



TO COMPARE THE EFFECTIVENESS OF BALANCE TRAINING COMBINED WITH STRENGTHENING EXERCISES AND BALANCE TRAINING COMBINED WITH COORDINATION EXERCISES IN IMPROVING BALANCE AFTER INDUCING QUADRICEPS MUSCLE FATIGUE IN NORMAL HEALTHY INDIVIDUALS.

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ABSTRACT

The aim of this study was to investigate either balance training combined with strengthening exercise or balance training combined with coordination exercise in improving balance after inducing Quadriceps muscle fatigue in normal healthy individuals.

METHODOLOGY - 40 healthy subjects, both male and female physiotherapy students, with mean age 20.9 ± 2 , having no injury or pathology in any joint, were selected for study and were divided in two group A & B. Pre – fatigue assessment was done by using berg balance scale and strain gauge in both group before inducing fatigue. After that fatigue was induced in both groups, then treatment was given i.e. group A received balance training combined with strengthening exercise and group B received balance training combined with coordination exercise. Treatment was given for 8 weeks then post assessment was taken and then data was analyzed.

KEYWORDS – balance, strengthening exercise, coordination exercise, fatigue,

INTRODUCTION - Balance is the ability to align body segment against gravity to maintain or move the body (Centre of mass) within the available base of support without falling. The maintenance of balance is very

important in the prevention of injury and abilities depend on proprioceptive input from musculotendinous and capsuloligamentous mechano-receptors in the conjunction with visual and vestibular input to the central nervous system^{1, 2, 3}. This input is used in both feedback and feed forward loops to provide the appropriate neuromuscular response^{3,4}. Alteration in any these inputs would disturb balance and increase the risk of injury . When the muscles that control balance are fatigued, this system could be affected, thus inhibiting proper balance control. Many researchers have examined the effects of fatigue on both types of balance, static and dynamic, and have explained that fatigue to the stabilizing muscles may also cause the balance problem^{5,6}.

Fatigue can be defined as the inability to maintain a particular force or power output during or following a reported muscular contraction⁷. Muscle fatigue is associated with an impairment of motor performance that includes a perception of increased effort to sustain task and the eventual failure to do so due the reduced force capacity. Fatigue may alter the proprioceptive and kinesthetic properties of joints by increasing joint laxity and by causing sensorimotor and biomechanical deficits, such as reduced muscles strength and activity, therefore decreasing neuromuscular control, thus increasing the risk for injury^{8,9}. Common method to induce fatigue and associated balance include protocol on various ergometers. A common way to induce fatigue is to use a bicycle or treadmill, which may be more applicable to exercise prescription. Low levels of lower limb strength are associated with functional limitation in daily living¹⁰. In addition, muscle weakness is associated with an increased risk of falls¹¹ and adverse physiological changes such as osteoporosis¹². Weakness of core muscle and aging lead to loss of balance and stability. Hence core muscle strengthening program is effective in improving balance and quality of life¹³.

Coordination is the integrative action of nervous system as described by Sherrington, when a movement is initiated by an individual, with a fixed intention and a fixed objective, that movement achieves its objective¹⁴. The Ability to perform voluntary movement comprise coordination, equilibrium, agility and flexibility¹⁵. Coordination ability as the ability to move the body skillfully, a prerequisite for the athletic performance¹⁶. Coordination ability is related to rhythm skills, balance skills, transform skills, reaction skills, consolidation skills, orientation skills, and recognition skills.

AIMS AND OBJECTIVE OF THE STUDY

The aim of present study was to evaluate the effectiveness of balance training combined with strengthening exercise and balance training combined with coordination exercise in improving balance after inducing Quadriceps muscle fatigue in normal healthy individuals.

Purpose of selection of topic

The purpose of study was:

1. To find out which method has better efficacy in improving balance in healthy individuals.

2. To apply the approach in daily clinical scenario to provide benefits to individuals having balance problem.

Need of study

As fatigue causes injury and diminishes muscle activity. There is a need to develop such exercise protocol which can delay muscle fatigue and maintain joint proprioception along with strength of muscle in such a way to avoid any further injury in long term.

Hypothesis

Alternate hypothesis

There will be significant difference between the effect of strengthening exercise vs coordination exercise combined with balance training in improving balance after inducing fatigue in Quadriceps muscle.

Null hypothesis

There will be no significant difference between the effect of strengthening exercise vs coordination exercise combined with balance training in improving balance after inducing fatigue in Quadriceps muscle.

REVIEW OF LITRATURE

Wright, Katherine, conducted a study on "Effects of Exercise Induced Fatigue on Postural Balance: A Comparison of Treadmill Versus Cycle Fatiguing Protocols" (2008). Sixteen recreationally active volunteers (Male N=11, Female N=5) between the ages of 19 and 24 (average age = 21.2 + 2.04) who had no history of balance problems were chosen to participate in the study. The results of this study indicate that fatigue induced by the treadmill test does have a higher detrimental effect on postural balance when compared to the cycle ergometer test. This study showed that fatigue induced by the Bruce treadmill test significantly reduces postural stability performance¹⁷.

S.Rahmanto. (2017) proposed a study on muscle quadriceps femoris strength with postural balance level in elderly to know the relationship between the quadriceps muscle strength with postural level of balance in elderly. 39 subjects were selected for the study purpose and divided into three group i.e. group of elderly(55-64) is 16 people, (65-70) is 8 people, (high risk group) is 15 people. The study concluded that there is a strong relationship between the quadriceps femoris muscle strength with postural balance¹⁸.

Paul J, Balakrishnan P, (2014) proposed a study to find out the effect of isometric strengthening exercise on the strength of quadriceps at 45 and 90 degree of knee joint and also to compare the effect of strengthening exercise on strength of quadriceps at multiple Angles of knee joint among control and experimental group and

subjects were randomly selected by inclusion criteria and randomly divided equally in to two group with 20 subjects in each group, isometric strengthening exercise and squatting exercise were given to intervention program for 8 weeks respectively for experimental and control group then pre and post data of quadriceps muscle strength measured were collected separately at 45 and 90 degree of knee joint using goniometer during resisted extension of knee joint, study conclude that isometric strengthening exercise can improve quadriceps strength at 45 and 90 degree of knee joint and also found that strength at 90 degree has improved more compared to strength at 45 degree¹⁹.

Rajabi S., Goodazi B., Mazidi M. (2017) conducted a study to compare the effects of eight weeks spark and Frenkel exercise on static and dynamic balance in blinds. 30 blind people with no other disabilities aged between 15 and 49 years old were randomly assigned to three groups of control (n=10), Spark (n=10) and Frenkel (n=10). At first, a pre-test of static balances and dynamic balance were performed for all three groups; Spark Group received Spark program exercises and Frenkel group received Frenkel exercises for two months, with no intervention for the control group. After two months, the required post-test exercise protocols were performed. The results indicated that both Frenkel and Spark training programs had a significant effect on static and dynamic balance of the blind, but Frenkel exercises had a greater influence on the dynamic balance²⁰.

A Carolyn, classify D, klassen P Terry, JRohanda, H Brian(2005) studied the effectiveness of a home based balance training program using a wobble board in improving the static and dynamic balance and in reducing sports related injuries among healthy adolescent, 127 participants are randomly selected for the study and divided into 2 group, one intervention group and one control group, participants in the intervention group participated in a daily 6 week and then a weekly 6 month home based balance training program using wobble board and participants in control group received testing only , after 6 weeks improvement in static and dynamic balance were observed in the intervention group I.e. study conclude that balance training using wobble board is effective in improving static and dynamic balance and reducing sports related injuries among healthy adolescent²¹.

METHODOLOGY

Research design - Experimental study

Sample size – 40

Source of subjects – college of physiotherapy (SBMU University)

Sample design – convenient sampling

Inclusion criteria

1. Physiotherapy students having healthy status.
2. Age 18-21years.
3. They should be regular.
4. They did not undergo in any form of medication for any pathologic condition during the course of study or any other interventions which could influence the body.

Exclusion criteria

1. Any joint pathology.
2. Musculoskeletal problem such as pain, fracture.
3. Psychiatric condition like depression, anxiety.
4. Uncooperative patient.
5. Respiratory and heart problem.
6. Pregnancy.
7. Any neurological condition.



VARIABLES

Independent variable

1. Strengthening exercise and coordination exercise
2. Balance training.

Dependent variable

1. Strength
2. Balance
3. Coordination.

INSTUMENTATION

1. Strain gauge was used to measure strength of Quadriceps muscle before and after fatigue²².
2. Wobble board was used to improve balance²³.
3. Static cycle was used to induce fatigue.
4. Quadriceps table was used to perform strengthening exercise.
5. Weights was also used for performing strengthening exercise²⁴.
6. Chair was used to measure berg balance scale.

PROCEDURE - 40 healthy subjects, both male and female physiotherapy students, with mean age 20.9 ± 2 , having no injury or pathology in any joint, were selected for study and were divided in two group A & B by convenient sampling.

All subjects signed an informed consent form and were informed about the whole procedures before testing and training. In the both groups A & B balance was measured by berg balance scales. Strength was measured by using strain gauge before and after intervention²⁵



Figure 1 Weight and Strain Gauge

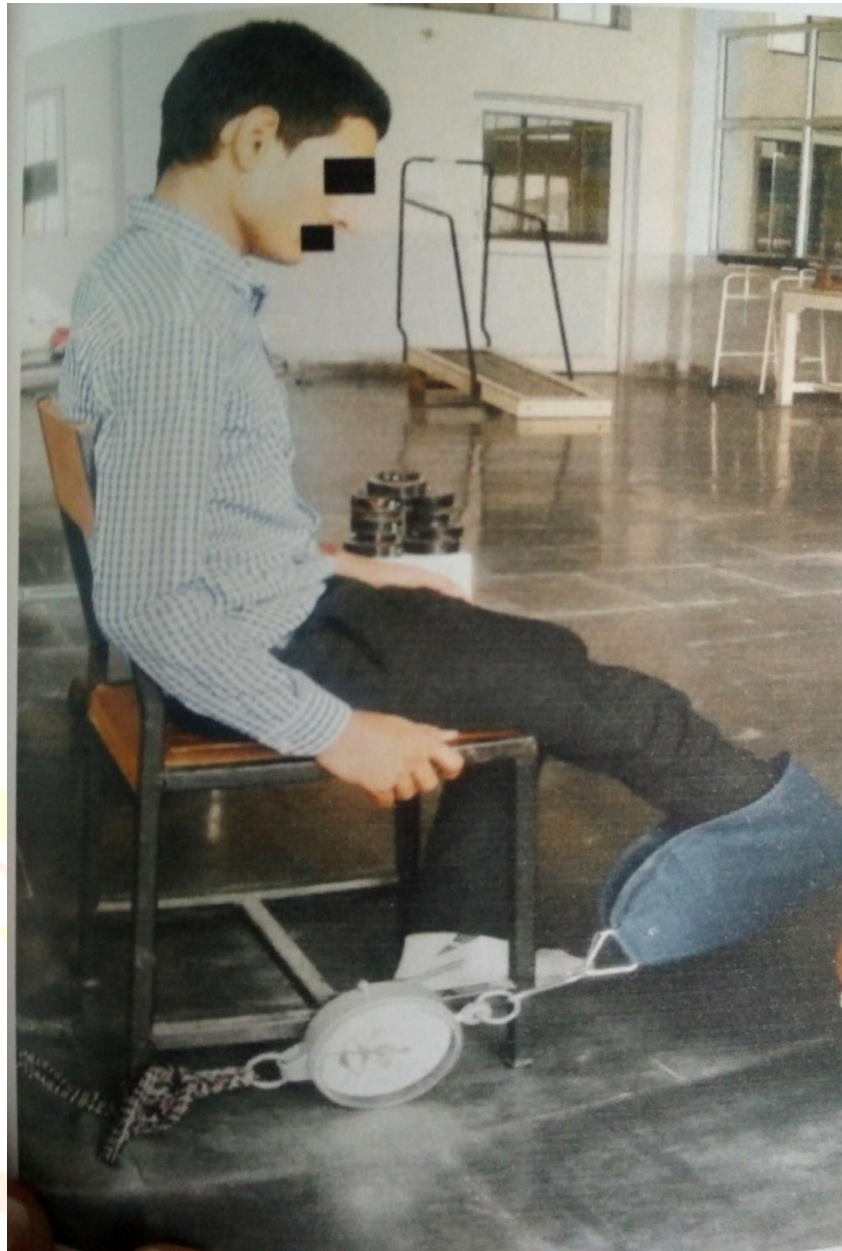


Figure 2 Strength Measurements by Strain Gauge

The subjects in both groups were put to fatigue by asking to do static cycling for a period of 20 minutes. The strain gauge was used in order to record the strength of quadriceps muscle in the above fatigued subjects²⁶.

Now in both the group A and B were asked to perform wobble board exercise in standing position for 20 minutes.

After the completion of above protocol, the subjects of A group were performed quadriceps strengthening exercise by full extension of knee joint against 2 kg (in 90 degree) on quadriceps table. Trunk maintained in erected and hip stabilized at 90degree flexed position, followed by active extension of knee joint. Resistance with weight cuff in high sitting position and hold for 10 seconds followed by 5 seconds rest in flexed position. The exercise was performed for 10 times per session for five days in a week and continued for 8 weeks for both legs. Weight was progressively increased after each 15 days²⁷.

The subjects of group B were submitted to perform coordination exercise in the form of Frenkel's exercise.

Exercise in supine:

1. One leg, for example, the left one bends, then extends as the right leg then bend the left leg again while the right leg extends. This training starts again with the right leg.
2. Bend the right leg at the hip and the knee and place the right heel on the knee of the left leg which is kept in extension. With the right heel in this position, the left leg is flexed. Reverse the movement. Repeat the exercise with the other leg.
3. Flex one leg at the hip and the knee and keep its heel on the knee of the other leg which is kept extended. Now extend the leg by sliding along the leg till heel reaches the middle of the tibia. Now place the heel on the tibia. Now extend the leg by sliding along the leg till the heel reaches the level of the ankle. Now place the heel on the ankle. During these movements, the other leg bends and extends. Repeat with the other leg.

Exercises in sitting position

These exercises should be done sitting on a chair or stool.

1. Patient pulls his knees under the stool
2. Then bends the trunk forward.
3. He stands up by extending his hips and knees.
4. The patient is forced to touch the points marked on the ground with their feet.

Exercise in standing:

1. Walking forward

A full step, $\frac{1}{2}$ step, $\frac{1}{4}$ step forward and alternately with each leg, and like the previous one by counting to three for each step starting with the right leg, the heel is placed right at the front on the ground, then the weight is transferred to the right leg and left heel is lifted off the ground and eventually left foot is placed next to the right foot.

2. Walking back.
3. Walking from heel to toe
4. Walking on special bulging marks
5. on the ground
6. Turning (axial turning done in stages)
7. Going up and down the stairs

The exercises were performed for 8 weeks, three times per week, each session 45 minutes, under the supervision and support of a therapist²⁸.

Reliability of procedure and outcome measures:

1. Major M.J., et al. validity and reliability of berg balance scale.2013; arch phys med rehabil.
2. Down S, Marque J, Chiarelli P(2013) the berg balance scale has high intra and inter rater reliability but absolute reliability varies across the scale ; journal of physiotherapy 59 : 93-99.
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RESULTS

Data was meaningfully assorted through calculation of mean and standard deviation. Thereafter paired and unpaired 't' test was applied in group A and group B within and between the groups. The level of significance was <0.001 .

Table 5.1: description of subjects with the mean age (standard deviation)

Group	No. of subjects	Standard deviation	Mean
Group A	20	0.60	18.55
Group B	20	6.54	19.85

Table 5.1 shows description of subjects with mean value of age with standard deviation for Group A (n= 20) Normal subjects are 18.55 ± 0.60 respectively. Group B (n=20) subjects with mean value of age and standard deviation 19.85 ± 6.54 respectively.

Table 5.2 Comparison between pre intervention balance error in group A before and after fatigue:

Paired 't' test	Pre intervention	
	Pre fatigue	Post fatigue
Group A		
Mean	54.150	44.200
S. D.	1.309	1.240
'T' value	32.809	
Result	S	

Table 5.2 shows comparison between pre reading balance error in group A before and after fatigue find out with the help of paired t test and 't' value was 32.809. the result was significant for balance error (0.001).

Table 5.3 Comparisons between pre intervention balance error in group B before and after fatigue:

Paired 't' test	Pre intervention	
Group B	Pre fatigue	Post fatigue
Mean	53.800	43.600
Standard deviation	1.322	1.698
't' value	35.597	
Result	S	

Table 5.3 shows comparison between pre reading balance error in group B before and after fatigue find out with the help of paired t – test and 't' value was 35.597. There is a statistically significant change ($P = <0.001$)

Table 5.4 Comparisons between post intervention balance error in group A before and after fatigue:

Paired 't' test	Post intervention	
Group B	Pre fatigue	Post fatigue
Mean	55.550	51.900
Standard deviation	0.605	1.447
't' value	12.105	
Result	S	

Table 5.4 shows comparison between pre reading balance error in group A before and after fatigue find out with the help of paired t – test and 't' value was 12.105. there is a statistically significant change ($P = <0.001$).

Table 5.5 Comparison between post intervention balance error in group B before and after fatigue:

Paired 't' test	Post intervention	
Group B	Pre fatigue	Post fatigue
Mean	55.850	46.650
Standard deviation	0.366	1.843
't' value	21.559	
Result	S	

Table 5.5 shows comparison between post reading balance error in group B before and after fatigue find out with the help of paired t test and 't' value was 21.559. There is a statistically significant change ($P = <0.001$)

Table 5.6 Comparison between pre and post intervention balance error in group A:

Paired 't' test	Pre intervention	Post intervention
Group A		
Mean	9.950	3.650
Standard deviation	1.356	1.348
't' value	16.098	
Result	S	

Table 5.6 shows comparison between pre and post reading balance error in group A, find out with the help of paired 't' test and 't' value was 16.098. The result was significant for balance error (0.001).

Table 5.7 Comparison between pre and post intervention balance error in group B≤:

Paired 't' test	Pre intervention	Post intervention
Group B		
Mean	10.200	9.200
Standard deviation	1.281	1.908
't' value	21.559	
Result	S	

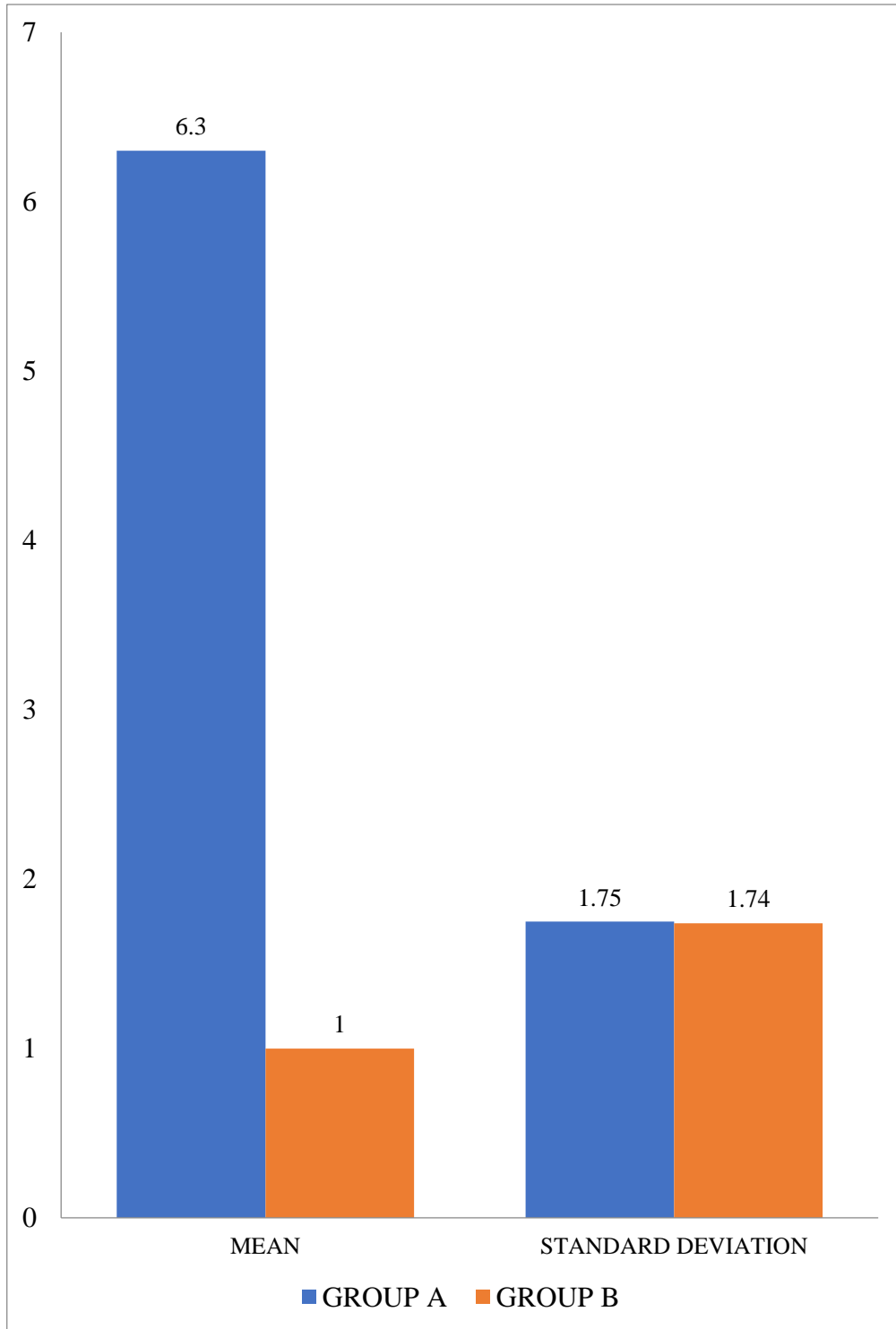
Table 5.7 shows comparison between pre and post reading balance error in group B, find out with the help of paired 't' test and 't' value was 21.559. The result was significant for balance error (0.001).

Table 5.8 Comparison between group A and B post intervention balance error:

Unpaired 't' test	Post fatigue	
	Group A	Group B
Mean	6.300	1.00
Standard deviation	1.750	1.747
't' value	9.584	
Result	S	

Table 5 shows that comparison between post reading balance error in group A and B post fatigue find out with the help of unpaired ‘t’ test and ‘t’ value was **9.584**. There was a statistically significant difference between the input groups ($P \leq 0.001$).

Graph 5.8 Comparison between group A and B post intervention balance error:



DISCUSSION: The data of present study reveals that Group A (n=20) healthy subjects with mean age 18.55 ± 0.60 and Group B (n=20) healthy subjects with the mean age 19.85 ± 6.54 examined for balance before and after fatigue. Paired 't' test was applied within the group A and Group B before and after fatigue and pre and post intervention. Un-paired t- test was applied between the group A and B before and after intervention. In group A during pre-intervention shows mean difference in subjects for balance error pre fatigue 54.150 and post fatigue 44.200 (paired 't' value was 32.809), mean differences in normal subjects of group B for balance error pre fatigue 53.800 and post fatigue 43.600 (paired 't' value was 35.597), result shows significant differences in both groups on pre intervention. Paired 't' test was also applied in group A and group B post intervention. Mean difference in normal subjects of group A for balance error pre fatigue 55.550 and post fatigue 51.900 (paired 't' value was 12.105), result shows significant difference in group A, mean difference in normal subjects of group B for balance error pre fatigue 55.850 and post fatigue 46.650 (paired 't' value was 21.559), result shows significant differences. Unpaired 't' test was applied between the groups A and B post intervention for balance error pre and post fatigue. Mean differences in normal subjects for balance error pre fatigue post intervention in group A 6.300 and in group B 1.000 (unpaired 't' value was 9.584) and significant difference found on post fatigue. So, this study shows a significant improvement in balance error, thereby alternate hypothesis is accepted.

The result of present study indicate that fatigue reduces balance and after giving strengthening exercise and coordination exercise combined with wobble board, we can improve balance. Rahmanto Safun.(2017) proposed a study on muscle quadriceps femoris strength with postural balance level in elderly to know the relationship between the quadriceps muscle strength with postural level of balance in elderly The study conclude that there is a strong relationship between the quadriceps femoris muscle strength with postural balance¹⁸. Abutaleb E. E., Mohamed A. H..(2016) proposed a study to look into the effect of induced fatigue on dynamic postural balance in healthy young adults. The study was concluded that induced whole body fatigue decreased the dynamic postural balance (overall stability index, anteroposterior stability index and mediolateral stability index) in healthy young adults⁹. The finding of Hee Lee I., Park S. Y. (2013) on elderly, Study evaluating the balance improvement by strength training. They also used strengthening exercise for improving balance in their study and found a statically difference in improving balance²⁹. Panwar N, Narwal R, kadyan G, Gupta A, Narwal RV (2014) found in their study the wobble board balance training program is an effective mean for improvement of static and dynamic balance in male collegiate basketball athletes³⁰.

Granacher U. et al. Can Balance Training Promote Balance and Strength in Prepubertal Children? (2011).. This study concluded that there was a significant improvement in postural control, increases in RFD (rate of force development) of the leg extensors as well as an enhanced jumping height in squat jump (SJ) and CMJ after 4 weeks of Balance Training implemented in PE lessons in healthy active adolescent high-school students³¹. Fitzgerald D. Trakarantankul N. Smyth B. Caulfield B (2010). Conducted a study to compare the Effects of a Wobble Board-Based Therapeutic Exergaming System for Balance Training on Dynamic Postural Stability and

Intrinsic Motivation Levels. In this study showed an improvement in dynamic postural stability similar to that of a conventional training program³².

Surenkok et al. (2006), the authors investigated how balance, specifically static balance, was affected by knee muscle fatigue and lactate. It was concluded that muscle fatigue has a detrimental effect on balance³³. A Carolyn, classify D ,klassen P Terry,JRohanda, H Brian(2005) concluded in their study a home based balance training program using a wobble board is effective in improving the static and dynamic balance and in reducing sports related injuries among healthy adolescent³⁴. Buchner D. M. et al. (1997) evaluated the Effect of Strength and Endurance Training on Gait, Balance, Fall Risk, and Health Services Use in Community-Living Older Adults. The study concluded that there were no effects of exercise on gait, balance, or physical health status. Exercise had a protective effect on risk of falling³⁵.

Goel A, Agrawal S, Verma M. conducted a study to know the Effect of Balance Exercise on Balance, Pain and Functional Performance in Osteoarthritis Knee. This study found that the balance exercises are effective in improving balance, functional performance and decreasing pain in osteoarthritis knee³⁶. **Wright, Katherine,** "Effects of Exercise Induced Fatigue on Postural Balance: A Comparison of Treadmill Versus Cycle Fatiguing Protocols" (2008). The results of this study indicate that fatigue induced by the treadmill test does have a higher detrimental effect on postural balance when compared to the cycle ergometer test. This study showed that fatigue induced by the Bruce treadmill test significantly reduces postural stability performance¹⁷. **Jung yang D. et al. (2016) evaluate** the correlation between quadriceps muscle activity and balance and gait in stroke patients. This study confirmed that significant correlations exist between quadriceps muscle activity and stability limits and gait velocity in stroke patients³⁷.

These previous studies proved that fatigue decreases the balance and also suggest that improvement of balance by rehabilitation program resulted from improved muscle strength. This is consistent with the previous literature, where improved muscle strength led to improved proprioceptive accuracy and functional abilities of patient. They all suggested that strength, proprioception and balance are correlated to each other. This is because that proprioceptors are not only present in joint, but they also present in muscle spindle and tendon. As we also fatigue the muscle then give a session of strengthening exercise with wobble board exercise to one group and coordination exercise with wobble board exercise to second group for 8 weeks (4-5 days in a week) for improving strength of quadriceps muscle and outcome measures show that strengthening exercise combined with wobble board exercise improves the balance in subjects.

So, it is concluded that both strengthening exercise and coordination exercise with balance training through wobble board are effective in improving balance. But strengthening exercise with balance training through wobble board has better effect in improving balance than coordination exercises.

CONCLUSION AND SUMMARY

The data reveals that Group A (n=20) normally healthy subjects with the mean age 18.55 ± 0.60 and Group B (n=20) subjects with mean age 19.85 ± 6.54 examined for balance before and after fatigue. The result showed that there were clinically and statistically significant differences between these two groups. It is concluded that fatigue decreases the balance and strengthening exercise with balance training through wobble board give better result to improve balance.

Limitation of study

- Small sample size.
- Females' subject ratio was more than male ratio.

Duration of study was much less and also long-term effect of result improvement could not be recorded.

Future scope of study

As, we proved that strengthening exercise combined with balance training through wobble board is better in improving in strength and balance. So, researcher can also consider this study in older patient and through other muscle which plays an important role in maintaining balance. It will also help in improving balance in clinical practice.

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