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Full Length Research Paper

Efficacy of proprioceptive neuromuscular facilitation on shoulder function in subjects with secondary shoulder impingement in males and females.

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Study design was Pretest -Posttest experimental group study. The study determines The Efficacy of Proprioceptive Neuromuscular Facilitation on Shoulder Function in subjects with secondary shoulder impingement. Previous researches have established relationship between shoulder muscle weakness and its relation to causation of secondary shoulder impingement. Recent evidences showed that proprioceptive neuromuscular facilitation was effective in relieving pain and increase in overhead reach. None of the studies have measured shoulder function after PNF application. 30 subjects (15 male and 15 female) with a diagnosis of secondary shoulder impingement were recruited from hospital setting and were divided into 4 groups. Group 1 (males) and Group 2 (females) received both PNF and conventional protocol while Group 3 (males) and Group 4 (females) received only conventional protocol. All groups received intervention for a period of 3 weeks. Shoulder pain and disability index score (SPADI Score) and Overhead Reach were analysed in all groups. Group 1 and 2 showed significant improvement over Group 3 and 4 in terms of SPADI Score and Overhead Reach. The Experimental Groups showed significant improvement in reduction of SPADI Score over Control Groups (23.8 $\pm$ 4.88) at a significance level of $p \leq 0.0001$. Experimental Groups showed significant difference over Control Groups for Overhead Reach (3.63 $\pm$ 1.85) at a significance level of $p \leq 0.030$. Addition of Proprioceptive Neuromuscular Facilitation to conventional treatment brings significant improvement in Shoulder Function in comparison to conventional treatment only in subjects with secondary Shoulder impingement

Keywords: SPADI score, shoulder function, PNF facilitation, overhead reach

INTRODUCTION

Dynamic upper extremity dominant tasks such as throwing, hitting, and serving occur as the result of the integrated, multisegmented, sequential joint motion, and muscle activation system known as the kinetic chain. Open chain exercises attempt to isolate the rotator cuff muscles through long lever (Aaron Sciascia et al., 2012).

Table 1: Descriptive Statistics for Subjects

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
SEX	**Male**	**Female**	**Male**	**Female**
AGE (In Years)				
Mean ± S.D	45.88± 8.306	45.86± 9.245	52.14±4.634	44±9.258
Range	32 - 55	31 - 55	42 – 55	31-55
WEIGHT(In kg)				
Mean ± S.D	66.88± 7.22	57± 4.899	65.57±14.368	60.88±8.741
Range	55 - 74	52 - 66	43-85	50-74
HEIGHT (In cm)				
Mean ± S.D	162 ± 3.24	154.29± 6.422	165.79±8.051	157.25±9.498
Range	158 - 199	142 - 161	152-177	140-170

In human beings; most of the activities of daily living are unimaginable without the use of shoulder. The prevalence of shoulder symptoms have been reported to range from 20-35% (Vander Windt DA et al., 1995) and sex and age matched incidence of shoulder pain was 9.5 per 1000 (Ostor AJK et al., 2005). The most commonly occurring problems include rotator cuff disease or tendinopathy, which can progress to rotator cuff tear and glenohumeral joint instability and adhesive capsulitis (Bigliani et al., 1997). Shoulder impingement accounts for 44 to 65% of shoulder complaints (Page P, 2011).

Thus making shoulder impingement syndrome is one of the most common shoulder disorders in adults. Neer first introduced the concept of impingement in 1972 (Chang WK, 2004). There are two types of impingement primary and secondary. Primary shoulder impingement occurs when the rotator cuff tendons, long head of the biceps tendon, glenohumeral joint capsule, and/or subacromial bursa become impinged between the humeral head and anterior acromion. Secondary shoulder impingement is defined as a relative decrease in the subacromial space due to glenohumeral joint instability or abnormal scapulothoracic kinematics (Kachingwgwe AF et al., 2008).

The projected medical cost incurred on shoulder impingement is estimated to be approximately 1- 2 billion dollars annually. (Flanagan SR et al., 2010).

The shoulder complex relies on muscles to provide dynamic stability during its large range of mobility. Weakness in any of the shoulder muscles can cause instability, which can lead to numerous injuries. Secondary impingement results from a characteristic pattern of muscle imbalance including weakness of the lower and middle trapezius, serratus anterior, infraspinatus and deltoid, coupled with tightness of the upper trapezius, pectorals and levator Scapula (Page P, 2011).

Physical therapy has been found to be effective in reducing pain and disability in patients with shoulder impingement. Effective interventions include therapeutic exercises focusing on strengthening the rotator cuff and scapular stabilizing musculature, stretching to decrease capsular tightness, scapular taping techniques, and patient education of proper posture. A dilemma currently exists for the best physiotherapy treatment of secondary shoulder impingement (Bang MD et al., 2000).

Proprioceptive neuromuscular facilitation (PNF) is an approach to therapeutic exercise that combines functionally based diagonal patterns of movement with techniques of neuromuscular facilitation to evoke motor

S.No	INCLUSION CRITERIA	EXCLUSION CRITERIA
1.	Male/Female	Primary shoulder impingement
2.	Age: 30-55 years	Bilateral shoulder impingement
3.	Secondary Shoulder impingement	Surgical procedure to the affected upper extremity
4.	Positive Neer's sign	Trauma to the shoulder less than 12 weeks
5.	Positive Hawkins-Kennedy Test	Shoulder instability, shoulder dislocation, cervical rib etc
6.		History of infection, tumours, congenital anomalies etc
7.		Reflex sympathetic dystrophy and Related syndromes.
8.		Corticosteroid Injection in the shoulder Region less than 12 weeks
9.		Noncooperative subjects
10.		Any Systemic illness

responses and improve neuromuscular control and function. It is used to increase strength, flexibility, and ROM (Engle RP et al., 1986). PNF incorporates mass functional movement patterns that are diagonal and spiral in nature and often cross the midline of the body. Everyday tasks and skills, from picking up a bottle of water to throwing and kicking naturally utilize diagonal and spiral movements (Burton L et al., 2011).

So, my purpose of study is to evaluate the effectiveness of addition of Proprioceptive Neuromuscular Facilitation to the conventional protocol will produce a significant improvement in Shoulder Function in subjects with secondary shoulder impingement that would improve the outcome of the physical therapy intervention on the subject in Males and Females.

METHODS

Thirty subjects, 15 men and 15 women meeting the inclusion and exclusion criteria were randomized into two groups by lottery system (chit method):

Chit Method: Male subjects were given chits written Group 1 and group 3.On 8 chits Group 1 was written and on other 8 Group 3. Subject draws one chit and then that chit is discarded and Female Subjects were given chits written Group 2 and group 4 and similar method was followed:

Group 1, Group 2, Group 3 and Group 4 (Table 1). All subjects were referred by physicians with the diagnosis of shoulder impingement syndrome. Subjects were subsequently screened according to established inclusion criteria. Each subject signed an informed consent and was detailed about the benefits and risks of study.

Setting and Timescales

Research was conducted in Rehabilitation Centre, HAHC, Jamia Hamdard from October 2012 to February 2013.

Inclusion Criteria (Eric J Hegedus, 2012)

1. Male/Female
2. Age group: 30-55 years
3. Presence of secondary shoulder impingement
4. Positive Neer's sign

(Sensitivity and specificity 72% and 60% respectively)

5. Positive Hawkins-Kennedy Test

(Sensitivity and specificity 79% and 59% respectively)

Exclusion Criteria

1. Primary shoulder impingement (Patients had imaging Studies X-Ray to confirm)
2. Bilateral shoulder impingement
3. History of Any Surgical procedure to the affected upper extremity
4. History of Trauma to the shoulder less than 12 weeks
5. History of Shoulder instability, shoulder dislocation, cervical rib etc.
6. History of infection, tumours, congenital anomalies etc.
7. History of Reflex sympathetic dystrophy and related syndromes
8. History of Corticosteroid injection in the shoulder region less than 12 weeks

9. Non cooperative subjects (they not agree to the informed consent)
10. History of Any Systemic illness for example rheumatoid arthritis, ankylosing spondylitis, diabetes etc. diagnosed by physician.

Dependent Variables

We measured the patient's perception of shoulder function using shoulder pain and disability index and Overhead Reach using measuring tape. Subjective responses were recorded for the functional assessment activities using shoulder pain and disability index (SPADI) (Roach KE et al., 1991; Hill CL et al., 2011). Which has shown to be reliable tool for measuring shoulder function?
SPADI Score has Reliability coefficients of ICC ≥ 0.89 in a variety of patient populations.
When the SPADI is used more than once on the same subject, e.g., at initial consultation and then at discharge, the minimal detectible change (MDC 95%) is 18 points (Breckenridge JD et al., 2011)
Subjects were explained and given the shoulder pain and disability index and asked to complete it. It is a self-administered questionnaire that consists of two dimensions, one for pain and the other for functional activities. The pain dimension consists of five questions regarding the severity of an individual's pain. Functional activities are assessed with eight questions designed to measure the degree of difficulty an individual has with various activities of daily living that require upper-extremity use. To answer the questions, subjects are asked to place a mark on a 0-10 visual analogue scale for each question. Verbal anchors for the pain dimension are 'no pain at all' and 'worst pain imaginable', and those for the functional activities are 'no difficulty' and 'so difficult it required help'. The scores from both dimensions are averaged to derive a total score. Measurement of Overhead Reach (Hayes K et al., 2001).
The subject's standing head height (measured in centimetres) is measured by a measuring tape. The subject is turned to face the wall with toes touching the wall and takes the affected extremity to a maximum overhead position. The overhead reach value is recorded as the position of maximum reach minus the subject's standing head height. Overhead Reach has Reliability coefficients of ICC ≥ 0.74 in a variety of patient populations.
When the Overhead Reach Scores are used more than once on the same subject, e.g., at initial consultation and then at discharge, the minimal detectible change (MDC 95%) is 0.49 cm.

Procedure

The tester was responsible for measurement for all dependant variables and subjects were randomly assigned into four groups. All screening, testing and examination were standardized and pre-printed on data recording forms. The study was conducted over 9 therapy sessions in a 3-week period. SPADI Score and Overhead Reach measurements were carried on 3rd, 6th and 9th treatment session.
On day 1, male subjects signed the informed consent and were appointed to either Group 1 or Group 3 and female subjects signed the informed consent and were appointed to either Group 2 or Group 4. Subjects were then directed to us, to carry out initial measurements of all the dependant variables.

Treatment

Experimental Groups (1 and 2): Subjects in this group received conventional treatment Conventional Treatment (Chang WK, 2004; Bang MD et al., 2000)

Table 2: Within subject improvements in Group 1

	Pre-treatment			**Post treatment**		
	N	Mean	SD	N	Mean	SD
SPADI Score	8	83.75	13.905	8	38.38	10.888
Overhead Reach	8	35.812	5.593	8	42.125	5.5404

SPADI: Shoulder Pain and Disability Index

Week 1

1. Cold pack to the shoulder for 10 minutes.

2. Isometric Exercises– external rotation, internal rotation ,deltoid (anterior, middle, posterior) 3 sets of 10 repetitions and a 60 sec rest period

Week 2 and 3 same as for week 1.

FLEXIBILITY EXERCISES

1. Anterior shoulder musculature – Subject is in a high sitting position with his/her hands resting above the head. He /She is instructed to take his/her elbow backwards. Hold to a count of 30.
2. Posterior shoulder musculature - Subject is in a high sitting position with his/her hand resting on non-affected shoulder. His /her non affected hand, hold an elbow and brings it toward midline.
Each stretch is held for 30 seconds and performed 3 times and with a 10 seconds rest period. Strengthening

Table 3: Within subject improvements in Group 2

	Pre-treatment			Post treatment		
	N	Mean	SD	N	Mean	SD
SPADI Score	7	75.71	14.244	7	37.43	14.831
Overhead Reach	7	31.286	4.0708	7	38.214	2.6118

SPADI: Shoulder Pain and Disability Index

Table 4: Within subject improvements in Group 3

	Pre-treatment			Post treatment		
	N	Mean	SD	N	Mean	SD
SPADI Score	7	69.71	22.962	7	53.71	15.305
Overhead Reach	7	34.14	6.283	7	36.786	5.9712

Table 5: Within subject improvements in Group 4

	Pre-treatment			Post treatment		
	N	Mean	SD	N	Mean	SD
SPADI Score	8	80.75	10.899	8	68.75	9.285
Overhead Reach	8	33.5	5.657	8	36.562	5.206

SPADI: Shoulder Pain and Disability Index

Variables	F-value	t-value	Sig(1-tailed)
SPADI0	0.251	0.748	0.230
SPADI1	0.891	-1.042	0.153
SPADI2	0.051	-3.528	0.0001
SPADI3	0.241	-4.875	0.0001
OHR0	0.195	-0.049	0.481
OHR1	0.106	0.629	0.267
OHR2	0.590	1.772	0.044
OHR3	0.555	1.967	0.030

Table 6: Between group 1 and 2 with 3 and 4 for all variables

SPADI0: Shoulder Pain and Disability Index Score at baseline

SPADI1: Shoulder Pain and Disability Index Score after 1 week

SPADI2: Shoulder Pain and Disability Index Score after 2 weeks

SPADI3: Shoulder Pain and Disability Index Score after 3 weeks

OHR0 : Overhead reach (in cm) at baseline

OHR1 : Overhead reach (in cm) after 1 week

OHR2 : Overhead reach (in cm) after 2 weeks

OHR3 : Overhead reach (in cm) after 3 weeks

program

The use of weights was determined by the observation movement quality and the subject responses with regard to fatigue and pain; 3 sets of 10 repetitions and a 60 sec rest period

1. Supraspinatus strengthening-: Empty can position (shoulder flexed to 90^0 in scapular plane)

2. Internal rotation and external rotation with the arm adducted to side

3. Seated press-up: Subject is in a high sitting position and instructed to lift his lower trunk on both hands.

Table 7: Between group 1 and 2 for all variables

Variables	F-value	t-value	Sig(2-tailed)
SPADI0	0.000	1.104	0.290
SPADI1	1.826	0.618	0.547
SPADI2	0.802	0.866	0.402
SPADI3	1.057	0.142	0.889
OHR0	1.341	1.767	0.101
OHR1	1.033	2.200	0.046
OHR2	1.045	1.844	0.088
OHR3	6.070	1.703	0.112

Table 8: Between group 3 and 4 for all variables

Variables	F-value	t-value	Sig(2-tailed)
SPADI0	3.337	-1.216	0.245
SPADI1	1.245	-1.517	0.153
SPADI2	3.323	-1.675	0.118
SPADI3	2.130	-2.337	0.036
OHR0	0.380	0.209	0.838
OHR1	0.753	-0.085	0.934
OHR2	0.292	-0.76	0.940
OHR3	0.485	0.777	0.939

4. Elbow push up plus: Subject is in a prone lying position, supported at level of forearms. He lifts his/her trunk upwards and sustains it for a period of 10 seconds.

Followed by PNF procedures (Gorges JJ et al., 2003)

Subjects were instructed to actively move through the PNF flexion-abduction external-rotation diagonal pattern for 3 sets of 10 repetitions with manual facilitation (combination of isotonics).

Conventional Groups (3 and 4)

Subjects received only conventional treatment as mentioned above. Ethical approval for the study was obtained.

Data Analysis

The effect of addition of Proprioceptive Neuromuscular Facilitation to the conventional protocol in subjects with secondary shoulder impingement was tested with independent T test for between group comparisons and repeated measures analysis of variance (ANOVA) for Within group analysis. (Table 2-Table 5)

The independent variable was mode of exercise procedure (PNF + conventional protocol, conventional protocol). The between subject dependant variables used were SPADI score (at baseline, 1 week, 2 week, 3 weeks) and overhead reach (at baseline, 1 week, 2 week, 3 weeks).
The α level was set at 0.05 for all analyses. Post hoc analysis was performed using paired t tests with Bonferroni correction. Data analysis was accomplished with the following software packages: STATA: version 12. SPSS (version 16.0 SPSS Inc. Chicago, IL), EXCEL (Professional EDITION 2007; Microsoft Corp, Redmond, WA)

RESULTS

Statistical analysis revealed that both experimental and Control groups showed no significance difference between anthropometric variables and age between groups, age ($p=0.27$), weight ($p=0.41$) and height ($p=0.43$) between the groups ($p>0.05$)
Group 1 showed significant improvement over Group 2 in terms of SPADI Score and Overhead Reach and Group 3 showed significant improvement over Group 4 in terms of SPADI Score and Overhead Reach. The Experimental Groups showed significant improvement in reduction of SPADI Score over Control Groups (23.8 ± 4.88) at a significance level of $p \leq 0.0001$. Experimental Group showed significant difference over Control Group for Overhead Reach (3.63 ± 1.85) at a significance level of $p \leq 0.029$.

DISCUSSION

This study was designed to determine the significance of incorporating PNF in secondary shoulder impingement. To our knowledge, this is the first study that had taken into account the measurement of SPADI score and Overhead Reach and short term effects of PNF in secondary shoulder impingement.
In Group 1 and 2 both PNF, along with conventional protocol were given to the volunteers. While in Group 3 and 4, they were given only conventional protocol. The dependent variable studied were Shoulder Function measurement by SPADI Score and Overhead Reach.
The results of our study showed that in within- subject analysis as well as in between group analysis, there was a significant difference in SPADI Score and Overhead Reach.

SPADI Score

The results of our study showed that in within group analysis, both groups showed a significant reduction in SPADI Score. In a small scale experimental interventional study of 11 subjects, Kline et al. examined the impact of PNF on physical function. A beneficial effect of PNF training was found for flexibility (ROM shoulder flexion, ankle dorsiflexion) and isometric strength (hip extension, ankle flexion and extension). Measures of physical function (sit-to-stand) also improved (Westwater-Wood S et al., 2010).
The mechanism behind this finding in control groups could be attributed to the fact that active exercises help in maintaining joint and soft tissue integrity, enhance synovial movement for cartilage nutrition and diffusion of materials in the joint, to maintain mechanical elasticity of muscle and motor learning to normalize dysfunctional patterns of motion (Nellutla NMM et al., 2009)
In between group analysis, the experimental group showed a significant improvement over control group at a significance level of $p<0.0001$. The mechanism behind this finding in could be attributed to body's neuromuscular components being adaptable or plastic; and that functional movement occurs in patterns which are spiral in nature. Proprioceptive neuromuscular facilitation techniques are used to target all aspects of muscle training, e.g. sustained isometric activity to mobilize muscle groups thus improving range of movement and/or reduce pain, functional patterns and handling techniques to facilitate both co-ordination and stability in muscle groups (Westwater-Wood S et al., 2010). Previous reviews stated that the addition of pragmatic manual therapy was shown to be effective in reducing pain intensity compared to exercise alone (Bang et al., 2000). In a study by (S. Citaker et al., 2005) it was observed that mobilization and proprioceptive neuromuscular facilitation methods are both similarly effective.

Overhead Reach

A reduction in pain and disability is definitely associated with an increase in Overhead Reach. Experimental group has shown a significant improvement over Control Group for Overhead Reach (6.6 ± 0.488) Overhead Reach at a significance level of ($p<0.0001$) while control group showed (2.867 ± 0.186) increase of Overhead Reach. The mechanism behind this finding in experimental group could be attributed to four mechanisms autogenic inhibition, reciprocal inhibition, stress relaxation, and the gate control theory (Hindle KB et al., 2012)
Results of our study are in concordance with previously mentioned studies. Previous researches (Godges et al., 2003) found significant increases in glenohumeral rotation and overhead reach ROM with PNF as an adjunct to soft tissue mobilization alone.
No significant difference was found between Males and Females (Group 1 and 3 vs. Group 2 and 4). This was conducted as in several researches response of males and females to therapy has been found to be different (Suraj Kumar et al., 2010). No significant difference between males and females could be attributed to similar effect of PNF in males and females.

CONCLUSION

The results of the study showed that addition of Proprioceptive Neuromuscular Facilitation to conventional treatment brings significant improvement in Shoulder Function in comparison to conventional treatment only in subjects with secondary Shoulder impingement. Thus the study concludes by rejecting the null hypothesis and accepting the experimental hypothesis.

Relevance to Clinical Practice

Results of present study support the practice of application of PNF to improve shoulder function in subjects with secondary shoulder impingement. Beliefs concerning functional limitations have permeated into medical and physiotherapy clinical practice are used to explain to patients the basis for pathology and rationale for rehabilitation, and underpin the importance of functional assessment for subjects with secondary shoulder impingement. However the evidence to support these theories is limited. Results of present study tried to support these theories. Results of this study also support the practice of strengthening scapular stabilizers in rehabilitation of rotator cuff impingement, as a stable base of support is needed for these muscles to perform optimally as revealed in this study.

Limitations of Study

Random sampling was not done, sample of convenience

was used and as our study involves a small sample size, so its results cannot be justified over a large population.

Future Research

1. Random sampling can be done.
2. As our study involves a small sample size, so its results cannot be justified over a large population. Larger sample size can be used.
3. Follow up of PNF can be documented after treatment is completed.
4. Individual effects of PNF on shoulder function can be seen.
5. Functional evaluation is carried by one scale only SPADI other functional evaluation scales
can be added.

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