Effects of pilates training on the flexibility and strength of female students

Efectos del entrenamiento de pilates sobre la flexibilidad y la fuerza de las estudiantes

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How to cite in APA

Tanphukwan, M., Nontakhod, K., Khongnam, B., Wongsurin, S., Buathong, J., Pakkaro, P., & Intanoo, K. (2025). Effects of pilates training on the flexibility and strength of female students. *Retos*, *68*, 1196–1205. https://doi.org/10.47197/retos.v68.115956

Abstract

Introduction: Pilates training is an effective form of exercise for improving flexibility and strength. However, only a few studies have focused on female students.
Objective: The research aimed to study the effects of Pilates training on the flexibility and strength of female students.
Methods: The participant group consisted of female student aged 18–22 years at from the faculty of science Buriran Rajabhat University, 20 people, all voluntarily signed a letter of consent. Systematic Random Sampling was performed, with the experimental group (EXG) (n=10) training with Pilates for eight weeks, three days per day, 60 minutes per session. The control group (CG) (n=10) did not undergo any training. Quantitative data were collected, including flexibility and upper and lower body strength, before training and after the fourth and eighth weeks of training.
Results: It was found that after training with Pilates after week four and week eight, the experimental group had a mean flexibility, upper and lower strength that was significantly better than before training and better than the control group . ($p<0.05$).
Conclusions: Pilates training helps improve flexibility and strength in female students, promotes good health, and can serve as an alternative activity for maintaining health and enhancing physical fitness for people of all ages.

Keywords

Pilates, flexibility, strength, female student.

Resumen

Introducción: El entrenamiento de Pilates es una forma efectiva de ejercicio para mejorar la flexibilidad y la fuerza. Sin embargo, solo unos pocos estudios se han centrado en las estudiantes femeninas.
Objetivo: Esta investigación tuvo como objetivo estudiar los efectos del entrenamiento de Pilates sobre la flexibilidad y la fuerza de las estudiantes femeninas.
Metodología: El grupo participante estuvo compuesto por 20 estudiantes femeninas, de entre 18 y 22 años de edad, de la Facultad de Ciencias de la Universidad Rajabhat de Buriram. Todas firmaron voluntariamente una carta de consentimiento informado. Se utilizó un muestreo aleatorio sistemático. El grupo experimental (EXG) (n=10) realizó entrenamiento de Pilates durante ocho semanas, tres días por semana, con sesiones de 60 minutos. El grupo de control (CG) (n=10) no recibió ningún tipo de entrenamiento. Se recopilaron datos cuantitativos que incluyeron medidas de flexibilidad y fuerza del tren superior e inferior antes del entrenamiento, así como después de la cuarta y la octava semana de entrenamiento.
Resultados: Se encontró que, después de la cuarta y la octava semana de entrenamiento con Pilates, el grupo experimental presentó una media significativamente mayor en flexibilidad y fuerza del tren superior e inferior en comparación con los valores antes del entrenamiento y con el grupo de control ($p<0.05$).
Conclusiones: El entrenamiento de Pilates ayuda a mejorar la flexibilidad y la fuerza en las estudiantes femeninas, promueve una buena salud y puede servir como una actividad alternativa para mantener la salud y mejorar la condición física en personas de todas las edades.

Palabras clave

Pilates, flexibilidad, fuerza, estudiante femenina.

Introduction

New exercise guidelines published by the WHO in 2020 recommend engaging in 150-300 min of moderate-intensity exercises on a weekly basis (Bull et al., 2020), and the exercise intensity can be easily adjusted according to an individual's physical fitness level (Henriksen, 2002; Jeong et al., 2024). Exercise is considered an effective method for slowing down and preventing the progression of age-related diseases (Ciolac, 2013; Gronek et al., 2021). Improve body composition, increase muscle strength, enhance cardiovascular fitness, and condition muscles. (Jinakote et al., 2024; Lephart et al., 2007). It enhances metabolic function, stimulates calcium deposition in bones, reduces pain, increases mobility, enhance whole-body strength and ROM and effectively relax tense muscles (Kim et al., 2014; Pojskic et al., 2015; Ryu et al., 2024). Exercise has demonstrated improvements in both physical and mental health through psychological and physiological mechanisms (Ballmann, 2021; Nontakhod et al., 2025; Terry et al., 2020). Regular physical activity is essential for the healthy growth of adolescents and is associated with both physical and mental well-being throughout different stages of life (Batista et al., 2019; Silva et al., 2022; Jee, 2025). Research in adolescents has shown a positive association between regular exercise and improvements in bone strength, cardiorespiratory fitness, blood pressure, lipid profile, and insulin sensitivity (Farooq et al., 2020; Zon et al., 2023).

In modern society, lack of physical activity among students due to studies, can cause various physical and psychological problems (Ha et al., 2016). Fundamentally, these problems can be solved by increasing physical activity through methods that spur interest in participating in sports and exercise. Previous studies reported that students physical activities were significantly related to academic achievements and physical fitness (Lambourne et al., 2013). Pilates is an effective health fitness system (Kashuba et al., 2020; Marionda and Dzhuhan, 2007), Pilates is a mind-body exercise that connects breathing with concentration in each movement (Mikalacki et al., 2017). It also helps improve posture, flexibility, muscle strength, cardiovascular function, weight control, and stress, all of which have been proven to enhance independence in daily activities, static balance, and quality of life (Siqueira Rodrigues et al., 2010). Increasing the efficiency of the respiratory system, and reducing stress (Janphonak et al., 2025; Worapongpichet and Kamoltham, 2018). Pilates exercise are designed to involve the body's postural muscles, aiming to improve stability and strength within the core of the body, which can help them achieve overall body balance (Jaeho and Lee, 2012; Smith and Smith, 2005). In terms of mental health, Pilates and yoga have been shown to promote mental clarity, concentration on positive thinking, reduce stress, and improve the ability to manage anxiety (Adams, 2018; Mental Healthy, 2019).

The study of Pilates has been shown to improve dynamic balance, flexibility, and strength (Irez et al., 2011; Lim and Prak, 2019), core stability, control of trunk and pelvic segments, posture and breathing (Kliziene et al., 2017; Wells et al., 2012). Recent studies have shown that quality of life can be enhance through the use of Pilates (KauricKlein, 2019; Rahimimoghadam et al., 2019). However, in Southeast Asia, there is limited information on the combination of Pilates training. This is because flexibility and strength play an important role in the daily activities of female students. Therefore, it is necessary to summarize current knowledge on this topic as a guideline for maintaining health and physical fitness for people of all ages, to ensure a good quality of life.

Method

Participants

The participants in this study were female students aged between 18 and 22 years from the Faculty of Science, Buriram Rajabhat University, who voluntarily joined the project. A simple random sampling method was used by drawing lots to select individuals who had no prior experience with Pilates training and no medical contraindications for participating in Pilates training. All participants signed a written informed consent form after being fully informed about the details, objectives, risks, and potential of a moderate-intensity Pilates training program. They also completed a Physical Activity Readiness Questionnaire (PAR-Q) to assess their overall health status. Subsequently, 20 participants were selected for flexibility testing. The flexibility scores were then sorted and assigned using a systematic random sampling method to ensure that the pre-training flexibility levels in both groups were comparable. This

research was approved by the Human Research Ethics Committee of Buriram Rajabhat University (BRU: 004/2025).

There were the following sample groups: 1) an experimental group (EG) that with Pilates training (PT) for eight weeks, three days a day, 60 minutes per session, and 2)

a control group (CG) that did not receive any instruction. All of the participants voluntarily signed a letter of consent.

Criteria for selecting research participants included female students aged 18 to 22 years, those able to move normally and perform light exercises, and those without any congenital disease that has previously hindered their ability to engage in Pilates training (PT). The criteria for choosing participants in the research involved excluding those who had injuries or illnesses that prevented them from engaging in PT and those who missed more than three sessions. Additionally, the research also excluded participants who withdrew from the training before completing it for the specified duration.

Procedure

Study Organization

The participants were randomly divided into two groups: the Pilates training group (PT, n = 10), which participated in Pilates training three days a week for 60 minutes per session over a period of eight weeks, and the control group (CG, n = 10), which did not engage in any exercise and continued their normal daily routine. Flexibility and upper and lower body strength were measured before the training, after the 4th week, and after the 8th week of training.

Training Program

The Pilates training program lasted 60 minutes per day, 3 days per week, for a total of 8 weeks. The Pilates routine, consisting of 17 poses, was divided into three phases: (1) a 10-minute warm-up phase, (2) a 40-minute Pilates training phase, and (3) a 10-minute cool-down phase.

Data analysis

The statistical analyses were conducted using SPSS 25 (IBM Corp., IBM SPSS Statistics for Windows, Version 25.0; Armonk, NY: IBM Corp). The data are reported as the mean ± standard deviation (SD). The normality of the data was assessed using the Shapiro-Wilk test. The one-way analysis of variance with repeated measures followed by the Bonferroni post-hoc test was used to evaluate differences in flexibility and muscular strength between groups (comparisons between values obtained before, after 4-week and after 8-week training) and independent t-tests (comparisons of differences to baseline between groups) were completed. The data demonstrated a normal distribution with a 95% Confidence Interval (CI).P values < 0.05 was statistically significant.

Results

The research found that following, after with Pilates training (PT) after week four and week eight, the experimental group had a mean flexibility and upper and lower body strength that was significantly better than before training and better than the control group p<0.05.

Table 1. Baseline characteristics in the control and experimental group

Parameters	CG (*n* = 10)	EXG (*n* = 10)	t	P-value
Age)y(	19.08 ± 0.67	19.17 ± 0.83	0.270	0.790
Weight)kg(	52.00 ± 5.68	49.64 ± 4.18	-1.073	0.298
Height)cm(	160.67 ± 5.81	160.45 ± 4.16	-0.095	0.925
BMI)kg/m²(	19.00 ± 4.42	19.36 ± 1.86	0.249	0.806

Description: CG; control group and EXG; Experimental group; BMI; body mass index.Values are mean±SD.p>0.05 No significant difference was found between the two groups for any variable.

Table 2. Mean changes in flexibility and muscular strength parameters in all two groups after a 4-week (MID) and an 8-week (POST) training period

Parameters	Time	CG (n = 10)	EXG (n = 10)	t	P-value
		Flexibility			
Sit and reach test)cm(	PRE (week 0)	11.25 ± 2.53	13.08 ± 3.90		
	MID (week 4)	10.75 ± 2.26	17.25 ± 3.02		
	POST (week 8)	10.75 ± 2.56	20.58 ± 3.34		
	%Changes (MID vs. PRE)	-4.44 ± 6.68	31.85 ± 26.44*)p = 0.001(	-5.329	0.001‡
	%Changes (POST vs. PRE)	-4.44 ± 7.01	57.32 ± 32.12#)p = 0.001(	-7.329	0.001 Ω
	%Changes (POST vs. MID)	0.00 ± 8.18	19.32 ± 8.48†)p = 0.001(	-5.921	0.001§
		Muscular strength			
Hand grip strength)kg/weight(	PRE (week 0)	0.49 ± 0.05	0.53 ± 0.09		
	MID (week 4)	0.49 ± 0.06	0.61 ± 0.07		
	POST (week 8)	0.48 ± 0.06	0.66 ±0.08		
	%Changes (MID vs. PRE)	-0.34 ± 4.73	16.12 ± 17.18*)p = 0.003(	-3.068	0.007‡
	%Changes (POST vs. PRE)	-2.30 ± 4.23	26.47 ± 21.15#)p = 0.001(	-4.308	0.001 Ω
	%Changes (POST vs. MID)	-1.96 ± 3.56	8.92 ± 2.72†)p = 0.001(	-7.778	0.001§
Leg strength)kg/weight(	PRE (week 0)	1.14 ± 0.28	1.45 ± 0.55		
	MID (week 4)	1.13 ± 0.29	1.84 ±0.63		
	POST (week 8)	1.13 ± 0.28	2.14 ± 0.79		
	%Changes (MID vs. PRE)	-1.07 ± 2.43	26.50 ± 27.25*)p = 0.005(	-3.865	0.003 ‡
	%Changes (POST vs. PRE)	-1.21 ± 1.68	47.57 ± 40.51#)p = 0.005(	-4.478	0.001 Ω
	%Changes (POST vs. MID)	-0.15 ± 1.99	16.65 ± 17.19†)p = 0.046(	-3.242	0.008§

Description: *Significant p<0.05)MID vs. PRE(, #Significant p<0.05)POST vs. PRE(,† Significant p<0.05)POST vs. MID(, ‡Significant p<0.05) %Changes MID vs. PRE), Ω Significant p<0.05) %Changes POST vs. PRE), §Significant p<0.05)%Changes POST vs. MID)

Figure 1. Changes in the sit and reach test before (PRE), after 4 weeks (MID), and after 8 weeks (POST) of the training period. Values are present as mean ± SD. *Significant p<0.05)MID vs. PRE(, #Significant p<0.05)POST vs. PRE(,† Significant p<0.05)POST vs. MID(, ‡Significant p<0.05) %Changes MID vs. PRE), ΩSignificant p<0.05) %Changes POST vs. PRE), §Significant p<0.05)%Changes POST vs. MID)

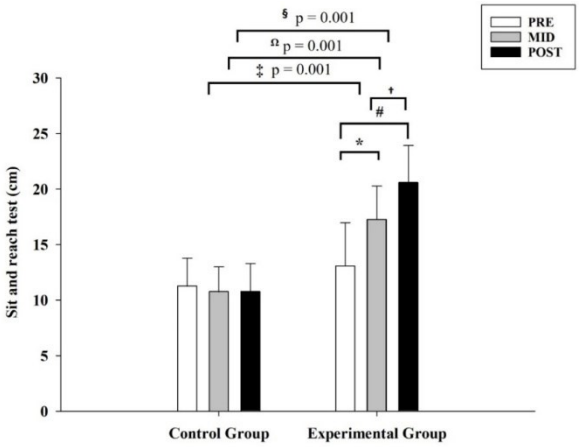


Figure 2. Changes in the handgrip strength test before (PRE), after 4 weeks (MID), and after 8 weeks (POST) of the training period. Values are present as mean ± SD. *Significant p<0.05)MID vs. PRE(, #Significant p<0.05)POST vs. PRE(,† Significant p<0.05)POST vs. MID(, ‡Significant p<0.05) %Changes MID vs. PRE), ΩSignificant p<0.05) %Changes POST vs. PRE), §Significant p<0.05)%Changes POST vs. MID)

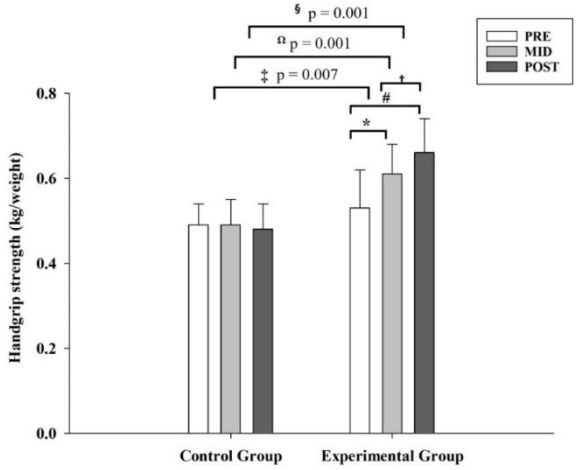
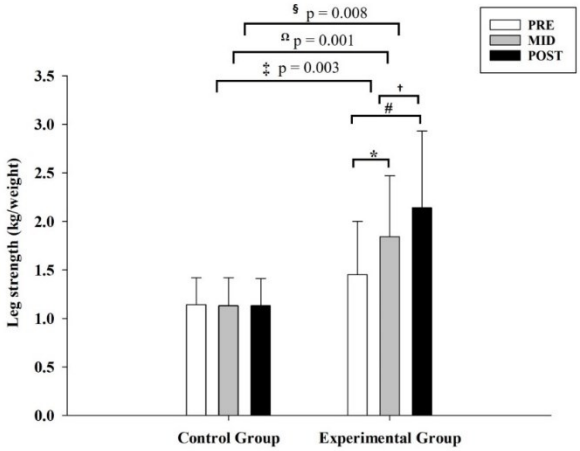


Figure 3. Changes in the leg strength test before (PRE), after 4 weeks (MID), and after 8 weeks (POST) of the training period. Values are present as mean ± SD. *Significant p<0.05)MID vs. PRE(, #Significant p<0.05)POST vs. PRE(,† Significant p<0.05)POST vs. MID(, ‡Significant p<0.05)%Changes MID vs. PRE), ΩSignificant p<0.05) %Changes POST vs. PRE), §Significant p<0.05)%Changes POST vs. MID)



Discussion

This research supports the concept of Pilates training for improving flexibility and strength in female students. The results after an 8-week training period revealed improvements in both flexibility and strength. These finding are consistent with research by Park et al. (2020), reported 8 weeks Pilates training in adolescent baseball players has benefits on hamstring/quadriceps ratio, trunk and shoulder strength, the results from this study suggest that Pilates training to increase muscle mass, trunk and shoulder strength. It has been reported that Pilates training has significant positive effects on flexibility and isometric trunk flexion strength in patients with chronic low back pain (Kliziene et al., 2017). Borah et al. (2024), reported mat Pilates training program significant enhances various dimensions of functional fitness in older adults, the study results have profound implications for older individuals' well-being and quality of life, Pilates emerges as an essential intervention for promoting active ageing, potentially improving daily functioning, reducing fall risk, and enhancing independence in the elderly. Similarly, Irez et al. (2011) which demonstrated that Pilates, a regimen incorporating major movement similar it those in this study's exercise program, effectively improves flexibility and balance while reducing fall risk. Pilates is widely recognized for its ability to strengthen core and spinal muscles, stabilize the core, and promote proper posture. An interesting finding of this study was the improvement in Pilates

a regimen of low-to moderate-intensity exercises designed to enhance strength and flexibility while alleviating body tension (Oliveira et al., 2016; Ryu et al., 2024; Teixeira et al., 2017).

The Pilates also showed better results in pain reduction and disability and range of motion. Pilates improved absolute core strength and moreover encouraged proper activation patterns of core musculature (Bhadauria and Gurudut, 2017; Gladwell et al., 2006). Pilates increase flexibility can reduce the risk of injuries, alleviate joint pain, and improve overall mobility (Behm and Chaouachi, 2011). Including, improvements in body composition, muscular strength, flexibility, balance, fall prevention, functional performance, and quality of life (Tejada Medina et al., 2021). Moreover, training in Pilates, yoga, tai chi has been linked to improved overall physical, mental, and social health, as well as increased balance, strength, and flexibility, leading to a sense of relaxation and mental well-being. This involves enhancing physical fitness and overall health to promote a higher quality of life (Nontakhod et al., 2022; Park and Lim, 2019; Saetae et al., 2018).

Among the many benefits of the Pilates method, we highlight joint mobility, muscle flexibility, strength, and balance, following fundamental principles (i.e., breathing technique, concentration, control, core stabilization, movement quality and increasing isometric trunk extension and flexion strength (Bertoli et al., 2022; Kliziene et al., 2017; Latey, 2002;). Additionally, Pilates can be an effective exercise intervention to improve the lifestyle quality (Chmielewska et al., 2019; Lee et al., 2021). In conclusion, the research findings presented demonstrate improvements in flexibility and strength among female students after participating in an 8-week Pilates training program, compared to the control group. The effects of Pilates training led to enhanced flexibility and strength, which are associated with better health outcomes. Given the convenience and safety of Pilates exercises, these positive health benefits are important for promoting lifestyle changes among female students.

Conclusions

Pilates-related exercises provide health benefits by enhancing flexibility and strength, promoting cardiovascular health, and regulating blood pressure. They can be performed safely in accordance with an individual's abilities. Therefore, incorporating Pilates as a means to promote health is a valuable approach for people of all ages.

Acknowledgements

The author would like to thank the participant that helped and supported this research.

Human research ethics

This research was approved by the Human Research Ethics Committee of Buriram Rajabhat University (BRU: 004/2025).

References

Adams, C. (2018). Physical and mental health benefits of yoga, barre, Pilates & spinning [Internet]. RIPPED. ME. 2018. September. [Cited 2024 July 21]. Available from: https://ripped.me/physical-and -mental-health-benefits-of-yoga-barre-pilates-spining.

Ballmann, C. G., McCullum, M. J., Rogers, R. R., Marshall, M. R., & Williams, T. D. (2021). Effects of preferred vs. conferred music on resistance exercise performance. *Journal of Strength and Conditioning Research,* 35(6), 1650-1655. https://doi.org/10.1519/JSC.0000000000002981.

Batista, M. B., Romanzini, C. L. P., BlasquezShigaki, G., Romanzini, M., & Ronque, E. R. V. (2019). Participation in sports in childhood and adolescence and physical activity in adulthood: a systematic review. *Journal of Sports Sciences,* 37(19), 2253-2262. https//doi.org/10.1080/02640414.2019.1627696. Epub 2019 Jun 8.

Behm, D. G., & Chaouachi, A. (2011). A review of the acute effects of static and dynamic stretching on performance. *European Journal Applied Physiology,* 111(11), 2633-2651. https://doi.org/10.1007/s00421-001-1879-2.

Bertoli, J., de Souza Bezerra, E., Dos Santos, S. F. D. S., Gobbo, L. A., & Junior, I. F. F. (2022). The influence of mat Pilates training adherence on strength and flexibility parameters in breast cancer survivors undergoing hormone therapy. *Journal of Exercise Rehabilitation,* 18(4), 272-283. https://doi.org/10.12965/jer.2244298.149.

Bhadauria, E. A., & Gurudut, P. (2017). Comparative effectiveness of lumbar stabilization, dynamic strengthening, and Pilates on chronic low back pain: randomized clinical trial. *Journal of Exercise Rehabilitation,* 13(4), 477-485. https://doi.org/10.12965/jer.1734972.486.

Borah, P., Hussain, I., Gogoi, L., Govindasamy, K., Sarkar, S., Elayaraja, M., & Balaji, E. (2024). Effect of mat Pilates training program on function fitness in older adults. *Pedagogy of Physical Culture and Sports,* 28(1), 16-25. https://doi.org/10.15561/26649837.2024.0102.

Bull, F. C., AI-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., Lambert, E., Leitzmann, M., Milton, K., Ortega, F. B., Ranasinghe, C., Stamatakis. E., Tiedemann, A., Troiano, R. P., van der Ploeg, H. P., Wari, V., & Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviors. *British Journal of Sports Medicine,* 54(24), 1451-1462. https://doi.org/10.1136/bjsports-2020-102955.

Chmielewska, D., Stana, M., Kucab-Klich, K., Blaszczak, K., Kwasna, K., Smykla, A., & Dolibog, P. (2019). Electromyographic characteristics of pelvic floor muscles in women with stress urinary incontinence following SEMG-assisted biofeedback training and Pilates exercise. *Public Library of Science,* 14(12), e0025647. https://doi.org/10.1371/journal.pone.0225647.

Ciolac, E. G. (2013). Exercise training as a preventive tool for age-related disorders: a brief review. *Clinics (Sao Paulo),* 68(5), 710-717. https://doi.org.10.6061/clinics/2013(05)20.

Glawell, V., Head, S., Haggar, M., & Beneke, R. (2006). Does a programs of Pilates improve chronic non-specific low back pain. *Journal of Sport Rehabilitation,* 15(4), 338-350. https://doi.org/10.1123/jsr.15.4.338.

Farooq, A., Martin, A., Jassen, X., Wilson, M. G., Gibson, A. M., Hughes, A., & Reilly, J. J. (2020). Longitudinal changes in moderate-to-vigorous-intensity physical activity children and adolescents: a systematic review and meta-analysis. *Obesity Reviews,* 21, e12953. https://doi.org/10.1111/obr.12953.

Gronek, J., Boraczynski, M., Wielinski, D., Tarnas, J., Maeszalek, S., & Tang, Y. Y. (2021). Exercise in aging: be balanced. *Aging and Disease*, 12(5), 1140-1149. https://doi.org.10.14336/AD.2021.0107.

Ha, S. A., Lee, S. Y., Kim, K. A., Seo, J. S. Sohn, C. M., Park, H. R., & Kim, K. W. (2016). Eating habits, physical activity, nutrition knowledge, and self-efficacy by obesity status in upper-grade elementary school students. *Nutrition Research and Practice,* 10(6), 597-605. https://doi.org/10.4162/nrp.2016.10.6.597. Epub 2016 Aug 17.

Henriksen, E. J. (2002). Effects of acute exercise and exercise training on insulin resistance. *Journal of Applied Physiology,* 93(2), 788-796. https://doi.org/10.1152/japplphysiol.01219.2001.

Irez, G. B., Ozdemir, R. A., 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. PMID: 24149302; PMCID: PMC3737905.

Jaeho, Y., & Lee, G. (2012). Effect of core stability training using Pilates on lower extremity muscle strength and postural stability in healthy subject. *Isokinetic and Exercise Science,* 20, 141-146. https://doi.org/10.3233/IES-2012-0462.

Jangphonak, P., Bussamonkol, P., Suksong, P., & Thonglong, T. (2025). Effect of yoga combined elastic band program on health-physical fitness and balance in older adults. *Physical Rehabilitation and Recreational Health Technologies,* 10(1), 42-48. https://doi.org/10.15391/prrht.2025-10(1).06.

Jee, H. (2025). Association between regularly performed physical activity and academic performance in female adolescents from middle to high school. *Journal of Exercise Rehabilitation,* 21(1), 25-31. https://doi.org/10.12965/jer.2550002.002.

Jeong, S. Y., Yu, J. I., Seo, T. B., & Kim, Y. P. (2024). Effects of music during walking exercise on heart rate variation, lactic acid, and aerobic variables in male college students. *Journal of Exercise Rehabilitation,* 20(6), 220-226. https://doi.org/10.12965/jer.2448598.299.

Jinakote, M., Jeeratantorn, P., Surapolchai, L., Dornbunlon, P., Yoysungnoen, B., & Kasiyaphat, A. (2024). Effects of brisk walking with or without music on body composition, standing balance, cardiovascular parameter, and salivary biomarkers in older women. *Journal of Exercise Rehabilitation,* 20(3), 100-111. https://doi.org.10.12965/jer.2448154.077.

Kashuba, V., Tomilina, Y. U., Byshevets, N., Khrypko, I., Stepanenko, O., Grygus, I., Smolenska, O., & Savliuk, S. (2020). Impact of Pilates on the intensity of pain in the spine of women of the first mature age. *Physical Education Theory and Methodology,* 20(1), 12-17. https://doi.org/10.17309/tmfv.2020.1.02.

KauricKlein, Z. (2019). Effect of yoga physical and psychological outcome in patients on chronic hemodialysis. *Complementary Therapies in Clinical Practice,* 34, 41-45. https://doi.org.10.1016/j.ctcp.2018.11.004.

Kim, H. J., Kang, C. K., Park, H., & Lee, M. G. (2014). Effects of vitamin D supper mentation and circuit training on indices of obesity and insulin resistance in T2D and vitamin D deficient elderly women. *Journal of Exercise Nutrition & Biomechemistry,* 18(3), 249-257.

Kliziene, I., Sipaviciene, S., Vilkiene, J., Astrauskiene, A., Cibulskas, G., Klizas, S., & Cizauskas, G. (2017). Effects of a 16-week Pilates exercise training programs for isometric trunk extension and flexion strength. *Journal of Bodywork and Movement Therapies,* 21(1), 124-132. https://doi.org/10.1016.j.jbmt.2016.06.005.

Lambourne, K., Hansen, D. M., Szabo, A. N., Lee, J., Herrmann, S. D., & Donnelly, J. E. (2013). Indirect and direct relations between aerobic fitness, physical activity, and academic achievement in elementary school students. *Mental Health Physical Activity,* 6(3), 165-171. https://doi.org/j.mhpa.2013.06.002.

Latey, P. (2002). Updating the principles of the Pilates method-Part 2. *Journal of Bodywork and Movement Therapies,* 6, 94-101. https://doi.org/10.1054/jbmt.2002.02.90.

Lee, H., Kang, G., Moon, H., Lee, J., Kang, M., & Kim, M. (2021). Interventional benefit of Pilates using Oov and mat on middle-age women with lower urinary tract symptoms: emphasis on abdominal muscle thickness and muscular function. *Journal of Exercise Rehabilitation,* 17(3), 192-197. https://doi.org/10.12965/jer.2142240.120.

Lephart, S. M., Smoliga, J. M., Myers, J. B., Sell, T. C., & Tsai, Y. S. (2007). An eight-week golf-specifics exercise program improves physical characteristics, swing mechanics, and golf performance in recreational golfers. *Journal of Strength and Conditioning Research,* 21(3), 860-869. https://doi.org/10.1519/R-20606.1.

Lim, E. J., & Park, J. E. (2019). The effect of Pilates and yoga participant's on engagement in functional movement and individual health level. *Journal of Exercise Rehabilitation,* 15(4), 553-559. https://doi.org.10.12965/jer.1938280.140.

Marionda, I. I., & Dzhuhan, L. M. (2007). Use of the basic principles of Pilates in process of training with students of special medical groups. *Scientific Journal of Uzhgorod National University,* 31, 94-96.

Mental Healthy. (2019). Pilates, a total mind and body workout [Internet]. Mental Healthy [Cited 2024 July 22]. Available from: https://www.mentalhealthy.co.uk/home/about-us.

Mikalacki, M., Cokorilo, N., & Ruiz-Montero, P. J. (2017). The Effect of a Pilates-aerobic program on maximum exercise capacity of adult women. *RevistaBrasileirade Medicina do Esporte,* 23, 246-249. https://doi.org/10.1590/1517-869220172303156004.

Nontakhod, K., Chuaibunchum, J., Klaharn, C., & Phunsang, N. Effects of tai chi and resistance training on balance and elderly's strength. *Physical Education Theory and Methodology,* 22(4), 530-536. https://doi.org/10.17309/tmfv.2022.4.11.

Nontakhod, K., Ratchakit, K., Krobtong, P., Ketthaisong, S., Sremsiri, C., & Intanoo, K. (2025). Exercise selection for health to elderly after the COVID-19 outbreak. *Journal of Human Sport and Exercise,* 20(2), 596-605. https://doi.org/10.55860/27ncq749.

Oliveira, L. C., Oliveira, R. G., & Pires-Oliveira, D. A. (2016). Comparison between static stretching and the Pilates method on the flexibility of older women. *Journal of Bodywork Movement Therapies,* 20(4), 800-806. https://doi.org/10.1016/j.jbmt.2016.01.008.

Park, J. H., Kim, H. J., Choi, D. H., Park, S., & Hwang, Y. Y. (2020). Effects of 8-week Pilates training program on hamstring/quadriceps ratio and trunk strength in adolescent baseball players: a pilot case study. *Journal of Exercise Rehabilitation,* 16(1), 88-95. https://doi.org/10.12965/jer.1938732.366.

Park, J. E., & Lim, E .J. (2019).The effects of Pilates and yoga participant's on engagement in functional movement and individual health level. *Journal of Exercise Rehabilitation,* 15(4), 553-559. https://doi.org/10.12965/jer.1938280.140.

Pojskic, H., Pagaduan, J., Uzicanin, E., Muratovic, M., & Tomljanovic, M. (2015). Acute effects of loaded whole body vibration training performance. *Asian Journal of Sports Medicine,* 6(1), e24054. https://doi.org.10.5812/asjsm.24054.

Rahimimoghadam, Z., Rahemi, Z., Sadat, Z., & Mirbagher Ajorpaz, N. (2019). Pilates exercises and quality of life of patients with chronic kidney disease. *Complementary Therapies in Clinical Practice,* 35, 35-40. https://doi.org.10.1016/j.ctcp.2018.10.107.

Ryu, H. R., Kim, M. J., Yoon, E. S., & Kim, D. Y. (2024). Effects of foam roller-based combined exercise on functional fitness, balance, and gait in older women. *Journal of Exercise Rehabilitation,* 20(6), 240-249. https://doi.org/10.12965/jer.2448640.320.

Saetae, R., Supaporn, S., & Peepathum, P. (2018). Effects of combined gigong with yoga practice and qigong practice upon fear of falling and holistic health of elderly: a qualitative study. *Journal of Faculty of Physical Education,* 21(2), 43-54.

Silva, G. C., Tebar, W. R., Lemes, I. R., Sasaki, J. E., Mota, J., Ritti-Dias, R. M., Vanderlei, L. C. M., & Christofaro, D. G. D. (2022). Can sports practice in childhood and adolescence be associated with higher intensities of physical activity in adult life a retrospective study in community-dwelling adults. *International Journal of Environmental Research and Public Health,* 19, 14753. https://doi.org/10.3390/ijerph192214753.

Siqueira Rodrigues, B. G., Ali Cader, S., Bento Torres, N. V., Oliverira, E. M., & Martin Dantas, E. H. (2010). Pilates method in personal autonomy, static balance and quality of life of elderly females. *Journal Bodyweight Movement Therapy,* 14(2), 195-202. https://doi.org/10.1016/j.jbmt.2009.12.005.

Smith, K., & Smith, E. (2005). Integrating Pilates-based core strengthening into older adult fitness programs: Implications for practice. *Topics in Geriatric Rehabilitation,* 21(1), 57-67. https://doi.org/10.1097/00013614-200501000-00007.

Teixeira de Carvalho, F., de Andrade Mesquita, L. S., Pereira, R., Neto, O. P., & Amaro Zangaro, R. (2017). Pilates and proprioceptive neuromuscular facilitation methods induce similar strength gains but different neuromuscular adaptations in elderly women. *Experimental Aging Research,* 43(5), 440-452. https://doi.org/10.1080/0361073X.2017.1369624.

Tejada Medina, V., Diaz Caro, C., Gonzalez Garcia, C., & Montero, P. J. (2021). Physical intervention programs in older women trough the Pilates method: a systematic review, *Retos,* 39, 1006-1016. https://doi.org/10.47197/retos.vOi39.78005.

Terry, P. C., Karageorghis, C. I., Curran, M. L., Martin, O. V., & Parsons-Smith, R L. (2020). Effects of music in exercise and sport: a meta-analytic review. *Psychological Bull,* 146(2), 97-117. https://doi.org/10.1037/bul0000216.

Wells, C., Kolt, G. S., & Bialocerkowski, A. (2012). Defining Pilates exercise: a systematic review. *Complementary Therapies Medicine,* 20(4), 253-262. https://doi.org/10.1016/j.ctim.2012.02.005.

Worapongpichet, P., & Kamoltham, S. (2018). *Yoga manual for the elderly.* Division of Complementary and Alternative Medicine, Ministry of Public Health, Thailand.

Zou, L., Wang, T., Herold, F., Ludyga, S., Liu, W., Zhang, Y., Healy, S., Zhang, Z., Kuang, J., Taylor, A, Kramer, A. F., Chen, S., Tremblay, M. S., & Hossain, M. M. (2023). Associations between sedentary behavior and negative emotions in adolescents during home confinement: mediating role of social support and sleep quality. *International Journal of Clinic and Health Psychology,* 23(1), 100337. https://doi.org/10.1016/j.ijchp.2022.100337. Epub 2022 Sep 22.

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