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Research Article

# Comparison of two types of strengthening exercises in upper limbs for improvement of wheelchair propulsion in paraplegics

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**Keywords:** Mat Activities; Paraplegia; Theraband; Wheelchair propulsion

**Limitations:** Small sample size, no control group and no follow-up was taken and standardized procedures for testing wheelchair specific fitness was not used.

**Future Suggestions:** Large sample size can be taken; same type of study can be conducted on individuals with complete versus incomplete paraplegia, with higher paraplegia versus lower paraplegia. A follow-up study after withdrawing strengthening exercises can be done to establish the carry-over effect of theraband exercises. Standardized instrumented wheelchair specific testing can be used.

## ABSTRACT

**Introduction:** A reduction in physical activity due to spinal cord injury leads to deconditioning and increased dependency. Manual wheelchair propulsion is a straining form of ambulation and propulsion is based on the use of upper extremities, which are usually capable of producing less force with less efficiency. Theraband can be an exercise mode, which resembles wheelchair activity. Mat exercises are also given for strengthening of upper limb muscles in persons with paraplegia. The aim of this study is to compare effects of both elastic resistance strength training and strengthening by mat activity of upper limb muscles on wheelchair propulsion efficiency in persons with paraplegia.

**Materials and Method:** The selected subjects were randomly assigned into Theraband and Mat exercise groups with 15 subjects each. Theraband group received theraband strengthening of wheelchair propulsion muscles, whereas mat activity group received mat strengthening of wheelchair propulsion muscles. Total duration of treatment was 5 days per week for 5 weeks.

**Results:** Results of the study showed both mat exercise and theraband groups showed significant improvement in wheelchair 15 meter sprint test and wheelchair propulsion for 50 meters in paraplegics due to spinal cord injury. However, theraband group showed significantly more improvement.

**Conclusion:** The study revealed that theraband exercises for improving upper limb strength for wheelchair propulsion is superior to strengthening through mat exercise.

## INTRODUCTION

Spinal cord injury is a low incidence, high cost disability requiring tremendous changes in an individual's lifestyle. Injury to spinal cord may be due to any cause, it leads to variable amount loss of motor function. This loss of motor function by spinal cord injury may lead to a relatively sedentary lifestyle. A reduction in physical activity leads to deconditioning and to a decreased capacity for physical work. Furthermore, a spinal cord-injured person's daily activities are not intense enough to prevent deterioration of their physical fitness. Although the life expectancy may have improved, many patients report a low level of functioning and well-being [1-3]. It was reported that cardiovascular and respiratory diseases were the leading cause of death among the spinal cord-injured population [4]. A lack of physical fitness for specific tasks can be a serious obstacle to autonomy and can lead to a loss of independency. Wheelchairs are important in achieving mobility in approximately 82% of persons with spinal cord injury [5]. When ambulation is impaired, a hand rim wheelchair provides relatively



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fast. Manual wheelchair propulsion is a straining form of ambulation [6], both for the cardiopulmonary as well as the musculo-skeletal system. It is effective means of mobility for people with lower limb disabilities. A hand-rim wheelchair can provide the necessary access to social, vocational and recreational activities that are conditional to a productive and rewarding life. Manual wheelchair propulsion is based on the use of upper extremities which are usually capable of producing less force than the lower limbs with less efficiency. The normal daily locomotor patterns of wheelchair dependent individuals are insufficient to maintain or improve fitness levels. The lack of adequate fitness is a major concern in individuals who have lower body disablement. Therefore, an upper limb exercise is important to maintain adequate levels of fitness in spinal cord person using wheelchair. It is important to attempt to establish training models that serve the needs of persons confined to the wheelchair. The concepts of exercise specificity however suggest that the use of an exercise mode which resembles wheelchair activity may be advantageous. Mat exercises/ activities have been given to strengthen upper limb muscles. In past several years resistance training has been proven to be safe and effective method conditioning various muscles. Physical therapists must take advantage of newer methods available, basing use on traditional, established theory. One such example is elastic resistance or theraband exercises for strengthening as an intervention. The strength training using elastic resistance or weight machines and free weights lead to an equivalent increase of isometric strength [7].

## AIM OF THE STUDY

The aim of this study is to compare effects of elastic resistance strength training and mat strengthening of upper limb on wheelchair propulsion efficiency and of persons with paraplegia.

## METHODOLOGY

### Study design

Pre-test and post-test experimental study design.

Subjects: A total of 30 subjects with paraplegia due to spinal cord injury using manual wheelchair, who met inclusion and exclusion criteria were recruited from the outpatient and in-patient department of Swami Vivekanand National Institute of Rehabilitation Training and Research and a written consent were obtained from each subject. The selected subjects were randomly assigned into two groups.

### Inclusion criteria

spinal cord injury ASIA (A-C) with neurological level of lesion from T1 to L1, both gender , duration of injury more than 5 weeks, and those who were able to propel wheelchair for at least 3 minutes were included in the study.

### Exclusion criteria

Current health problems that would contraindications for exercise testing and training. (Any cardio-respiratory problem, pressure sores ischemic heart disease, unstable angina, dysrhythmia, or autonomic dysreflexia, recent osteo-porotic fracture, and tracheostomy) those who participated in wheelchair training program or wheelchair sports, any recent surgery in around period of 3 months, any systemic disease or malignant condition were excluded from the study.

### Procedure

All subjects after meeting inclusion and exclusion criteria were asked to fill the consent form and then randomly divided into 2 groups. Before initiating treatment, subjects were assessed for baseline values of all the dependent variables. 15 meter sprint test - Anaerobic work capacity was determined in a 15 meter over ground sprint test in the participants' own wheelchairs [8]. Participants were familiarized with the wheelchair propulsion on ground, which took 5-10 minutes, this also served as warm up for subjects, in addition to experiencing how to safely perform over ground sprint propulsion. Two markers were placed in ground 15 meter apart. The participants sat in wheelchair, with front casters turned backward behind the starting line (first marker), the participants propelled wheelchair towards second marker as fast as possible after receiving a verbal encouragement. Time was manually recorded using a stopwatch from the moment start signal was given to the time front casters crossed second marker.

Wheelchair propulsion Speed test (50 meters) - Participants were instructed to propel wheelchair in a pre-measured distance of 50 meters in whichever way they were comfortable until any shoulder pain developed or they felt fatigue. Stopwatch was used to record the time of start of propulsion from first marker and distance was measured when subjects wanted to stop the propulsion. Both time and distance was recorded manually.

Therapy was started the day after the measurement was taken. Group-I (15 subjects) received conventional exercises i.e. stretching of tight structure, strengthening of upper limb, regular instruction regarding pressure relief plus strength training of muscles responsible for wheelchair propulsion (push phase muscles :- anterior deltoid, supraspinatus, infraspinatus, serratus anterior, biceps and recovery phase muscles:- middle and posterior deltoid, supraspinatus, subscapularis, middle trapezius, triceps) [9] by theraband. Shoulder external rotation for supraspinatus, infraspinatus, protraction for serratus anterior, elbow flexion for biceps brachii , horizontal abduction for posterior deltoid, shoulder internal rotation for subscapularis, elbow extension for triceps, horizontal adduction for pectoralis major, shoulder extension for latissimus dorsi were performed. Subjects performed exercises with the band of selected color code fit to them 10 times without being fatigue in-between in 1$^{st}$ week with a hold of 5 seconds, progressed to 15 repetitions on 2$^{nd}$ week, 20 repetitions on 3$^{rd}$ week, 25 repetitions on 4$^{th}$ week and 30 repetitions on 5$^{th}$ week. Group-II (15 subjects) received conventional exercises i.e. stretching of tight structure, strengthening of upper limb, regular instruction regarding pressure relief plus strength training of muscles responsible for wheelchair propulsion by mat exercises like Prone pushups, Prone rowing, Seated pushups, Prone scapular retraction, Reverse flies in sitting. 5 sets of exercises with 10 repetitions with 5 seconds rest in-between the sets wer performed in the 1$^{st}$ week, progressed to 15 repetitions on 2$^{nd}$ week, 20 repetitions on 3$^{rd}$ week, 25 repetitions on 4$^{th}$ week and 30 repetitions on 5$^{th}$ week. Total duration of treatment was 5 days per week for 5 weeks.

### Data Collection

Measurements were taken prior to the beginning of treatment and were repeated after completion of five weeks. The evaluator was blinded to the types of interventions.

### Date Analysis

The dependent variables were analyzed using a 2×2 ANOVA, repeated measures on second factor. There was one between factor (group) with two levels (groups: theraband, mat) and one within factor (time) with two levels (time: pre, post). Tukey's Post hoc analysis was done using a 0.05 level significance.

## RESULTS

Figure 1 illustrates that there was improvement in fifteen meter sprint in both the groups following treatment for 4 weeks. The theraband group showed greater improvement in strength during wheelchair propulsion in the post- treatment measurements as compared to the mat activity group. There was main effect for time F=33.333, df=1, p=0.000. There was main effect also for group, F=125.244, df=1, p=0.000, The main effect also qualified to interaction of time x group: F=8.838, df=1, p=0.006. Tukey's post hoc analysis shows statistical significant improvement in 15 meters sprint test scores in both the groups after 5 weeks of intervention. However, the improvement in theraband group is significantly more than mat activity group.

Figure 2 illustrates that there was improvement in wheelchair propulsion speed in both the groups following four weeks of treatment. Theraband group showed better improvement in wheelchair propulsion speed in post treatment measurements as compared to the Mat Activity group. There was a main effect of time F=61.546, df=1, p=0.000. The main effect for group did not attain significant level, F=590.08, df=1, p=0.215. The main effect qualified to interaction of time x group: F=21.136, df=1, p=0.000. Tukey's post hoc analysis shows statistical significant improvement in wheelchair propulsion (50 meter) scores in both the groups after 5 weeks of intervention. However, the improvement in theraband group is significantly more than mat activity group.

## DISCUSSION

The overall results of the study on strength in wheelchair propulsion of paraplegics suggest that after intervention of 5 weeks both the groups (theraband strengthening and strengthening in mat ) improved significantly from pre to post treatment in both the variables (fifteen meter sprint test and wheelchair propulsion test ) at the end of five weeks. Theraband strengthening group showed significantly better improvement in fifteen meter sprint test and wheelchair propulsion speed.

In our study both groups improved significant from pre to post tests measurement in fifteen meter sprint, 52.3% in theraband group where as mat activity group improved only 14.66%. Improvement in 50 meter wheelchair propulsion speed was found in both groups from pre to post tests measurement, theraband group improved 26.91%% where as mat activity group improved only 7.11%.

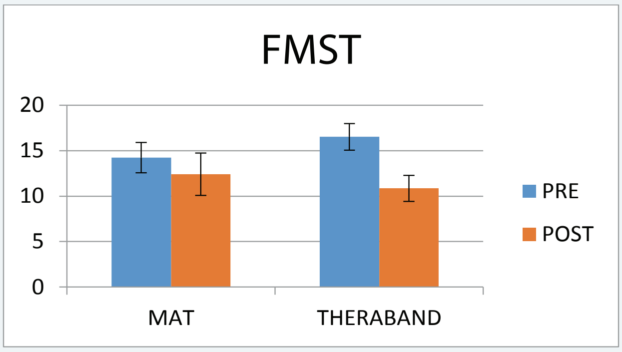


**Figure 1:** Figure shows change in 15 meters sprint test.

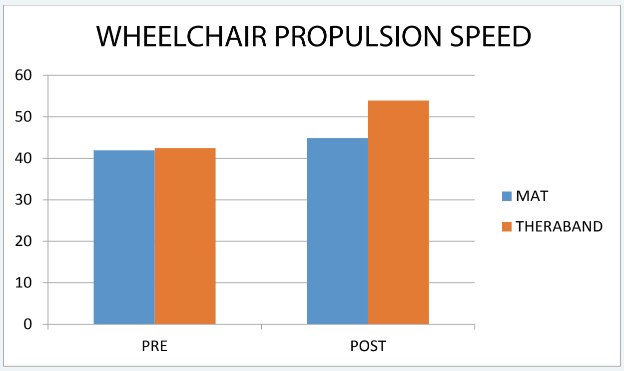


**Figure 2:** Figure illustrating changes in pre and post values in wheelchair propulsion speed.

LM Olenik in a study on efficacy of rowing, backward wheeling and isolated scapular retractor exercise as remedial strength activities for wheelchair users found that strength and co-ordination of scapular retractor provide scapular stability which is quite necessary for wheelchair [10]. This study found that rowing and scapular retraction was more effective in activating scapular retractor. In our study mat activity group included strengthening of scapular retractor through prone rowing, reverse flies and prone scapular retraction [10].

In a similar study by Sara J Mulroy et al., in a electromyographic study done on effects of SCI level on the activity of shoulder muscles during wheelchair propulsion concluded on the pattern of muscle activity during push and recovery can be directly related to the shoulder muscles movement patterns and the external demands placed on it. For the push phase muscles, activity of the anterior deltoid, pectoralis major, and biceps brachii decelerates arm extension in late recovery and then contributes to shoulder flexion in push [11]. The pectoralis major also produces shoulder adduction, whereas the infraspinatus and supraspinatus yield external rotation. Finally, the serratus anterior contributes to the dynamic stability of the shoulder complex [11].

Tarik Ozmen in a study on Explosive Strength Training Improves Speed and Agility in Wheelchair Basketball Athletes, in which the participants were familiarized at six exercise stations including bench press, biceps curl, shoulder press, lateral pull-down and triceps extension concluded that a short-duration (6-week) explosive strength training programme in wheelchair basketball athletes results in significant improvements in sprint and agility performance. The neural adaptations such as increased motor unit synchronization and firing rate may have contributed to the improvement of speed. It is very likely that the development of strength was the result of neural adaptations because the training period was shorter than eight weeks. The role of these adaptions is well recognized during the early phase of strength training. Their data showed that explosive strength training improved sprint speed by 2% for a 20-m distance [12]. In our present study participants performed short duration (5 weeks) and showed 14.6 % improvement in mat activity group similar sprint but of 15 meter distance. Our significant more improvement in mat activity group when compared to this study may be related to our participants were not involved in any kind of sports and thus had much scope for improvement in comparison to wheelchair basketball athelete who had much less scope for improvement [12].

Lars L Anderson investigated muscle activation and perceived loading during upper-extremity resistance exercises with dumbells compared with elastic tubings and concluded that comparably high levels of muscle activation were obtained during resistance exercises with dumbells and elastic tubing, indicating that therapists can choose either type in clinical practice [13]. In this study, elastic therabands were used for strengthening.

A study published in a 1998 issue of American Journal of Sports Medicine, reported that collegiate tennis players who trained using elastic bands increased their shoulder strength and the speed of their tennis serve [14]. In our study theraband group significantly improved probably because elastic resistance does not depend on gravity to provide resistance and increases its potential for use in more functional movement patterns that mimic both everyday activities and sport-specific activities, whereas free weights rely on gravity to provide resistance, they can only provide resistance in a vertical plane - against gravity.

Randall E. Keyser conducted a study on manual wheelchair users subjects underwent 12 weeks of simulated wheelchair rolling exercise using elastic straps positioned to mimic the motion of propulsion [15]. JUMP and constant work rate tests were performed before training and after 6 and 12 weeks of exercise. Endurance test duration was significantly increased ($p<0.0122$) after 12 weeks of conditioning.

The significant improvement in both the variables in theraband group as compared to mat activity group could be explained as follows:

A study, performed at the University of Wisconsin-La Crosse, reported in a 2006 issue of the Journal of Strength and Conditioning Research [16], that when athletes used elastic band training in addition to free-weight training they had significantly more leg power than when they only utilized free-weight training. This is due to the linear variable resistance that the elastic resistance equipment offers. This allows a greater number of muscle fibers to be used and taxed throughout the range of motion [17].

One more benefit elastic resistance offers is it does not allow participants to use momentum. This is because the resistance from the elastic equipment comes from the stretching of the elastic material and not the mass of the elastic equipment. The only way to continue a movement, while performing an exercise with elastic resistance, is to utilize more muscle fibers in the exercising muscle to continue stretching the elastic material [18].

Linear variable resistance, as provided by elastic resistance, is beneficial is due to what is known as the strength curve of muscles. The linear variable resistance provided by elastic tubing better mimics the strength curves of most muscles. In our study theraband group utilized strengthening of particular wheelchair propulsion musculatures providing resistance linearly, which was lacking in mat activity group. Also in mat activity group muscles were strengthen in groups and mostly in nonfunctional positions [18].

## CONCLUSION

The study demonstrates that strengthening with theraband has showed more effective results in improving upper limb strength for wheelchair propulsion in paraplegics compared with strengthening of upper limbs through mat activities.

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