



P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2022; 9(3): 97-102
© 2022 IJPESH
www.kheljournal.com
Received: 15-02-2022
Accepted: 23-04-2022

Dr. Shweta Ravindra Kulkarni
M.P.T, P.E.S Modern College of
Physiotherapy Pune,
Maharashtra, India

Dr. Priyanka Honkalas
Associate Professor, P.E.S
Modern College of
Physiotherapy, Pune,
Maharashtra, India

Dr. Sucheta Golhar
Principal of P.E.S Modern
College of Physiotherapy, Pune,
Maharashtra, India

Corresponding Author:
Dr. Shweta Ravindra Kulkarni
M.P.T, P.E.S Modern College of
Physiotherapy Pune,
Maharashtra, India

Effect of Pilates and core stabilization exercises on flexibility and strength in postmenopausal female: An experimental study

Dr. Shweta Ravindra Kulkarni, Dr. Priyanka Honkalas and Dr. Sucheta Golhar

Abstract

Background: Post-menopausal women experience a number of physical changes that are loss of muscle strength and flexibility, which contributes to majority of musculoskeletal disorders. Aim was to study the effect of Pilates and core stabilization exercises on flexibility and strength in postmenopausal women.

Materials and Methodology: Experimental study was conducted with convenient sampling. Postmenopausal female who fulfilled screening criteria (n=60) were assigned to Group A (n=30) Group B (n=30). All the participants in the study were assessed for flexibility by sit and reach test and strength by Pressure biofeedback unit and were given interventions for 3times/week for 6 weeks. Participants were divided into 2 groups: Group A received Pilates training while Group B received Core stabilization exercises. Post intervention again flexibility and strength were assessed by Sit and reach and Pressure Biofeedback Unit respectively. Data collected was analyzed using parametric test. P value less than 0.05 was considered statistically significant.

Statistical Analysis: Intergroup analysis was done using paired t test and intragroup analysis was done using unpaired t test P value less than 0.05 was considered statistically significant.

Results: Statistically no significant ($p < 0.05$) changes were seen in the score of Sit and reach and Pressure Biofeedback Unit. But mean difference suggests more improvement in Group A than Group B.

Conclusion: Pilates training is better compared to Core stabilization technique in improving flexibility and strength in postmenopausal women.

Keywords: Postmenopausal, flexibility, strength, pressure biofeedback unit, sit and reach

Introduction

All women, beyond middle age, experience a transition period that is from reproductive stage to non-reproductive stage of life. The most striking feature of non-productive stage is cessation of menstruation, which is also known as menopause [1].

According to the World Health Organization, "natural menopause" is defined as "no menses for 12 consecutive months with no obvious intervening cause, such as pregnancy, lactation, exogenous hormone use, dietary deficiencies, or surgical removal of the uterus or ovaries."

Menopause accelerates ageing process; menopause leads to the cessation of estrogen production. Estrogen has strong effect on function of muscle, tendon and ligament.

The prevalence of menopausal symptoms was found to be 47% and Mean age at menopause was 44.9 years [3]. The most common menopausal symptoms among postmenopausal women were of physical domain (around 81%) [2].

Physical symptoms are perceived more due to normal ageing process and are overly emphasized, as a limitation to their daily work performance [4].

Menopausal women experience a number of physical changes that are loss of muscle strength and flexibility, which contributes to majority of musculoskeletal disorders [3, 5].

The loss of muscle strength appears to be concurrent with the occurrence of menopause [10].

In postmenopausal women physiological process of aging is seen markedly, that is decrease in motor skills, reduced strength, flexibility and speed, hindering daily activities and maintenance of a healthy lifestyle, although individual variation is considerable. Practicing regular physical exercises minimizes changes resulting from senescence and menopause as reflected by

improved body composition, decreased joint pain and vascular resistance, increased bone mineral density, aerobic capacity, muscle strength and flexibility [6].

Core should be stable for optimal posture and to move the limbs. Stable spine is attained, largely by core muscles and partly by passive and neural elements. Stable spine needs for lower limb activities.

Core is the center of kinetic chain, links the upper limb and lower limb. A strong core allows an individual the full transfer of forces generated from the ground through the lower extremities, the torso, and finally to the upper extremities.

A weak core is believed to cause alterations in the transfer of energy, resulting in reduced performance. The ability to generate the lower body power is essential for enhanced performance in many day-to-day activities like walking, running, sit to stand and transfers. Several methods of exercises have been administered for core stability. Among those Pilates is also more concerned about core stability [10]. Core stability is usually used to strengthen the muscles around the abdominal, lumbar, and pelvic regions, because the muscles of these regions play an important role in stability as well as in controlling the lumbar posture by using tonic or postural muscles during whole-body exercises (Marshall and Murphy, 2005). Although muscles related to core stability have individual roles, they function in concert via cooperative contraction to establish core stability (Richardson *et al.*, 1995). Exercises for core stability serve as treatment for simultaneously activating the abdominal and multifidus muscles in order to stabilize the body and head during the beginning of limb movements and during the course of these movements (Hodges and Richardson, 1997). The cooperative contractions of transversus abdominis and multifidus muscles improve the stability of each part when the spine is in neutral position or in motion (Porterfield *et al.*, 1998) [10].

During last decade demand of physiotherapy has been increased for improving core fitness. Among these such interventions, which are proved to be effective in improving core strength and flexibility, are Pilates and core stabilization exercises [10].

Pilates and core stabilization exercises both work on improving strength and flexibility of trunk and both limbs. Several methods are advocated to evaluate truncal strength and flexibility, among which pressure biofeedback unit (PBU) and sit and reach are efficient and easy to administer in postmenopausal population [11].

It has been suggested that PBU can aid in the quantification and retraining of deep stabilizing muscle groups by accessing sensory factors such as those identified by Miller and Mederio (Richardson and Jull, 1995). Sit and reach can be used in quantification of flexibility of trunk and hamstring muscles [22]. The muscles around the abdominal, lumbar, and pelvic regions are important to maintain stability as well as for controlling the lumbar posture by using tonic or postural muscles during whole-body exercises [4, 8].

Women can enjoy a good quality of life after menopause even without hormones. Exercise works by improving muscle mass, strength, flexibility, balance, and coordination. Reduced flexibility and strength in postmenopausal women can lead to various biomechanical changes and altered postures. This can affect balance and eventually lead to fall [6]. Flexibility and strength are required to perform daily activities with ease.

There is a dearth of literature on the comparison of short term effect of Pilates and Core stabilization on postmenopausal

women.

Hence there is need to compare the effect of Pilates and core stabilization exercises on flexibility and strength in postmenopausal females.

Materials and Methodology

- **Study Design:** Experimental study.
- **Study Type:** Pre-Post Comparative.
- **Study Setting:** In and around city.
- **Study Population:** Post-menopausal females Age 45-60 [11].
- **Sample Size:** 60

Eligibility Criteria

Inclusion Criteria

1. Post-menopausal Female population from age group 45-60 who were in menopausal stage for >1yr [23].
2. Having >11 cm/average value in sit and reach test [47].
3. Females not undergoing any intense exercise programme.
4. Abdominal strength more than or equal to fair.

Exclusion criteria

1. Having complains of musculoskeletal, neurological problems, pulmonary disorders and cardiac problems that would contradict physical activity.
2. Receiving hormonal replacement therapy within the past 6 months.
3. Acute Abdominal surgeries.

Materials Used

Measuring tape, Pen and paper, Mats for exercises, Pressure biofeedback unit

Outcome Measures

- YMCA SIT AND REACH: ICC for SIT AND REACH score is 0.92 [9].
- PRESSURE BIOFEEDBACK UNIT score is 0.81 [10].

Procedure

The study began after approval from the ethical committee.

Post-menopausal women were approached. The subjects were given information about study

Subjects were selected according to inclusion and exclusion criteria and written consent was given after explaining aims and objectives.

Each of them was asked to fill consent form.

Sampling of populations was done in two group.

Outcome measures were assessed pre and post intervention program

Participants underwent a Thrice-a-week 45 mins of exercise intervention for 6 weeks. Starting 5 min warm-up with very low-intensity exercises, including breathing and joint mobility exercises carried out in upright position. Finally, subjects will perform a 5-min cool down consisting of stretching exercises

Group A consist of Pilates program as follows:

Pilates program consisted of exercises that emphasize the 6 principles of Pilates such as the Hundred, Roll Up, Leg Stretch (single and double), Leg Circles (single and double), Rolling like a Ball, Spine Stretch Forward, Saw, Teaser, Swan Dive, Crisscross, Coccyx Curl and Curl up. Each exercise will be repeated 10–15 times for 2–5 sets, with a 10-sec rest per repetition and 60 sec between sets.

The rating of perceived exertion (RPE) will be used to gradually increase the program intensity.

Group B will consist of Core stabilization exercise:

- a. Train TrA muscle activation in a prone lying position without spinal and pelvic movements for 10seconds. Keep respiration normal. Gently draw in the lower anterior abdominal wall below the navel level (abdominal drawing-in manoeuvre) with supplemented contraction of pelvic floor muscles, control your breathing normally, and have no movement of the spine and pelvis while lying prone on a couch with a small pillow placed beneath your ankles.
- b. Train MF activation in an upright sitting position. You raise the contralateral arm while performing the abdominal drawing-in manoeuvre in a sitting position on a yoga ball.
- c. Perform co-contraction of the two muscles in a crooked lying position with both hips at 45 degrees and both knees at 90 degrees. Then, you abduct one leg to 45 degrees of hip abduction and hold it for 10 seconds.
- d. Train co-contraction of these muscles in a crooked lying position with both hips at 45 degrees and both knees at 90 degrees. Then, you slide a single leg down until the knee is straight, maintain it for 10-second holds, and then slide it backup to the starting position.
- e. Perform co-contraction of the two muscles while raising the buttocks off a couch from a crooked lying position until your shoulders, hips and knees are straight. You sustain this pose for 10 seconds and then lower the buttocks back down to the couch.
- f. Train muscle co-contraction while raising the buttocks off a couch from a crooked lying position with one leg crossed over the supporting leg. You raise the buttocks off the couch until the shoulders, hips, and knees are straight. You sustain this pose for 10 seconds and then lower the buttocks back down to the couch.
- g. Perform co-contraction while raising a single leg from a four-point kneeling position and keeping your back in a neutral position. You sustain this pose for 10seconds and then return the leg to the starting position.
- h. Train muscle co-contraction while raising an arm and alternate leg from a four-point kneeling position and keeping your back in a neutral position. You sustain this pose for 10seconds and then return to the starting position. Black arrows show the contraction direction of core muscles.

7. Results and Tables

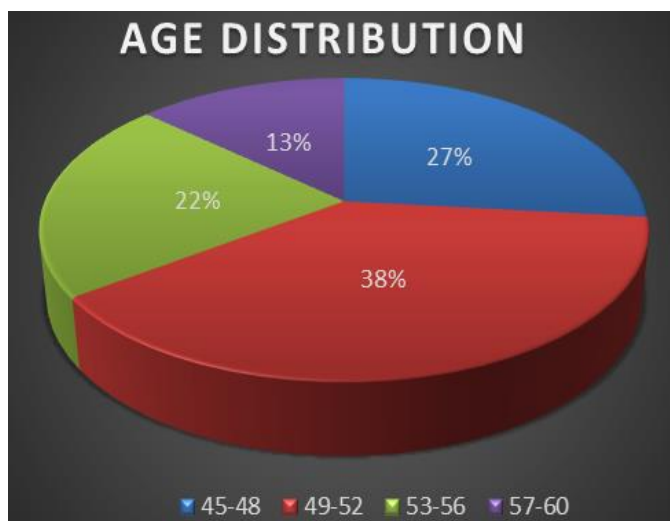
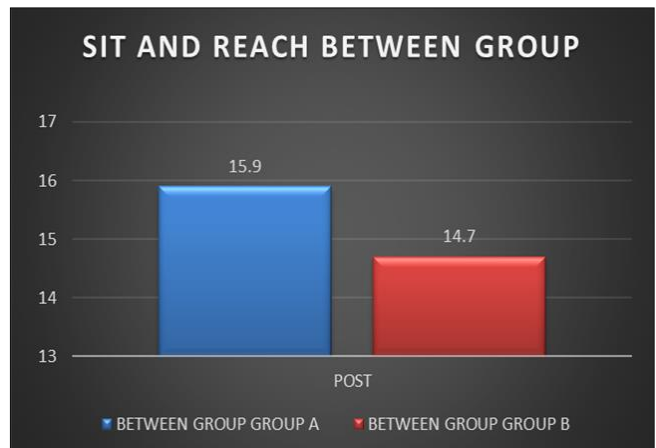


Fig 1: Age Distribution of the Sample

Table 1: SIT and reach between Group: unpaired test

Group	Mean	STDV	p Value	t Value
A (Post)	15.9	2.01	P value is 0.0253	t = 2.2955 with 58 degrees of freedom
B (Post)	14.7	1.81		



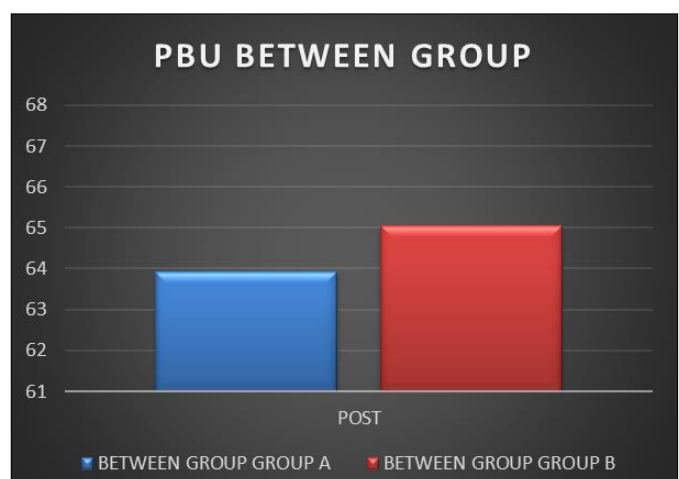
Graph 1: SIT and Reach Between Groups: Unpaired Test

Graphical Interpretation: This graph shows changes in post values of SIT AND REACH compared with post values of group A and group B. Y axis shows difference in SIT AND REACH score and X-axis shows post values

Graphical Result: The result obtained for Unpaired t test for SIT AND REACH suggests considered extremely significant improvement in 'p' value obtained (p=0.0253) for both groups statistically. But group A (mean 15.9) suggests more significance and increase in flexibility more than group B (mean 14.7).

Table 2: PBU between Group: Unpaired Test

Group	Mean	STDV	p Value	t Value
Post (A)	63.93	2.22	0.0357	t = 2.1869 with 58 degrees of freedom.
Post (B)	65.06	1.76		



Graph 2: PBU between Group: Unpaired Test

Graphical Interpretation: This graph shows changes in PBU post values of group A and group B. Y axis shows difference in strength by PBU and X-axis shows post values.

Graphical Result: The result obtained for Unpaired t test for PBU suggests considered statistically significant improvement in 'p' value obtained (p=0.0357) for both groups statistically. But mean difference of group A (63.93)

suggests more significant and increase in strength more than group B (65.06).

Discussion

The aim of the present study was to study the effect of Pilates versus core stabilization exercises on flexibility and strength in post-menopausal females. Study was conducted on total 60 subjects who have had menopause since > 1yr. Study included 45-60yrs of postmenopausal female (Group A (51.06 ±3.63) Group B (51.63 ±3.64), sit and reach score Group A (13.43) Group B (13.46).

All the participants in the study were assessed for flexibility by sit and reach test and strength by pressure biofeedback unit and were given interventions for 6 weeks. Participants were divided into 2 groups: Group A received Pilates training while Group B received core stabilization exercises. Post intervention again flexibility and strength were assessed by Sit and reach and PBU respectively. There is no significant difference in p value (>0.05) between PRE values of both outcome measures of both the groups and hence both the groups are comparable.

Data collected was analysed using parametric test. P value less than 0.05 was considered statistically significant.

There is a statistically significant difference (p=0.0253) in flexibility within Group A and Group B. But group A (mean 15.9) suggests more significance and increase in flexibility more than group B (mean 14.7).

There is a statistically significant improvement in 'p' value obtained (p=0.0357) in strength for Group A and Group B. But mean difference of group A (63.93) suggests more significant and increase in strength more than group B (65.06)

The Pilates method has a main objective to strengthen the abdominal and pelvic muscles. These muscles, including the iliopsoas, lumbosacral region, pelvic floor and quadriceps, are widely used to stabilize the torso, providing thereby improvement in the pain condition, spinal stabilization, and posture maintenance also preventing damage. The Mat Pilates are the exercises performed on the floor wherein our own body weight and gravity is used as resistance.

One of the key Pilates techniques to align, lengthen, and protect the spine is to draw the navel to the spine. Abdominal hollowing, or the abdominal drawing-in maneuver, preferentially recruits TrA, internal obliques, and multifidi. One of the proposed benefits of hollowing is to decrease the laxity of the sacroiliac joint more than abdominal bracing. Pilates emphasized posture as an integrated whole-body activity. Muscles not primary to the movement pattern remain actively engaged and in alignment with each exercise. This concept exemplifies muscle integration in lieu of isolation and illustrates an application of the regional interdependency approach. Total leg strengthening, total arm strengthening, and total core strengthening capitalize on the radiation concept, whereby weaker muscles are facilitated by the stronger ones in the movement pattern [24].

In the Pilates stance, body weight is maintained slightly forward on the balls of the feet. With the core already engaged and with alignment optimal, the spine is prepared and protected for performing more skilled tasks

Pilates exercises as found to be an efficient training method with significant changes in abdominal strength, and endurance in sedentary adult females. There is improvement of strength which occurs due to deep inhalation, the diaphragm drops allowing more air to the lungs, this volume of air of lungs increases the pneumatic pressure within the abdominal cavity due to drooping of diaphragm resulting in increase in the

pressure of the entire trunk providing greater strength stabilization and will increase the core stability of the trunk.²⁴

The core stability or trunk stability trainings will stabilize the body and ensure balance of the body when moving the limbs. Strengthening the main muscles involved in this stability (transverse abdominal muscles, and pelvic floor) maintains a greater balance and stability of the trunk in the everyday activities. Also, core stability trainings lead to improved activity prediction and thus reduce disturbance in the displacement and vacillation of the center of gravity [25].

A large part of the core stability and Pilates trainings are focused on movements to enhance balance, power and flexibility. Therefore, the improvement of balance and physical flexibility in experimental groups seems obvious. Reducing strength, flexibility, and muscular endurance all contribute to changing patterns of stepping and are potential factors for falling, which in this regard a selected program can compensate for such a decline.

In one study, main finding was that both TrA and OI muscles were significantly thicker during all correctly performed Pilates exercises investigated compared with resting supine. TrA and OI muscle thickness change has been shown to correlate with EMG muscular activity up to moderate levels of effort, suggesting that this thickness increase indicates muscle activity, possibly in order to help stabilize or protect the spine [26].

Together, the core stability training monitored by rehabilitative ultrasound imaging and surface electromyogram can markedly activate and enhance local core muscles in healthy people, providing a potential strategy to treat low back pain more effectively [12].

Proximal stability for performing distal movements improves the motion patterns and reduces the incidence of falling in the elderly. In the case of Pilates trainings, the role of stabilizing, moving, and contracting muscles is constantly being replaced. This change in the role of muscles can be effective in improving muscle strength, and hence Pilates trainings can increase muscle strength [26].

Sekendiz *et al.* (2007) examined the effects of Pilates exercise on abdominal and lower back strength, abdominal muscular endurance and posterior trunk flexibility of sedentary adult females. Participants consisted of 21 women (mean age: 30 ± 6.6 range 26–47) in the exercise group and 17 women (mean age: 30 ± 8.6 range 26–47) in the control group. Their abdominal and lower back strength, posterior trunk flexion and extension data were obtained concentrically on a Biodex isokinetic dynamometer at speeds of 60° and 120°s⁻¹. They concluded that there was a positive effect of Modern Pilates mat exercises on abdominal and lower back muscular strength, abdominal muscular endurance and posterior trunk flexibility in sedentary adult females regardless of the fact that the body weight and fat percentages did not differ significantly. These results are similar to the results of our trials in older adults [27].

Skeletal muscle can be influenced greatly by Pilates-evolved exercises. In contrast to traditional modes of muscle conditioning that seek maximal voluntary contractions, Pilates evolved muscle conditioning focuses on recruitment of the most effective motor units. This form of recruitment allows for an emphasis to be placed on energy efficiency and quality of performance. Physiologically, most muscle recruitment during day-to-day activities occurs in postural muscles, which contain predominately type I fibers. By facilitating postural muscles in the right sequence, a therapist can assist a patient in improving the efficiency of static and dynamic posture and

decreasing significantly the likelihood of self-induced destructive forces.

Conclusion

The findings of the study conclude that Pilates exercises and core stabilization exercises can be used to improve flexibility and strength in post-menopausal women

However, Pilates training is better as compared to Core stabilization technique in improving flexibility and strength in post-menopausal women

Limitation

Dropouts due to ongoing pandemic

Clinical Implication

Easy ADLs are necessary for each and every individual, especially those undergoing decline in their physiological condition. Balance is most vital for an independent individual. Strength and flexibility have the most contribution in an individual to maintain its balance. Therefore, it is vital to improve flexibility and strength.

Pilates and core stabilization exercises once mastered by patients can be performed by themselves as a home program for improving strength and flexibility.

Future Scope

This study was done on healthy subjects' similar study can be done in females who are overweight and have risk of osteoporosis.

Similar participants can be followed for Longitudinal study with different modules of Pilates

Acknowledgement

The satisfaction that accompanies the successful completion of any task would be incomplete without mentioning of people whose ceaseless co-operation, guidance and encouragement crowns all the efforts with success. I would like to express my sincere gratitude to all those who supported me in any respect during the completion of the study. Last, but not the least, I express my sincere thankyou to all the subjects who participated and gave their full co-operation for the study.

References

- Pallikadavath S, Ogollah R, Singh A, Dean T, Dewey A, Stones W. Natural menopause among women below 50 years in India: A population-based study. *Indian J Med Res.* 2016;144(3):366-377.
- Pathak N, Shivaswamy MS. Prevalence of menopausal symptoms among postmenopausal women of urban Belagavi, Karnataka. *Indian J Health Sci Biomed Res.* 2018;11:77-80.
- Shukla R, Ganjiwale J, Patel R. Prevalence of Postmenopausal Symptoms, Its Effect on Quality of Life and Coping in Rural Couple. *J Midlife Health.* 2018;9(1):14-20. Doi: 10.4103/jmh.JMH_34_16
- Bergamin M, Gobbo S, Bullo V, Zanotto T, Vendramin B, Duregon F, *et al.* Effects of a Pilates exercise program on muscle strength, postural control and body composition: results from a pilot study in a group of post-menopausal women. *Age.* 2015 Dec;37(6):1-8.
- Borker SA, Venugopalan PP, Bhat SN. Study of menopausal symptoms, and perceptions about menopause among women at a rural community in Kerala. *Journal of mid-life health.* 2013 Jul;4(3):182.
- De Souza Santos C, Cader S, Dantas E, Moreira M. Physical fitness of post-menopausal women submitted to a physical activities programme. *Biomedical Human Kinetics.* 2010;2:93.
- Kapdule P, Pol T. Relationship between Core Stability and Physical Activity in Young Adults. *International Journal of Health Sciences & Research (www.ijhsr.org)* 126 July 2019;9(7).
- Pournima Pawar A, Anuja Bochare B. Effects of mat based Pilates exercises Vs conventional exercises on core muscle strength in postnatal women *International Journal of Academic Research and Development* Volume 3; Issue 1; January 2018, 772-776.
- Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. *Current sports medicine reports.* 2008 Jan 1;7(1):39-44.
- Ragunath B. Effects of Pilates and Conventional Core Stability Exercises on Core Stability and Vertical Jump Performance of Basketball Players (Doctoral dissertation, KMCH College of Physiotherapy, Coimbatore).
- Akuthota, Venu & Ferreiro, Andrea & Moore, Tamara & Fredericson, Michael. Core Stability Exercise Principles. *Current sports medicine reports* 2008;7:39-44. 10.1097/01.
- Zheng Y, Ke S, Lin C, Li X, Liu C, Wu Y, *et al.* Effect of Core Stability Training Monitored by Rehabilitative Ultrasound Image and Surface Electromyogram in Local Core Muscles of Healthy People. *Pain Research and Management.* 2019; ID 9130959 P 8
- Naderi Z, Jalali K. The Effect of Eight Weeks of Core Stability and Pilates Trainings on Ankle Proprioception, Postural Control, Walking Performance, Self-efficacy and Fear of Falling in Elderly Women. *Report of Health Care.* 2018 Sep 1;4(3):1-3.
- Dr. Shamla Pazare, Dr. Neha Tambe. Effect of Pilates exercise on abdominal strength & endurance, girth & skin fold in young women *Indian Journal of Basic and Applied Medical Research;* June 2018;7(3):177-183.
- Vikranth GR, Lawrence Mathias. Effectiveness of core stabilization exercise and motor control exercises in patient with low back ache. *Int J Physiotherapy.* June 2015;2(3):544-551.
- Lee H, Caguicla JM, Park S, Kwak DJ, Won DY, Park Y, *et al.* Effects of 8-week Pilates exercise program on menopausal symptoms and lumbar strength and flexibility in postmenopausal women. *Journal of exercise rehabilitation.* 2016 Jun;12(3):247.
- Hsu SL, Oda H, Shirahata S, Watanabe M, Sasaki M. Effects of core strength training on core stability. *Journal of physical therapy science.* 2018;30(8):1014-8.
- De, César, Santos Souza, Cader Samária, Dantas Estélio, Helena Maria. Physical fitness of post-menopausal women submitted to a physical activities programme. *Biomedical Human Kinetics.* 2010;2:93-96.
- Özmen T, Gafuroğlu Ü, Aliyeva A, Elverici E. Relationship between core stability and dynamic balance in women with postmenopausal osteoporosis. *Turkish Journal of Physical Medicine and Rehabilitation.* 2018 Sep;64(3):239.
- Yu SH, Park SD. The effects of core stability strength exercise on muscle activity and trunk impairment scale in stroke patients. *Journal of exercise rehabilitation.* 2013 Jun;9(3):362.
- Yang KH, Park DJ. Reliability of ultrasound in combination with surface electromyogram for evaluating

- the activity of abdominal muscles in individuals with and without low back pain. *Journal of exercise rehabilitation*. 2014 Aug;10(4):230.
22. Cairns MC, Harrison K, Wright C. Pressure biofeedback: a useful tool in the quantification of abdominal muscular dysfunction?. *Physiotherapy*. 2000 Mar 1;86(3):127-38.
 23. Larroy C, Marin Martin C, Lopez-Picado A, *et al*. The impact of perimenopausal symptomatology, sociodemographic status and knowledge of menopause on women's quality of life. *Arch Gynecol Obstet*. 2020; 301: 1061-1068
 24. Pazare S, Tambe N, Bhadgaonkar B. Effect of Pilates exercise on abdominal strength & endurance, girth & skin fold in young women. *Indian Journal of Basic and Applied Medical Research*. 2018;7(3):177-83.
 25. Naderi Z, Jalali K. The effect of eight weeks of core stability and Pilates trainings on ankle proprioception, postural control, walking performance, self-efficacy and fear of falling in elderly women. *Report of Health Care*. 2018 Sep 1;4(3):1-3.
 26. Marshall PW, Murphy BA. Core stability exercises on and off a Swiss ball. *Archives of physical medicine and rehabilitation*. 2005 Feb 1;86(2):242-9.
 27. Irez GB, Ozdemir RA, Evin R, Irez SG, Korkusuz F. Integrating Pilates exercise into an exercise program for 65+ year-old women to reduce falls. *Journal of sports science & medicine*. 2011 Mar;10(1):105.
 28. Anderson BD, Spector A. Introduction to Pilates-based rehabilitation. *Orthopedic Physical Therapy Clinics of North America*. 2000 Sep;9(3):395-410.
 29. Daniel FD, de Souza Vale RG, Giani TS, Bacellar S, Dantas EH. Functional autonomy of elderly women enrolled in a physical activity program. *Acta Scientiarum. Health Sciences*. 2012 May 7;34(2):151-6.
 30. Puntumetakul R, Areeudomwong P, Emasithi A, Yamauchi J. Effect of 10-week core stabilization exercise training and detraining on pain-related outcomes in patients with clinical lumbar instability. *Patient preference and adherence*. 2013;7:1189.
 31. Chidi-Ogbolu N, Baar K. Effect of estrogen on musculoskeletal performance and injury risk. *Frontiers in physiology*. 2019 Jan 15; 9:1834.
 32. Kapdule P, Pol T. Relationship between Core Stability and Physical Activity in Young Adults. *International Journal of Health Sciences & Research* 126 Vol.9; Issue: 7; July 2019
 33. Mishra N, VN Mishra D. Exercise beyond menopause: Dos and Don'ts. *Journal of mid-life health*. 2011 Jul;2(2):51.
 34. Fourie M, Gildenhuis GM, Shaw I, Shaw BS, Toriola AL, Goon DT. Effects of a mat Pilates programme on body composition in elderly women. *West Indian Med J*. 2013 Jul 1;62(6):524-8.
 35. Oliveira LC, Oliveira RG, de Almeida Pires-Oliveira DA. Pilates increases the isokinetic muscular strength of the knee extensors and flexors in elderly women. *Journal of bodywork and movement therapies*. 2017 Oct 1;21(4):815-22.
 36. Zandi S, Shadmehri S, Kazemi N. The effect of Pilates training on isoprostane, fasting glucose and body composition in women with breast cancer. *rep health care*. 2016; 2 (4): 26- 33.
 37. Menacho MO, Obara K, Conceição JS, Chitolina ML, Krantz DR, da Silva RA, *et al*, Electromyographic effect of mat pilates exercise on the back muscle activity of healthy adult females. *J MPT*. 2010;33(9):672- 678.
 38. Shadkampung S, Rahnama N. The effect of stabilization exercise with and without aquatic exercise on pain and disability of female patients with chronic low back pain. *Rep Health Care*. 2016;2(3):25- 34.
 39. Shea S, Moriello G. Feasibility and outcomes of a classical pilates program on lower extremity strength, posture, balance, gait, and quality of life in someone with impairments due to a stroke. *JBWMT*. 2014;18(3):332-360.
 40. Campos de Oliveira L, Gonçalves de Oliveira R, Pires-Oliveira DA. Effects of Pilates on muscle strength, postural balance and quality of life of older adults: a randomized, controlled, clinical trial. *J Phys Ther Sci*. 2015;27:871-876.
 41. Chang WD, Lai PT. Different exercise behaviors influence heart rate variability, autonomic nerve system function and menopausal symptoms in post-menopausal women. *J Phys Ther Sci*. 2013;25:477-481.
 42. Chedraui P, Aguirre W, Hidalgo L, Fayad L. Assessing menopausal symptoms among healthy middle aged women with the Menopause Rating Scale. *Maturitas*. 2007;57:271-278.
 43. Choi MS. Effects of a program for relieving menopausal symptoms [dissertation]. Seoul: Graduate School Korea Univ. 2001.
 44. Ozhan BAVLI, Ozlem Koybasi. Investigation the effects of 6 weeks pilates exercises on biomotorical variables and self-esteem scores of young women, School of Physical Education and Sport, Çanakkale Onsekiz Mart University, Çanakkale, Turkey, Year: 2016;18(1):127-131.
 45. Latey P. Updating the principles of the Pilates method e part 2. *Journal of Bodywork and Movement Therapies*. 2002;6:94e101.
 46. Mannion AF, Pulkovski N, Toma V, Spratt H. Abdominal muscle size and symmetry at rest and during abdominal hollowing exercises in healthy controls. *Journal of Anatomy* 2008; 213:173e82.
 47. Miyamoto N, Hirata K, Kimura N, Miyamoto-Mikami E. Contributions of hamstring stiffness to straight-leg-raise and sit-and-reach test scores. *International journal of sports medicine*. 2018 Feb;39(02):110-4.