

EFFICACY OF STRENGTH TRAINING PROGRAM ON MUSCLE PERFORMANCE BY DETERMINING 1 REPETITION MAXIMUM IN ADULTS

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Abstract: Background: Strength training is recommended for improving muscular strength and slowing deterioration of age-dependent muscle power and for rehabilitating patients with musculoskeletal conditions. Reliable method of assessing muscle strength is essential for standard procedure of strength training protocol for safeguard, sport and rehabilitation. One repetition maximum (1RM) is a reliable means for the measurement of muscle strength and is termed as the value of load against which prescribed movement is achieved with complete full range of motion only once with free weights

Objectives: To establish the role of strength training protocol in strengthening muscle assessed by 1 repetition maximum before and after training in adults.

Methods: The sample consists of thirty healthy adults were selected randomly on basis of inclusion criteria with age group of 20 to 40 years. The strength training program lasted for 3 weeks (3 × weeks, 60 to 90% of 1RM for 6 to 12 minute, 2 sets, and 10 repetitions) for 5 days a

week. 1 repetition maximum test (RM) was baseline outcome measure which was assessed for shoulder and elbow flexors and hip and knee extensors before and after strength training.

Results: Statistical analysis of data was done by using Paired t-tests to analyze 1RM Pre and post strength training protocol. The results of the study showed a significant improvement in strength in both upper and lower limbs in a short duration of time and the protocol can be used for rehabilitative purposes.

Conclusion: There is significant effect of strength training on 1 repetition maximum. This strength protocol can be used for the rehabilitation of various musculoskeletal conditions for the early rehabilitation

Keywords: *One Repetition Maximum, strength training protocol*

INTRODUCTION

Strengthening exercise program is required to promote healthy lifestyle which helps in to prevent early aging in adults and prevention of age related musculoskeletal conditions due to deterioration of muscle strength.^[1, 2]

Strength training is recommended for improving muscular strength and slowing deterioration of age-dependent muscle strength and for rehabilitating patients with musculoskeletal conditions.^[3] Strength training is necessary to improve muscle performance which helps in recovery of Musculoskeletal symptoms like pain, weakness, stiffness and decreased range of motion.^[3] Strength training improves muscle strength by performing movement against load which enhances activities of daily living. Key aim of strength training is to transmit the achievement in strength from one to another movement to enhance the performance by influencing the entire neuromuscular system.^[4]

Reliable method of assessing muscle strength is essential for standard procedure of strength training protocol for safeguard, sport and rehabilitation. One repetition maximum (1RM) is a reliable means for the measurement of muscle strength and is termed as the value of load against which prescribed movement is achieved with complete full range of motion only once with free weights.^{[3, 5].}

Estimation of 1RM is carried out over series of trials where the volume of load to be lifted is increased gradually until the participant fails to achieve a complete range of motion. Multiple repetitions are required in this method, fatigue may alter the results.^[6] The mean of 1RM may be estimated based on the number of time a participant can work with a submaximal load^[7]. 1RM is safe method for healthy adults to assess muscle strength and also for patients with cardiovascular disease^[8]

In lower extremities most of functional activities are performed with distal segments fixed i. e closed kinematic chain. Functional activities are considered activities of daily living as opposed to isolated movements performed in normal individuals. In upper extremities most movements involve open chain kinematic activities.^[4]

It is difficult to strengthen the specific movements, as muscles of those particular movements are required to train in functional training. The brain has controls on muscular movement of whole motions and not peculiar muscles. ^[5]

Components of strength training:-

In strength training body parts are aligned consists of stabilization of proximal and distal parts. Strength training consists of Intensity also called the exercise load. Volume –number of muscle worked, sets of prescribed exercise. Frequency- number of session achieved per day. Rest interval – time required to recover from fatigue. Duration – total number of weeks or months that program is carried out. Mode of exercise- method in which the strengthening is carried out. ^[5]

Strength training plays a preventive and rehabilitative role in Physiotherapy. It helps in delaying the degenerative changes taking place in normal individuals. The muscles utilized in the study are flexors in upper limbs and extensor in lower limbs, as the open chain kinematic movements are more in upper limbs and closed chain kinematic movements are more in lower limbs. ^[9, 10, 11,]

Hence, the need of this study was uplifted to find the effect of strength training protocol used in the study can get beneficial results in individuals who need to get back to their functional activities and activities of daily living. ^[9]

AIM: To establish the role of strength training protocol in strengthening muscle assessed by 1 repetition maximum.

OBJECTIVES –

1. To establish the strength training protocol for the normal individuals.
2. To evaluate 1 Repetition Maximum before and after strength training.
3. To compare the effect with appropriate statistical tools.

Material and methods:

This was a randomised Prospective Experimental study . Total 30 healthy adults of both genders between 20 to 40 years of age were included in the study. They were selected on basis of inclusion criteria randomly and were given a brief idea about the nature of the study and the intervention. Prior to the initiation of the procedure, informed written consent was taken from the participants. A pilot study was performed by using the protocol below; the actual study was then conducted using the same protocol. Participants who had risk for soft tissue injury, osteoporosis, cardiovascular pathology, Joint impairments, overweight/obesity, hypertension, dyslipidaemia and hyperglycaemia and athletic were excluded from the study. Every participant underwent a strength-training program comprising of 5 sessions a week for 3 weeks for flexors of upper limb and extensors of lower limbs with help of Dumbbells, weight cuffs and Quadriceps table.

1 repetition maximum was baseline intervention outcome measure. 1RM was defined as the greatest amount of load a subject can raise through full range of motion once with a standard lifting technique, without trick movements. Once set up of the baseline RM, the initiation of

strength training (exercise weight) was calculated as a percentage of a 1 RM for a particular muscle group.^[5]

A pre-test was performed which includes – 1 repetition maximum test for elbow flexors, shoulder Flexors, knee extensors and hip extensors.^[10]

One Repetition Maximum Testing. A 1RM using the free weight was used to assess 1RM for elbow flexor, participants position was standing, shoulder relaxed (proximal joint) and stabilised, upper arm parallel to the body. The participants were asked to lift dumbbells held in a hand by flexing the elbow in full range.(Sagittal plane).

Position of participants for shoulder flexion was standing and movement performed lifting of dumbbells held in a hand in a forward direction in sagittal plane from neutral position to overhead.

Position of participant for hip extensor was prone lying .Weight cuff was attached o the exercising leg in a comfortable position. Movement were performed straight leg raising and extended the weight leg backward until full range was achieved.

For knee extension participant was sit on edge of quadriceps table the back of the knees touching the edge of the table .Placed the top of both feet and ankles against the foot pad . Sat with the back flat against the back support. The participants were asked to extend the knees until both legs were nearly parallel to the floor. The position was hold briefly and then gradually lowers the legs back to the starting position.^[5]

Prior to 1RM assessment and strength training, performed a detailed examination of the participants , including a health history, ROM assessment , measurement of baselines of muscle strength and endurance, and overall level of functional capacity. The Participants were taught appropriate exercises form before adding resistance with the equipment. Standard lifting method of load and assessment procedures were briefly instructed to the participants.[5] The participants were instructed to lower the weight gradually , under control, warm-up was performed with a self selected weight , a minimum of 6-10 repetitions (approx. 50% predicted 1RM). 1 to 5 minutes of rest interval was given between the attempts. Participants then choose a load based on the previous effort which allowed 3- repetitions to be performed (approx. 80% of predicted 1RM) followed by 1-minute rest interval. Load was increased gradually to attempt their 1RM. A series of single trail finished until a 1RM was achieved. 1 -5 minutes rest interval was given between each trial and for the upper-body load increments range between 5-10% and 10-20% for the lower-body exercises. 1 RM was achieved within 3-7 attempts. This test was performed again after 48 hours with one kg less than the One Repetition Maximum received in the first process, and gradually increased to determine the exact one Repetition Maximum. Again after 48 hours the same process was repeated. Mean of the three days was taken and it was considered as the exact One Repetition Maximum for that participant. After that a strength training protocol was followed for upper and lower extremity for 3 weeks. A post test was performed after the 3 weeks of strength training.^[12, 13, 14]

The exercise protocol of 3 weeks was as followed. Mild exercises followed by 20 percent of 1 repetition maximum just 5 repetitions of each exercise for 6 to 12 minutes.^[15]

The strength training program was performed for 5 day a week for 3 weeks. In the first week, the subjects performed warm up exercises with the intensity of 60 percent of 1RM^[5] for 6 to 12 minute^[16], 2 sets of 10 Repetition and 60 seconds of rest interval between the exercises.^[5]

In second week, the participants performed warm up exercises with the intensity of 80 percent of 1RM for 6 to 12 minute^[5], 2 sets of 10 Repetition and 120 seconds of rest interval between the exercises.

Then in third week, the participants performed warm up exercises with the intensity of 90 percent of 1RM for 6 to 12 minute^[5], 2 sets of 10 Repetition and 180 seconds of rest interval between the exercises

In the first 2 wks, the subjects performed 3 sets of 15 reps (low intensity) while in the last 8 wks they performed 3 sets of 8 to 10 reps (Moderate intensity).

RESULTS:

Statistical analysis of data was done by using Paired t-tests to find differences on 1 RM before and after training. Thirty normal adult with age group of between 20 to 40 years (21 male, 9 female) participated in the intervention. There were no apparent differences at baseline outcome measures. As a result of the training program, none of the sessions were missed due to soreness, injury, or illness. In the present study pre-interventional mean of 1RM of Left elbow flexors was 6.83 which improved 9.56 after strength training protocol with statistical significance. In Right elbow flexors, mean of 1RM of was 6.92 changed to post-interventional mean of 9.65. Similarly post -interventional mean of 1RM of Left shoulder Flexors improved to 7.14 from pre-interventional 4.45. Pre-interventional mean of 1RM of Right shoulder Flexors was 4.48 which boost to 7.23 after strength training program. Improvement in all movements of upper limbs was statistically significance. [Table 1] [Figure 1]

Pre-interventional mean of 1RM of Left knee extensors was ± 12.12 which advanced to 18.91 after post intervention with statistical significance. Post-interventional mean of 1RM of Right knee extensors was ± 18.19 from baseline 12.16. [Table 2] Pre-interventional mean of 1RM of Left hip extensors was ± 4.39 changed to 5.43 after strength training protocol. Pre-interventional mean of 1RM of Right hip extensors was 4.42 and post-interventional mean was ± 5.58 . [Figure 2] On comparing pre-interventional versus post-intervention values by using paired T test showed statistically significant improvement in 1RM in both upper and lower limbs after strength training.

1 RM of elbow flexors was more than 1 RM of shoulder Flexors and dominant side had slightly higher values than non dominant side but magnitude of difference was too small to be documented. In lower extremities the 1RM of hip extensors was less as compared to knee extensors.

DISCUSSION

Strengthening exercise program is required to promote healthy lifestyle which helps in to prevent early aging in adults and prevention of age related musculoskeletal conditions due to deterioration of muscle strength.^[1, 2] The common Musculoskeletal symptoms encountered by

the society due to Musculoskeletal conditions which are characteristics as pain, stiffness weakness and decreased range of motion.^[5,17] Strength is the major factor responsible for most of above symptoms. These symptoms lead to major disability in the individuals.^[17] Strength training is recommended for improving muscular strength and slowing deterioration of age-dependent muscle strength and for rehabilitating patients with musculoskeletal conditions^[3]

To find the efficacy of strength training and its intensity accurate assessment of muscle strength is needed to prescribe safe and effective strength Training. Reliable method of assessing muscle strength is essential for standard procedure of strength training protocol for safeguard, sport and rehabilitation. One repetition maximum (1RM) is a reliable means for the measurement of muscle strength and is termed as the value of load against which prescribed movement is achieved with complete full range of motion only once with free weights.^{[3, 5].}

This study was uplifted to check the efficacy of strength training on 1 repetition maximum in normal individuals. This study was performed in Krishna College of Physiotherapy outpatient department on 30 healthy adults of both genders between 20 to 40 years of age were selected on basis of inclusion criteria randomly. A written consent was taken from participants before the study. A pilot study was conducted before conducting the actual study.

A Pre test and post test was performed followed by a 3 week strength training protocol for elbow and shoulder Flexors and for knee and hip extensors.[5] Statistical analysis was done by using paired t test to find out 1 Repetition Maximum before and after strength training.

On comparing pre-interventional versus post-intervention values by using paired T test showed statistically significant improvement in 1RM in both upper and lower limbs

The concept behind performing this study especially to find the effect of protocol used in the study can get beneficial results in individuals who need to get back to their functional activities and activities of daily living.

Studies have being done previously by Dr JOHN MA QUELL had studied the effect of strength training for 8 weeks in down's syndrome and had concluded that there was more increment in lower extremity strength than upper extremity.^[18,19]

Jerry L. Mayhew, et al; had concluded that Resistance training can change the relationship between strength and muscle endurance in young women without altering the accuracy of predicting maximal strength across a wide range of RTF.^[20]

Chapman, et al. (1998) found that total number of submaximal load can predict 1RM and also beneficial for strengthening the muscles.^[21]

Nelson Sousa, Romeu Mednes ,et al; had studied intense strength training program can produce differences in maximum strength and concluded that the achieve of 1RM mean values were higher for upper limbs than lower limbs muscles ,as it may not be that much effective in improving strength at older age.^[22,23]

CONCLUSION

The study shows that there was a significant improvement in strength in both upper and lower limbs in a short duration of time and the protocol can be used for rehabilitative purposes. Moreover the normal individuals used in the study were benefited as flexors and extensors were strengthened and they are the agonists used for most purposes.

In this study, Strength training protocol was done in normal individual and has a prominent effect on 1RM and muscle strength. So this strength protocol can be used for the rehabilitation of various musculoskeletal conditions for the early rehabilitation and in geriatric populations to prevent deterioration of muscle strength.

Table 1: Table 1: Outcome of strength training on 1RM in upper limb

Mean values of 1RM of upper limb	Pretest (mean±SD)	Post test (mean±SD)	P value
Right Shoulder Flexors	4.72 ± 1.47	7.23 ± 2.16	<0.0001
Left Shoulder Flexors	4.47 ± 1.45	7.14 ± 2.08	<0.0001
Right Elbow Flexors	6.92 ± 2.55	9.65 ± 3.09	<0.0001
Left Elbow Flexors	6.83 ± 2.5	9.56 ± 3.06	<0.0001

Graph 1: Outcome of strength training on 1RM in upper limb

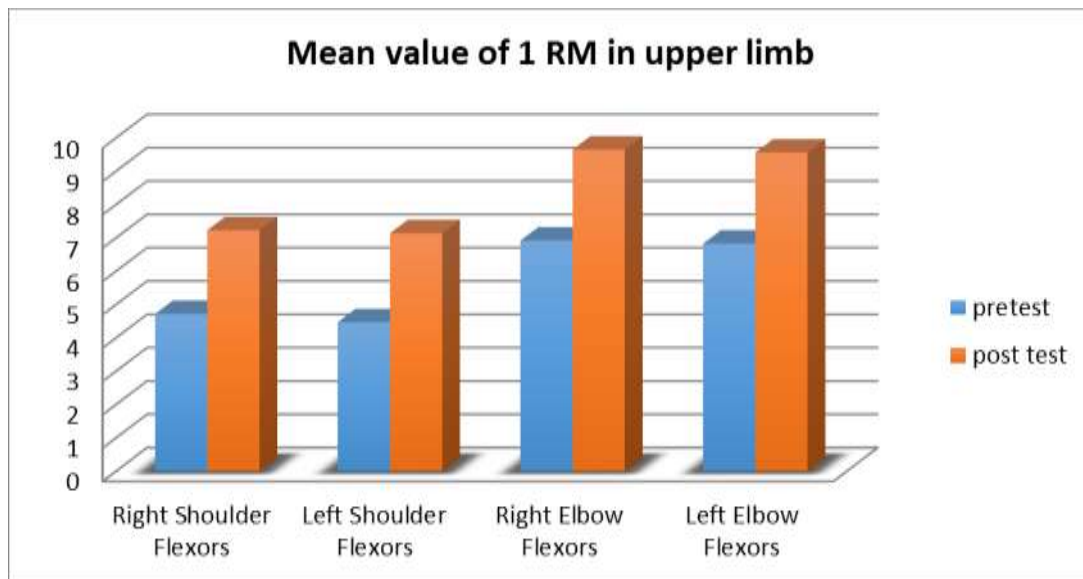
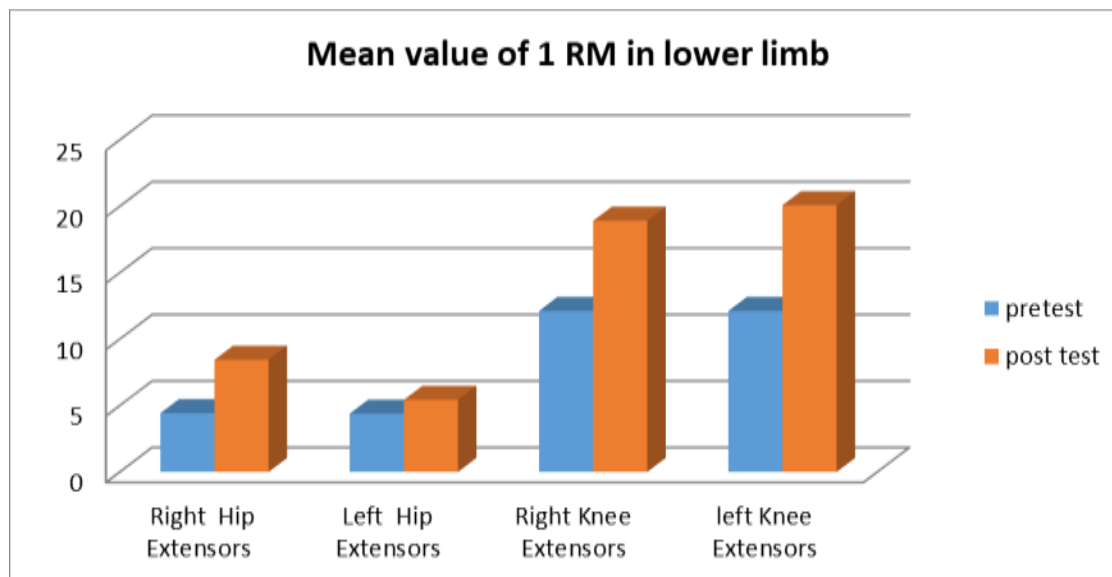


Table 2: Outcome of strength training on 1RM in lower limb

Mean values of 1RM of lower limb	pretest (Mean±SD)	post test(Mean±SD)	P value
Right Hip Extensors	4.43 ± 1.12	8.44 ± 1.33	0.061
Left Hip Extensors	4.39 ± 1.11	5.43 ± 1.78	<0.0001
Right Knee Extensors	12.12 ± 6.07	18.91 ± 7.05	<0.0001

left Knee Extensors	12.12 ± 6.72	20.08 ± 7.02	<0.0001
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Graph 2: Outcome of strength training on 1RM in lower limb



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References:

- [1] Hara T, Shimada T. Effects of exercise on the improvement of the physical functions of the elderly. *Journal Physical Therapy Science*. 2007; 19:15–26.
- [2] Candow DG: current theories and the potential beneficial effect of creatine application strategies. *Biogerontology*. 2011 Aug; 12(4):273-81
- [3] Niewiadomski Wiktor, Laskowska Dorota: Determination and Prediction of One Repetition Maximum (1RM): Safety Considerations, *Journal of Human Kinetics* volume 19 2008, 109- 120
- [4] Mc Ardle WdKatch F1 and Katch, VI: *Essentials of Exercise Physiology*.4th revised international ed Edition, 2011.
- [5] Caronyl Kisner , MS , PT: *Resistance Training In : Therapeutic Exercise Foundation Techniques*.(Edition 2003, Jaypee Productions).
- [6] Chandler J., Duncan R., Studenski S. (1997) Choosing the best strength measure in frail older persons: importance of task specificity. *Muscle and Nerve; Suppl 5: S47- S51*.
- [7] LeSuer D.A., McCormick J.H., Mayhew J.L. Wasserstein R.L., Arnold, M.D. (1997) The accuracy of prediction equation for estimating 1- RM performance in the bench press, squat and deadlift. *J Strength and Cond. Res*;11: 211- 213.

- [8] Hamill, BP. Relative safety of weightlifting and weight training. *J Strength Cond Res* 8:53–57, 1994
- [9] Hislop H.J And Prurience J : Isokinetic Concept Of Exercise Physical Therapy, 41:114:1967
- [10] Augustson J Et .AL; Weight Training Of Thigh Muscles Using Closed Chain Exercises versus Open Chain Exercises, A Comparison Of Performance Enhancement Ortho Sports Physical Therapy.
- [11] Dr Richard A. Dicenso : Functional Versus Traditional Weight Training Workout Programs, [www.shapefit.com/FunctionalVs Traditional](http://www.shapefit.com/FunctionalVsTraditional)
- [12] Jimenez Clarissa: Understanding 1-RM and Predicted 1-RM Assessments, October 19, 2018.
- [13] Hollander, DB, Kraemer, RR, Kilpatrick, MW, Ramadan, ZG, Reeves, GV, Francois, M, Hebert, EP, and Tryniecki, JL. Maximal eccentric and concentric strength discrepancies between young men and women for dynamic resistance exercises. *J Strength Cond Res* 21: 34–40, 2007
- [14] Rose, K and Ball, TE. A field test for predicting maximum bench press lift of college women. *J Strength Cond Res* 6:103–106, 1992.
- [15] Sanders B. : Exercise and Rehabilitation Concepts , In Malone TR, Mcpoil, T and Nitu, AJ (Eds) : Orthopaedics And Sports Physical Therapy, Ed 3, Mosby ,St.Louis ,1997, P112.
- [16] Rahman, E., Akter, M. F., Haque, M. O., & Habibur Rahman, M. (2019). Common Sports Injuries among Male Cricket Players in Bangladesh. *Journal of Current Medical Research and Opinion*, 2(11), 331-333. <https://doi.org/10.15520/jcmro.v2i11.229>
- [17] Smith CA : The Warm Up Procedure: To Stretch or Not. a Brief Review *J Orthop Sports, Physical Therapy* 19:12 :1994.
- [18] O' Sullivan SB : Assessment Of Motor Function. In O' Sullivan, SB and Schmitz , T J : *Physical Rehabilitation: Assessment And Treatment* Ed, 4 FA Davis Philadelphia 201, P177.
- [19] Pearn J , Bullock K A: Pearn -1979- Cited By 6- Related Articles : *Aust Paediatrics J.* 1979, Jun;15 (2):107-9, A Portable Hand Grip Dynamomete, www.ncbi.nlm.gov/pubmed/485989
- [20] Stoppani Jim, *Encyclopedia Of Muscle Strength In Muscle and Fitness* (Oct 2004) Reprinted, By Permission, From RJ Robertson 2004, Page No.15.
- [21] Mayhew L. Jerry, Johnson D. Blair, et al: Accuracy of prediction equations for determining one repetition maximum bench press in women before and after resistance training. *Journal of Strength and Conditioning Research*, 22(5) /1570–1577, 2008.
- [22] Chandler J., Duncan R., Studenski S. (1997) Choosing the best strength measure in frail older persons: importance of task specificity. *Muscle and Nerve; Suppl* 5: S47- S51.
- [23] Sousa Nelson, Mednes Romeu, et al: Differences in Maximum Upper and Lower Limb Strength in Older Adults After a 12 Week Intense Resistance Training Program. *J Hum Kinet.* 2011 Dec; 30: 183–188