29.06+6.20. In Group B, there were 9 males and 6 females with the mean age of 54.13 + 0.96 years and MMSE mean of 29.26+0.96.

Berg Balance Scale before and after Exercises in Experimental Group.

The mean of berg balance scale score before exercises was 38.7 and the standard deviation was 3.82598.The mean of BBS after the exercises was 49.6 and the standard deviation was 4.40454.On comparison, the results showed significant difference.

Walking Speed before and after Exercises in Experimental Group.

The mean of walking speed before exercises was 0.327 and the standard deviation was 0.249.The mean of walking speed after exercises was 0.44 and the standard deviation was 0.030.On comparison the results showed significant difference.

Cadence before and after Exercises in Experimental Group.

The mean of cadence before exercises in was 48.58 and the standard deviation was 4.013.The mean of cadence in after exercises was 67.88 and the standard deviation was 6.81. On comparison the results showed significant differences.

Berg Balance Scale before and after exercises in Control Group.

The mean of BBS before exercises was 38.4 and the standard deviation was 4.40454.The mean of BBS after exercises was 47.2 and the standard deviation was 3.034. On comparison the results showed significant differences.

Walking Speed before and After Exercises in Control Group.

The mean of walking speed before exercises was 0.334 and the standard deviation was 0.155.The mean of walking speed after exercises was 0.404 and the standard deviation was 0.025.On comparison the results showed significant differences.

Cadence before and after Exercises in Control Group.

The mean of cadence before exercises was 49.05 and the standard deviation was 3.58.The mean of cadence after exercises was 63.82 and the standard deviation was 3.90. On comparison the results showed significant differences.

Berg Balance Scale Before Exercises in Experimental and control Group.

The mean of BBS before the exercises for the experimental group was 38.7 and the standard deviation was 3.82598.The mean of BBS before the exercises for control group was 38.4 and the standard deviation was 4.40454.On comparison, the results showed insignificant difference.

Berg Balance Scale after Exercises in Experimental and control group

The mean of BBS after the exercises in experimental group was 49.6 and the standard deviation was 1.877. The mean of BBS after the exercises in control group was 47.2 and the standard deviation was 3.03472.On comparison the results showed significant difference.

Walking Speed Before Exercises in Experimental and Control Group.

The mean of walking speed before the exercise for the experimental group was 0.327 and the standard deviation was 0.024.The mean of walking speed before the exercises for the control group was 0.334 and the standard deviation was .015.On comparison the results showed insignificant difference.

Walking Speed After Exercises in Experimental and Control Group

The mean of walking speed after the exercises in experimental group was 0.440 and the standard deviation was 0.030.The mean of walking speed in control group was 0.404 and the standard deviation was 0.025.On comparison the results showed significant difference.

Cadence Before Exercises in Experimental and Control Group.

The mean of cadence before the exercises in experimental group was 48.5 and the standard deviation was 4.013.The mean of cadence in control group was 49.05 and the standard deviation was 3.580.On comparison the results showed insignificant differences.

Cadence after Exercises in Experimental and Control group

The mean of cadence after exercises in experimental group was 67.8 and the standard deviation was 6.819.The mean of cadence after exercises in control group was 63.82 and the standard deviation was 3.906.On comparison no significant difference was found.

Table 1 Comparison of characteristics (Age, MMSE) of patients between the groups.

Variable	Group A Mean ± S.D	Group B Mean ± S.D
Age (yrs)	53.93 ± 6.36	54.13 ± 6.20
MMSE	29.06± 0.96	29.26 ± 0.96

Table 2 Comparison of Pre and Post BBS within experimental group.

Variable	Mean± S.D N=15 Pre Post	z value	P value	Mean Difference (%)
Berg balance scale Score	38.73±3.825 49.66±1.87	3.4111	0.001*	28.2

*= significant (p<0.05)

Table 3 Comparison of walking speed and cadence before and after training within experimental group.

Variable	Mean± S.D N=15 Pre Post	T value p value	Mean Difference (%)
Walking speed	0.327±0.024 0.44±0.030	19.38 0.000*	37.5
cadence	48.58±4.013 67.88±6.81	15.23 0.000*	39.7

*=significant (p<0.05)

Table.4 Comparison of Pre and Post Berg Balance Scale Score within Control group.

Variable	Mean± S.D N=15 Pre Post	z value	P value	Mean Difference (%)
Berg balance scale Score	38.4±4.404 47.2±3.034	3.42	0.001*	22.9

*=significant (p <0.05)

Table 5 Comparison of Pre and Post walking speed and Cadence within Control Group.

Variable	Mean± S.D N=15 Pre Post	T value p value	Mean Difference (%)
Walking velocity	0.334±0.015 0.404±0.025	10.53 0.000*	21.2
cadence	49.05±3.58 63.82±3.90	11.58 0.000*	30.1

*=significant ($p<0.05$)

Table.6 Comparison of Mean Difference of Pre and Post Berg Balance Scale Score between the groups.

Berg balance scale	Mean ± S.D	z value	U value	P value
Pre	38.73±3.825	0.146	109	0.884^{NS}
Post	49.66±1.877	2.21	59.5	0.027*

*=significant ($p<0.05$), $^{NS=}$not significant

Table 7 Comparison of Pre and Post walking speed between the groups.

Walking speed	Group A Mean ± S.D	Group B Mean ± S.D	t value p value
Pre	0.327±0.024	0.33±0.015	0.967 0.342^{NS}
Post	0.440±0.030	0.40±0.025	3.53 0.001*

*=significant, $^{NS=}$not significant

Table 8 Comparison of Pre and Post Cadence between the groups.

Cadence	Group A Mean ± S.D	Group B Mean ± S.D	t value p value
Pre	48.58±4.01	49.05±3.58	0.341 0.736^{NS}
Post	67.88±6.81	63.82±3.906	2.001 0.05^{S}

$^{NS=}$ not significant, *= significant

Table 9 Comparison of Mean Differences of Cadence and walking speed between Group A and Group B

	GROUP A	GROUP B	t value	p value
	Mean±SD	Mean±SD		
Cadence	19.30±4.90	14.76±4.81	2.55	0.01
Walking speed	0.11±0.02	.069±.025	4.93	.000

*= significant ($p<0.05$)

Conclusion

The study concluded that the strength training using progressive resistive exercises are effective to improve gait and balance by means of intermanual transfer in stroke.

Ethical Clearance: Taken

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Conflict of Interest: Nil

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