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Effect of progressive controlled weight bearing of upper extremity following proximal humeral fracture: Randomised control study

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***Abstract*- Background**: Proximal humeral fracture is the second most common fracture of upper limb. The problem like swelling, pain, stiffness, functional disabilities were the major problem, even after the physical therapy of proximal humeral fracture.

Objective: To find out the effect of progressive controlled weight bearing on upper extremity following proximal humeral fracture using functional range of motion and shoulder pain and disability index(SPADI) over a period of 6 week.

Method: The study duration was from Feb 2012 to Jun 2013. 30 participants both males and females based on inclusion and exclusion criteria were alternately allocated in two groups i.e. group A (study) and group B (control). There were 12 participants in group A and 13 participants in group B. There were 3 drop out in group A and 2 drop out in group B. Group A received progressive controlled weight bearing along with conventional physiotherapy and Group B received conventional physiotherapy. The duration of the treatment for both the group were same i.e. 30-45 minute. Assessment was done on the first day of 6^{th} week post fracture and the last day of 12^{th} week.

Result: Functional range of motion: There was highly significant difference seen between the mean difference of two groups for flexion, abduction, internal rotation and external rotation were p' value was 0.0001 and for extension p' value was 0.74 showing non-significant difference. SPADI: There was highly significant difference between the mean difference of two groups were p' value was 0.0004, t was 4.171.

Conclusion: Progressive controlled weight bearing may be used as an adjunct to conventional physiotherapy for the treatment of proximal humeral fracture in terms of improving functional range of motion and shoulder pain and disability index.

I. Introduction

Shoulder joint is a ball and socket type of synovial joint. In shoulder joint dynamic stability is been provided by muscles and static stability is been provided by ligaments. Injuries over shoulder joint can be traumatic or non-traumatic. In traumatic injuries the mechanism can be fall on an outstretch hand, blow over the lateral aspect, sports, rarely seizure. According to the statistical report in the year 2004 presented by US Census Bureau, International Data Base, India demonstrated a high prevalence of shoulder fracture around 12,28,059 and USA were 3,38,593. Proximal humeral fracture is the second most common fracture of the upper extremity followed by distal forearm fracture. According to Neer's classification shoulder fractures had been divided one part fracture, two part fracture, three fracture, and four part fracture. One part fracture is seen in 8 out of 10 proximal humeral fracture. Prevalence of 2 part fracture is 10%with either involvement of anatomical neck or surgical neck or greater or lesser tuberosity. Surgical neck is commonly involved follow by greater tubercle. Prevalence of 3 part fracture is about 5% were two fracture segment are displaced in relation two each other, surgical neck and one of the tuberosity is commonly involved. Prevalence of four part fracture is about 5% and very rare presentation with valgus impaction. Clinical sign and symptom of fracture are pain, localised swelling, deformity, loss of function, inability to bear weight. Numerous radiological view are available to investigation and confirm the diagnosis of proximal humeral fracture which includes AP-view, transcapular Y view, axillary view, west point view, MRI or CT scan. Depend on the type of fracture appropriate orthopaedic decision are taken for maximum beneficial of patient. After orthopaedic management patient are referred to the post fracture rehabilitation to orthopaedics physiotherapy department. Depending on type of fracture and orthopaedic management, different types of physical therapy approach are planned for the rehabilitation. Exercises for the post fractured management are active exercises, active assistive exercise, passive exercises, strengthening exercises, weight bearing exercises and mobilisation etc. Weight bearing protocol are consider as standard protocol for the post fracture management specially for the lower limb. Different type of weight bearing exercises are planned for the post fractured cases such as toes touch weight bearing, touch down weight bearing, partial weight bearing, weight bearing to tolerated, followed by full weight bearing. Still there is no standardization of weight for weight bearing protocol. Different studies demonstrated different idea about weight bearing, some study say that toe touch are 10-15kg of weight, some demonstrated that partial weight bearing as 20-25 kg of weight. Numerous studies related to weight bearing had proven that it help in strengthening bone, muscles, joint, increases proprioception etc. in lower limb when planned for post fracture rehabilitation. Since similar kind of studies are hardly done for the upper limb fracture. So weight bearing exercises followed by proximal humeral fracture can be planned as finger touch weight bearing, finger down weight bearing, weight of upper limb weight bearing, full weight bearing of upper limb.

Method

Design: Randomized control study

Setting: Department of orthopedic physiotherapy, Pravara Rural Hospital (tertiary hospital), Loni, Tal- Rahata, Dist- Ahmednagar, Maharashtra State, India- 413736.

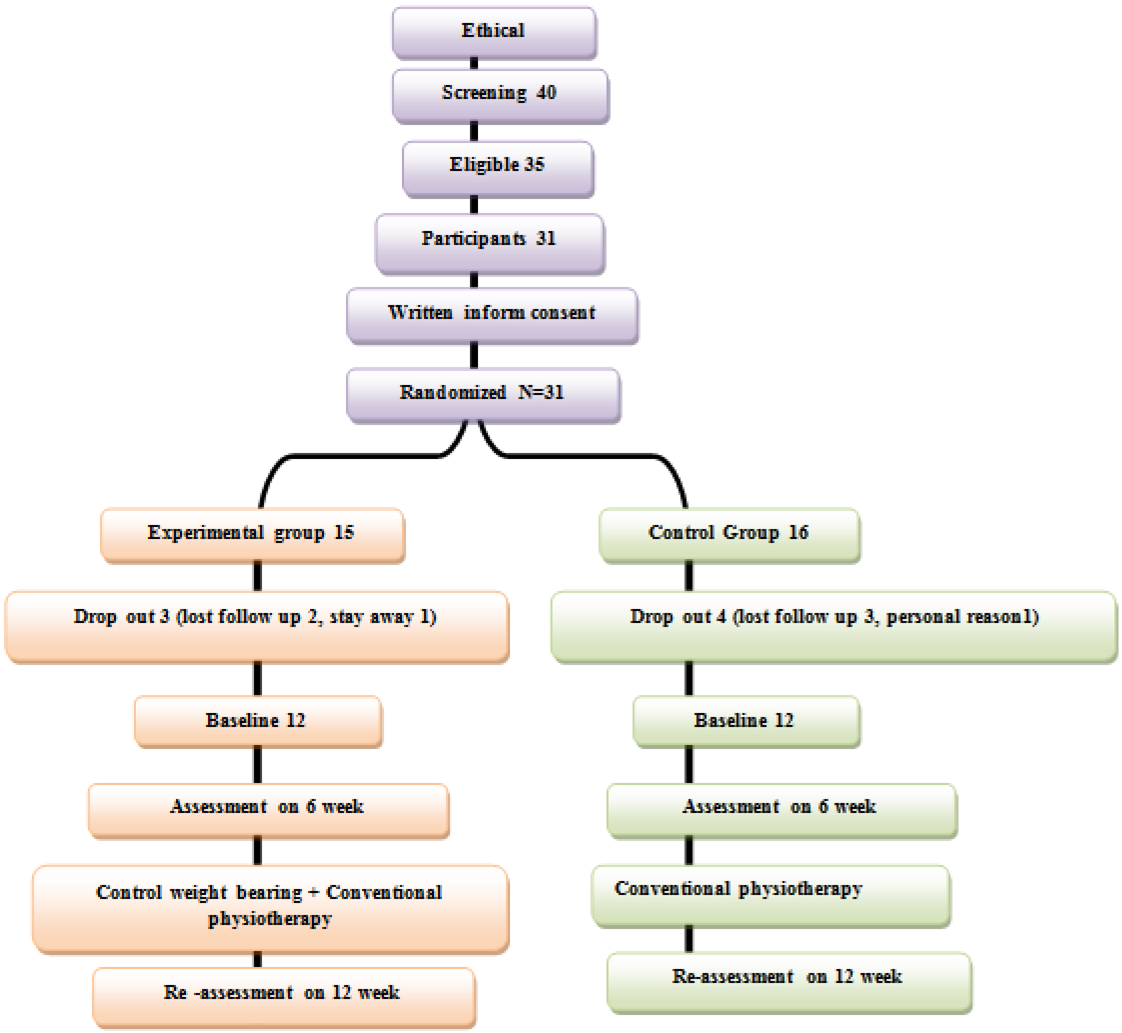
Outcome measure: Functional range of motion and Shoulder pain and disability Index (SPADI).

Participant: There was 40 participant with the diagnosed case of proximal humeral fractured which were referred to the orthopaedic physiotherapy department. The mean age of control group was 44.61±11.08 and study group was 42.58±12.65 years. The mean height of control was 156.07±6.38 and study group was 157.08±9.307(cm). The mean weight of control was 67±12.36 and study group was 66.91±11.047. BMI of control group was 27.34±4.8 and study was26.92±2.72.

Criteria for study: Inclusion criteria were both male and female of age over 18years, traumatic cases of proximal humeral fracture according to Neer's classification (one and two part fracture),conservative treated un-displaced fracture of proximal humeral fracture, operated cases of one, two part fracture of proximal humeral fracture, stress, avulsion, impact and hairline fracture of proximal humerus. Exclusion criteria were bilateral shoulder fracture, rotator cuff tear, shoulder dislocation with fracture, previous history of surgery of ipsilateral side of shoulder, elbow, wrist, previous history of ipsilateral proximal humeral fracture, nerve injury during trauma, neurovascular and neuromuscular condition, cognitive impairment.

Procedure: The study received approval from the Institutional Ethical Committee (IEC) of PIMS, Loni. There were 40 participants with clinical diagnosis of proximal humeral fracture treated by Orthopaedic surgeon and are referred to the orthopaedic physiotherapy department for the physical rehabilitation. From these 40 participants, screening was done, as per the inclusion and exclusion criteria 35 participants were found eligible for the study. 30 participants were included in the study and five participants were not willing to participate. Written informed consent were obtained. Thus 30 participants who were willing to participate were briefed about the study. The participants were randomized into two groups i.e. Group A (Study group) and Group B (Control group). Both the groups contain 15 participants. There was 3 drop out in group A and 2 drop out in group B. The detailed assessments of the participants in term of orthopaedic physical rehabilitation were taken for the study on the first day of sixth week post fracture. For quantifying the improvement of the proximal humeral fractured the Shoulder Pain and Disability Index and Functional ROM were used to assessed on the first day of 6^{th} week and last day of 12^{th} week. Beside controlled weight bearing exercises the rest of the treatment protocol and physical therapeutic duration were same for both the groups.

Procedure : Flow chart



Data Analysis

Shoulder Functional range of motion : Shoulder range of motion was assessed by universal goniometer for flexion, extension abduction, internal rotation and external rotation.

Intra group comparison:

Study Group: (Intra group comparison within experimental group using paired t' test). **Flexion:** The pre-interventional mean at first day of 6th weeks for flexion was 48.5±14.06 and post interventional mean i.e. at 12th weeks was 149.08±14.003. **Extension:** The pre-interventional means at first day of 6th weeks for extension was 27.9±11.9 and the post interventional means at 12th weeks was 49.08±4.22.**Abduction**: The pre-interventional means at first day of 6th weeks for abduction was 41±10.27 and the post interventional means i.e. 12th weeks was 159.91±12.73.**Internal rotation**: The pre-interventional means at 6th weeks for internal rotation was 27.33±8.88 and the post interventional means at 12th weeks was 68.58±9.51**External rotation:** The pre-interventional means at 6th weeks for external rotation was 18.75±4.82 and the post interventional means at 12th weeks was 73.25±13.404.

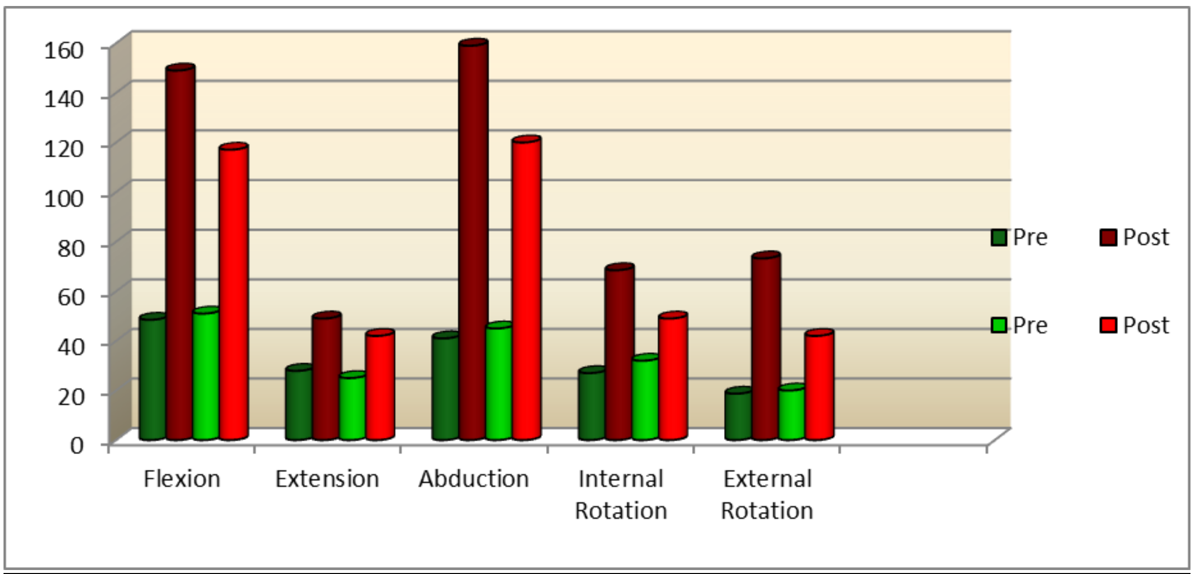
Control Group: (Intra group comparison within control group using paired t' test for intra group comparison.) **Flexion:** The pre-interventional mean at 6th weeks for flexion was 51.15±11.20 and post interventional mean at 12th weeks was 117.07±12.93. **Extension:** The pre-interventional means at 6th weeks for extension was 25.38±12.15 and the post interventional means i.e. 12th weeks was 42.076±5.75.**Abduction**: The pre-interventional means at 6th weeks for abduction was 45.38±14.64 and the post interventional means at 12th weeks was 120.61±10.28.**Internal rotation**: The pre-interventional means at

6th weeks for internal rotation was 32.538±7.93 and the post interventional means at 12th weeks was 49.23±7.59.**External rotation:** The pre-interventional means at 6th weeks for external rotation was 20±5.40 and the post interventional means 12th weeks was 42±5.85.

Table 4.3: Intra group comparisons of Functional range of motion of Pre and Post (of study and control group)

Movement	Study group Pre	Study group Post	'p' value	t value	Re-sult	Control group Pre	Control group Post	'p' value	t value	Re-sult
Flexion	48.5±14.06	149.08±14.0	0.0001	18.42	H.S	51.15±11.20	117.07±12.93	0.0001	13.30	H.S
Extension	27.9±11.9	49.08±4.2	0.0003	5.228	H.S	25.38±12.15	42.076±5.75	0.0001	6.052	H.S
Abduction	41.0±10.27	159.9±12.73	0.0001	24.760	H.S	45.38±14.64	120.61±10.28	0.0001	21.17	H.S
Internal Rotation	27.33±8.88	68.58±9.5	0.0001	9.305	H.S	32.53±7.93	49.23±7.59	0.0001	6.444	H.S
External Rotation	18.75±4.82	73.25±13.4	0.0001	12.412	H.S	20±5.40	42±5.85	0.0001	10.29	H.S

H.S: Highly significant N.S: Non-significant

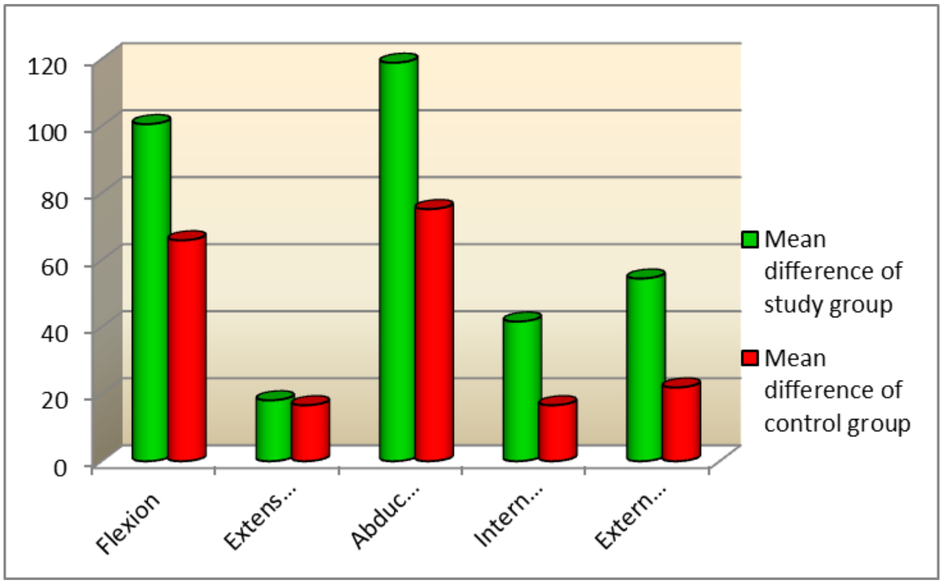


Graph 4.1 Intra group comparisons of Functional range of motion of Pre and Post in both the groups

Inter group comparison of experimental and conventional group : **Flexion**: The mean difference of pre and post study group was 100.58±18.913 and the mean difference of pre and post control group was 65.92±17.86 using unpaired t' test, p' value was 0.0001, t was 4.7 concluded highly significant result. **Extension:** The mean difference of pre and post study group was 18.16±12.03 and the mean difference of pre and post control group was 16.69±9.94 using unpaired t' test, p' value was 0.74, t was 0.33 concluded non- significant result. **Abduction:** The mean difference of pre and post study group was 118.91±16.63 and the mean difference of pre and post control group was 75.23±12.80 using unpaired t' test, p' value was 0.0001, t was 7.392 concluded highly significant result. **Internal Rotation:** The mean difference of pre and post study group was 41.66±15.38 and the mean difference of pre and post control group was 16.69±9.34 using unpaired t' test, p' value was 0.0001, t was 4.95 concluded highly significant result. **External Rotation:** The mean difference of study group was 54.5±15.211 and the mean difference of control group was 22±7.70 using unpaired t' test, p' value was 0.0001, t was 6.822 concluded highly significant result.

Table 4.4 Inter group comparison of Functional range of motion between Study and control group

Movement	Mean difference of study group	Mean difference of control group	'p' value	t value	Results
Flexion	100.58±18.913	65.92±17.86	0.0001	4.71	Highly significant
Extension	18.16±12.03	16.69±9.94	0.335	0.74	Non significant
Abduction	118.91±16.63	75.23±12.80	0.0001	7.39	Highly significant
Internal rotation	41.66±15.38	16.69±9.34	0.0001	4.95	Highly significant
External rotation	54.5±15.211	22±7.70	0.0001	6.822	Highly significant

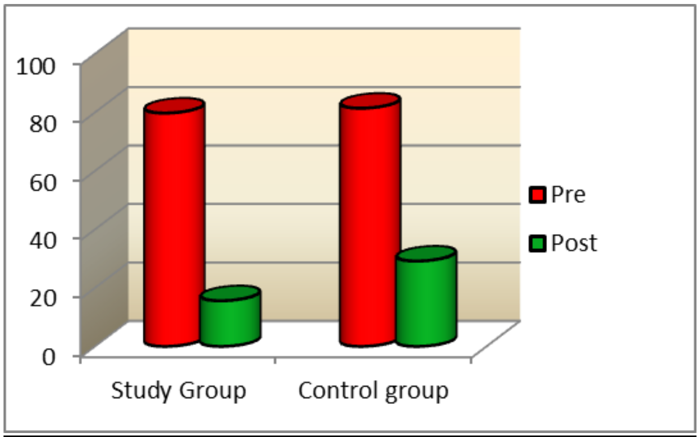


Graph 4.2 Inter group comparison of Functional range of motion between Study and control group

Shoulder pain and Disability Index (SPADI): The intensity of pain and function difficulties or disability of shoulder is measured with the help of shoulder pain and disability index. The pre-interventional average SPADI score in study (PCWB) group was 79.75 ± 6.69. After 6weeks, the average SPADI score of these participants was 15.58±3.47. The average difference in pre and post SPADI scores was 64.16± 6.67. The pre-interventional average SPADI score in control group was 81.416 ±6.253. After 6 weeks, the average SPADI score of control participants was 29.15± 3.91. The average difference in pre and post SPADI scores was 52.30±7.47. After application of "Unpaired t test" there was "highly significant" reduction in mean difference of pre and post SPADI of the study group when compared to control group. ('t'=4.171, df=23, p<0.0004) (Table 4.6)

Table 4.5: Intra group comparisons of SPADI scores in study and control group

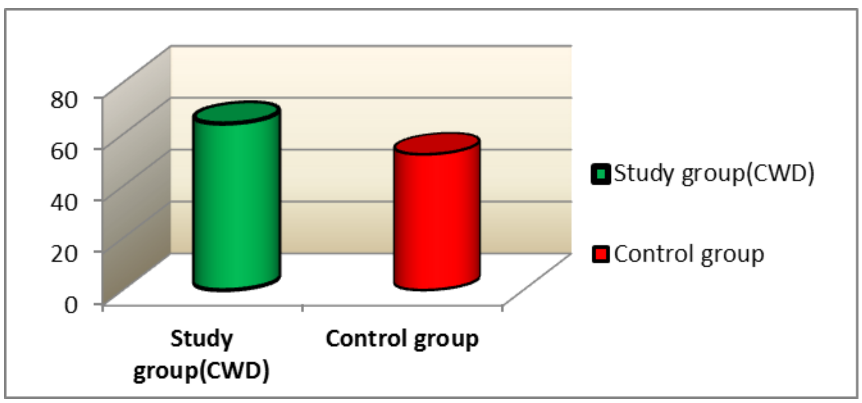
SPADI Means ± S.D	Pre (6th week)	Post (12th week)	'p' value	't' value	Result
Study Group	79.75±6.69	15.583±3.47	<0.0001	33.315	Highly significant
Control group	81.416±6.253	29.15±3.91	<0.0001	25.226	Highly significant



Graph 4.3 Intra group comparisons of SPADI scores in study and control group

Table 4.6: Inter group comparison of SPADI scores between Study and control group

SPADI	**Study group(CWD)**	**Control group**	**'p' value**	**'t 'value**	**Result**
Mean difference ±SD	64.16± 6.67	52.30±7.47	<0.0004	4.171	Highly Significant



Graph 4.4 Inter group comparisons of SPADI scores of Study and control group

The results of the present study showed that progressive controlled weight bearing on upper extremity following proximal humeral fracture may be an effective treatment protocol for patient in term of increasing functional range of motion and functional ability of ADL.

According to the Lynn Allen Colby and Carolyn[12] weight bearing exercise is a type of closed chain exercise which stimulate the mechanoreceptor present in the muscle, hence facilitate the co-activation of agonists and antagonists i.e. co-contraction of the muscle which subsequently promote dynamic stability of the joint, since muscles contractions have a compressive effect which approximate the joint surface and provide stability to the joints[12]. The conscious awareness of joint position and movement are normally present, but in fracture along with soft tissue, bone, proprioception etc are disrupted and alter neuromuscular control. Re-establishment of the efficient use of sensory information to initiate and control movement is one of the priority in rehabilitation. The weight bearing element of closed chain exercises, which causes joint approximation is believed to stimulate mechanoreceptors in muscles, in and around joints to enhance sensory input for the control of movement[12]. James R Roush[29] (2007) concluded that closed chain exercises provide large resistance with low acceleration, greater compression forces, increased joint congruency low shear force and enhance dynamic stabilization. TimL Uhl et al[10] concluded that shoulder muscles get activated during upper extremity weight bearing exercises. Helga T Tucci et al [43]state that shoulder musculature get activated during unilateral wall and brench press task under submaximal isometric effort. Ian M. Rogal (et al)[58] state the mechanism for the improvement of joint reposition sense is related to the stimulation of the joint and muscle receptors brought about by the resistance exercise how these receptor and the corresponding afferent and efferent loops adapt to bring about these improvements in proprioception is not entirely clear. Receptors responsible for detecting joint position include the Pacinian corpuscles and Ruffini end-organs found in the joint capsule and Golgi tendon organs and muscle spindles found in the muscles. All these receptors are sensitive to changes in tension within the muscles (golgi tendon organs and spindles) or non-contractile tissue (pacinian corpuscles) and Ruffini end-organ. Voight ML et al[59] assessed joint reposition sense in uninjured subjects before and after a shoulder fatigue protocol. They found significantly greater error in both active and passive reposition testing immediately after strenuous exercise to fatigue when compared with the pretest. This emphasized the importance of the muscle receptors in the detection of joint position sense. Ann Katrin et al[60] reported that exercises in closed kinetic chain promotes more balanced initial quadriceps activations than does exercise in open kinetic chain. This may be of importance in designing training programs aimed toward control of the patellofemoral joint.

Controlled weight bearing with the help of weighing machine allowed visual feedback to the participants because of which the errors of applying more weight on weighing machine by post fractured limb are avoided and the chances of re-fracture to the formed callus were avoided which are important for the fracture healing. Other advantage of the weight bearing can be seen in bone mineral density. According to Pamela Levangie the early callus of fracture healing consist of fibrocartilage material containing a high proportion of proteoglycan, glycosaminoglycan and glycoprotein. Undifferentiated mesenchymal cells migrate to the fracture sites and have the ability to form cells which in turn form cartilages, bones or fibrous tissue. The fracture hemotoma is organized, fibroblast and chondroblasts appear between the bone end and cartilages (type 2) is formed, later cells begin to form type 1 collagens that mineralized to form bones. The amount of callus formed is inversely proportional to the period of immobilization of the fracture[3]. Loading from multiple direction have been suggested to influence the distribution of bone density and tubercular orientation. Increase in bone density in some areas and decrease in density in other areas occur in response to the load place on the bone[3].According to the Bente Morseth, (2011) mechanical loading increases the bone mineral density. Harold Frost (2003) had invented the theory of Mechanostat which explains the local deformation from the mechanical loading stimulates the bone cells, resulting in bone adaptation, under the influence of parameters such as age, sex, environment, genes, nutrition and systemic biochemical factors.[24,23] Akesons WH, Amiel D had explained the effect of immobilization on joints during fracture and concluded that early mobilization is beneficial for bone as well as joint[26] . Stuart J.Warden (2006) had explained the mechanism of how loading had a effect on bone through mechano-transduction process in the skeletal system (bone). According to his study, bone is a porous tissue consisting of a fluid phase, a solid matrix, and cells. It is a common belief that mechano-transduction in the skeleton involves the movement of the fluid phase in relation to the solid matrix, which subsequently stimulates "detector" cells and triggers a cascade of adaptive molecular events resulted in intra-cortical fluid flow via load induced alterations in intra-medullary pressure .[27] Zhang et al reported that ephiphyseal loading stimulated periosteal(cortical) bone adaptation at a site 4mm distant to the loading site. The load induced alteration in intramedullary pressure which is the mechanism for the adaptive response, this pressure change is propagated throughout the entire intramedullary cavity. The fluid flow rate increases with the increases in loading frequency resulting in greater cellular stimulation and a greater adaptive response. S.L.Bass (2002) suggested that in tennis player, loading humerus with racquets while playing had more bone mineral content as compared to unloaded humerus of the same player. Thus there are several articles which concluded that axial loading on bone help in increasing bone mineral density which help in increasing bone mass[25].

Thus several studies had represented that axial loading i.e CKC strengthened the muscle through co-contraction, improved joint congruency, stability and improved proprioception. Since the progressive controlled weight bearing is a type of closed kinetic chain exercise it helps in increasing the bone mineral density of the fracture site, it decreased the period of immobilization because of which secondary complication like joint stiffness, decreased in muscles strength are avoided and its promotes the co-contraction of the muscle which help in facilitating the joint approximation. Thus early rehabilitation of the fracture is useful in terms of functional range of motion and abilities of performing activities of daily living(ADL).

The muscles are strengthened through the CKC exercises then it helps in achieving the early functional range of motion. Functional range of motion are such ROM which are necessary to do the normal physical activities of daily living. Since SPADI had the activities of daily living such as how much difficulties do you have while washing your back, hair etc. how much difficulties, and pain while performing various activity graded from zero to ten was used. And it can be used in proximal humeral fractured cases to quantify the improvement and it is a widely accepted scale to measure shoulder condition.

Clinical implications: Progressive control weight bearing (CWB) is safe, non-invasive technique for the upper limb fracture. CWB provide improvement in bone mineral density, muscle co-contraction, joint approximation (joint compression and dynamic stability) and improved proprioception. Patient with the upper limb fractures will be benefit from the progressive control weight bearing along with conventional physiotherapy.

Limitation and Suggestion for further research: Various limitations of the present study includes: Small sample size, short treatment duration, this study was focused only on patients with proximal humeral fracture., no long term follow up was done. Since there are very few studies and limited literature regarding the use of progressive control weight bearing on proximal humeral fracture, so further research is suggested to find out effectiveness of control weight bearing exercises with larger sample size, longer duration and follow up. Future studies should be carried out to find the effects of only control weight bearing exercises as a single intervention in the treatment of upper limb fracture.

Conclusion: On basis of present study, it can be concluded that control weight bearing may be used an adjunct to conventional physiotherapy in treatment of proximal humeral fracture for relief of joint stiffness, pain, improving shoulder range of motion and minimized functional disability.

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