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Contents

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Effect of Positive Expiratory Pressure (PEP) Vs Routine Physiotherapy in preventing pulmonary complications following CABG – Results of a pilot study

Ayesha Kishori Miranda*, Narasimman Swaminathan, Cherisma D'silva***, Jayakrishnan A. J.******

Abstract

Background: Chest physiotherapy is an established and routinely used therapy to prevent and treat post operative pulmonary complications after cardiac surgery. Positive expiratory pressure (PEP) is an expiratory resistance breathing exercise which has been incorporated into the routine post-operative regime after open heart surgery. The present study was aimed to evaluate and compare the efficacy of routine physiotherapy and PEP in preventing post-operative pulmonary dysfunction in patients undergoing CABG.

Methods: Subjects (n=18) who underwent elective coronary artery bypass grafting were included in the study. They were randomly assigned into 2 groups. Group 1 was given PEP therapy and Group 2 were administered routine chest physiotherapy .Arterial Blood Gas, PFT (FEV_1, FVC, PEFR,) SPO2 and 2 min walk distance were measured pre and post cardiac surgery.

Data analysis and Results: 16 subjects completed the study. Fishers exact t test, Mann Whitney 'U' test and Wilcoxon Signed Ranks test were used compare the parameters between and with the groups. There was no significant difference in any of the outcomes between the groups.

Conclusion: Positive Expiratory Pressure clinically as well as statistically has equal effects in preventing postoperative pulmonary complications when compared with conventional physiotherapy.

Keywords: physiotherapy; Thoracic surgery; Coronary artery bypass graft; Post-operative pulmonary complications; Positive expiratory pressure; Breathing exercises; Incentive spirometery.

Introduction

Cardiovascular disease is the cause of steadily rising death rate in developed and developing countries. Cardiac surgery is widely used to treat patients with heart problems despite the numerous alternatives for the treatment of coronary artery disease, it has shown good mid and long term results, providing the remission from angina symptoms increasing the life expectancy and improving their quality of life.[1, 2] Post cardiac surgery pulmonary dysfunction is one of the most important causes of morbidity and mortality [3, 4] Resulting in decrease in FRC leading to impaired gas exchange, arterial hypoxemia and increase in intrapulmonary shunt due to atelectasis related to the use of cardiopulmonary bypass.[6]

Chest physiotherapy is an established and routinely used therapy to prevent and treat post operative pulmonary complications after cardiac surgery. [2, 4] It includes airway clearance techniques, positioning, breathing exercises, incentive spirometry, early mobilization [5, 8] and several newer techniques like active cycle of breathing (ACBT), inspiratory muscle training (IMT), autogenic drainage (AD), positive expiratory pressure (PEP), flutter etc. [9] Postural drainage with percussion was the gold standard of chest physiotherapy for many years and was proved to be superior to breathing exercises in the 1950's. Recently PEP has been used in

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postoperative patients to enhance the function of the diaphragm and improve oxygenation.

Positive expiratory pressure (PEP) is an expiratory resistance breathing exercise which has been incorporated into the routine post-operative regime after open heart surgery in many Western Countries. It prevents or reduces alveolar collapse, mobilizes secretions, favors expectoration, improves inhalational muscle strength. [8, 10, 11, 12]

Strong scientific evidence is lacking as to the most effective chest physiotherapy technique for airway clearance post cardiac surgery. [5, 7, 8] some studies suggest that positive expiratory pressure (PEP) is more effective than conventional chest physiotherapy in post thoracic surgical patients. [10, 11]

The purpose of this study was to evaluate and compare the efficacy of routine physiotherapy and PEP in preventing post-operative pulmonary dysfunction in patients underwent CABG.

Methodology

Subjects posted for elective coronary artery bypass graft aged 50-70 years of males and females with More than 2 vessel diseases were recruited from Father Muller Medical College Hospital from February to September 2010. Subjects who had undergone Emergency Coronary Artery Bypass Graft surgery patients, Intraoperative or post operative Cerebral Vascular Accident, Hemodynamic instability and more than 24 hours of assisted ventilation post operatively were excluded from the study

Procedure

Informed consent was obtained from each patient, and the study was approved by the institutional ethical committee. Subjects were randomly assigned into 2 groups by using simple randomization procedure. In Group 1 subjects received positive expiratory pressure (Threshold PEP) and Group 2 subjects received conventional physiotherapy.

Routine protocol was used pre operatively which consisted of; patient education, general chest assessment and examination, pulmonary function test, preoperative physiotherapy and 2 min walk distance. Oxygen saturation was measured using a pulse oximeter in both groups.

Chest expansion was measured at the level of 2nd, 4th and 6th intercostal space using a tape measure. A minimum of 3 readings were taken and the best reading was recorded. The vitals of the subject at rest namely temperature, heart rate; respiratory rate and blood pressure were also noted.

Pulmonary function testing was performed pre and post operatively in upright sitting position. The instructions given to the subjects to perform pulmonary function testing were to place the mouth piece in the mouth and to form a tight seal with their lips without using their teeth to hold the mouth piece in place. All instructions were given by the same researcher throughout the procedure in the subject's language. Once the subject was familiar with the maneuver, the readings were recorded. They were made to perform three trials with adequate rest. The trials were repeated if the variation was more than 10%.

The 2 minute walk test was performed in an indoor premeasured of 30 metres. Subjects were asked to walk as far as they can in 2 minutes, back and forth along the corridor. No encouragement was given and no talking was allowed during the test. Immediately before and after the walk test, arterial oxygen saturation (SPO_2), heart rate (HR) and respiratory rate (RR) was measured. The distance walked (in meters) was recorded.[15]

All the subjects were given adequate instructions about the surgical procedure they were to undergo.

Subjects of Group 1 were taught PEP. In this subject was made to sit comfortably and upright while holding the mouthpiece tightly between the lips. Expiratory resistor dial was adjusted according to patient's comfort. It was kept between 5-20 cm H_2O.

• The subject was asked to breathe from the diaphragm, taking in a larger than normal tidal breath, but not to total lung capacity.

• The subject was asked to gently exhale approximately 3 times longer than inhalation, maintaining a prescribed pressure of 0–20 cm H_2O as per patient's comfort.

• Subject performed 15 PEP breaths, followed by 2–3 splinted forced exhalation manoeuvres or huff. The procedure was repeated until secretions were cleared.

The subjects of Group 2 were taught SMI, deep breathing exercise with splinted huffing/coughing. They were made to perform the maneuver until they were familiar with it.

Postoperative physiotherapy

Postoperatively, Group 1 subjects received only Threshold PEP from 1^{st} post operative day, 3 times a day and mobilization from 2^{nd} post operative day.

Group 2 subjects received conventional physiotherapy; SMI, breathing exercises, splinted huffing /coughing and mobilization from 2^{rd} post operative day.

Arterial blood gas, SPO_2, temperature, respiratory rate, auscultation changes and chest radiography were analyzed to document the occurrence of postoperative pulmonary complications.

Measurements

On the sixth postoperative day, oxygen saturation (SpO_2), respiratory rate, pulse rate, blood pressure and temperature, pulmonary function tests and 2 minute walk test were repeated in both the groups. This was compared with the baseline readings (preoperative readings) to document the occurrence of PPCs. Data was entered in the data collection form.

Data analysis

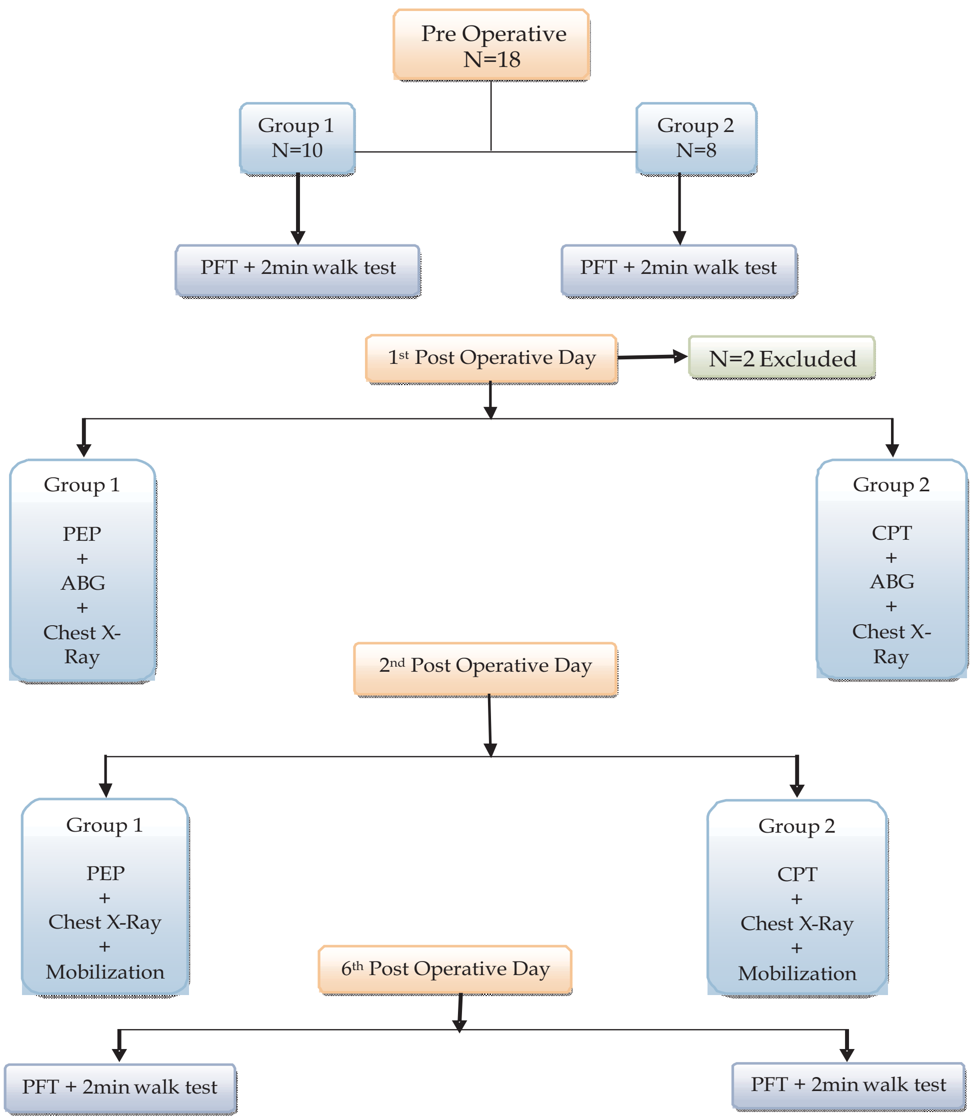
The software programme used for data analysis was SPSS 13. Demographic data of both the groups were analyzed by using Fishers Exact Test. Pulmonary function test parameters, SpO_2 and chest expansion measurements within the group were analyzed by using Wilcoxon Signed Ranks test. Analysis of pulmonary function tests between the groups was done by using Mann Whitney 'U' test. Probability values of less than 0. 05 were considered significant.

Fig 1. Suject performing post op PEP

Fig 2. Ambulating on POD2

Fig 3. Perfoming SMI

Fig 4. Flow chart of methodology



Results

Sixten subjects completed the study with 1 female and 15 male. There were 10 in PEP group and 6 in Conventional PT group. The mean age in PEP group was 54.70 ± 5.6 SD and 64.6 ± 10 SD in Conventional Physiotherapy group. The average BMI of the subjects was 23.1 ± 2.0 SD in PEP group and 22.1 ± 2.8 SD in Conventional PT group.

For male and female in both the groups the Fishers exact test showed p=0.625 and for the grafts used inboth the groups Fishers exact test showed p=0.837, which Showed no significant difference between the groups in the demographic data.

Chest Xray and Oxygen saturation

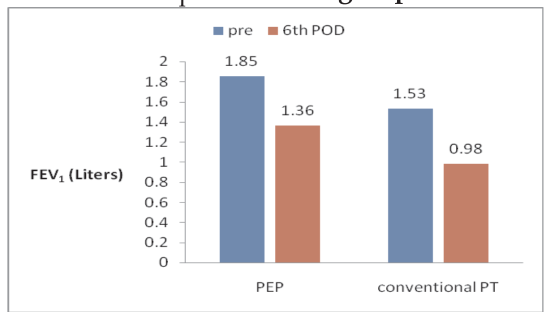
No significant difference was seen in pre and post operative Chest X-rays and Oxygen saturation when compared between the groups.

Pulmonary Function Test

Wilcoxon Signed rank test was used to analyze the significance of reduction in pulmonary function test values from pre operative to 6th post operative day. For FEV1 the Wilcoxon Signed rank test showed a value of 1.48 (p=1.39) in PEP group and 2.0 (p=0.46) in Conventional PT group, For FVC the test showed a value of 0.46 (p=0.64) in PEP group and 1.21 (p=0.22) in Conventional PT group and For PEFR the test showed a value of 1.27 (p=0.20) in PEP group and 1.63 (p=0.10) in Conventional PT group which was not significant.

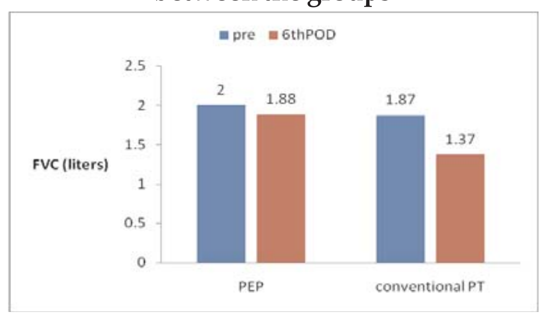
There was no significant change in pulmonary function when compared between the groups postoperatively.

Fig 5. Comparison of pre and post operative FEV_1 between the groups



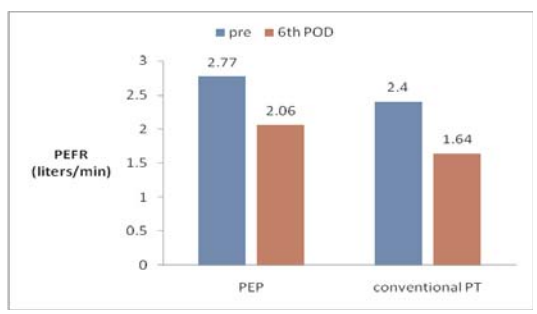
There was no significant reduction in FEV_1 when compared between the groups.

Fig 6. Comparison of pre and post operative FVC between the groups



There was no significant reduction in FVC when compared between the groups.

Fig 7. Comparison of pre and post operative PEFR between the groups



The demographic data are shown

	Conventional group				PEP group			
	Number 6	Minimum	Maximum	Mean	Number 10	Minimum	Maximum	Mean
AGE		50	74	64.6		46	62	54.70
Sex	0 Female	0	0	-	1 Female	1	1	-
	6 Male	6	6	-	9 Male	9	9	-
BMI	-	18.0	29.0	22.16	-	19.7	26.2	23.11

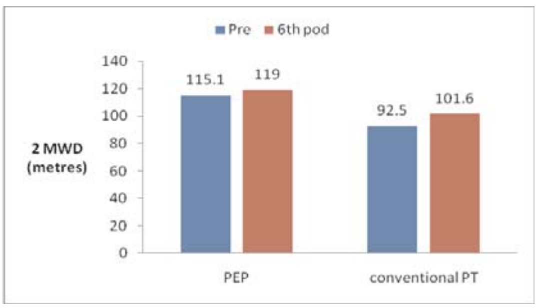
No significant reduction in PEFR was seen when compared between the groups.

There was no significant change in pulmonary function test values between the groups when compared postoperatively.

Two Minute Walk Test

There was no significant change in 2 minute walk distance between the groups when compared postoperatively.

Fig 8. Comparison of 2 Minute Walk Distance between the groups



Discussion

Postoperative physiotherapy is known to improve respiratory mechanics, decreases the incidence of PPCs and shortens length of hospital stay[2, 5].But strong scientific evidence is lacking as to the most effective chest physiotherapy technique for airway clearance post cardiac surgery [7, 9, 11].

Therefore, this study aimed to compare the effect of positive expiratory pressure as compared to conventional physiotherapy on post operative pulmonary function in CABG. PEP was used in this study as it has been proven that, it helps to slow the emptying of lungs and increases lung volume, prevents or reduces alveolar collapse, mobilizes secretions and favors expectoration[8,10,13]. It also helps in improving inhalational muscle strength. Both the groups were also mobilized early (on 2nd POD).

This study was completed within 8 months, therefore the sample size was too small and two subjects from group were lost because of untoward events. Therefore this study strongly prove or disprove the hypothesis that was put forth.

Ninety percent of the subjects in PEP group were male as opposed to the Conventional group where 100% were male. The mean age in PEP group was 54.7 ± 5.6 SD and BMI was 23.1 ± 2.0 SD while in Conventional group it was 64.6 ± 10 SD and BMI was 22.1 ± 3.8.

Comparing both groups 87.5% presented with normal chest x– rays pre operatively, 100% showed abnormal chest x - ray on 1st POD as opposed to 93.8% normal chest x-rays on 6th post operative day. This could be attributed to the positive effects of PEP which prevents or reduces alveolar collapse, mobilizes secretions and favors expectoration [11] conventional physiotherapy also had a similar effect. [8]

All the subjects presented with abnormal values of FEV1, FVC and PEFR pre operatively which had increased to near pre operative levels on the 6th POD. PEFR values were highest in the PEP group on the 6th POD as compared to the conventional group. This could be because PEP exerts a positive pressure during expiration slows the emptying of lungs and therefore increases lung volume. [11, 12] On the other hand the SMI that was administered to the conventional physiotherapy group aids in lung expansion while DBE reduce atelectasis.[13, 16] This could be the reason the PFT values also increased in this group.

Sixty percent of the subjects in PEP group and 83.3% subjects in Conventional group had more than four grafts. While only 20% patients in PEP group had three grafts. IMA graft was used in 100% of the subjects. The numbers of grafts used do not predict post operative outcomes.[1] No significant graft related post operative pulmonary complications were seen in any subject from either group.

Hypoxemia post surgically is well documented.[4] Both the groups had hypoxemia but it was not statistically significant. 60% of the subjects were administered with Oxygen through face mask till the 2nd POD. Post operative physiotherapy recruits lung tissue and this tissue is converted to from a shunt region to a zone with low ventilation in relation to perfusion, thus increasing the oxygenation of blood. [14]

Altered respiratory mechanics, pain and weak cough reflex normally cause a decrease in thoracic expansion post CABG.[2,3] Respiratory physiotherapy uses techniques capable of improving respiratory mechanics, pulmonary re - expansion and bronchial hygiene. [10] This could possibly explain why the chest expansion values in this study did not decrease despite surgical trauma.

The 2MWD is a measure used to assess functional capacity or ADLs after cardiac surgery. Test values are sensitive to change after cardiac surgery.[15] In this study the distances walked after surgery was improved in both the groups. This is not in accordance with the literature but could be due to chest physiotherapy and early mobilisation which has been proven to have a positive effect in improving functional capacity. [12]

This study was mainly done to demonstrate the efficacy of PEP and conventional physiotherapy and to compare the two techniques in the management of patients who have undergone CABG.

Though there was no statistically significant difference in all the parameters used in this study, the PEP group improved clinically when compared to the conventional physiotherapy group. This shows that PEP has a positive effect in preventing PPCs.

Limitations of the study

Postoperative pain was not quantified by means of any subjective pain scale. Since this study shows that PEP is as effective as Conventional Physiotherapy, a similar kind of study with a larger sample size should be undertaken to find out the real efficacy of PEP. Blinding the therapist who administers the techniques and measures the outcomes would also improve the quality of the study.

Clinical Implications

PEP may be an effective technique in preventing PPC in patients with preoperative risk factors or who develop complications after cardiac surgeries, provided they are trained with the technique preoperatively.

Conclusion

PEP clinically as well as statistically has equal effects in preventing postoperative pulmonary complications when compared with conventional physiotherapy. More studies in patients with preoperative risk factors should be undertaken to find out the efficacy of PEP in preventing postoperative pulmonary complications.

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Conflict of Interest: None

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Original article

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Effect of Retro-Treadmill Ambulation Training in Patellofemoral Pain Patients

Kedia S*, Sharma Saurabh**

Abstract

Objective: Patellofemoral pain syndrome (PFPS) is defined as the presence of pain around the patella, The goals of patellofemoral rehabilitation are to maximize quadriceps strength.. Backward locomotion may be a useful rehabilitation modality in the treatment of patellofemoral pain syndrome.

Methods: Study was conducted on 26 subjects for a period of 4 weeks in two groups. Outcome measures of pain and function were taken to assess the effect of intervention.

Conclusion: Statistically significant improvements in pain and function outcome measures in the patients with patellofemoral pain following intervention comprising of backward walking on treadmill indicate its effectiveness when incorporated as a therapeutic regime in these patients and is therefore recommended in the rehabilitation of PFPS patients.

Keywords: PFPS; Backward walking; Retro treadmill.

Introduction

Anterior knee pain is one of the most common conditions seen in outpatient However it has been suggested that backward walking may offer some benefits beyond those experienced through forward walking alone [7]. Graded walking provides a functional exercise that improves muscular activity around the affected joints, employs an appropriate range of motion and provides a controlled environment which minimizes the possibility of further damage.[8]

Flynn [9] reported significantly lower peak knee extensor moments and peak patellofemoral compressive forces in backward vs. forward running. Thus backward running may be a useful rehabilitation modality in the treatment of patellofemoral pain syndrome. According to Cipriani and Grasso backward running has been documented to increase quadriceps strength and power [10 11]. However there has not been any clinical trial conducted to support or refute the positive effects of backward treadmill walking in altering pain and physical functions in subjects with patellofemoral pain. Thus the purpose of this study is to examine the effects of uphill backward treadmill walking in altering pain and physical functions in subjects with patellofemoral pain syndrome.

Thorstensson [12] and Sang Wan Hang [13] also concluded that the effects of forward walking and backward walking on surface EMG analysis of Quadriceps at treadmill grades of 0%, 5%, and 10%. The results of their study indicated that SEMG activity levels of rectus femoris,vastus lateralis, and vastus medialis obliqus were significantly different between directions.

Methods

Design

Pre-test-posttest experimental design was used in this study.

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Subjects

Subjects were included on following inclusion criteria: age 18 to 35 years. Both males and females, history of retro or peri patellar pain during physical activities including jumping ,squatting, running, or stair ambulation or after prolonged sitting with flexed knees, symptoms for atleast two months,presence of at least one of the following clinical signs: tenderness on palpation or compression of patella, pain on isometric quadriceps contraction against supra-patellar resistance, pain on resisted knee extension, non-traumatic onset of symptoms, negative findings on clinical examination of knee ligaments, menisci, bursae (inflammation), iliotibial band (friction syndrome), negative findings on radiographs of the knee (AP and skyline views) with regards to changes of the osteoarthritis,osteochondritis dissecans,or loose bodies in the patellofemoral and tibiofemoral joints. Subjects were excluded if H/O any recent knee surgery, history of patellar subluxation or dislocation, severe knee pain that preclude treadmill walking(VAS equal to greater than 8),cardiopulmonary conditions that preclude treadmill exercise, neurological disorders affecting gait of the individual, significant injury to or any other pathology of hip,ankle,rheumatic disease affecting musculoskeletal system or sensorimotor performance

Procedure

A total of thirty two subjects were screened with the help of history taking and clinical examination for inclusion. Twenty six subjects met the inclusion criteria.A detailed explanation about the procedure was given. The subjects were then randomly allocated into either of the two groups: the intervention group or the control group. Demographic data and dependent variables were recorded. Measurement of function(KPS score) the Kujala scale is a self administered questionnaire (valid and reliable). Measurement of pain (vas): the pain levels of the patient were assessed using visual analog scale (VAS).. Both pre- and post-intervention measurements were taken. If the patient scored lesser post –intervention as compared to pre-intervention, it means that the patient responded well to the interventions as his pain levels reduced. After randomization pre-intervention measures were taken. Each group respectively underwent an intervention for four weeks depending upon their designated group. Subjects in group one received retro walking intervention and subjects in the second group i.e. control group received conventional quadriceps exercises.

Experimental group

All the subjects who were allocated to the retro walking intervention group were first familiarized with the backward walking pattern on the level ground such that during backward walking the toes strike the ground first instead of the heel .subject was asked to walk in backward direction for 2-3 rounds over ground. Then the patient was made to stand on the treadmill and face in the direction opposite to the direction of the moving belt of treadmill such that retro walking movement occurred. The subject began a practice session (10 min) on the treadmill consisting of backward walking initially holding the hand rails bilaterally and walking at a comfortable slow speed..Within this period the subject was instructed to remove the support from the hand railings, and for safety concerns the safety knob was hooked to the subjects clothes. The following protocol was used:

Speed(MPH)	INCLINE	Time(min.)
2.5	0%	5
2.5	3%	2
2.5	0%	2
2.5	5%	2
2.5	0%	2
2.5	10%	2

Pre-intervention measurement: pre intervention measurements for the VAS and KPS were taken at first day of intervention. Control group: the control group subjects during the period of study were made to perform maximal isometric quadriceps tensioning and straight-leg raising exercises at once a day. Both exercises were performed in the supine position, with the knee in full extension, to minimize patellofemoral compression forces. The minimum demand for each session and both types of exercise was 3 sets of 10 contractions for 10-15 seconds. Thereafter the patients were advised to perform the conventional static quadriceps-stretching exercises.

Statistical analysis

Data analysis was done using SPSS software (version 10.5).Student's t test was used for in between analysis and paired t test was used for within group analysis for both the groups.

Results

On comparing baseline characteristics between two groups, no statistically significant difference was found between the two groups indicating that there is homogeneity in the groups at the baseline. The paired t-value analyzed for Kujala patellofemoral scale scores difference in the experimental group between the baseline and post 4 weeks of intervention (mean difference =11.17,S.D.=10.69) values showed significant difference at 0.01 level($P<0.01$) indicating that there was marked improvements in function in the subjects with PFPS post retro treadmill intervention. the paired t-value analyzed for VAS (Worst) scores difference in the experimental group between the baseline and post 4 weeks of intervention (mean difference=3.43,S.D=1.07) values showed significant difference at 0.01 level ($p<0.01$) indicating that there was marked difference in the pain in subjects with PFPS post retro treadmill intervention. The level of significance was decided at $p<0.05$. the paired t-value analyzed for VAS (Worst) scores difference in the experimental group between the baseline and post 4 weeks of intervention (mean difference=1.97,S.D=0.64) values showed significant difference at 0.05 level ($p<0.05$) indicating that there was significant difference in the pain in subjects with PFPS with control conventional quadriceps exercises.

The paired t-value analyzed for Kujala patellofemoral scale scores difference in the control group between the baseline and post 4 weeks of intervention (mean difference =6.21,S.D.=4.21) values showed significant difference at 0.05 level($P<0.05$) indicating that there was marked improvements in function of the subjects with control group conventional quadriceps exercises.

Discussion

Knee extensor strength deficit is a common finding in patients with PFPS.[14,15] Quadriceps strengthening exercises have been used in the rehabilitation of PFPS, and "closed-chain" quadriceps strengthening or quadriceps strengthening in a weight-bearing position, has become an accepted method of treatment. Backward walking incorporates the closed chain concept of quadriceps exercise. Extended periods of backward locomotion are generally used by only for therapeutic or conditioning purposes.[16,17.] In recent years, Backward running has been popularized in the literatures a means to increase forward running performance, rest injured muscles.[18] Backward locomotion has gained popularity as a part of a program to rehabilitate certain knee injuries. Backward walking training or rehabilitation has been reported to decrease patellofemoraljoint compressive forces [19], to protect ACL from overstretching [20]and to decrease eccentric loading of the knee extensors.[21]

Researches has indicated that backward or retro walking can provide a number of benefits to patients suffering from patellofemoral pain, however no clinical trial till date has been undertaken to solidify or refute its place in rehab. When analysed within the group both the groups both the groups showed statistically significant improvement in function and pain scoring. The subjects in the experimental group showed highly statistically significant improvement in Kujala patellofemoral scale and VAS during worst pain when compared between baseline and week 4. Rationale behind such significant effect could be that the rate of patellofemoral joint compressive force loading has been shown to be significantly slower, occurring in later period of stance phase during backward gait. Articular gait has viscoelastic properties that make it rate sensitive to loading so that it is more susceptible to injury during rapid loading which prevents sufficient accommodation.[17, 22.] Backward walking incorporates isometric and concentric nature of quadriceps activity, and backward running has been shown to increase concentric strength of the extensor mechanism. In addition rehabilitation protocols isometric and concentric training in the treatment of PFPS. Also in a recent study participants completed four weeks of backward walking on a treadmill for 10-15 minutes/day, four days/week. The sit and reach scores revealed that retro locomotion may be a practical means to improve flexibility of hamstrings[22]. Since hamstrings tightness has been shown to be frequently associated with PFPS. Thus, improved flexibility might have also contributed to improvements in the subjects.

Within the group the analysis, the subject in control group also showed significant improvements in pain, function scoring. This could be attributed to the performance of the home exercise regime by the control group subjects. These results are consistent with previous studies where the standard quadriceps exercises have resulted in significant improvements[23].

Between group analysis, both experimental and control group subjects improved pain and functional scores. However, on comparing both the groups it was revealed that the experimental group consisting of retro walking gained greater improvements in the outcome measures on week 3 and week 4.

The key to this difference could be that retro walking incorporates a closed kinetic chain or weight bearing rehabilitation. Weight bearing rehabilitation is more functional than non weight bearing exercises because they require multi joint movement, facilitate a functional pattern of muscle recruitment and stimulate proprioception[24]. It is also known that exercise exerts its effects on the brain through several mechanisms, including neurogenesis, mood enhancement, and endorphin release. For persons with chronic pain, exercise may decrease fear/avoidance beliefs, leading to increase function and improved conditioning[25].

Table I. Comparison of KPS Within Experimental Group

VARIABLE	DIFFERENCE MEAN	S.D	T VALUE
KPS0/KPSW1	0.001	3.21	0.221[NS]
KPS0/KPSW2	1.30	6.06	0.519[NS]
KPS0/KPSW3	5.71	9.07	8.67*
KPS0/KPSW4	11.17	10.69	12.38**
KPSW1/KPSW2	2.12	6.067	1.25[NS]
KPSW1/KPSW3	6.21	9.08	9.68*
KPSW1/KPSW4	11.16	10.6	13.20**
KPSW2/KPSW3	3.21	6.66	9.33*
KPSW2/KPSW4	10.15	10.37	11.13**
KPSW3/KPSW4	5.27	7.90	6.73*

S.D: Standard Deviation

KPS: KUJALA PATELL OF EMORAL SCALE

*Significant at 0.05 level

**Significant at 0.01 level

Table II. Comparison of VAS Within Experimental Group

VARIABLE	DIFFERENCE MEAN	S.D	T VALUE
VAS0/VASW1	0.14	0.23	0.94[NS]
VAS0/VASW2	0.30	0.61	2.23*
VAS0/VASW3	1.63	0.92	10.26*
VAS0/VASW4	3.43	1.07	12.80**
VASW1/VASW2	0.16	0.72	7.11*
VASW1/VASW3	1.49	1.02	9.61**
VASW1/VASW4	3.29	1.14	12.15**
VASW2/VASW3	1.33	0.74	2.11*
VASW2/VASW4	3.13	1.12	12.01**
VASW3/VASW4	1.80	0.79	7.87*

S.D: Standard Deviation

VAS: Visual Analog Scale

*Significant at 0.05 level

**Significant at 0.01 level

Table III. Comparison of VAS Within Control Group

VARIABLE	DIFFERENCE MEAN	S.D	T VALUE
VAS0/VASW1	0.012	0.42	0.52NS
VAS0/VASW2	0.28	0.47	1.76NS
VAS0/VASW3	0.61	0.67	8.41NS
VAS0/VASW4	1.97	0.64	8.88*
VASW1/VASW2	0.23	0.43	1.41NS
VASW1/VASW3	0.66	0.62	1.21NS
VASW1/VASW4	1.04	0.74	9.46*
VASW2/VASW3	0.74	0.66	0.98NS
VASW2/VASW4	1.51	0.64	9.65*
VASW3/VASW4	0.78	0.72	3.02*

S.D: Standard Deviation

*Significant at 0.05 level

Table IV. Comparison of KPS Score Between Two Groups

Variables	EXPERIMENTAL GROUP(N=13)		CONTROL GROUP(N=13)		t VALUE
	MEAN	S.D.	MEAN	S.D	
KPS0	68.91	7.67	69.10	10.68	0.30NS
KPSW1	68.92	7.67	69.10	10.68	0.30NS
KPSW2	70.21	7.47	69.60	8.32	0.52NS
KPSW3	74.62	8.06	72.46	9.7	2.58*
KPSW4	80.08	6.45	75.31	9.9	5.09**

S.D: Standard Deviation

N=No. of patients

*Significant at 0.05 level

**Significant at 0.01 level

Table V. Comparison of VAS Score Between Two Groups

Variables	EXPERIMENTAL GROUP(N=13)		CONTROL GROUP(N=13)		t VALUE
	MEAN	S.D.	MEAN	S.D	
VAS0	5.15	0.86	5.26	0.83	0.25NS
VASW1	5.01	0.91	5.21	0.95	0.04NS
V ASW2	4.58	0.84	4.98	0.79	0.09NS
VASW3	3.52	0.91	4.25	0.71	5.08**
VASW4	1.72	0.80	3.47	0.61	6.23**

S.D: Standard Deviation

N=No. of patients

**Significant at 0.01 level

Conclusion

Statistically significant improvements in pain and function outcome measures in the patients with patellofemoral pain following intervention comprising of backward walking on treadmill indicate its effectiveness when incorporated as a therapeutic regime in these patients and is therefore recommended in the rehabilitation of PFPS patients.

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Original article

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Close kinematic strengthening of gluteus maximus is more effective than rectus femoris in improving dynamic and static balance in asymptomatic population

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Abstract

Question: Is there any significant difference in strengthening of gluteus maximus and rectus femoris on dynamic and static balance? **Design:** Experimental design comparative in nature. **Participants:** Thirty asymptomatic participants (mean age 21.39±1.99) of Sardar Bhagwan Singh Institute, Dehradun, India, with normal body mass index and right dominant lower extremity, were divided randomly in three groups of 10 participants in each. **Intervention:** Two week (5 sessions a week) close kinematic chain strengthening program of gluteus maximus (group c) and rectus femoris (group b) where gluteus medius (group a) is controlled. **Outcome measures:** Single limb stance time, star excursion balance test (sebt) in eight (Anterior, Anteriomedial, Medial, Posteriomedial, Posterior, Posteriolateral, Lateral, Anteriolateral) directions. whereas in sebt improvement for group c was greater (8.26±4.30, 7.13±4.48, 7.25±4.0, 10.62±5.31, 6.9±6.05, 8.38±3.11, 6.38±3.54) compare to group b (4.63±4.47, 6.63±3.81, 5.63±3.81, 4.5±1.85, 10.5±5.78, 7.5±5.4, 5.13±4.36, 4.5±3.02) and group a (2.25±3.57, 2±3.02, 2±3.30, 1.75±5.36, 2±5.04, 3.25±5.25, 2.62±5.85, 3.25±2.66) in all eight (Anterior, Anteriomedial, Medial, Posteriomedial, Posterior, Posteriolateral, Lateral, Anteriolateral) directions. **Conclusion:** This study provides idea that the strengthening program of rectus femoris and gluteus maximus has the effect on static as well as dynamic balance as the improvement of single limb balance and SEBT was documented in both the groups. Data analysis revealed that improvement was more in group in comparison to group B and group A (C>B>A) which stated that gluteus maximus strengthening has better effect on static (single limb stance) and dynamic (SEBT) balance in comparison to rectus femoris strengthening.

Introduction

Balance is a generic term to describe a dynamic process through which the body's position is maintained in equilibrium (Anne D. Kloos, 2004). balance has two basic component static balance and dynamic balance; functional task requires static balance to maintain a stable antigravity position while at rest such as during sitting, dynamic balance to stabilize the body when support surface is moving, thus Basic activities of daily living (like walking sitting etc.), require the background of a normal balance (Frances E Huxham, 2001).Maintenance of balance is complex task which involves various system of human body, these includes nervous system, contextual system, somatosensory system, visual, auditory, vestibular and musculoskeletal system, Interplay among these systems is required to maintain balance (Anne D. Kloos, 2004).

Musculoskeletal system is an important factor in the balance control as balance control requires a complex and significant change in muscle length and muscle tone (Anne D. Kloos, 2004), normal balance requires control of acceleration forces to maintain equilibrium, which is done by musculoskeletal system (Frances E Huxham, 2001).balance control requires an adaptability to counter act any changes in body's equilibrium (Frances E Huxham, 2001).muscular contribution is an important factor for the maintenance of balance during stance phase(static balance)

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and swing phase (dynamic balance) (Woollacott Mh, Tang P-I, 1997).

Musculature surrounding hip and knee joints plays an important role in maintaining balance as they work to counter act the external force acting up on the body, specifically Hip and knee extensors (gluteus maximus and rectus femoris) are the major group which works to control balance (Allison S. Arnolda, 2005), these two are the major muscles group, responsible for hip strategy of maintaining balance (L. M. Nashner, 1986),which plays an important role in maintaining balance when supporting surface is short in relation to foot length[6],during single limb stance anterior and posterior body sway are the main reason of misbalance, by counteracting the anterior and posterior body sway hip strategy helps in maintaining balance in Saggital plane around hip and knee joint (Anne D. Kloos, 2004).during posterior body sway gluteus maximus activation takes place to maintain balance, whereas during anterior body sway rectus femoris activation maintains the balance (L. M. Nashner, 1986).

Research Question

Is the gluteus maximus strengthening has better effect then the rectus femoris strengthening, on the improvement of static and dynamic balance on asymptomatic population controlled with gluteus medius strengthening?

Method

Design

Experimental design- comparative in nature.

Participants, Therapists, Centers

Inclusion Criteria

1). Students of SBSPGI of age 18-25 yrs.

2). Normal body mass index (18.5-24.9) (P.Halun, 2006).

3). Normal range of motion around hip and knee joint.

4). Muscle strength >3 around hip and knee joint.

5). Normal pattern of gait (Sandra J Olney, 2006).

Exclusion Criteria

1). History of any kind of systemic disease for which subject is on medication or any kind of other therapy. 2). Past or present history of hip, knee, ankle joint dysfunction. 3). History or complaint of any kind of back pain with duration more than six weeks (Suraj Kumar, 2010). 4). History of spinal injury or disorder. 5). Any kind of foot deformity (pes cavus or pes planus) (Jay Hertel, 2002). 6). Known history of hypertension, or hypotension.

Intervention

Hip Hiking (Group A)

Position of the subject was with one leg (testing extremity) on a 2-4 inch block or step raise, another leg hanging out of the block. Body was straight and both the hand on pelvis or on the shoulder of the therapist for support (initially) (Carylon Kisner, 2006). Subject asked to alternatively lower and elevate the pelvis on the side of unsupported leg. (Fig 5)

Single Leg Partial Squatting (Group B)

Subject standing on one leg (targeting extremity), both hand across the chest or on the chair for support (initially).Subject asked to flex his knee 30-40 degree then extend alternatively. (Fig 6)

Unilateral Bridging (Group C)

Subjects were positioned in hook lying position with one lower extremity (hip flexed abducted, externally rotated and knee flexed to form figure of four position) rested on the other knee (targeted extremity). Subjects were asked to press the upper back and foot in to the mat, elevate the pelvis, and extend the hips. (Fig 7)

Outcome Measures

Star Excursion Balance Test

The SEBTs are functional tests that incorporate a single-leg stance on one leg with maximum reach of the opposite leg. The SEBTs are performed with the subject standing at the center of a grid placed on the floor, with 8 lines extending at 45° increments from the center of the grid (Allison S. Arnolda, 2005). The 8 lines positioned on the grid are labeled according to the direction of excursion relative to the stance leg: anterolateral (AL), anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL), and lateral (L) (Rasool, K. George, 2009). The grid was constructed in an athletic training facility using a protractor and 3-in (7.62-cm)-wide adhesive tape and was enclosed in a 182.9-cm by 182.9-cm square on the hard tile floor.

A verbal and visual demonstration of the testing procedure was given to each subject by the examiner (L.C.O.). Each subject performed 6 practice trials in each of the 8 directions for each leg to become familiar with the task (Rasool, K. George, 2009) after the practice trials, subjects rode a stationary bike for 5 minutes at a self-selected pace and then stretched the quadriceps, hamstrings, and triceps surae muscle groups before testing. To perform the SEBTs, the subject maintained a single-leg stance while reaching with the contralateral leg (reach leg) as far as possible along the appropriate vector. The subject lightly touched the furthest point possible on the line with the most distal part of the reach foot. The subject was instructed to touch the furthest point on the line with the reach foot as lightly as possible in order to ensure that stability was achieved through adequate neuromuscular control of the stance leg (Allison S. Arnolda, 2005). The subject then returned to a bilateral stance while maintaining equilibrium. The examiner manually measured the distance from the center of the grid to the touch point with a tape measure in centimeters. Measurements were taken after each reach by the same examiner.

Three reaches in each direction were recorded. Subjects were given 15 seconds of rest between reaches. The average of the 3 reaches for each leg in each of the 8 directions was calculated. Reach leg (right, left), order of excursions performed (clockwise, counterclockwise), and direction of the first excursion (A, M, L, P) were counterbalanced to control for any learning or order effect (Allison S. Arnolda, 2005), All trials were then performed in sequential order in either the counterclockwise or clockwise directions.

Trials were discarded and repeated if the subject (1) did not touch the line with the reach foot while maintaining weight bearing on the stance leg, (2) lifted the stance foot from the center grid, (3) lost balance at any point in the trial, or (4) did not maintain start and return positions for one full second. If a subject was judged by the examiner to have touched down with the reach foot in a manner that caused the reach leg to considerably support the body, the trial was discarded and repeated. In other words, if the reach foot was used to widen the base of support, the trial was not recorded. The base of support was the stance foot for the entire trial with the fraction of a second in which the reach foot very lightly touched the ground. It was atypical for subjects to have discarded trials, and none reported fatigue during or after the testing session.

Single Leg Stance

Single limb stance is a tool to assess the balance variables (static balance) (Eva Ageberg, 2003).single limb stance time is one of the four tasks to assess the balance and gait (Richerd W Bohanon, 1993). Single limb stance denotes the stance phase of gait as well as static balance (Frances E Huxham, 2001). Criteria to assess single limb stance; instruction for the subject according to the criteria were, “Stand on one leg, place your arms across your chest with your hands touching your shoulders and do not let your legs touch each other. Look straight ahead with your eyes open and focus on an object about 3 feet in front of you". Instructions to stop the criteria were, if the legs touched each other, the feet moved on the floor, their foot touches down, or the arms moved from their start position. Subjects were barefooted and eyes were opened (O'loughllin J, 1993). procedure was performed for 3 times and mean were noted down.

Data analysis

One way annova (analysis of variance) test has been performed to compare the improvement of single limb stance time and SEBT in 8 directions in all the 3 groups.

Post hoc scheffe's test has been performed to find out which group has the more effect in improvement of single limb stance and SEBT.

The significance (probability) level has been selected as 0.05.

Results

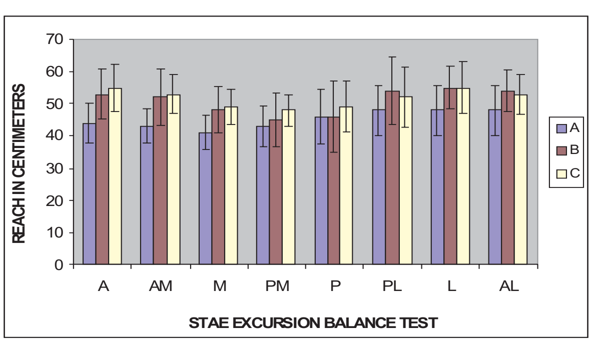
In this study, 30 subjects (mean age 21.36 ± 1.29) were selected and were divided into three groups A (Mean age 21±1.63), B (Mean age 21.4±0.8) and C (Mean age 21.7±1.33) with 10 subjects in each group.

Mean values of all 8 directions A, AM, M, P, PM, P, PL, L, AL, (Graph:1) and single limb stance at week 0 (Graph:3) were, 44.6±6.20, 43.6±5.35, 41±4.69, 43.1±6.26, 46.3±8.6, 48.1±7.75, 48.3±6.7, 48±5.8 and 34.47±17.85 respectively for group A, 56.3±7.70, 52.1±8.9, 48.2±7.09, 45.3±8.27, 46±10.91, 54.6±10.52, 55.7±6.76, 54.6±6.38, and 34.27±13.85 respectively for group B, 55.9±7.21, 53.1±5..87, 49.8.±75.4, 48.2±5.01, 49.5±7.98, 52.5±9.57, 55.4±8.07, 53.4±6.18 and 54.17±12.91 respectively for group C (Table:1). One way anova were applied to compare the difference, It shown the significant difference in single limb stance and anterior, anterio-medial, medial, components of SEBT.

As the result was significant for baseline, data were and analyzed with mean difference of week 2and week0 (table:2), (graph:2), (Graph 4). The mean values were, 2.25±3.57, 2±3.02, 2±3.30, 1.75±5.36, 2±5.04, 3.25±5.25, 2.62±5.85, 3.25±2.66 and 2.82±11.34 respectively for group A, 4.63±4.47, 6.63±3.81, 5.63±3.81, 4.5±1.85, 10.5±5.78, 7.5±5.4, 5.13±4.36, 4.5±3.02 and 7.37±8.02 respectively for group B, 8.26±4.30, 7.13±4.48, 7.25±4.0, 10.62±5.31, 6.9±6.05, 8.38±3.11, 6.38±3.54 and 14.72±7.32 respectively for group C. One way anova were applied to compare the mean difference value. Result was statically significant for single limb stance and A, AM, M, PM, P and L component of star excursion balance test.

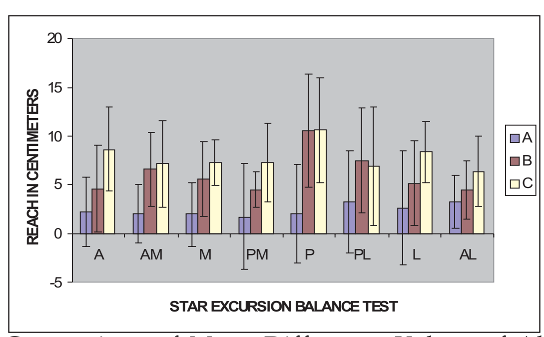
Post hoc scheffe's test was performed on the significant values of one way annova on single limb stance time and SEBT (Table 3). It shows the significant value for A-C group in single limb stance, anterior, anterio-medial, medial, posterior-medial, posterior, lateral component of SEBT. It also shows the significant value for A-B group in posterior component of SEBT.

Graph 1



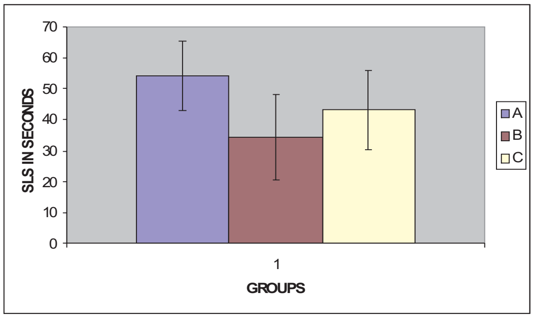
Star Excursion Balance Test (Mean ±S.D) at week 0

Graph 2



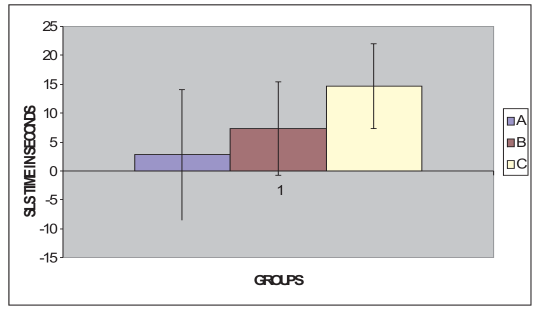
Comparison of Mean Difference Values of All 8 Directions of SEBT (Week2-0)

Graph 3



Single Limb Stance (Mean ±S.D) At Week 0

Graph 4



Comparison of Mean Difference Values of Single Limb Stance Time (Week2-0)

Table 1. Comparison of Mean Values of All 8 Directions of SEBT and Single Limb Stance Time- One Way Annova (Week 0)

GROUPS	A	AM	M	PM	P	PL	L	AL	SLST
GROUP A	44.6	43.6	41.0	43.1	46.3	48.1	48.3	48.0	34.17
	±6.20	±5.35	±5.35	±6.26	±8.6	±7.75	±7.75	±7.75	±11.34
GROUP B	53.3	52.1	48.2	45.3	46.0	54.6	55.7	54.6	34.27
	±7.70	±8.9	±7.09	±8.27	±10.91	±10.52	±6.76	±6.38	±13.85
GROUP C	55.9	53.1	49.8	48.2	49.5	52.5	55.4	53.4	54.17
	±7.21	±5.87	±5.47	±5.01	±7.98	±9.57	±8.07	±6.18	±12.91
F VALUE	8.6	5.7	6.40	1.47	0.4	1.25	3.35	3.26	5.8
SIGNIFICANCE	S	S	S	NS	NS	NS	NS	NS	S

Table 2. Comparison of Mean Difference Values of All 8 Directions of SEBT and Single Limb Stance Time- One Way Annova (Week 2-Week 0)

GROUPS	A	AM	M	PM	P	PL	L	AL	SLST
GROUP A	2.25	2	2	1.75	2	3.25	2.62	3.25	2.82
	±3.57	±3.02	±3.30	±5.36	±5.04	±5.25	±5.85	±2.66	±11.34
GROUP B	4.63	6.63	5.63	4.5	10.5	7.5	5.13	4.5	7.37
	±4.47	±3.81	±3.81	±1.85	±5.78	±5.4	±4.36	±3.02	±8.02
GROUP C	8.62	7.13	7.25	7.25	10.62	6.9	8.38	6.38	14.72
	±4.30	±4.48	±2.43	±4.00	±5.31	±6.05	±3.11	±3.54	±7.32
F VALUE	4.9	4.6	5.5	3.8	6.5	0.3	5.7	2.06	3.5
SIGNIFICANCE	S	S	S	S	S	NS	S	NS	S

Table 3. Post Hoc Scheffe's Test on the Significant Values of One Way Annova on SEBT and Single limb stance time (Week 2-Week 0)

GROUPS	VALUES	A	AM	M	PM	P	L	SLST
A VS B	P	1.32	6.26	5.29	1.99	27.79	2.17	1.004
	SIGNIFICANCE	NS	NS	NS	NS	S	NS	NS
B VS C	P	3.76	0.07	1.00	1.90	0.01	3.56	2.63
	SIGNIFICANCE	NS	NS	NS	NS	NS	NS	NS
A VS C	P	9.48	7.54	10.56	7.6	28.98	11.04	6.9
	SIGNIFICANCE	S	S	S	S	S	S	S

S: Significant ($p>0.05$)
NS: Non significant ($p<0.05$)
The significance (probability) level has been selected as 0.05.

Discussion

Data analysis revealed that the improvement of balance is greater in the group which undergone the strengthening of gluteus maximus (c) than the other group. As discussed earlier that hip strategy is an important factor in maintaining balance because it counteracts the anterior and posterior body sway (Vleeming A, 1989), impairment in hip strategy can lead to an impaired balance. Gluteus maximus strengthening was more effective because, Hip extensors are the major muscles which counteract the posterior body sway thus help in maintaining balance. Among the hip extensors gluteus maximus is the most efficient muscle due its muscle properties (large cross sectional area, angle of penetration, moment arm) (Sandra J. Shultz, 2001). Gluteus maximus is the largest muscle of the human body and it has a important role in walking.[39] During normal walking gluteus maximus has a role of providing stabilization to the sacro iliac joint and it also has an important role in the rehabilitation which is been proved in previous literatures by Judy Wilson et al, 2005. G. Nemeth et al, 2009 sated that in the anatomical position of hip joint the moment arm of gluteus maximus to the bilateral motion axis was 79 mm, which was greater than any other muscle surround hip joint (F Fryssebech, 2009), thus it has greater influence in maintaining hip joint position in neutral. Gluteus maximus is a part of core musculature, weakness of which can lead to impaired hip strategy adding to this Nicola W Mok et al, 2004, stated that efficacy of hip strategy reduced in people with low back ache and also added that the main reason behind low back ache is the weekness of core musculature (Papadopoulus S Emmanual, 1987), which indicates a greater influence of gluteus maximus on hip strategy in comparison to rectus femoris. It has greater role in controlling single limb stance (static balance) in compare to rectus femoris which is supported by Allison.s.Arnolda et al, 2004 who stated that during single limb stance, per unit force, gluteus maximus has the more potential than the quadriceps muscle group). During the process of rehabilitation following an injury, recovery of gluteus maximus is faster than other muscle to control hip extension which is also been supported previous literature by Gerogery. J. Leheman et al, 2006.

Major function of gluteus maximus as during running, is to control flexion of the trunk on the stance-side and to decelerate the swing leg; contractions of the stance-side gluteus maximus may also help to control flexion of the hip and to extend the thigh (Daniel. E. Lieberman et al, 2006). Along being an extensor gluteus maximus is also a weak abductor of hip thus it also helps to maintain frontal plane balance of hip joint, (Signe Brunnstrom 1983), but rectus femoris has contribution only in Saggital plane maintenance of balance thus gluteus maximus has more influence on balance. Gluteus maximus also works as a dynamic stabilizer as it is thought to cause tightening of hip joint ligaments thereby reducing mobility, suggested by Vleeming et al, 1989.

Contraction of hip extensors significantly reduces the sacral mobility and thus produces the stability to the trunk and as well as the hip joint (J.G. Wilson, Judy Wilson, Emma Ferris, 2005). Gluteus maximus contributes most significantly to support the lower limb via the vertical ground reaction force during the early stance phase from foot flat to just after contralateral toe off that how it contributes an effective functioning to the normal cycle of gait pattern (Anderson et al, 2003).

Future research

1). A larger sample size can be taken for the study.

2). Study can be carried out on symptomatic population (stroke rehabilitation, post immobilization etc.

3). Study can be carried out on specific population like athletes.

4). Specific work group can be taken for the study eg. Desk job population, as they are prone to develop low back ache and are prone to impairment in hip strategy.

5). Old age group can be taken for the study as balance is an important factor of injurious falls in older people.

6). More objective method can be use to assess the static balance.

7). Study can be carried out with larger duration of 6-8 week as hypertrophic changes can be seen after 6 weeks of strengthening.

Relevance to clinical practice

Balance is an important factor of injurious falls. As health professionals; physiotherapists have a specific interest in recognizing and treating balance problems. People with balance difficulties constitute a large proportion of all neurological and musculoskeletal workloads. To be effective, physiotherapists therefore need ways to assess patients, measure the outcome of treatment and predict which people, particularly amongst the older population, are at risk of falling. However, selecting an appropriate regimen for the improvement of balance among individuals with musculoskeletal deficit is difficult, as there are many regimens available to treat the impaired balance. In this study it has been proved that the gluteus maximus strengthening regimen has the greater effect on improving static and dynamic balance than the rectus femoris strengthening regimen, and the reason is the physiological properties of the gluteus maximus. Through this regimen emphasis on both static balance as well as on dynamic balance can be given and it can be applied as a treatment protocol among the patient with impaired balance due to musculoskeletal reasons, as well as on the asymptomatic population.

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Original article

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Comparison of Haemodynamic Responses of Different Balance Training Exercises in Hypertensive Elderly Adults

Saurabh Sharma*, Majumi Mohamad Noohu, Deepti Parashar*****

Abstract

Objective: This study was carried out to find the difference in haemodynamic responses of different balance training exercise in hypertensive elderly adults. **Methods:** Elderly adults between the age of 60-80 years (n=80) with controlled hypertension allocated into two groups. Group 1 underwent specific balance training and group 2 general balance training exercises for a single session. They were measured for systolic blood pressure, diastolic blood pressure, heart rate and rate pressure product before the exercise, immediately after the exercise and 5 minutes after the exercise. The hemodynamic responses were compared between the groups for difference. **Results:** The study showed a significant difference in all haemodynamic parameters such as blood pressure, heart rate and rate pressure product immediately except diastolic blood pressure and after 5 minutes of exercise between the groups. **Conclusion:** The general balance exercise is safe in terms of hemodynamic changes in elderly hypertensives.

Keywords: hypertension, elderly adults, balance exercises.

Introduction

Hypertension is a common problem in community. Study update shows that prevalence of hypertension is about 70% in elderly.[1] Some reports from India indicate that the prevalence ranges from 60 to 70%.[2] Hypertension is defined as systolic blood pressure greater than 140 mm Hg or a diastolic blood pressure greater than 90 mm Hg. Hypertension results due to loss of arterial wall elasticity major vessels including aorta become stiff and less distensible and there is loss of beta adrenergic receptors also. Both these factors raise peripheral vascular resistance and aortic impedance to overcome this there is a need of a powerful systolic ejection of left ventricle. Which result in rise in systolic blood pressure (SBP) and increase in left ventricle (LV) mass with compromised cardiac output and renal blood flow.[1]

High blood pressure may cause impaired exercise intolerance in elderly, so it is important to evaluate the haemodynamic response before any exercise training.[3] The anticipation of exercise increases the heart rate through activation of the sympathetic nervous system. As exercise begins, the heart rate increases rapidly because of a reduction of vagal tone, followed later by a further increase in sympathetic tone and circulating catecholamine levels. Stroke volume (about 70 mL at rest), increases early and then levels off at approximately one third of the maximal oxygen uptake, or half of the maximal cardiac output. This is due to an increased venous return, an increased end-diastolic volume, and the sympathetic nervous system stimulation of myocardial contractility and active myocardial relaxation.[4] As exercise progresses in normal persons, the systolic pressure increases by 50 mm Hg to 70 mm Hg, whereas the diastolic blood pressure remains unchanged or decreases by 4 mm Hg to 8 mm Hg as a result of vasodilatation and decreasing total peripheral resistance. Resting cardiac output

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(5 to 6 L/min) increases to as high as 20 to 25 L/min during peak exercise, an increase proportional to the workload and exercise demand. The rate-pressure product (RPP) or double product is highly related to oxygen consumption and coronary blood flow in healthy subjects over a wide range of exercise intensities, and therefore is an index of relative cardiac work. The rate-pressure product makes use of product of peak systolic blood pressure (SBP), as measured artery, and heart rate (HR). It is computed as RPP = SBP x HR / 100.The product of SBP and HR is divided by 100 in order to reduce the value to a smaller number and to closely agree with the oxygen consumption (mL/min) of the heart. The RPP is not meant to reflect differences in stoke volume between individuals, but is an accurate reflection of the myocardial oxygen demand and the myocardial workload.[4]

Increasing age is associated with a reduction in the increase in heart rate , cardiac output and stroke volume either remains the same or declines, blood pressure during exercise increases more steeply and the maximal heart rate decreases. Filipovsky and colleagues studied blood pressure reactivity in hypertensive and normotensive persons and found that peak systolic blood pressures are often greater than 200 mm Hg because of higher baseline blood pressures in hypertensives.[4] Montain et al reported that that older hypertensive persons have an altered cardiovascular response to exercise as compare with age matched normotensive subjects.[5]

Researchers have shown that elderly having history of hypertension were significantly associated with falls.[1] Several fall prevention strategies have shown effectiveness in preventing fall or injuries &decreases risk of falling. Previous studies shown that exercise such as strength, flexibility, balance training and combination of these activities have increased strength, improve balance and improved functional ability in addition to reducing risk of falls. Thus balance-training interventions have an important place in fall prevention. Geriatric balance training included conventional coordination exercises, aerobic training, muscle strengthening exercise regime, and specific strategy exercise protocol.[6] There is lack of studies which investigated the haemodynamic response of these exercises in geriatric population. This study will provide the information regarding physiological response of different exercise used for balnce retraining in gelderly adults.

Methods

A pre-post experimental repeated measure design was used in this study and the study was approved by research and ethical committee of department of therapies and health sciences, Faridabad Institute of Technology, Manav Rachna Educational Instituites, Faridabad. 80 elderly subjects were recruited from Faridabad and Delhi and they were randomly allocated into group A or group B. Subjects with following characteristics such as elderly adults between the age of 60-80 years living in the community, subjects with history of hypertension controlled by medication, not using any walking aid were included and subjects with following problems such as unstable cardiac problem, not able to understand the verbal information provided, hearing difficulty, permanent history of dizziness, acute pain and severe breathing difficulty were excluded. Materials used in the study were digital heart rate measuring device(A&DMOD UA-774) approved by British hypertensive society, stop watch ,wooden blocks of various heights chair of different heights with and without arm rest ,balls of various size,weights ,foam, shelves of various heights, mirror and Weights. The following procedure was followed in the study initially demographic data of the subject was collected then subjects were assessed on cardiac parameters such as systolic blood pressure ,diastolic blood pressure, heart rate and rate pressure product. Group A subjects received specific balance strategy training which consisted of endurance training, strengthening, co-ordination exercise, balance strategy practice, sensory integration and added attentional demand during function and multitask practice. Various simple tasks were selected as sit to stand. This tasks were done using different chair heights with/ without upper limb assistance balancing cup with/without water on a saucer or while adding cognitive task to manual task. Each task was graded to cater to various level of ability and the level of difficulty progressed to increase the challenge.The exercises for group consisted of 8 components and 5 minute rest was provide after 4 components, while group B subjects received general balance and mobility exercise which consisted of active stretching and strengthening of the lower limb muscles, control exercises, endurance walking and repetitive muscle co-ordination exercise. Both programme initially started with a low level of frequency. It started from 5 – 10 repetition. The rest interval of 5 minute was provided between sets. The balance exercises lasted for 45 for both groups. Immediately after exercise the post evaluation had done for systolic blood pressure, diastolic blood pressure, heart rate and rate pressure product for both groups After completion of 5 minutes again the haemodynamic parameter were were measured. In this study the blood pressure and heart rate is measured with the help of automated device.

Data Analysis

Data analysis was performed using SPSS software. A student's unpaired t' test was used to analyze the difference between group 1 and 2 for systolic pressure, diastolic pressure, heart rate and rate pressure product. The haemodynamic parameters were compared before the exercise, immediately after the exercise and 5 minutes after the exercise. A significance level of p£ 0.05 was fixed.

Results

The data analysis revealed the following results. The group A consisted of 21 male and 19 female with a mean age of 68.50 ± 4.48 years. The group B consisted of 19 males and 21 female with a mean age of 66.85 ± 3.02.There was no significant difference between the groups on hemodynamic parameters such as systolic pressure, diastolic pressure, heart rate and rate pressure product before (Table 1, Figure 1) the exercise while there was significant difference between groups on systolic pressure (Table 1, Figure 1) heart rate(Table 1, Figure 2), rate pressure product (Table 1, Figure 3) and no significant difference between diastolic blood pressure immediately (Table 1, Figure 1) after the exercise and there was significant difference in systolic pressure, diastolic pressure, (Table 1, Figure 1) heart rate (Table 1, Figure 2) and rate pressure product (Table 1, Figure 3).

Table 1. Comparison of haemodynamic parameters between group 1&2 before exercise, immediately after exercise and 5 minutes after exercise

Variable			Group A	Group B	t value	p value
Blood pressure	Systolic	Before exercise	142.63±3.310	141.75±3.57	1.14	0.260 N.S
		Immediately after exercise	162.32±5.98	147.55±2.50	14.42	0.001*
		After 5 minutes of exercises	153.25±5.42	143.27±2.38	11.17	0.001*
	Diastolic	Before exercise	83.77±5.34	83.90±4.31	.13	0.900 N.S
		Immediately after exercise	89.56±5.71	88.80±4.32	.93	0.357 N.S
		After 5 minutes of exercises	87±5.34	84.77±4.20	2.26	0.027*
Heart rate		Before exercise	83.10±6.14	83.35±6.39	1.78	.588 N.S
		Immediately after exercise	104.87±7.91	91±5.95	8.59	.001*
		After 5 minutes of exercises	99.02±6.98	86.550±6.25	8.40	.001*
Rate pressure product		Before exercise	117.93±8.73	118.16±10.07	11.7	0.494 N.S
		Immediately after exercise	169.19±15.35	134.97±9.12	12.12	0.001*
		After 5 minutes of exercises	155.81±13.03	124.15±9.26	12.52	0.001*

*Significant, NS-Not Significant

Figure 1. Comparison of blood pressure changes between the groups

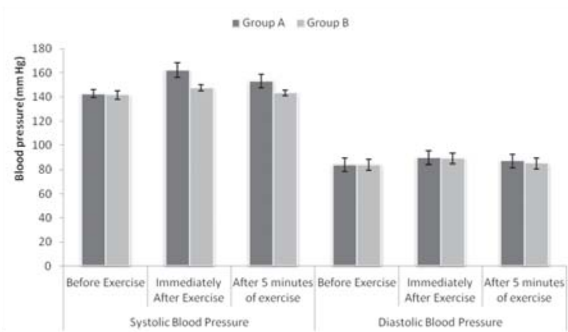


Figure 2. Comparison of heart rate changes between the groups

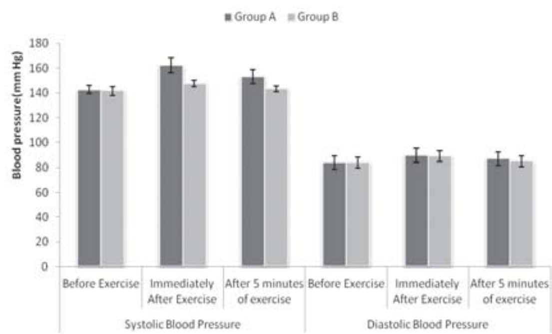
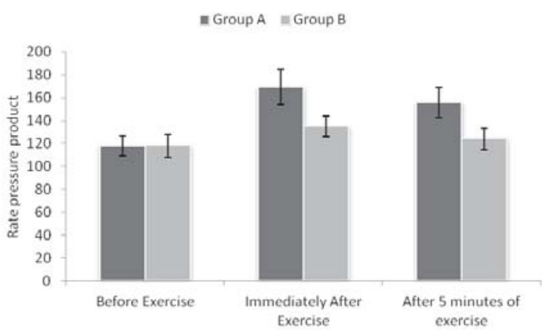


Figure 3. Comparison of rate pressure product changes between the groups



Discussion

The result obtained showed that there is significant difference between the values of systolic blood pressure, heart rate, diastolic blood pressure and rate pressure product between two groups immediately after the exercise. In this study the systolic blood pressure rise more steeply immediately after specific strategy balance training exercise as compare to general balance and mobility exercises. The reason for steep rise of systolic blood pressure more in group 1 could be due to more intensity of exercises provided to subjects which lead to increased sympathetic activity. The results showed that there was significant difference between immediate and recovery systolic blood pressure which was taken after 5 minute of exercise in specific strategy balance training and general mobility and balance exercises. The reason might be due to less reduction in sympathetic activity in specific strategy balance training as compare to general mobility and balance exercises.Forjaz et al found a significant decrease in muscle sympathetic nerve activity after acute exercise in hypertensive and normantensives humans.[7]

The results also showed that the blood pressure did not recover to their resting level in subjects performing specific strategy balance training however in general mobility and balance exercises the blood pressure had reached closer to their resting level. The reason of delayed recovery in specific strategy balance training may be due to autonomic dysfunction and vasoreactivity abnormalities. Also there could be chances of decreases in NO synthase activity which is responsible for decreases in exercise blood pressure by increasing the capacity of endothelial cells to evoke vasodilatation. In the present study there is no significant difference in mean value of diastolic blood pressure immediately after exercise between groups. These results are in confirmation of study done by Faranz, however some researcher have observed significant rise in diastolic blood pressure.[8] The results also confirmed that there is delayed recovery of diastolic blood pressure in performing specific balance strategy training protocol as compare to those subjects performing general balance and mobility exercises .The reason may be due to autonomic dysfunction and vasoreactivity abnormalities, due to hypertension thus there may be delayed vasodilatation.

In this study the mean of heart rate rise more steeply immediately after specific strategy balance training exercise as compare to general balance and mobility exercises. The reason for steep rise of heart rate could be due to more intensity of exercises. The heart rate response to dynamic exercise follows a well-defined pattern, which is primarily modulated by the autonomic nervous system. During the first few seconds of exercise, there is a rapid heart rate increase, known as the initial transient that is exclusively mediated by vagal inhibition, regardless of exercise intensity. As the exercise continues, there is increasing sympathetic activity, proportional to the intensity of the exercise, which progressively accelerates the heart rate. Immediately after exercise, a final transient period represented by a decreasing heart rate response is observed. This is a result of vagal reactivation and a reduction in the sympathetic stimulation, with the latter contributing more effectively to the slow or late deceleration phase of post exercise heart rate. In this study we found that the protocol having general balance and mobility exercise show normal level of heart rate immediately after exercise and better heart rate recovery as compare to specific balance training protocol .The reason may be related to sympathetic activity which is proportional to intensity of exercise which influences the vagal tone.

The results showed that there was elevated mean level of rate pressure product in performing the specific strategy training protocol as compare to general balance and mobility exercises, there were also delayed recovery of rate pressure product performing the specific strategy training protocol. The present study demonstrated that general mobility and balance exercise group, besides producing lower increases in rate pressure product during exercise, the level also reaches closer to resting level, hence it reduces the myocardial oxygen consumption and consequently the cardiovascular risks after exercise .In contrast the specific balance strategy training group produces greater increases in rate pressure product during exercise. The rate pressure product does not recover near to baseline during recovery period. Forjaz suggested that moderate and high intensity exercise bouts produced greater increases in rate pressure product during exercise and fail to reduce below base line during the recovery period.[7] This study was done for a single session. Future research can be done involving a longer duration comparing two-intervention programme.

Conclusion

These findings of the study suggest that the general balance and mobility exercise is safer in terms of their physiological response in community dwelling older adults as compared to specific balance training exercises.

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Original article

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Effects of Electromyographic Biofeedback Training of Triceps Surae Muscle on Functional Performance in Chronic Quadriplegics

Deepti Sharma*, Majumi Mohamad Noohu**

Abstract

Objective: This study was carried out to find the changes in functional status of chronic spinal cord injured patients with treatment of electromyography biofeedback. **Methods:** A sample of 30 subjects randomly allocated into group A and B participated in the study .Group A received electromyographic biofeedback training along with conventional exercise and Group B received conventional exercises only. The subjects were assessed for electromyographic amplitude, quadriplegic index of function and spinal cord independence measure scores. They were assessed before the treatment and after treatment. The total duration of the study was 3 weeks with 5 session of treatment in a week. Results: The study showed significant changes in all variables studied during a intra group analysis as well as intergroup analysis. There was a significant change in EMG amplitude scores of both upper extremities, quadriplegic index of function and spinal cord independence measure scores in both group A and group B after the treatment. There was significant difference in electromyographic amplitude values, quadriplegic index of function and spinal cord independence measure scores after the treatment between the groups. **Conclusion:** The electromyographic biofeedback can be used along with conventional exercises to improve the function in chronic spinal cord injury patients.

Keywords: Quadriplegia; Electromyography biofeedback; Functional performance.

Introduction

Spinal cord injury is one of the most challenging medical conditions for entire rehabilitation team. Transection of the spinal cord will result in loss of motor power, deep and superficial sensation, vasomotor motor , bladder and bowel control, sexual function , finally patient and care givers develop a sense of hopelessness. A spinal cord lesion at the cervical level often results in quadriplegia individuals at the critical functional levels of C_6 and C_7 quadriplegia are on the borderline of achieving total independence in self-care tasks.[1] M.Mizakaumi et al in a study done on 109 quadriplegics found that when triceps brachii muscle begins to function and the deltoid muscle also contributes then effective balance control during push up develops. Thus, transfer in the push up posture becomes much easier.[2]Welch and colleagues surveyed 29 quadriplegic patients 3 months to 4 years post discharge and found that the presence of functional triceps was a significant determinant for functional independence in self-care task. Those subjects having triceps as the lowest functional muscle displayed a significantly greater amount of independence in self care areas than subjects with wrist extensors as the lowest functioning muscle group, both at discharge and follow up.[3]

Biofeedback may be defined as technique of using equipment (usually electronic) to reveal to the human beings some of their internal physiological events, normal and abnormal, in the form of visual and auditory signals in order to teach them to manipulate these otherwise involuntary or unfelt events by manipulating the displayed signals. The application of feedback is often considered as

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an operant conditioning technique. Mechanism of biofeedback is the process of enhancing awareness and self-regulation.[4] Historically, it was realized that organisms learned by using feedback and that it is possible to control physiology by using the feedback loop. The most commonly used biofeedback modality is surface elecrtomyography (EMG, measured in micro-volts). EMG instruments pick up and detect those electrical impulses and are displayed them on the monitor of EMG biofeedback instrument and in the form of auditory signals so the subjects can modify these signals to get the desired result.[5] Reports on EMG feedback training to spinal cord injury patients are few and they provide scanty information regarding techniques and outcome. Several studies document the effect of EMG biofeedback in stroke patients and other neurological conditions. Procedures incorporating EMG feedback have been reported effective in treating neuromuscular dysfunction, both in obtaining voluntary relaxation of unwanted activity and in improving strength, range of motion and control of paretic muscles. It was found that electromyographic biofeedback with physical therapy is effective in training motor activity in patients with hemiplegia but in some cases it was counterproductive.[6] Brucker treated a C_{5-6} spinal cord injury, in his late 20's suffering for past 11 years with EMG biofeedback to increase triceps function to almost normal, wrist flexors to 70% of normal function and finger extensors and flexors enabling the man to write, type and feed himself.[7] Sarah A. Morrison in a case report discussed the effectiveness of EMG biofeedback in re-educating and strengthening the accessory breathing muscles in an individual with high- level (C1) complete quadriplegia. The study results indicated EMG biofeedback is a helpful modality in training accessory breathing muscles to enable an individual with high-level quadriplegia to become independent of mechanical ventilation for varying amounts of time.[8] Klose et al tested the efficacy of biofeedback when administered in conjunction with physical therapy to chronic C_{5-7} quadriplegics. The result showed an increase in function of triceps brachii, biceps brachii, wrist extensors and wrist flexors.[9] Evaluation of disability is important in documenting improvement in clinical and research settings and measurement of functional outcome is an integral part of any goal-oriented, multidisciplinary rehabilitation program .[1,10] So it becomes imperative to study the outcome of treatment procedures in terms of function and there are scales developed to assess the effect of treatment .Short form of quadriplegic index of function (QIF) provides a more specific and sensitive instrument to document the functional improvements achieved during the rehabilitation of tetraplegics patient. The index is composed of 7 variables: transfers, grooming, bathing, feeding, dressing, wheelchair mobility and bed activities. The items are scored on a five point scale (0-4) in order of increasing independence. They were scored on a 5- point scale and total score of QIF ranges from 0-132.[11] Spinal cord independence measure (SCIM) was developed by Catz et al in 1997. This disability scale was developed specifically for spinal cord injured persons in order to make the functional assessments of persons with paraplegia or tetraplegia more sensitive . The SCIM covers three areas of function: self- care (0-20), respiration and sphincter management (0-40) and mobility(0-40). 16 items are scored on ordinal scale varying from three to nine classes. The final score ranges between 0 to100.[12]

Application of EMG biofeedback to the spinal cord injury has resulted in mixed results with some studies documenting the use of EMG biofeedback in spinal cord injury while other contradicting the use of spinal cord injury and there is a paucity of data exists on the impact of EMG biofeedback in functional performance in spinal cord injury. So this study was under taken to characterize the effect of EMG biofeedback in quadriplegic index of function scale scores and spinal cord independence measure scores and to see changes in EMG amplitude. It was hypothesized that there will be significant effect of EMG biofeedback and on EMG amplitude in chronic spinal cord injury patients.

Methods

The study was a quasi-experimental design. A sample of convenience of 30 subjects with spinal cord injury who were being treated in Indian Spinal Injuries Center New Delhi was included. Subjects were randomly assigned to one of the two groups, group A (Biofeedback and conventional exercises) and group B(Conventional exercises).Subjects were included in the study based on the following criteria stable incomplete spinal cord injury, as determined by clinical examination with American spinal injury association scale (Grade B,C and D),12 months post injury , neurological level C_6 and above, triceps muscle strength grade 2 as measured in medical research council grading system, vision and hearing intact, and patients who are able to follow commands. Patients with following problems were excluded such as spinal shock, peripheral nervous system injury of upper extremity, upper extremity fracture, upper limb amputation and upper limb spasticity more than grade 1 as determined by modified Ashworth scale, contracture or deformity of upper limb and altered sensorium .The variables studied were EMG amplitude, quadriplegic index of function(QIF) scores and spinal cord independence measure(SCIM) scores.

Equipment used in the study was Myomed 932, which is a complete unit for EMG biofeedback, pressure feedback and electrotherapy and electro diagnosis. Myomed 932, analysis and provide feedback of EMG signal. It consists of 2 independent channels EMG feedback unit. EMG activity could be displayed either in the form of bar or curve or bar and curve. Threshold value can be adjusted between 0-100% with audio feedback dependent on threshold, proportional or rough EMG. It has adjustable volume and can be switched off. Treatment time could be adjusted between 0-60 minutes.

Following procedure was followed in the study. Subjects were briefly explained about the procedure and purpose of study and informed consent was duly signed. Demographic data, neurological details , muscle power of triceps , EMG amplitude (highest averaged), QIF scale and SCIM scale scores were collected from the subjects and the subjects underwent assessment on all the parameters after 3 weeks also. For measuring EMG amplitude, subject was seated in his or her wheelchair in front of the color monitor of the EMG biofeedback instrument and two pregelled Ag-AgCl surface electrodes were placed over the triceps of one extremity with a third electrode used as ground electrode placed on the ulnar styloid process of the opposite extremity. Electrodes were centered within a small oval area whose center is located 50% of the distance between the angle of the acromion and the olecranon spaced 3 cm. apart .[7] The electrodes were connected to the EMG biofeedback instrument. Then the subjects were asked to extend the elbow and when a favorable EMG response was achieved, the specific placement was recorded and used during subsequent sessions.[13] For the purpose of pretest, the subjects were instructed to extend their right elbow, with the shoulder held in 90^0 flexion and elbow at a starting position of 90^0 flexion. The monitor was configured to display the amplitude of the integrated EMG. The integrated EMG calibrated in microvolts during the attempted elbow extension was recorded. The pretest data were obtained from the highest voluntary EMG amplitude from the triceps during elbow extension. An identical procedure was used for the left arm. The pretest was followed by biofeedback treatment procedure. The highest averaged recorded EMG responses from the triceps during the pretest was placed as criterion line.[14] The subject was advised that the moving line, which he or she was about was about to see on the monitor, was a reflection of the EMG signal of the triceps. The subject was then instructed to attempt an elbow extension while watching the monitor and told them not to be concerned about the actual extension of the elbow. The task was to increase the level of the moving line to a level higher than the criterion line.[15] Audio feedback was chosen to complement the reinforcement of the visual feedback.[8] The auditory display provided rising and falling intensity of sound. All the displays were proportional to the integrated EMG activity, over a selected time period.[16] On subsequent days, the threshold setting was changed. Criterion line was adjusted each time depending upon the patient's previous level of achievement. In each session, 20 seconds were given to complete one contraction and between subsequent contractions 16 second inter-trial interval was given. A total of 10 repetitions were given in a set. Thus in each session there was 20 contractions (2 sets) intervened by rest periods of 10 minutes. The subjects were verbally reinforced every time during elbow extension to raise the amplitude of the EMG higher than the criterion line.[17] The patient received 5 sessions per week for three weeks.[18] This was followed by therapeutic exercises. The session lasted 1 hour . The subjects in the control group also followed the same procedure as of group A barring that subjects in group B were not provide with any EMG biofeedback treatment. Data was analyzed using SPSS software. Paired't' test was used for analysis within the group changes and unpaired 't' test was used for inter group changes in the values of variables studied.Significance level of p d" 0.05 was fixed.

Results

The mean+ S.D of subjects in group A were 34.06 +9.79 years while in group B it was 34.03+ 9.01years and the mean + S.D for time post injury was 17. 4+ 3.56 months in group A and for group B it was 17.6 + 3.45 months. There was a significant change in EMG amplitude scores of both upper extremities (table 1,figure 1), QIF scores (table 2,figure 2)and SCIM scores (table 2,figure 3)in both group A and group B after the treatment.There was no significant difference between EMG amplitude values (table3, figure 4) , QIF (table 4,figure 5)scores and SCIM scores(table 4,figure 6) between the groups before the treatment but there was significant difference in EMG amplitude values (table 3 ,figure 4), QIF score((table 4,figure 5)and SCIM scores (table 4, figure 6) after the treatment between the groups.

Discussion

EMG feedback along with conventional exercise and conventional exercise has shown highly significant increments in the electromyographic activity , it was noticed that mean difference for groupA was higher than the group B (table 1) and there was highly significant difference in EMG amplitude values between two groups after the treatment. The results of this study is similar to the results of previous studies.[19,20] Possible neuronal mechanisms that can be suggested for increased surface EMG generated in the muscles through the use of biofeedback are increased firing rates motor units that were less activate before biofeedback ,increased number of motor units recruited to fire, increased synchronization of motor unit firing so that less cancellation occurs in the surface

Table 1. Intra group comparison of changes in EMG amplitude (micro volt)

Group	Side	EMG scores (micro volt)		p-value	Mean difference
		Pre treatment Mean ± S D	Post treatment Mean ± S D		
Group A N=15	Left	193.2 ± 79.06	231.8 ± 77.42	0.001*	38.6
	Right	180.0 ± 46.83	221.26 ± 39.24	0.001*	41.2
Group B N=15	Left	151.2 ± 42.87	177.26 ± 43.47	0.001*	26.06
	Right	163.2± 34.32	189.33 ± 393.01	0.001*	26.13

*Significant at 0.05 level, EMG-Electromyography

Table 2. Intra group comparison of changes in Quadriplegic Index of Function Scores (QIF)

Name of the Scale	Group	Pre treatment Mean ± S D	Post treatment Mean ± S D	p-value	Mean difference
QIF	Group A N=15	10.46 ±1.59	11.26 ± 1.53	0.001*	0.8
	Group B N=15	9.86 ± .99	10.13 ± 1.12	0.041*	0.267
SCIM	Group A N=15	19.93 ± 2.18	21.06 ± 2.25	0.011*	1.1333
	Group B N=15	19.8 ± 2.077	20.06 ± 2.28	0.041*	0.2667

*Significant at 0.05

Table 3. Comparison of changes in EMG amplitude (micro volt) between two groups

Side	Time	Group A [N=15] Mean± S D	Group B [N=15] Mean ±S D	p-value
Left	Pre treatment	193.2 ± 79.06	151.2 ± 42.87	0.081
	Post treatment	231.8 ± 77.42	177.2 ± 43.47	0.024 *
Right	Pre treatment	180 ± 46.83	163.20 ±34.32	0.272
	Post treatmen	221.26 ±39.24	189.33 ± 33.01	0.023*

*Significant at 0.05 level, EMG-Electromyography

Table 4. Comparison of changes in Quadriplegic Index of Function Scores(QIF)

Functional Test	Time	Group A [N=15] Mean ± S D	Group B [N=15] Mean ± S D	p-value
QIF	Pre treatment	10.46 ± 1.59	9.86 ± .99	0.227
	Post treatment	11.26 ± 1.53	10.13 ± 1.12	0.029 *
SCIM	Pre treatment	19.93 ± 2.18	19.8 ± 2.07	0.865
	Post treatment	21.06 ± 2.25	20.06 ± 2.28	0.023 *

*Significant at 0.05 level

Fig 1. Intra group comparison of changes in EMG amplitude (micro volts)

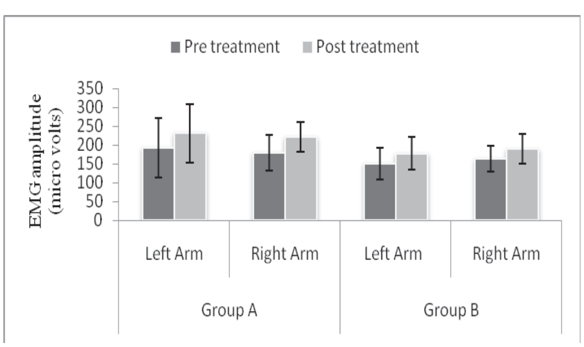


Fig 2. Comparison of changes in quadriplegic index of function scores(QIF) within groups

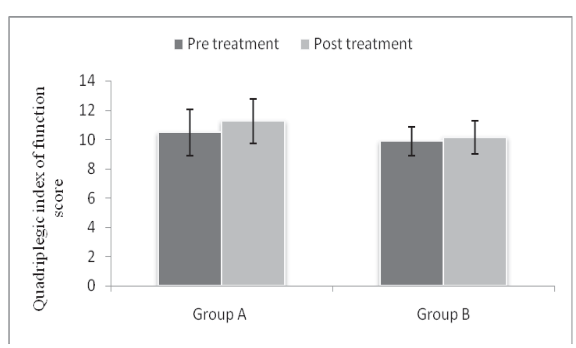


Fig 3. Comparison of changes in spinal cord independence measure score (SCIM) within groups

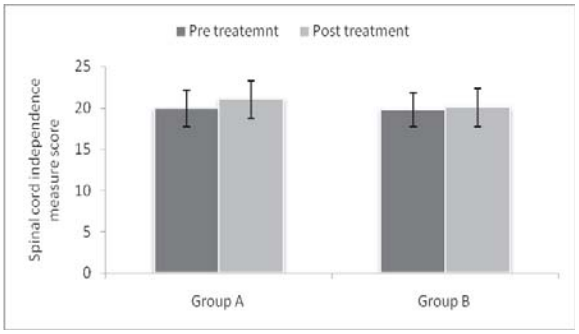


Fig 4. Comparison of changes in EMG amplitude (micro volt) between two groups

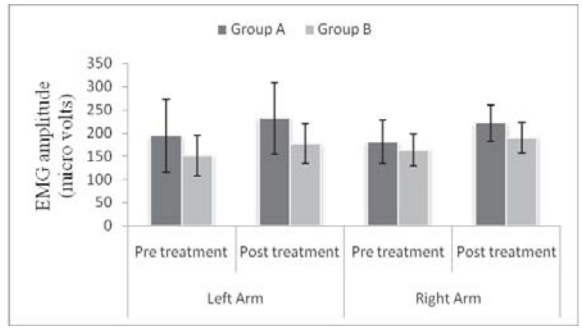


Fig 5. Comparison of changes in quadriplegic index of function scores(QIF) between groups

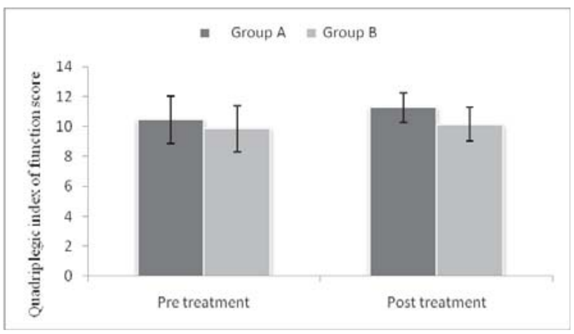
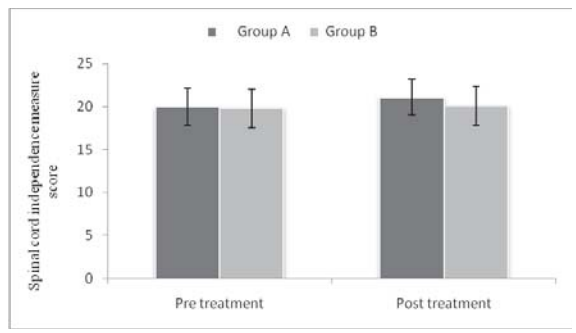


Fig 6. Comparison of changes in spinal cord independence measure scores (SCIM) between groups



*Significant at 0.05 level

EMG and sprouting of motor nerve terminals to innervate additional muscle fibers.[12] The increase may be the result of some 'masked' neural recovery that has taken place but the subject was unaware of or unable to exploit was developed into full potential with biofeedback.[20] The fact that Klose and colleagues did not find biofeedback interventions to effective in increasing EMG or function in spinal cord injury patients is most likely because of procedures for biofeedback used in those studies. It consisted of visual display without specific operant conditioning paradigms for increasing voluntary control of physiological responses. There was significant increase in QIF and SCIM scores, in both groups but the mean difference (table 2) for both the scores was higher for group A than group B. Also there was highly significant difference in QIF scores and SCIM scores in between two groups after the treatment The gains made by the biofeedback groups may be the result of learning, while the gains demonstrated by the other groups may be merely the result of muscle strengthening . There are some unused neurons in the spinal cord which is not utilized under normal circumstances. During the therapy a specific task is assigned to them. As the patient learns to follow instructions in a specific learning paradigm and learns to separate signals, after a few days of application of biofeedback the patient relates EMG signals with function.[6,21] Thus biofeedback adds on to the improvement by providing the patient with immediate, direct information concerning the use of muscle. Such information serves the purpose of reinforcing only positive behavior and motivating the patient. So findings of the study confirms that the increases in EMG amplitude obtained with the biofeedback procedures could translate into functional gains.Future research would include the application of biofeedback protocol to a longer duration with appropriate functional training. Thus, it can be concluded that EMG biofeedback can be used as an adjunct to physical therapy in chronic spinal cord injured patients for improving the motor unit activity and improvement of functional activity.

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Difference in back extensor endurance among smokers and non - smokers

Sumit Garg, Vivek Gaur, Nalina Gupta, Ajay Arora, Rahul Shankar

Abstract

Studies have linked strong adverse effects of nicotine on musculoskeletal, cardiopulmonary, neural and endocrinal system. Studies have particularly shown that prolonged smoking severely impacts strength and endurances in various muscle groups with increase incidences of chronic pain syndromes. Our study used correlation design to see the effects of prolonged smoking on endurance of postural back muscles. Criteria based selection was done and 30 subjects were recruited with informed consent and then divided into two groups, group A (smokers) and group-B (Non-smokers). With adequate explanation and demonstration Sorenson's endurance test was carried out to see the back extensor endurance time in two groups of subjects. The isometric hold time was recorded for both the groups. Data was obtained and smoking index was correlated subsequently.

Results show that with high smoking index, mean endurance time for smokers was less than non-smokers.

Keywords: Nicotine, Smoking Index, Sorenson's Endurance Test, Back Extensor Endurance, Mean Endurance Time.

Introduction

Out of 4000 lethal chemicals in cigarette-smoke, 60 are known to cause cancer.[1] Out of these Nicotine, Carbon monoxide (CO) and tar are major composition of cigarette-smoke. Whereas Nicotine affects the contractility of skeletal muscle, thickening of blood vessel wall, neuromuscular receptor desensitization and hence reducing the maximal tension a muscle can produce,[2] CO on the other hand has affinity to bind to Hemoglobin (Hb) 300 times more than oxygen and therefore reduces blood oxygen level.[1] Oxygen which is crucial for aerobic phosphorylation and metabolism is severely shortened as more and more CO binds to the Hb in circulation. The third major component of cigarette-smoke is tar which coats the lung and distal areoles thereby reduces the natural elasticity of lungs and causes less O_2 absorption and increased airway resistance.[3]

Smoking as a whole is well known risk factor for cardiovascular diseases including MI, Hypertension, Diabetes, stoke and pulmonary diseases including chronic bronchitis and emphysema.[4, 5, 6] Additionally smoking is said to increase the incidences of rheumatoid arthritis in women, rotator cuff diseases, and degenerative diseases in cervical spine, postural tremors and osteoporosis.[7, 8, 9, 10, 11, 12]

In particular with skeletal system, the prolonged Para-spinal muscle malnutrition caused by chronic inhalation of nicotine could compromise spinal stability in chronic smokers by its effects on muscle function and spinal mechanism.[11, 13] Impaired muscle strength and

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endurance reported among individual who smoke may lead to weakness with impaired postural muscle co-ordination and abnormal spinal loading.[4]

This study was done to bring forward endurance testing of spinal extensor muscles in smokers and non-smokers using Sorenson's endurance test specifically measuring back muscle endurance. Sorenson's test was described by Biering Sorenson as a useful measure for predicting first time occurrence of low back troubles with men.[14]

Methods

On Criteria based selection, 30 male Subjects were recruited for study from Balawala village, Dehradun. Subjects were equally divided into two groups, one comprising of smokers Group-A and one that of Non-smokers, Group-B. To participate these subjects had to meet the following criteria.

Smokers (Inclusion criteria) : 1) All the subject of age group 35-50 years. 2) No recent or previous history of Low Back Pain. 3) Subjects are smokers. 4) BMI 19-27. 5) Smoking was restricted to cigarettes and similar things. 6) Smoking with the frequency of 3 or more cigarettes per day for at least past 8-10 years[15].

Non-Smokers (inclusion criteria) : 1)All the subject of age group 35-50 years. 2) No recent or previous history of Low Back Pain. 3) BMI 19-27. 4) Subjects should not be ex- smokers.

Exclusion Criteria for both groups were: 1) History of trauma or injury to back. 2) Sign of systemic infections like fever, anemia and weight loss etc. 3) Active participation of subjects in strength or endurance training of trunk muscles in gym or health centers at time of study. 4) Subjects having spinal or lower limb surgery.

Instruments used: Couch, Stop watch, 3-Suspension straps, 3-Ropes, Pillows, Height meter and weighing machine.

Informed consent form was obtained from all the subjects. Approval was given by ethical committee for this study. Before doing Sorensen test, subjects were given adequate explanation of the test and were also given a demonstration of the procedure using an instructed or trained model.

In this test, subject lies prone with cranial border of iliac crest at edge of the couch. The buttocks and legs are fixated by 3 broad suspension straps. One across the middle of gluteal region, one just proximal to popliteal region and one across the ankle region.

During the test, upper part of body with arms crossed in front of chest, was unsupported and kept horizontal by trunk extensors till exhaustion. The time was measured with Stopwatch from the moment, trunk was unsupported till the time subject was completely fatigued and again put the hands on floor for support. The isometric hold time was recorded for both the groups.

Only one attempt was allowed and while the test was performed, stopwatch was kept out of sight of subject. Subjects were tested separately rather than among a group or crowd. They were not informed about their hold time to eliminate any motivational bias or error. Subjects were given a cold Pack immediately after the test to relieve soreness and discomfort in low back, if present.

Data was taken for both the groups and smoking index of smokers was calculated.[16] The data was subjected for Statistical Analysis.

Instructions to Subjects

• Subject should be comfortable.

• If there is pinching on iliac crest bone during testing subject should inform to the therapist.

• During testing the subject was asked to attained and maintain a horizontal position with no rotation or lateral shifting.

Smoking Index

is a parameter used to express cumulative smoking exposure quantitively which is a parameter similar to "pack-year" but more suitable for Indian Subjects.[30]

Statistics

SPSS software (version 16.0) was used to analyze the results. Unpaired t-test was performed to compare the difference in back extensor endurance time among smokers and non-smokers. Karl Pearson's correlation test was performed to correlate between the variables i.e. Back Extensor Endurance time and smoking index. A 0.05 level of significance was used.

Results

Back Extensor Endurance Time that of Smokers (Group A) and Non-smokers (Group B) were analyzed. 30 subjects were taken, 15 in Group A (mean age 36.3 ± 5.36 and mean BMI 23.08 ± 2.301) and 15 in group B (mean age 36.6 ± 6.39 and mean BMI 22.35 ± 2.11). The mean endurance time of smokers (47.6 ± 20.67) was found to be less than that of non-smokers (74.73 ± 24.29). (Refer table 1 and 2 and graph 2.)

Data analysis revealed that there was a significant reduction in back extensor endurance time of Smokers when compared with Non-Smokers. ($p < 0.05$) (Refer table 3.)

The correlation of the two variable i.e. back extensor endurance time of smokers and smoking index, mean 47.6 ± 20.6 and 136.4 ± 152.82 respectively, was – 0.44. (Refer table 4 and graph 3.)

Table 1. depicts Mean value of Endurance time and Smoking Index among Smokers (Group A). Here the high smoking index is noteworthy

Group	N	Sex		Age	B.M.I	Endurance Time	Smoking Index
A	15	M	Mean	36.3	23.08	47.6	136.4
			S.D.	5.36	2.30	20.67	152.82

Table 2. depicts Mean value of Endurance time of Non - Smokers (Group B)

Group	N	Sex		Age	B.M.I	Endurance Time
B	15	M	Mean	36.6	22.35	74.73
			S.D.	6.39	2.11	24.29

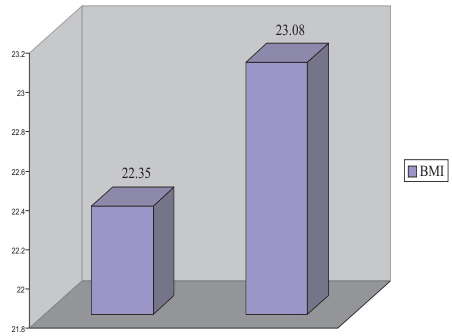
Table 3. shows Significant Differences between Endurance Time of Smokers and Non – Smokers

	Number of subjects	Endurance Time
Smokers	15	47.6 20.67
Non-Smokers	15	74.73 24.29
Significance	S	

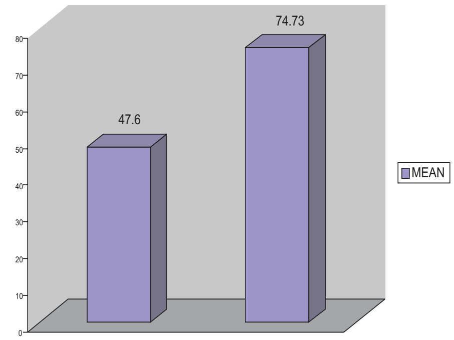
Table 4. shows Karl Pearson correlation used between two variables

Karl Pearson Correlation	-0.44

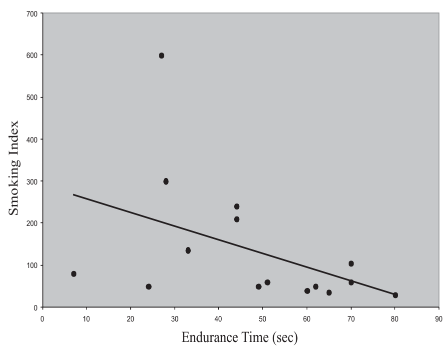
Graph 1. Graph depicting mean values of BMI for Group A and Group B



Graph 2. Graph depicting mean values of Back Extensor Endurance Time of Group A and Group B



Graph 3.Graph depicting Correlation between Endurance Time and Smoking Index for Group A (Smokers)



Discussion

This is a "Correlation" study which compares the back extensor endurance time among Smokers (Group A) and Non – Smokers (Group B), with15 subjects each. The hypothesis that the smoking has significant effect in reducing the back extensor endurance time among Smokers and Non – Smokers, is fully accepted on the basis of finding in this study.

Mean Endurance time of smokers was less than non-smokers.

Data was analyzed by using unpaired t-test and Karl Pearson correlation. The data analysis revealed that there was significant decrease in back extensor endurance time in smokers than non-smokers. ($p < 0.05$) This finding is supported with the studies done by:

Wust RC. et. al. (1992) stated that smoking reduces fatigue resistance[17]. Conway TL et al (1992) suggested that smokers will have lower physical endurance than nonsmokers[18]. Kumar PR, Kumar NV (1998) concluded that tobacco smoke inhalation affects muscle flexibility and strength required for athletes[19]. Edward F Domino et al (1998) concluded that tobacco smoking produces a remarkable, short term depression of the human skeletal motor system i.e. patellar reflex[20]. Thomas B. Price et al (2002) concluded that cigarette smoking impairs the insulin dependent portion of muscle recovery from glycogen depleting exercise. This impairment likely results from reduction in glucose uptake[21]. Chen HI (1988) concluded that chronic smoking can raise respiratory muscle strength but impair the inspiratory muscle endurance[22]. Klausen K et al (1983) suggested that the decrease in the oxygen capacity of the blood during smoking decreases endurance time.[23]

Phyllis Pugh (2002) stated that nicotine mimics a naturally occurring substance in the body i.e. Acetylcholine (ACh). There are two major types of Acetylcholine receptors in the body: nicotine and muscarine. Nicotinic Acetylcholine Receptors (nAChR) are found throughout the body, but they are most concentrated in the nervous system and on the muscles of the body (in vertebrates). Nicotine Acetylcholine Receptors cause the muscle to get excited and contract. If a muscle is dissected out, and nicotine applied to it, the muscle will still contract. Nicotine acts like Acetylcholine at the receptors to activate them so both substances are agonists[24]. Gayathri Jeyarasasingam et.al. (2000) stated that Nicotine activates receptors on muscle cells (nAChR) resulting in cell stimulation. Excessive stimulation of these receptors, however results in muscle deterioration.[25] Foster RW (1996) stated that cigarette smoking leads to neuromuscular blockage and receptor desensitization, reducing the capacity of the muscle to produce maximum tension[2].

Smoking causes increase in airway resistance and therefore reducing the amount of oxygen absorbed into the blood[3]. Therefore less oxygen reaches to the muscle this in turn affects energy production required for muscle contraction[3]. Smoking causes an increase in heart-rate, and blood pressure, paradoxically, decreases the flow of blood through the blood vessels, and this, in turn, reduces performance[3]**.** Tobacco significantly reduces oxygen availability to the muscles during exercise: Carbon monoxide in tobacco smoke has a higher affinity to hemoglobin than does oxygen. Smoking, therefore, encourages the replacement of oxygen with carbon monoxide and, resultantly, causes oxygen depletion and a corresponding reduction in performance[3]. Research also shows that cigarette smoking probably damages cells in the testis - the cells that synthesize testosterone (Male Sex Hormone). Testosterone levels within the body govern the muscle growth process from training. Thus, smoking may well hinder optimal testosterone production and interferes with the body's capacity to build muscle[3]. Another recent study examined the effects of smoking on exercise recovery. Chronic exposure to the nicotine in cigarettes leads to insulin resistance, making nutrient transport into muscles and other tissues more difficult. This study demonstrated that the muscles of young men who smoked, recovered slower from exercise compared to non-smokers. Results showed that smoker's muscle glycogen replenishment rates were much slower compared to non-smokers[3].

However, a study done by Mundel T. (2006) did not support the current study. He stated that nicotine prolongs endurance by a central mechanism.[26] Interesting is to note that there were some smokers who had more endurance time than non-smokers. Therefore a lot of clinical research is required to closely analyze the effect of smoking on extensor endurance time.

Further analysis of our results points to co-relation between endurance time and Smoking Index which has not been emphasized in earlier studies. Our study established a negative co-relation between variables; this implies that as there is increase in Smoking Index there is decrease in endurance time and vice-versa.

Limitation of the study

1. There was fatigue in hamstring muscle while holding the Sorensen test position[27]. So Sorensen test may be limited by the endurance of the hip extensor muscle[28].

2. The time that the Sorensen test is held reflects the subject's willingness to sustain the posture[28].

3. Cigarette smoking has been associated with other unfavorable life style habits such as being sedentary, leading to reduced aerobic power and decrease general muscle strength in individuals[28]. So life style i.e. active or inactive should be considered.

4. Smaller Sample size.

5. Gender specific group: Only male were included.

Clinical relevence

Our study proved that smokers had less back extensor endurance time than non-smokers and with increasing smoking index the endurance time of smokers decreased. According to past studies reduced back extensor endurance cause low back pain and osteoporosis. So smoking has indirect effect on the low back pain and osteoporosis.[29] Therefore during assessment, smoking can also be taken into consideration while assessing or planning a treatment strategy for concerned individual.

Therefore, quitting smoking causes reversal effect of smoking on body and prevent from disease. Our study also has an important implication in assessment, treatment protocol, awareness of smoking effect and public health awareness.

Scope of future study

1. There is scope for applicability of EMG-Biofeedback device to spinal extensors to see electrical activity of these muscles during Sorensen test procedure.

2. It can also be carried out separately in male and female subject to investigate the role of gender factor.

3. Larger sample size.

4. Different age groups can also be studied i.e. young age group.

5. Life style factor can be taken into consideration.

Conclusion

This study correlates between smoking index and back extensor endurance time of smokers which was found negative therefore, more the smoking index less was the back extensor endurance time in smokers.

Therefore on the basis of results which were obtained after data analysis, it was concluded that smokers had significantly less back extensor endurance time than non smokers. (p d" 0.05).

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