

# Effect of Two Different Movement Patterns of Isotonic Muscle Work on Fatigue Index, Power, Strength and Endurance of Lower Limb

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**Abstract- Background:** Traditional exercise protocol emphasis towards terminal range of motion. This typically consists of a large braking phase. This occurs because of the ‘sticking region’ of microsecond while exchange from eccentric load to concentric and vice-versa. Activities of daily living did not include abrupt full range of motion. There is smooth and continuous change in muscle length. This mechanism of direct exchange without breaking down was ignored during fitness trainings. **Aim:** To update traditional isotonic exercise pattern and improve performance of fitness training of lower extremity by discovering the effect of full range abrupt movement training and near to full range, sinusoidal training. **Method:** Untrained males and females (n=51) as per homogeneous inclusion criteria were selected for study. Participants randomly separated into groups. Group-A(n=22) had performed Full range abrupt movement with resting period of micro second and group-B(n=22) was asked to perform nearly full range, sinusoidal movement on metronome rhythm to maintain small difference of amplitude and velocity between two groups. Both the groups had perform progressive resisted exercises on McQueen’s training protocol for 4 weeks. The

outcome measures for Pre and post assessment were Squat Test (ST) for strength, Fatigue Index (FI) to measure power and fatigue level and Beep Test (BT) to decide endurance level. **Results:** Inferential statistical analysis showed significant difference in strength and endurance level in both the groups between pre and post training values ( $p < 0.001$ ) within group. Fatigue index which shows level of fatigue and power was insignificant ( $p > 0.001$ ) for both the groups. Comparison of both the groups didn’t indicate any statistical significant difference between two groups but clinical significance showed that nearly full range, sinusoidal movement (ST-14.49%, BT-7.94%, FI-12.16%) will be more beneficial than full range abrupt movement (ST-8.03%, BT-7.33%, FI-2.12%). **Conclusion:** The inclusion of near to full range sinusoidal training pattern will not provide any improvement in fitness status in comparison with full range abrupt training pattern. Both the method of training appears to be an equally beneficial.

**Index Terms-** Abrupt movement, Endurance, Fatigue index, Near to full range movement, Strength

## 1. INTRODUCTION

Activities of daily living, it is very evident that they require relatively small percentage of their full active range of motion. However traditional resistance training is focused to increase strength and power with movement patterns concentrated on the terminal range of movement.<sup>1</sup>

Many activities of daily living demand a greater range of motion but maximum mechanical advantage of muscle is seen in middle range activities as more force is produced by mid range muscle work.<sup>2</sup> This is because full ROM exercises typically consist of a large braking phase/deceleration phase. This large deceleration phase occurs because of the ‘sticking region’, i.e. switch from eccentric load braking to concentric force.

Studies done by (Ross Clark et. al, 2011)<sup>1</sup> on the influence of variable range of motion training on neuromuscular performance and control of external loads and found that Various ROM training improves terminal and midrange performance gains, resulting in the athlete possessing an improved ability to control external loading and produce dynamic force for upper limb. Mookerjee S.et al 1999<sup>3</sup> mentioned that the comparison of strength differences and joint action durations between full and partial range-of-motion bench press exercise suggested that dynamic partial range of motion training is an advanced strength-training technique frequently utilized by athletes in many sports. But as per our knowledge, there was no study which focused on mechanisms of the exchange from eccentric load braking to concentric force for lower limb.

Figure: 1 Full range abrupt movement

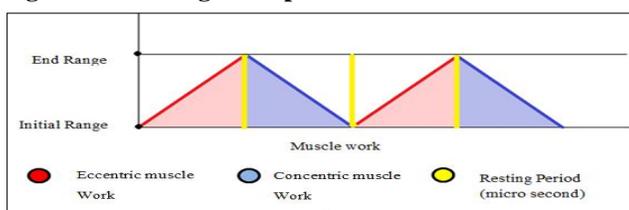
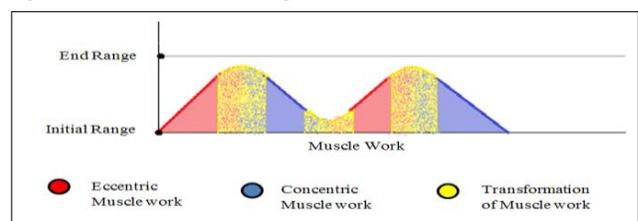


Figure: 2 Near to full range, sinusoidal movement



In resistance exercise, the mechanisms of the exchange from eccentric load braking to concentric are being ignored. This may reduce the effect of strength adaptations from resistance exercise because a countermovement is required in the midrange of the movement or near to full range of movement, resulting in a suboptimal ability to control external loading in this region and a resulting in increased risk of injury To overcome these limitations, a resistance training program that requires near-maximal countermovement performance.

We hypothesized that there will be no difference in the fitness status following 4 weeks of training program of two types

## 2. MATERIAL AND METHOD

51 participants with age between 20 to 24years, Height among 145 to 165 cm, weight between 50 to 70 kg were taken Deep squat test and leg press test were performed as a primary screening. Participants with any history of severe muscular-skeletal, cardio-respiratory or neurological disorders before or during 1 year which required immobilization or hospitalization for more than 72 hours and Individual who is instructed to avoid strenuous physical activity were excluded.

Ethical clearance was obtained from ethical committee. Written consent was obtained after explaining the procedure to the subjects. 44 participants were pre assessed by Squat Test (ST) for strength, Fatigue Index (FI) to measure power and fatigue level and Beep Test (BT).

As per Mcqueen exercise protocol of progressive Resisted exercise program of 4 week (i.e.3 alternate days/week) were explained to all subjects. Training protocol for first two weeks was decided by evaluating 10RM. Initiation of training protocol is based on 70-80% of 10RM. For open chain exercise training, elastic band color equivalent to 70-80% of 10RM was decided. Training protocol for both the groups involve 10 repetitions with 70% to 80% of 10RM weight with 3 minutes of

## 3. DATA ANALYSIS AND RESULTS

Descriptive and Inferential statistical analysis were comprehended by non-parametric Wilcoxon Signed Rank test within the group and comparisons between the groups for Post training were done using the Mann-Whitney U test.

A significant change between pre-testing session and post testing session were obtained for strength and endurance within same group after training of 4 weeks.(Table: 1,2) Fatigue index shows the level of fatigue and results for power, which needs to be decrease for positive training effects ,but it increased in both the groups(Table: 3).

of isotonic movement pattern (Hypothesis H0) Because both movement pattern involve same frequency and duration. Small difference of amplitude and velocity, so there is less possibility of difference and there will be difference in the fitness status following 4 weeks of training program (Hypothesis H1) although both muscle works involve same Intensity, volume, duration and similar muscle work, the pattern of work will be different. To update traditional isotonic exercise pattern and improve performance of fitness training of lower extremity by discovering the effect of full range abrupt movement training and near to full range sinusoidal training.

rest in between each exercise. One of the close chain exercise was leg press performed on leg press machine and another close chain exercise was deep squat. Deep squats were performed with different weights of dumbbells as per individual's difference of 10RM. Open chain exercise protocol includes quadriceps and hamstring training. These exercises were done by pre decided elastic band, color equivalent to 70-80% of 10RM.Angle of pull for all the participants were same. Group A performed full range abrupt movement with microsecond hold from eccentric to concentric transfer and vice-versa and Group B performed nearly full range, sinusoidal movements without hold for microseconds during transfer of eccentric to concentric and vice-versa on rhythmic manor with metronome.

After completion of two weeks 10RM were evaluated to decide progression of their protocol .Same training protocol was continued for next two weeks with increased or same amount of weight. To identify the effectiveness of two different exercise protocols, strength, endurance and fatigue index were checked again after 4 week.3 participants from group-A and 1 from group-B were terminated from study. 3 participants from group-A and 4 participants from group-B were willingly dropped out of study because of inconveniency with training timings and training protocol.

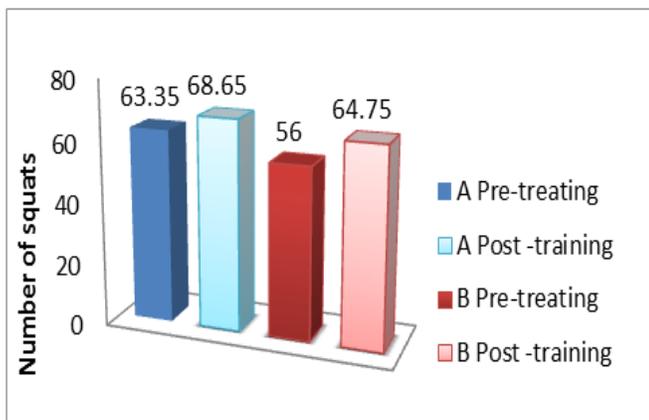
**Table: 1 Pre and Post training values of Squat test:**

Group		M(SD)	p value	Clinical difference
A	Pre-training	63.35(9.31)	<0.001	8.03%
	Post - training	68.65(11.02)		
B	Pre-training	56.00(9.70)	<0.001	14.49%
	Post - training	64.75(10.77)		

**Table: 2 Pre and Post training values of Beep test:**

Group		M(SD)	p value	Clinical difference
A	Pre-training	24.44(5.93)	<0.001	7.33%
	Post-training	26.3(6.05)		
B	Pre-training	22.01(2.69)	<0.001	7.94%
	Post-training	23.83(8.79)		

**Graph: 1 shows means of Group-A and Group-B increased significantly in pre to post training values of Squat test.**



**Table: 3 Pre and Post training values of Fatigue Index:**

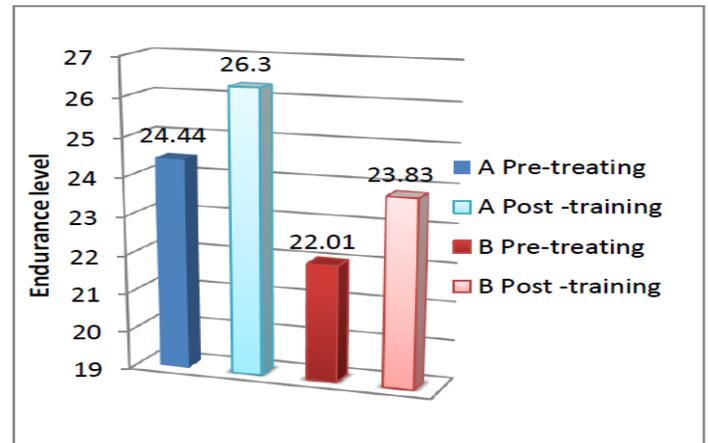
Group		M(SD)	p value	Clinical difference
A	Pre-training	2.75(2.38)	>0.001	7.69%
	Post-training	2.97(2.33)		
B	Pre-training	2.34(2.18)	>0.001	1.69%
	Post-training	2.38(1.93)		

**Table: 4 comparison of post training difference of group-A and Group-B**

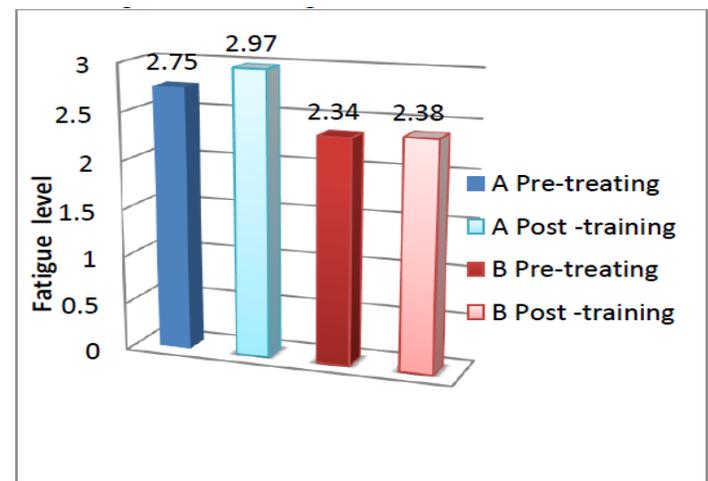
Outcome	Group-A	Group-B	p value
	Mean	Mean	
Squat Test	5.3	8.8	>0.001
Beep Test	1.86	1.81	>0.001
Fatigue Index	0.22	0.05	>0.001

Comparison of both the groups didn't indicate any statistical significant difference between two groups but clinical

**Graph: 2 shows means of Group-A and Group-B increased significantly in pre to post training values of Beep Test**



**Graph: 3 shows means of Group-A and Group-B increased which needs to be decrease and even there is no significant changed from pre to post training values of Fatigue Index.**



significance showed that nearly full range, sinusoidal movement (ST-14.49%,BT-7.94%,FI-12.16%) will be more beneficial than full range abrupt movement (ST-8.03%,BT-7.33%,FI-2.12%).

#### 4. DISCUSSION

These strength improvements within the group may have occurred due to motor learning and coordination. As it is believed that strength gain is a combination of factors such as volition, motor neuron activity, and the coordinated activation of the supporting musculature.

As there was no difference in the fitness status following 4 weeks of training program of two types of isotonic movement pattern. The apparent reason for this is that, when fatigue level and power of both the groups were compared with its pre and post data using the Fatigue Index, minimal changes were observed. As per our anticipation, in both the groups, fatigue level was expected to increase, rather than decrease. But the reverse happened i.e. the lactate threshold had decreased as seen in the Fatigue Index as there was no anaerobic training protocol given to the subjects. This supports the theory that anaerobic training will only lead to an adaptation of increase in the capacity for generating high level of blood lactate i.e. increase the Lactate Threshold and improve pain tolerance to fatiguing exercise.<sup>5</sup>

The muscle works in the activities performed in both the patterns of movement involve same intensity, volume, duration and similar muscle groups with only change in the pattern of movement caused by the differences in the level of contraction of muscle fibers. The resting period of a microsecond between eccentric and concentric work is seen in the full Range of movement performed by Group A whereas, there is a transfer of muscle contraction from concentric form to eccentric form and vice-versa in the work performed by Group B. However, as per literature, in near to full range sinusoidal movement, the

#### 5. CONCLUSIONS

The inclusion of near to full range sinusoidal training pattern will not provide any improvement in fitness status in comparison with full range abrupt training pattern. Both the

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movement does not complete its full range and therefore, there is no rest period as it involves a continuous change in muscle length followed by returning back to its starting position without a pause. This method of training appears to be beneficial component in comparison with strictly full range training.<sup>4</sup>In line of this, the dramatic increase in clinical significance for strength in near to full range movement pattern is 15.79% higher than abrupt training pattern i.e. 8.27%. This clearly explains why there is a recommendation for a minimum difference of amplitude and velocity during training which would be expected to improve fitness status. But the overall results were statistically insignificant for between group comparisons. The possible explanation for such statistically insignificant but clinically significant results can be that the success of different conditioning programs often is based on individual achievements. As a general rule, training- induced physiologic changes depend primarily on the intensity of the overload.<sup>1</sup>Present study follows Macqueen's exercise protocol that has moderate intensity of overload. This improved aerobic capacity of an individual but less supportive to improve anaerobic performance. Additional factors, responsible for less significant results of fatigue and power can be the brain has an extraordinary capacity for modifying its structure and function according to the influences of the environment and experience. In present study, the second testing for 10RM after 2 weeks of exercise showed better results than the first testing session which would have psychologically affected the subject's confidence level which was depicted as an increased sprint velocity in the first few laps of fatigue Index which abruptly decreased on the next laps. And this could be considered as a false positive finding from the subject's point of view.

method of training appears to be an equally beneficial component of training. However, both training pattern involve same frequency and duration some small difference of amplitude and velocity didn't indicate enhance large difference.

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## REFERENCES

- [1] Clark, R. A., Humphries, B., Hohmann, E., & Bryant, A. L. (2011). The influence of variable range of motion training on neuromuscular performance and control of external loads. *The Journal of Strength & Conditioning Research*, 25(3), 704-71
- [2] Katch, V. L., McArdle, W. D., Katch, F. I., & McArdle, W. D. (2011). *Essentials of exercise physiology*. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins Health.
- [3] Faigenbaum, A. D., Westcott, W. L., Loud, R. L., & Long, C. (1999). The effects of different resistance training protocols on muscular strength and endurance development children. *Pediatrics*, 104(1), e5-e5.
- [4] Hughes, C. J., Hurd, K., Jones, A., & Sprigle, S. (1999). Resistance properties of Thera-Band® tubing during shoulder abduction exercise. *Journal of Orthopaedic & Sports Physical Therapy*, 29(7), 413-420.
- [5] Sakanoue, N., & Katayama, K. (2007). The resistance quantity in knee extension movement of exercise bands (Thera-Band®). *Journal of Physical Therapy Science*, 19(4), 287-291
- [6] Rack, P. M., & Westbury, D. R. (1974). The short range stiffness of active mammalian muscle and its effect on mechanical properties. *The Journal of physiology*, 240(2), 331.

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## APPENDIX

### EXERCISE PROTOCOL

MacQueen exercise protocol

**Progressive Resisted Exercise program:** 4 week (i.e.3 alternate days/week) for both the groups.

**Training protocol:** 10 repetitions with 70% to 80% of 10RM weight following exercises with 3 minutes of rest in between each exercise.

- Close chain exercise: leg press and deep squatting.
- Open chain exercise: quadriceps and hamstring training

**Pre -evaluation to decide protocol [1/2 week]:** Evaluation of 10RM for all the exercise.

**Elastic band colour equivalent to 70-80% of 10RM for open chain exercise was decided.**

**Difference between two groups exercise performance:**

- Group: 1 Full range abrupt movement - There is resting period of micro second from eccentric to concentric change and vice-versa. eccentric to concentric change and vice-versa.- participants follow metronome rhythm to maintain same amplitude and velocity of exercise.
- Group: 2 nearly full range, sinusoidal movement - No resting period of micro second from

**Re -evaluation to decide protocol [3/4 week] :** After completion of two weeks 10RM were evaluated again for all the participants, to decide progression of their protocol.

**Progression:** Same training protocol was continued for next two weeks with increased or same amount of weight. (Depend upon progression of their 10RM).