

## Research Article

# Comparison of the effect of selected Pilates exercises, Traband training and weight training on strength and flexibility in elderly women

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### Abstract

**Background:** Changes in the human body due to the aging process, especially the loss of strength and flexibility of the lower limbs can increase the risk of falls. The aim of this study is to compare the effect of selected Pilates, Pilates with Traband and Pilates exercises with both factors such as strength and flexibility of the lower extremities of non-athlete 50-60 years old.

**Materials and Methods:** Thirty participants in this study have been randomly divided into three groups: quasi-experimental, Pilates (10), Pilates Traband (10) and Pilates (10). Before the beginning of the exercises, the strength of the lower limbs and static acceptance and the range of motion of extension and flexion of the thigh have been measured using the test of 30 sitting on a chair, static acceptance and goniometer, respectively. Moreover, all three groups as participated in a course of exercise. These exercises have performed for 8 weeks, 3 sessions per week for 1 hour and have performed after the participants. Data have been analyzed using paired t-test and ANOVA.

**Results:** As result, all three groups show the significant progress due to exercise but there is not any significant variance between the groups, as none of the methods is not better than other training methods.

**Conclusion:** performing Pilates exercises, Weight and Traband based on the availability of training equipment and facilities, is beneficial for the elderly, and this exercise may reduce the negative physical consequences and consequent treatment costs, and helps to slow down the aging process and is effective in improving the daily activities of the elderly.

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## 1. Introduction

The decline in functional capacity is associated with decreases in the level of flexibility, muscle strength, and lower limb strength. Simple functions (walking speed, sitting-up, and coping time) and muscle strength have been used to predict the onset of disability in older populations. (Hardy R 2003). With age, the function of most organs of the body and their physiological function gradually decreases, and the transformation and dysfunction of the organs of the body, including motor function, increase (1). However, in old age, due to the old age and reduced activity and physical activity, this decline will be greater. (2) With age, due to the inactivity and aging of muscle volume may lead to the muscle shortening due to a decrease in protein and muscle fibers, which can be directly affected by muscle strength, and on the other hand, poor performance in daily activities, Increases with decreasing muscle strength in the elderly (2, 3)

Because of ligaments, tendons, and cartilage harden with age, and this phenomenon usually results in changes in connective tissue and reduced elasticity, and overall reduced elasticity, as well as changes in connective tissue, a decrease in metabolism. It is associated with obstruction of blood vessels and wrinkles of the skin and restriction of joint movements (4, 5) Vojket et al. (2009). In the elderly, the main cause of decreased muscle strength is the result of aging, inactivity and both. A decrease in muscle volume can be due to a decrease in the total number of muscle fibers or an increase in type I slow-twitch fibers and a decrease in type II fast-twitch fibers (6). Falquito et al. (2007) stated that strength training is usually performed in three groups of static and dynamic contraction and introverted and extroverted, including the factors that neutralize age-related disorders (7).

Muscle strength also plays a very important role in maintaining independence and daily activities, especially in the elderly. Flexibility is defined as the ability to stretch motion in order to determine the appropriate amplitude for the associated joints. In old age, following a decrease in mobility, physiological changes occur in the structures which control the body's reception (8), including: wear and tear of tendons and ligaments, reduced adhesion of fluid inside the body, weak. Cartilage and their rupture indicated that this change would reduce the results (9, 10). It should be noted that physical flexibility as one of the fitness and physical capabilities related to health so particular importance to the middle-aged and elderly. Weakness in the muscles of the lower torso and reduced joint flexibility are among the causes of falls and reduced daily activities of the elderly. Regular and coordinated exercise is one of the ways to prevent daily inactivity and fractures caused by falling (11). Bagheri et al. (2010) by examining the effect of progressive resistance training on increasing lower limb strength and its impact on daily life activities of elderly women, concluded that resistance training increases strength in the lower limb and improves the ability of the elderly (12). Based on results of Mayer et al. (2011), the development of muscle volume is a suitable solution to reduce the processing of muscle breakdown and maintain strength capacity in the elderly. (13)

One of the exercises that have had many effects on the physical and mental performance of people, especially the elderly, in recent years, is the continuous and coordinated Pilates exercises in three positions: sitting, standing, lying down, and performing on the mat (14). Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading (14- 15). Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. . There are six basic principles associated with the use of the body strength center that in Pilates exercise include control, concentration, accuracy, smooth execution of movement and breathing (14, 16) Perform movement with control with the help of centrality along with focus and accuracy of correct breathing Psychological performance of movements from one exercise to another, these six principles at the heart of every Pilates movement, must be performed in harmony with each other, the center of body strength in Pilates includes the abdominal muscles, pelvis, lower extremities, lower limbs (14 , 16) It is important to notice that the Pilates was more effective to improve abdominal muscle strength, and the most important issue in Pilates is understanding the concept and knowing the center of power of the body. (14, 16, 17).

Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. Strengthens the body's power center connection with other organs, especially the lower limbs (16, 18).

There is evidence that mat Pilates improves dynamic balance, lower limb strength, hip and lower back flexibility, and cardiovascular endurance in elderly individuals. Furthermore, high-quality studies are necessary to clarify the effects of mat Pilates on other physical functional measurements among older adults (19).

Although many researchers have studied the effect of Pilates exercises on the elderly, but researchers have not been able to find the effects of different forms of Pilates in the elderly. Therefore, this study tries to compare the effect of selected Pilates exercises, Pilates with Traband and Pilates with weights on strength and flexibility of the lower limbs, which are the main factors in reducing muscle weakness, shortness and balance, and play a key role in maintaining stability and balance in the elderly.

## 2. Materials and Methods

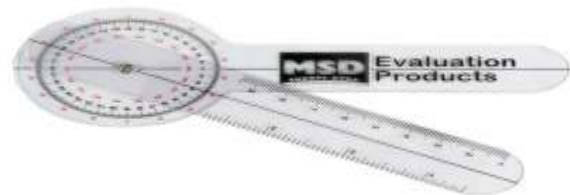
The present study is an experimental (interventional) research with pre-test and post-test design. The subjects are 30 elderly women in the age range of 60-50 years who were randomly selected from among those who referred to a sports complex in Punak neighborhood, District 5 and were randomly divided into three groups of Pilates exercises (10 people), Pilates exercises. Traband (n = 10) and weight training Pilates (n = 10) were included

Inclusion criteria included no history of heart disease, no use of assistive devices such as canes and walkers, elderly health in terms of cognitive vision and hearing, avoidance of exercise or strenuous activity, and no diabetes and limb fractures. All subjects are fully justified before the conducted research on test materials and how to perform the exercises, as well as the hours of the exercises. Participated in sports exercises. These exercises have performed for 8 weeks, 3 sessions per week for 1 hour and then the participants have been tested.

In this study, 30 second sit to stand test is used to measure the muscle strength of the lower limbs (20). This test is considered a valid and reliable tool for measuring the strength of the lower limbs of the elderly in society. To perform this test, the subject sits on a chair with his back flat and his legs are shoulder-width apart and his hands are in front of his chest. They are looped with the face sign and the person starts to get up completely and returns to a sitting position. The subject is encouraged to do the maximum number of sit-ups in 30 seconds. The test score is the total number of correct stands in 30 seconds.

**Sit and Reach Test** were used to measure pelvic flexibility. To perform this test, the subject sits on the floor and attaches the soles of their paired feet to the flexibility box of the bench to the box on the floor. The other person prevents the subject's knees from bending. The subject bends forward to the palms of his outstretched hands, places his hands on the box, and pushes forward. The hands should be on top of each other or along each other, and the middle finger is the criterion. The distance between the edge of the box and the tip of the middle fingers in centimeters is a person's record (21). The standard box has also designed to perform this test has dimensions according to the figure. The box can flexibly measure those who are not even able to reach the fingertips. Test error: 1) The knees should not be bent during the performance. 2) The body and upper torso should not be bent during the performance as recorded. Stretching exercises should be performed before performing the test (22).

**Static Flexibility** is measured a goniometer. This device has a degree that calculates the angles of range of motion on the lower limb by placing the center of the goniometer on the joint.



To measure the range of motion of the hip flexion, the subject is asked to lie on his back on the table. The non-test thigh and knee are tested in the extension position as able to actively flex the thigh. The Volgen trunk was constant during the measurement. The center of the goniometer on the large trochanter of the thigh was at the fixed arm parallel to the axillary line of sedition and the movable arm parallel to the longitudinal axis of the thigh toward the external epicondyle (23).



To measure the range of motion of the thigh extension, the subject is asked to lie on his stomach with the thighs and knees of both legs in a neutral position and to perform active thigh extensions. The pelvic measurements have fixed with a strip band. The center of the goniometer is located on the large trochanter of the thigh with a fixed arm parallel to the axillary line of the trunk and a movable arm parallel to the longitudinal axis of the thigh toward the external epicondyle of the thigh (23).

### 3. Results

Table 1 shows the demographic characteristics of the participants. As result, the groups did not differ significantly in these variables.

**Table 1: Demographic characteristics of the subjects in the research groups**

Variable	group	N	Pre-test	Post-test
Age (Year)	Pilates	10	52.2±2.84	52.2±2.84
	Pilates Traband	10	54.1±3.46	54.1±3.46
	Pilates Weight	10	54.2±3.37	54.2±3.37
Standing height(Cm)	Pilates	10	152.4±4.08	152.70±4.08
	Pilates Traband	10	157.3±4.37	157.3±4.37
	Pilates Weight	10	156.4±5.35	156.4±5.35
Body mass(Kg)	Pilates	10	69.8 ±93.98	68.3±10.23
	Pilates Traband	10	74.9±5.12	73.8±5.06
	Pilates Weight	10	79.5±4.59	78.6±4.61
BMI (kg.m <sup>2</sup> )	Pilates	10	29.89±4.15	29.17±4.31
	Pilates Traband	10	30.34±2.85	29.78±2.81
	Pilates Weight	10	32.50±2.74	31.81±2.78

Due to the fact based on Kolmogorov-Smirnov test, the explanation of variables in the groups is normal, paired data have been used to examine the mean difference within the group and ANOVA test also used to examine the difference between the groups.

Table 2 describes the variables as studied in the research groups.

**Table 2: Descriptive findings of research dependent variables with the results of paired t-test and ANOVA**

Variable	group	N	Pre-test	Post-test	T	P	F	P	$\eta^2$
Sit and stand (repeat)	Pilates	10	20.6±6.70	22.1±6.88	321.2	045.0*	2.108	0.141	0.135
	Pilates Traband	10	21.8±4.96	27.6±6.73	955.3	002.0**			
	Pilates Weight	10	20.0±4.00	24.2±4.10	853.3	007.0**			
Thigh flexion (degree)	Pilates	10	13.1±3.78	16.30±3.91	234.2	045.0*	0.821	0.451	0.057
	Pilates Traband	10	14.1±3.57	21.3±3.09	453.2	036.0*			
	Pilates Weight	10	13.4±3.94	22.6±4.19	571.2	017.0*			
Thigh extensions (degree)	Pilates	10	20.1±4.67	26.5±4.89	895.2	027.0*	2.333	0.116	0.147
	Pilates Traband	10	21.2±4.77	25.3±4.59	765.2	047.0*			
	Pilates Weight	10	18.6±4.29	24.2±3.62	993.2	035.0*			
Trunk flexibility (cm)	Pilates	10	11.9±7.93	17.3±8.28	11.9±7.93	008.0**	0.207	0.815	0.015
	Pilates Traband	10	10.8±5.34	13.8±6.03	10.8±5.34	033.0*			
	Pilates Weight	10	10.40±5.21	12.45±5.27	10.40±5.21	040.0			

The findings of Table 2 shows that all three groups have made significant progress as a result of the exercises but there is no significant difference between the groups also none of the methods is better than the other training methods.

## 4. Discussion

Part of the results of the present study indicated that 8 weeks of Pilates, Pilates with weight and Pilates with Traband exercises have a positive effect on lower limb strength. Also, the effect of the group is not significant. In other words, there was no significant difference between the effect of the three selected Pilates exercises on sitting and standing tests. In fact, all three exercise programs have the same effect on the strength of the lower limbs of older women. To justify this finding, it can be said that various Pilates exercises include strength and stretching exercises that increase strength in the muscles and establish a direct connection between the mind and the body (24). According to the results of some studies, Pilates, when added to dance training, can improve postural alignment, flexibility, and abdominal strength in dancers. Additionally, it is well tolerated by dancers, making it a potentially valuable cross-training tool (25). Based on study of Aibar-Almazán et al (2020), a 12-week Pilates exercise intervention on community dwelling women over 60 years old shows beneficial effects on muscle strength, physical performance, and BMI, but failed to induce any changes on body composition (26). Arti (2015) stated that performing 12 weeks of strength training using Traband in women over 50 years of age significantly improves muscle function and increases the strength and endurance of the subjects (27). Secandis (2007) in a study entitled The effects of Pilates exercise on torso strength, and flexibility in sedentary elderly women, concluded that the positive effect of Pilates exercises on muscle strength and endurance, abdominal and lower back and lower extremity muscles and flexibility Posterior trunk flexibility was undeniable, but body weight and fat percentage did not differ significantly from Pilates exercises (28).

Pilates and Theraband trainings lead to the increase of the dynamic balance and strength of lower limb in elderly women, but, Pilates training was more effective on strength of lower limb and Theraband training was more effective on dynamic balance (29). Pilates exercises can improve balance and reduce the percentage of body fat in older women, and it is a suitable and inexpensive alternative or complementary treatment to improve balance and reduce falls (30).

The Pilates training program was more effective for improving isometric hip and trunk extension strength, while the Muscular training program generated greater benefits on trunk and hip isokinetic strength. Moreover, both training programs showed moderate effects for the timed up and go (31).

In this research, the scores of flexibility factors (hip flexion, thigh extension and torso flexibility) improved from pre-test to post-test in all three groups, but in the post-test of the research groups, three selected exercise groups were Pilates, Pilates Traband and Pilates weight. No significance is observed. These results show the positive and identical effects of three training programs on flexibility factors, all three of which are able to increase flexibility factors over time (training duration) and therefore the interaction between group and time is very important factor. The present results are consistent with the results of other researchers regarding the positive effects of various Pilates exercises on flexibility and range of motion in the elderly (31).



The maximum range of motion of the hip and plantar flexion of the ankle while walking is lower in the elderly (whether or not they have a history of falls) than in the young. Because the range of motion of the thigh is affected by the stiffness of the antagonist muscles. Therefore, stretching exercises for hip flexors may improve performance in daily activities such as walking in the elderly. The results of Aires et al.'s research, 2011 disclosed that 12 weeks of Pilates training can be effective in preventing falls, increasing daily activities and increasing flexibility in some factors and reducing depression, as well as improving the quality of life of older women aged 50 to 60 years as consistent with the results of the present study (32). Neil et al. (2008) in a study entitled the effect of Pilates exercises on flexibility and body composition concluded that Pilates has a significant effect on flexibility. One of the advantages of trunk flexibility assessment is its simplicity and ease of assessment and its limitations are low accuracy and inability to measure the flexibility of each joint in particular. In this study, only the hamstring muscles (lower limbs) have been examined (33). Babigitt et al. (2010) revealed that Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading (34). Apple et al. (2012) in a study entitled the effect of 8 weeks of Pilates training on the physical characteristics of adults, concluded that in the flexibility test, they had improved 7.5 cm and flexibility after 8 weeks of training Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading (35).

Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. In Pilates, a person achieves a kind of natural coordination through the complete repetition of movements in a gradual but progressive manner. This sport is known by doctors as a combination of strengthening, stretching and breathing muscles used to develop trunk muscles and restore muscle balance. Unlike traditional resistance exercises where the muscles are trained separately, Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. Considering the Pilates exercises, it seems that flexibility is one of the most important components of Pilates exercises. Therefore, the increased flexibility is common factor in all studies, which is thought to be one of the reasons for increasing flexibility, frequent active and passive muscle stretching exercises, as well as focusing on the central muscles of the trunk and legs. In general, Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading. Pilates largely avoids high impact, high power output, and heavy muscular and skeletal loading.

## 5. Conclusion

According to the results of the present study, performing Pilates exercises, Weight and Trand based on the availability of training equipment and facilities, is beneficial for the elderly, and this exercise may reduce the negative physical consequences and consequent treatment costs, and can help to slow down the age processing. Finally, it is an effective way to improve the daily activities of the elderly.

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## Compliance with ethical standards

**Conflict of interest** The authors of the article state that there is no conflict of interest in the present study.

**Ethical approval** the research was conducted with regard to the ethical principles.

**Informed consent** Informed consent was obtained from all participants.

## Author contributions

Conceptualization: K.M.S, R.B.; Methodology: K.M.S, R.B.; Software: K.M.S, R.B.; Validation: K.M.S, R.B.; Formal analysis: K.M.S, R.B.; Investigation: K.M.S, R.B.; Resources: K.M.S, R.B.; Data curation: K.M.S, R.B.; Writing - original draft: K.M.S, R.B.; Writing - review & editing: K.M.S, R.B.; Visualization: K.M.S, R.B.; Supervision: K.M.S, R.B.; Project administration: K.M.S, R.B.; Funding acquisition: K.M.S, R.B.;

## References

1. Swift DL, McGee JE, Earnest CP, et al. The Effects of Exercise and Physical Activity on Weight Loss and Maintenance. *Progress in Cardiovascular Diseases*. 2018 Jul - Aug;61(2):206-213. DOI: [10.1016/j.pcad.2018.07.014](https://doi.org/10.1016/j.pcad.2018.07.014). PMID: 30003901.
2. Ryan, A., Murphy, C., Boland, F., Galvin, R., & Smith, S. M. (2018). What Is the Impact of Physical Activity and Physical Function on the Development of Multimorbidity in Older Adults Over Time? A Population-Based Cohort Study. *The journals of gerontology. Series A, Biological sciences and medical sciences*, 73(11), 1538–1544. <https://doi.org/10.1093/gerona/glx251>
3. Schrepft, S., Jackowska, M., Hamer, M. et al. Associations between social isolation, loneliness, and objective physical activity in older men and women. *BMC Public Health* 19, 74 (2019). <https://doi.org/10.1186/s12889-019-6424-y>
4. Cunningham C, O' Sullivan R, Caserotti P, Tully MA. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scand J Med Sci Sports*. 2020 May;30(5):816-827. doi: [10.1111/sms.13616](https://doi.org/10.1111/sms.13616). Epub 2020 Feb 4. PMID: 32020713.
5. Birgitta Langhammer, Astrid Bergland, Elisabeth Rydwik, "The Importance of Physical Activity Exercise among Older People", *BioMed Research International*, vol. 2018, Article ID 7856823, 3 pages, 2018. <https://doi.org/10.1155/2018/7856823>
6. Lopez, P., Pinto, R. S., Radaelli, R., Rech, A., Grazioli, R., Izquierdo, M., & Cadore, E. L. (2018). Benefits of resistance training in physically frail elderly: a systematic review. *Aging clinical and experimental research*, 30(8), 889–899. <https://doi.org/10.1007/s40520-017-0863-z>
7. Folquitto, J. C., Bustamante, S. E., Barros, S. B., Azevedo, D., Lopes, M. A., Hototian, S. R., Jacob Filho, W., Litvoc, J., & Bottino, C. M. (2007). The Bayer: Activities of Daily Living Scale (B-ADL) in the differentiation between mild to moderate dementia and normal aging. *Revista brasileira de psiquiatria (Sao Paulo, Brazil)* : 1999), 29(4), 350–353. <https://doi.org/10.1590/s1516-44462006005000037>
8. Muchiri, W. A. , Olutende, O. M. , Kweyu, I. W. , & Vurigwa, E. (2018). Meaning of Physical Activities for the Elderly: A Review. *American Journal of Sports Science and Medicine*, 6(3), 79-83.
9. Baily, N., Martinent, G., Ferrand, C., Agli, O., Giraudeau, C., Gana, K., & Roussiau, N. (2018). Spirituality, social support, and flexibility among older adults: a five-year longitudinal study. *International psychogeriatrics*, 30(12), 1745–1752. <https://doi.org/10.1017/S1041610218000029>
10. Douka, S., Zilidou, V. I., Lilou, O., & Manou, V. (2019). Traditional Dance Improves the Physical Fitness and Well-Being of the Elderly. *Frontiers in aging neuroscience*, 11, 75. <https://doi.org/10.3389/fnagi.2019.00075>
11. de Oliveira Francisco, C., de Almeida Fagundes, A., & Gorges, B. (2015). Effects of Pilates method in elderly people: Systematic review of randomized controlled trials. *Journal of bodywork and movement therapies*, 19(3), 500–508. <https://doi.org/10.1016/j.jbmt.2015.03.003>
12. Bahgeri H, Abdolvahab M, Raji P, Jalili M, Faghieh Zadeh S, Soltani Z. The effects of progressive resistive exercises on Activities of Daily Living of elderly persons. *mrj*. 2010; 4 (1 and 2) :56-59 URL: <http://mrj.tums.ac.ir/article-1-104-fa.html>
13. Mayer, F., Scharhag-Rosenberger, F., Carlsohn, A., Cassel, M., Müller, S., & Scharhag, J. (2011). The intensity and effects of strength training in the elderly. *Deutsches Arzteblatt international*, 108(21), 359–364. <https://doi.org/10.3238/arztebl.2011.0359>
14. Meikis, L., Wicker, P., & Donath, L. (2021). Effects of Pilates Training on Physiological and Psychological Health Parameters in Healthy Older Adults and in Older Adults With Clinical Conditions Over 55 Years: A Meta-Analytical Review. *Frontiers in neurology*, 12, 724218. <https://doi.org/10.3389/fneur.2021.724218>
15. Engers, P. B., Rombaldi, A. J., Portella, E. G., & da Silva, M. C. (2016). The effects of the Pilates method in the elderly: a systematic review. *Revista brasileira de reumatologia*, 56(4), 352–365. <https://doi.org/10.1016/j.rbre.2016.05.005>

16. Barrows S, Barrows M. Somatic Education: Feldenkrais® and Pilates. *The Feldenkrais Method*. 2021;2.
17. Rayes, A., de Lira, C., Viana, R. B., Benedito-Silva, A. A., Vancini, R. L., Mascarini, N., & Andrade, M. S. (2019). The effects of Pilates vs. aerobic training on cardiorespiratory fitness, isokinetic muscular strength, body composition, and functional tasks outcomes for individuals who are overweight/obese: a clinical trial. *PeerJ*, 7, e6022. <https://doi.org/10.7717/peerj.6022>
18. Lewitt, M. S., McPherson, L., & Stevenson, M. (2019). Development of a Pilates Teaching Framework from an international survey of teacher practice. *Journal of bodywork and movement therapies*, 23(4), 943–949. <https://doi.org/10.1016/j.jbmt.2019.02.005>
19. Bueno de Souza, R. O., Marcon, L. F., Arruda, A., Pontes Junior, F. L., & Melo, R. C. (2018). Effects of Mat Pilates on Physical Functional Performance of Older Adults: A Meta-analysis of Randomized Controlled Trials. *American journal of physical medicine & rehabilitation*, 97(6), 414–425. <https://doi.org/10.1097/PHM.0000000000000883>
20. Jones, C. J., Rikli, R. E., & Beam, W. C. (1999). A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Research quarterly for exercise and sport*, 70(2), 113–119. <https://doi.org/10.1080/02701367.1999.10608028>
21. Wood R. Sit and Reach Test: Topend Sports Website; 2008 [Available from: <https://www.topendsports.com/testing/tests/sit-and-reach.htm>].
22. Hancock GE, Hepworth T, Wembridge K. Accuracy and reliability of knee goniometry methods. *Journal of experimental orthopaedics*. 2018;5(1):1-6.
23. Chiacchiero M, Dresely B, Silva U, DeLosReyes R, Vorik B. The relationship between range of movement, flexibility, and balance in the elderly. *Topics in Geriatric Rehabilitation*. 2010;26(2):148-55.
24. Wells, C., Kolt, G. S., & Bialocerowski, A. (2012). Defining Pilates exercise: a systematic review. *Complementary therapies in medicine*, 20(4), 253–262. <https://doi.org/10.1016/j.ctim.2012.02.005>
25. Ahearn, E. L., Greene, A., & Lasner, A. (2018). Some Effects of Supplemental Pilates Training on the Posture, Strength, and Flexibility of Dancers 17 to 22 Years of Age. *Journal of dance medicine & science : official publication of the International Association for Dance Medicine & Science*, 22(4), 192–202. <https://doi.org/10.12678/1089-313X.22.4.192>
26. Aibar-Almazán, A., Martínez-Amat, A., Cruz-Díaz, D., Jesús de la Torre-Cruz, M., Jiménez-García, J. D., Zagalaz-Anula, N., Redecillas-Peiró, M. T., Mendoza-Ladrón de Guevara, N., & Hita-Contreras, F. (2020). The Influence of Pilates Exercises on Body Composition, Muscle Strength, and Gait Speed in Community-Dwelling Older Women: A Randomized Controlled Trial. *Journal of strength and conditioning research*, 10.1519/JSC.0000000000003790. Advance online publication. <https://doi.org/10.1519/JSC.0000000000003790>
27. Welling A. Comparative study between mat, swiss ball and theraband exercises on abdominal girth: KLE University, Belagavi, Karnataka; 2014.
28. Sekendiz B, Altun Ö, Korkusuz F, Akın S. Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. *Journal of bodywork and movement therapies*. 2007;11(4):318-26.
29. Dashti P, Shabani M, Moazami M. Comparison of the effects of two selected exercises of Theraband and Pilates on the balance and strength of lower limb in elderly women. *The Iranian Journal of Obstetrics, Gynecology and Infertility*. 2015;18(153):1-9.
30. Ramezani S, Biniiaz SA, Yaghoubi M, Asadollahi N. The Effect of Selected Pilates Exercises on Balance, Blood Pressure, and Body Composition of Inactive Healthy Elderly Women. *Journal of Vessels and Circulation*. 2021;2(1):17-26.
31. Carrasco-Poyatos, M., Ramos-Campo, D. J., & Rubio-Arias, J. A. (2019). Pilates versus resistance training on trunk strength and balance adaptations in older women: a randomized controlled trial. *PeerJ*, 7, e7948. <https://doi.org/10.7717/peerj.7948>

32. Irez, G. B., Ozdemir, R. A., Evin, R., Irez, S. G., & Korkusuz, F. (2011). Integrating pilates exercise into an exercise program for 65+ year-old women to reduce falls. *Journal of sports science & medicine*, 10(1), 105–111.

33. Segal, N. A., Hein, J., & Basford, J. R. (2004). The effects of Pilates training on flexibility and body composition: an observational study. *Archives of physical medicine and rehabilitation*, 85(12), 1977–1981. <https://doi.org/10.1016/j.apmr.2004.01.036>

34. Babayiğit İrez G. Pilates exercise positively affects balance, reaction time, muscle strength, number of falls and psychological parameters in 65+ years old women. 2009. <https://open.metu.edu.tr/handle/11511/19415>

35. Appell IPC, Pérez VR, Nascimento MdM, Coriolano HJA. The Pilates method to improve body balance in the elderly. *Archives of Exercise in Health and Disease*. 2012;3(3):188-93.