

Efficacy of Pilates in Functional Body Composition: A Systematic Review

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Abstract: **Background:** The aim of this review was to collect and systematize results of studies from the last 5 years concerning the influence of the Pilates method (PM) on functional body composition (FBC). **Methods:** The criteria of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were used in this review. We conducted research in three scientific databases: (i) Web of Science Core Collection, (ii) SCOPUS, and (iii) search directory of the library catalog of the Faculty of Sport and Physical Education of the University of Coimbra—EBSCO Discovery Services. We found 334 articles, covering the period between 1 January 2017 and 31 December 2021. After the selection process, we found 33 eligible articles. **Results:** The main results seem to point to a tendency to get a better body weight and body fat percentage (BFP), hip circumference (HC), waist, and skinfolds from the chest, abdomen, triceps, and supra-iliac in mostly female samples. Available evidence indicates that, in body composition (BC) and FBC, Pilates practice tends to be effective in reducing obesity as a multifactorial condition. **Conclusions:** It is concluded that there is a marked trend in the benefits of Pilates in FBC, which is in line with other systematic reviews at the BC level (which includes body weight (BW) and body mass index (BMI)) and in the reduction of the percentage of fat mass (FM). It is also concluded that there is a vast lack of studies on the male population, preventing further scientific development in this area. The limitations of this systematic review can be overcome with studies that bring together multidisciplinary aspects of FBC, better designed and methodologically more robust, which will allow more reliable analyses for the implementation of the Pilates method in terms of FBC. In addition, further studies with a male sample or mixed samples (men vs. women) could confirm the trend of no gender differences in the benefits of Pilates practice.

Keywords: body composition; fat mass; obesity; Pilates method; health

1. Introduction

Body weight (BW) is associated with biomedical characteristics which allow us to relate this measure to health and quality of life parameter [1]. Excess BW, defined as obesity, is related to the excessive accumulation of body fat and to several pathologies such as diabetes, cardiovascular diseases, and musculoskeletal diseases [2], leading to risk variables for chronic diseases and premature death [3]. Obesity and overweight are defined according to the World Health Organization (2021) as the abnormal and excessive accumulation of fat that can influence health. In numerical terms and according to the body mass index (BMI),

overweight exists in values equal to or greater than 25, whereas obesity exists when the BMI value is equal to or greater than 30.

Nevertheless, according to the World Health Organization (WHO, 2021), in 2016, 39% of the world population was overweight, and 13% of the population was obese. From an analytical and interventionist point of view, there is a need for a more in-depth and detailed analysis of this health problem. This implies a broader concept that passes from the BW to the functional body composition (FBC).

Thus, such a concept should focus on nutritional status, including dietary pattern or hydration level, metabolic analysis, such as aerobic thresholds or caloric consumption, and the practitioner's health context, especially in unrelated diseases. In this way, we will be able to achieve the full benefits of physical activity that, combined with nutrition, may influence weight loss and control, but more importantly, the prevention and control of obesity-related diseases [4].

Traditionally, physical exercise appears as one of the most effective ways to lose and control BW. Currently, the advantages of physical activity cover new areas directly related to BW, considered as a broader construct. In this way, we move from an analysis centered on mass (measured in kg) to the influence of various components and organs of the human body on BW, based on a multifunctional analysis, more analytical and prescriptive, directed to the "individual" as a whole, based on the functioning of human body systems, active lifestyles, nutritional status, and genetic variants. This analysis could optimize the quantitative result (decreasing weight) and improve the functioning of organs and body systems (e.g., improvement of the metabolic system). This is how the concept of FBC emerges as a fundamental tool for the fight against obesity, both from a health perspective and from the perspective of physical exercise, used as a preferred instrument against diseases associated with this condition [5].

Subsequently, from an interventionist point of view, Pilates can be one of the ways to achieve this purpose. This method can be characterized as a nonrepetitive and strenuous form of exercise, adapted to the needs of each person, with benefits at various levels [6,7], such as improvement in flexibility, strength, coordination, blood circulation, physical fitness, and postural alignment [8,9]. Due to its characteristics and also the trends presented by recent studies, Pilates appears to be a viable alternative for the control of blood pressure, among other pathologies [10,11], seen as important to fight obesity and related diseases [12].

Thus, the current state of the art mainly focuses on a partial view of the concept of body composition (BC) and Pilates itself [13]. In view of the above, this systematic review of studies aimed to collect and systematize the results of studies published in the last 5 years relating interventions in all Pilates method forms with FBC.

This time window, although configured as a limitation of the study, is justified by the recent introduction of the broad concept of FBC and by the increase in studies in this broader perspective, thus being able to bring an update of previous reviews and contribute to a better understanding of the effectiveness of the Pilates method (mat, small equipment, apparatus, etc.) in its practitioners [6,13].

2. Materials and Methods

2.1. Search Strategy

This systematic review used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [14] criteria for the selection, reading, and analysis of studies in this area. A search was conducted in three databases (Figure 1): (i) Web of Science (Core Collection), (ii) SCOPUS, and (iii) search directory of the library catalog of the Faculty of Sport and Physical Education of the University of Coimbra—EBSCO Discovery Services. The selection of these databases is consistent with a previous search and was based on the large number of articles found. The search was performed with the words "Pilates" or "Pilates-based" in the title, associated with the words "body composition", "fat", "bone", or "muscle mass" in the abstract or keywords, when performed in SCOPUS. The time period was between 1 January 2017 and 31 December 2021. This period was chosen due to

the increase in studies about Pilates in the last 10 years [15] and the need to update and systematize the studies carried out in the last 5 years (Figure 2).

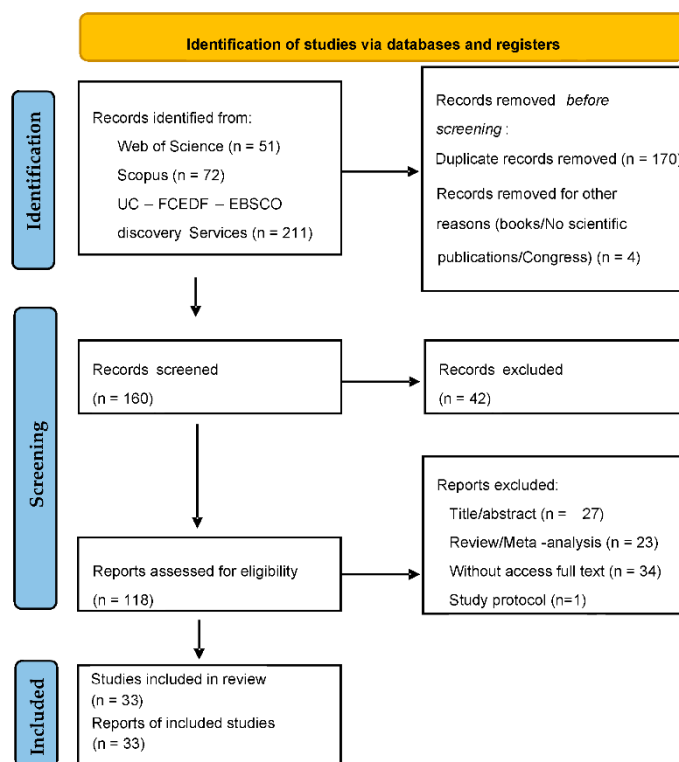


Figure 1. PRISMA 2020 flow diagram for new systematic reviews, which includes searches of databases and registers only (adapted from [14]).

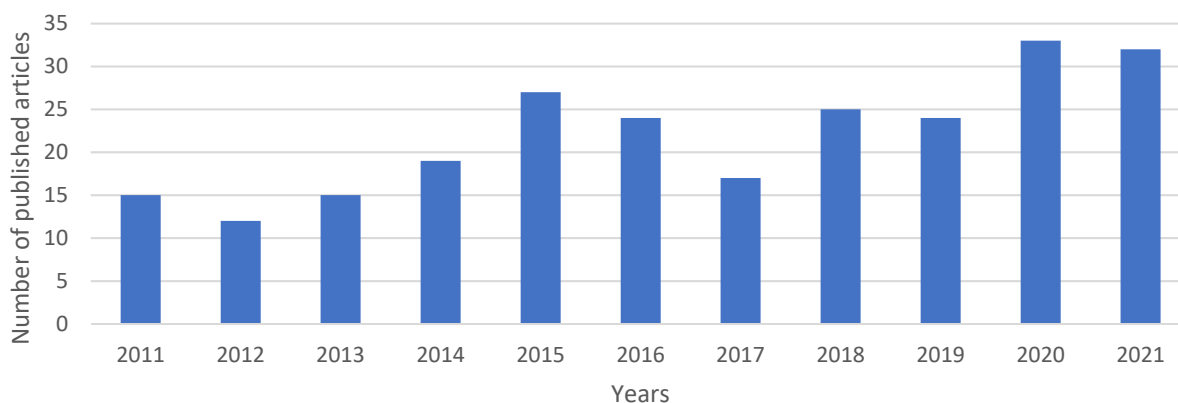


Figure 2. Articles found in the databases searched per year (10 years).

Cross-references in selected articles were analyzed. Communications in congresses, opinion articles, and other nonscientific sources were not analyzed, as there is no evidence that this is a relevant source of information in the Pilates domain.

2.2. Eligibility Criteria

In this review, the inclusion criteria were as follows: (i) published between 1 January 2017 and 31 December of 2021; (ii) written in Portuguese, Spanish, French, or English; (iii) whose title contained the word “Pilates”, which was the dependent variable. As exclusion criteria we defined articles (i) published outside the time frame, (ii) without full-text access, (iii) that were theses, books, opinion articles, and conference papers, and (iv) where the intervention was mixed with other techniques or interventions.

The article selection process followed the following steps: (i) studies that used the descriptors in the aforementioned databases; (ii) exclusion of duplicate articles; (iii) reading the titles and abstracts; (iv) reading and critical evaluation of the articles (cf. Figure 2). This process, as well as the extraction of information from each one, was carried out by two authors (M.P. and R.M.), independently. It was then standardized, after analysis and comparison. In the case of differences, a third author (R.S.M.) was called to analyze and issue his final decision.

3. Results

For this systematic review, without meta-analysis, 33 articles were selected, with experimental designs between randomized and cross-sectional experimental studies. In total, these studies involved 1112 people, mostly middle-aged women (e.g., Correio et al. (2020): mean age = 42.37 ± 7.86 years). It is important to highlight that there were only four studies with a mixed sample (male and female). Despite this, the results for this population agree with those obtained for the female population, as well as when compared with benefits of Pilates other than the FBC [16–18]. Thus, Table 1 present the main results obtained.

Table 1. Summary of studies included in the review.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
1	Aguado-Henche, S.; Arriba, C.; Rodriguez-Torres, R. (2017) [19]	Pilates mat and body composition of postmenopausal women: densitometric study	37 females (48–82 years)	The aim of this study was to quantify the changes in body composition after mat Pilates practice in postmenopausal sedentary women.	Pilates group (PG)—34 36 weeks 2× week (60')	Dual X-ray photon absorptiometry (DXA)	Pilates significantly increased the muscle mass of the trunk ($p = 0.028$), abdomen ($p = 0.010$), and arms ($p = 0.042$). A significant decrease was observed in the leg fat mass (FM) ($p = 0.000$). Bone mineral density of the lumbar spine (L2, L3 and L4) also increased significantly.	The results suggest that the practice of mat Pilates in postmenopausal women improves their body composition.
2	Savkin, R.; Aslan, U.B. (2017) [20]	The effect of Pilates exercise on body composition in sedentary overweight and obese women	37 females (30–50 years)	The aim of this study was to determine the effects of Pilates exercises on body composition in sedentary overweight and obese women.	PG—19 Control Group (CG)—18 8 weeks 3× week (90')	Bioelectric impedance analysis was used to determine the participants' body composition: weight, BMI, BFM, lean body mass (LBM), and waist, abdomen, and hip circumference (HC)	In the PG, weight, BMI, fat percentage, and waist, abdomen, and HC decreased significantly after training ($p < 0.05$) while no significant difference was observed in LBM ($p > 0.05$). In the CG, abdomen and HC increased ($p < 0.05$) as the other parameters showed the tendency for an increase, but no significant difference ($p < 0.05$).	The results of this study indicate that 8 weeks of Pilates exercises have positive effects on BC in sedentary overweight and obese women. Pilates exercises can be applied for improving body composition.
3	Andrei-Marius, I.S.; Sabina, M.; Mihaela, Z. (2017) [21]	Changes in the body composition of people practicing exercises on Pilates apparatus	20 females	The authors intended to track how a framework program of exercises on Pilates apparatus could influence body composition in adult women.	Pilates Group Apparatus (PGA)—20 16 weeks	Weight, BMI, body fat percentage (BFP), skeletal muscle percentage (SMP), visceral fat (VF), using OMRON BF511 Body Composition Monitor	The results showed changes in all indicators measured using OMRON BF511 Body Composition Monitor.	The performed measurements entitle us to state that Pilates exercises are beneficial to physical health and wellbeing by improving the indices of weight and FM, in close relationship with the muscle tissue.
4	Serbescu, C.I.; Pop, A.C. (2017) [22]	Bone mineral density in osteopenic early postmenopausal women practicing Pilates gymnastic for six years	22 women (50–65 years)	There were two aims of this study: to compare the body mineral density (BMD) values of an active female group at the end of the 5th year with those at the end of 6th year, and to compare the BMD in early menopausal women.	PG—22 CG—25 5 years 2× week (60')	Calcaneal ultrasound measurement with OsteoSysSonost 3000	The bone parameters of the experimental group were the same or did not change significantly in the last year of physical activity. At follow-up (the end of the 6th year), the bone parameters of the active group and sedentary group generated significant differences favoring the active group ($p < 0.01$).	A program of 12 months did not have an impact on the BMD values of women in menopause, but BMD values did not decrease as expected in women of this age. Regular physical activity performed over a 6 year period led to greater BMD values for active early menopausal women than their sedentary peers.
5	Sevimli, D.; Sanri, M. (2017) [23]	Effects of cardio-Pilates exercise program on physical characteristics of females	40 females (25–41 years)	This study aimed to investigate to effects of a 4 week cardio-Pilates exercise program on physical characteristics in females.	PG—22 4 weeks 3× week (60')	Body height and weight waist circumference (WC) and HC BFP	The cardio-Pilates exercise program significantly decreased BFP, body fat weight, WC, and HC. Cohen's <i>d</i> calculations showed that the 4 week exercise program had a significant moderate effect on BFP, body fat weight, and WC in females.	The 4 week exercise program seemed to be effective in decreasing the body fat and WC values in females. It was concluded that the magnitude of training effect depends on the duration and intensity of the exercise program.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
6	Eftekhari, E.; Etemadifar, M. (2018) [24]	Impact of clinical mat Pilates on body composition and functional indices in female patients with multiple sclerosis	30 females (mean = 33.00 ± 8.08 years)	Muscle weakness, movement disorders, and fatigue due to multiple sclerosis (MS) cause a decrease in balance and physical activity, which may be linked to the BC. The purpose of the study was to investigate the effect of clinical mat Pilates on anthropometric variables, functional indices, and fatigue in females suffering from MS.	PG—15 CG—15 8 weeks 3 × week (60')	BW, BMI, WC, HC, mid-arm muscle circumference (MAMC), calf circumference (CC), waist-to-hip ratio (WHR), 7-site skinfold (chest, abdominal, thigh, triceps, subscapular, suprailiac, and midaxillary), fat percentage (FP), FM, fat-free mass (FFM), and body density (BD)	Statistical analysis demonstrated a significant decrease in BW, BMI, WC, HC, MAMC, skinfolds of the chest, abdominal, triceps, and suprailiac, FP, FM, and fatigue, as well as an increase in BD, balance, walking speed, and endurance in Pilates group ($p < 0.05$).	An 8 week mat Pilates program as a nonpharmacological intervention may positively affect anthropometric variables, functional indices, and fatigue, which may decline some of the outcomes of muscle weakness as an MS complication.
7	Leal, J.B.; Leal, J.B.; Borges, Y.L.; Oliveira, D.C.; Cavalcante, D.S.; Maia, M.S.; Moura, M.L.; Neta, A.R. (2018) [25]	Changes in the body composition of women at cardiovascular risk by the Pilates method	7 females (>25 years; mean = 51 years)	The aim of this study was to verify the effects of the Pilates method supervised training on body composition of women with cardiovascular risk factors.	Pilates group apparatus (PGA)—7 7 weeks 3 × week (60')	BC, height, WC, and HC	There was a reduction in BMI ($p < 0.05$) and in FM ($p < 0.05$), as well as an increase in fat free mass ($p < 0.05$) and in the rate ($p < 0.05$). The effect size was high on weight, BMI, FM, fat-free mass, and basal metabolic rate.	The present research could highlight the benefits that Pilates can provide to the wellbeing of the individual, be it in the physical and mental conditioning or in the BC.
8	Lee, J.C. (2018) [26]	The effects of 8 week Pilates mat exercises on the body composition and level of satisfaction of female college students	22 females (20 > age < 30)	The purpose of this study was to identify the effects of Pilates exercises on the body composition and satisfaction level of female college students.	PG—22 8 weeks 2 × week (60')	BFP, LBM (kg), BMI, muscle mass (kg), basal metabolic rate (BMR, kcal), abdominal fat percentage (AFP, %) using Inbody 3.0	The components of body composition measured before and after the 8 week Pilates exercise program showed that FM and abdominal fat percentage were reduced, while LBM increased. The level of satisfaction of the group of those who performed Pilates exercises for 8 weeks showed positive effects.	It will be necessary to develop various systematic and science-based Pilates exercise programs that are customized for different age groups in order to reduce the level of the components of body composition associated with obesity.
9	Özcan, R.; İrez, G.B.; Saygin, O.; Ceylan, H.I. (2018) [27]	Aqua-Pilates exercises improves some physical fitness parameters of healthy young women	60 females	The aim of this study was to investigate the effects of 12 weeks of aqua-Pilates exercises applied to healthy young women.	PG—22 12 weeks 2 × week (60')	BW, BMI, BFP, flexibility, dynamic balance, muscle strength, and vital and forced capacity value (FVC-VC)	A statistically significant difference was detected between pre-test and post-test mean values of BW ($t = 4.39$, $p = 0.00$), BMI ($t = 5.49$, $p = 0.00$), and BFP ($t = 7.38$, $p = 0.00$) in the exercise group with a small effect size, except BFP (moderate effect).	It was observed that aqua-Pilates exercises positively affect the body composition, flexibility, dynamic balance, muscle strength, respiratory functions, and balance characteristics of young women.
10	Welter, M.T.; Lara, S.; Castro, A.M.; Balk, R.S. (2018) [28]	Effects of the Pilates method on physical ability variables in adolescents	51 (32 females, 19 male) (mean = 10 years)	The aim of this study was to assess the Pilates method over physical fitness variables in teenagers.	PG—28 CG—23 21 weeks 2 × week (60')	BC, mass, height, BMI, WC, WHR, and palmar grip strength	An increase in WHR in CG and maintenance of this variable was found in the PG, along with an improvement in the palmar grip strength for both groups post intervention.	PM practice showed positive effects in the maintenance of central fat measurements in these teenagers. Nevertheless, the effects of the Pilates method on palmar grip strength were not emphasized.

Table 1. Cont.

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11	Haas, A.N.; Júnior, O.B.; Bittencourt, D. (2018) [29]	Anthropometric profile of women practicing the Pilates method in two cities of Rio Grande do Sul	50 females (20–50 years)	The aim of this study was to evaluate and compare the anthropometric measurements, BMI, and body composition of female PM practitioners.	Pilates Group Osório (PGO)—25 Pilates Group Canoas (PGC)—25 27 weeks 2× week (60')	Height Weight Body Mass (BM) BMI, 9 Skinfolds, 17 perimeters, 9 circumferences, 9 lengths, and body composition of 5 elements (Ross and Kerr)	When evaluating measurements of skinfolds, perimeters, circumferences, diameters, lengths, and BMI, the authors did not observe significant differences between the two groups. However, BMI average was very close to the overweight range. As for the quantification within the reference indices for body fat in female individuals, 56% of the sample was above the average.	Anthropometric characteristics, BMI, and body composition of the participants were very similar. Although the practice of PM was regular, it was worrying that the BMI average of the two groups was next to the overweight range.
12	Widanita N.; Kusuma M.H.; Budi, D.; Suhartoyo, T.; Listiandi, A.D.; Anggraeni, D.; Gitya, N. (2019) [30]	The effectiveness of Pilates training model towards BMI and muscle mass for overweight women	12 females	This study aimed to determine the effectiveness of Pilates training model toward BMI and muscle mass for overweight women.	PG—25 4 weeks 3× week (45')	BMI and muscle mass	It can be stated that there was a significant effect of the Pilates model on the reduction in BMI.	It can be concluded that there was a significant effect of the Pilates training model. The results showed that the Pilates training model affected changes in BMI and muscle mass for overweight women.
13	Amirsan, R.; Dolgari, R.; Vakili, J. (2019) [31]	Effects of Pilates training and turmeric supplementation on Sirtuin 1 level and body composition in postmenopausal females with sedentary overweight: a randomized, double-blind, clinical trial	44 females (mean age = 50 years)	The randomized, double-blind, clinical trial aimed at evaluating the effects of a 12 week turmeric intake and Pilates training on serum level of SIRT1, weight, and FM in postmenopausal females.	PG—11 Turmeric supplement group (TSG)—11 Pilates group + turmeric supplement (PGTS)—11 CG—11 12 weeks 3× week (60')	Serum, SIRT1 level, weight, and BFP	According to the results, the 12 week Pilates and Pilates/turmeric intervention reduced weight and FM by ~8% and 6%, respectively, and increased serum SIRT1 content by ~2.9-fold ($p < 0.01$) in the training groups compared with the control group. There were significant differences between the training groups in comparison with the control or turmeric groups in all dependent variables. There was no significant difference between the Pilates and Pilates/turmeric groups. Moreover, no significant difference was observed in dependent variables in the turmeric supplementation group compared with baseline measures or the control group ($p \geq 0.05$).	Three months of Pilates training with and without turmeric supplementation seemed effective in increasing SIRT1 and improving body composition in middle-aged females. However, the results did not support the hypothesis that turmeric intake alone has potential exercise-like effects on healthy middle-aged females.

Table 1. Cont.

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14	Carrasco-Poyatos, M; Rubio-Arias, J.A.; Ballesta-García, I; Ramos-Campo, D.J. (2019) [32]	Pilates vs. muscular training in older women. Effects in functional factors and the cognitive interaction: a randomized controlled trial	60 females (60–80 years)	The goal was to analyze the effect of two different training programs on functional autonomy, balance, and body composition in aged women and to determine the influence of their cognitive function.	PG—20 Muscular group (MG)—20 CG—20 18 weeks 2× week (60')	GDLAM Mini-Mental State (MMS), static balance, with a force platform (Kistler 9286AA), body composition, with dual-energy X-ray bone densitometry	The Pilates and muscular groups improved significantly ($p < 0.05$) in every GDLAM test. The Pilates group had a better general functional condition index (IG) than the muscular group ($p = 0.042$). There was a significant interaction ($p \leq 0.05$) between the cognitive function and two items of the GDLAM test. The amplitude of displacement of the center of pressure in the antero-posterior plane decreased significantly in the muscular group ($p = 0.04$). The total lean body increased in the Pilates ($p < 0.001$) and the muscular groups ($p = 0.05$).	Pilates should be recommended for improving the general functional condition of older women, while muscular exercise is effective for enhancing the static balance. Both exercise programs are effective for increasing the total lean body mass. The cognitive function interacts with some functional autonomy parameters.
15	Chazali, A.; Mansur; Widanita, N.; Guntur; Putra, F.; Fajaruddin, S. (2019) [33]	Developing Pilates training model for decreasing the body fat ratio among overweight women	39 females (10 small test, 17 big test, 12 effectiveness test)	The study was aimed at generating a sufficient alternative training model for decreasing the body fat ratio among overweight women.	Mat Pilates exercises for 4 weeks (30')	BMI and questionnaires	The results of the study showed that the development of a Pilates training model for decreasing the body fat ratio was validated in terms of burning the body fat. In addition, the results of the test showed that the development of the Pilates training model belonged to the “good” category.	The PTM developed for the overweight women might be used as an alternative training model in an effort to decrease the body fat ratio. It should be equipped with an exercise supporting facility in order for it to be more enjoyable. It can be applied to all age groups with an overweight problem with adjustment to the participants’ characteristics. It can be performed in variation with other movements so that boredom when performing the exercise can be avoided. Instructors should be more active and more creative in implementing the Pilates movement so that the PTM is more enjoyable for the members.
16	Feldner, C.B.; Cezário, N.F.; Mendes, E.L. (2019) [34]	Effects of a mat Pilates program on health indicators in servers of a hospital	22 man/women (18–60 years)	The aim of this study was to evaluate the effect of a mat Pilates program regarding the body composition, quality of life, level of physical activity, and flexibility and strength in servants of a university hospital.	Pilates group (20) Control group (21) 20 weeks 2× week	Blood pressure (BP), body evaluation, abdominal strength test, and flexibility Questionnaires on quality of life, health, and physical activity level	Significant reductions in waist circumference, systolic and diastolic blood pressure, fat body mass, and fat percentage were observed after intervention. Furthermore, there was an improvement in physical activity levels, abdominal strength, flexibility, and domains of the quality of life.	Mat Pilates was efficient in improving hemodynamic, physical, and quality-of-life parameters in servants of a university hospital.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
17	Bastik, C. Cicioglu, H. (2020) [35]	Comparison of the effect of mat and reformer Pilates exercises on the waist–hip ratio and body composition of middle-aged sedentary women	57 sedentary middle-aged women	The aim of this study was to compare the effects of the 8 week mat and reformer Pilates exercises on body composition and WHRs of middle-aged sedentary women.	Mat Pilates exercises (21) Reformer Pilates EXERCISES (20) Control (17) 8 weeks 3× week (60–75')	Bioelectrical impedance analyzer, and waist and hip circumference measured using tape measure	BMI, body FM, fat-free mass, and WHRs of the exercise groups were found to be statistically different from the control group ($p < 0.01$). According to these results, the highest BMI (−1.87%) and body FM reduction (−5.35%) were found in the reformer exercise group. In contrast, the highest WHR reduction (−1.20%) was found in the mat exercise group. Moreover, the highest fat-free mass increase (0.39%) was found in the mat exercise group.	The 8 week mat and reformer Pilates exercises were found to have positive effects on the WHRs and body compositions of middle-aged sedentary women.
18	Correio, T.P., Correio, P.B., Correio, S.A. (2020) [36]	Effects of a 20 week Pilates method program on body composition	41 middle-aged men/women	The objective of this study was to evaluate whether there were changes in body composition after a 20 week (twice weekly) Pilates method (PM) program when compared to a control group.	Pilates group (20) Control group (21) 2× week	Weight, height, and 6 skinfolds	Significant differences were observed between the two groups for the sum of six skinfold measurements ($p = 0.01$) and body fat percentage ($p = 0.004$).	Practicing PM for 20 weeks seemed to positively influence changes in body composition.
19	Wong, A., Figueroa, A., Fischer, S.M., Bagheri, R., Park, S.Y. (2020) [4]	The effects of mat Pilates training on vascular function and body fatness in obese young women with elevated blood pressure	38 obese women with elevated blood pressure (BP)	This study examined the effects of method Pilates training (MPT) on vascular function and BF in young obese women with elevated blood pressure (BP).	Pilates group $n = 14$ Control group $n = 14$ 12 weeks 3× week 50'	Systemic arterial stiffness (brachial ankle pulse wave velocity (baPWV)), brachial and aortic BP wave reflection (augmentation index (AIx)), plasma nitric oxide (NO) levels, and BF percentage (BF%)	MPT significantly reduced ($p < 0.05$) baPWV (−0.7 ± 0.2 m/s), AIx (−4% ± 1%), brachial systolic BP (−5 ± 1 mm Hg), aortic systolic BP (−6 ± 1 mm Hg), and BF% (−2% ± 1%), while significantly increasing plasma NO (6 ± 2 μM) ($p < 0.05$) compared with CON. MPT improved systemic arterial stiffness, aortic BP, wave reflection, circulating plasma NO, and BF% in young obese women with elevated BP.	MPT may be an effective intervention for the improvement of vascular function and BF in young obese women with elevated BP, a population at risk for hypertension and early vascular complications.
20	Baek, S.G. (2020) [37]	The effect of 12 weeks of Pilates mat exercise on body composition and lipid metabolism in obese middle-aged women	19 obese middle-aged women	This study aimed to provide basic data for maintaining and promoting the health of obese middle-aged women at risk of various chronic diseases such as cardiovascular disease and coronary artery disease by comparing and analyzing the effect on body composition and lipid metabolism through a 12 week Pilates mat exercise program for obese middle-aged women.	Pilates group $n = 9$ Control group $n = 10$ 12 weeks 3× week 60'	Body composition: height, weight, skeletal muscle mass (kg), BMI, and FM (% fat) Blood analysis: triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), and free fatty acid (FFA)	As a result of the analysis, the exercise group had a positive effect on body weight, skeletal muscle mass, body FM, and BMI in terms of body composition, but not in the control group. In terms of lipid metabolism, the exercise group had a positive effect on TC, TG, HDL-C, LDL-C, and FFA, but not in the control group.	These results suggest that the 12 week Pilates mat exercise program conducted in this study is an exercise program that can prevent cardiovascular and chronic diseases in obese middle-aged women.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
21	Hyun, A.H. Jeon, Y.J. (2020) [38]	Effect of mat Pilates on body fluid composition, pelvic stabilization, and muscle damage during pregnancy	16 pregnant women (16–24 weeks)	The effects on muscle and muscle damage were investigated in pregnant women.	12 weeks 2× week 60' 50–60% (maximum heart rate)	Body composition before and after exercise, hip flexion and abduction, dilated lipids, inflammation, muscle damage, and stress hormones were measured through blood biochemical analysis	The difference in total body water, intracellular water, and skeletal muscle changes (post–pre) increased significantly in the Pilates exercise (PE) group compared to the control (CON) group, while the extracellular/intracellular water ratio significantly decreased. Blood tests showed significant increases in BW, BFM, and percentage of BFP in both groups post-test as compared to pre-test. Aspartate aminotransferase (AST) decreased significantly in the Pilates exercise group compared to that in the control group; as a result of confirming the difference in the amount of change in C-reactive protein (CRP), there was no significant difference between the two groups, and the PE group showed a tendency to decrease after inspection compared to the previous period, even in the difference between the periods in the group. Cortisol, a stress hormone, also increased significantly after inspection in both groups compared to before.	The 12 week Pilates exercise program conducted in this study had a positive effect on body water balance and strengthened the muscles related to pelvic stabilization within the range of reducing muscle damage or causing muscle damage and stress in pregnant women. It had an effective exercise intensity.
22	Bayram, L. Keskin, D.Y. (2020) [39]	Comparison of pre- and post-exercise body composition measurements and self-esteem of women who do Pilates exercise	10 young women	In this study, the effect of participation in a 12 week Pilates exercise program on some body composition characteristics and self-esteem was examined	Pilates mat or small equipment 12 weeks 3× week 60'	Rosenberg Self-Esteem Scale, height and weight measurement, BMI, and circumference measurements	A significant difference was found in favor of the participants who applied the program when pre-test and post-test body weight, BMI ($p < 0.05$), and waist circumference scores were analyzed ($p < 0.01$). The study also showed that there was no significant difference in self-esteem scores according to pre-test and post-test results ($p > 0.05$).	As a result, these findings showed that, at the end of the 12 week Pilates exercise program, the physical fitness levels of women were positively affected, while self-esteem levels did not differ.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
23	Keymasi, Z. Sadeghi, A. Pourrazi, H. (2020) [12]	Effect of Pilates training on hepatic fat content and liver enzymes in middle-aged men with nonalcoholic fatty liver disease	20 men with nonalcoholic fatty liver disease (NAFLD)	The aim of this study was to investigate the effect of Pilates training on hepatic fat content and liver enzymes in men with NAFLD.	Pilates group <i>n</i> = 10 Control group <i>n</i> = 10 8 weeks 3 × week 60'	Body composition anthropometric indices, liver fat content, and serum levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP)	After 8 weeks of Pilates training, liver fat content in the Pilates group was significantly lower than that in the control group ($p = 0.001$). Furthermore, the serum levels of ALT, AST, and ALP significantly decreased in the Pilates group compared to the control group ($p = 0.04$, $p = 0.05$, and $p = 0.02$, respectively). In addition, 8 weeks of Pilates training significantly reduced body weight, BMI, fat percentage, and the waist-to-hip ratio of patients, while no significant changes were observed in the control group.	Pilates training could be effective in improving liver fat content and reducing the serum levels of ALT, AST, and ALP in men with NAFLD. Furthermore, Pilates training helped to improve body composition and anthropometric indices in patients afflicted with NAFLD and could play a role in the management of this condition.
24	Jung, K. Kim, J. Park, H.-Y. Jung, W.-S. Lim, K. (2020) [40]	Hypoxic Pilates intervention for obesity: a randomized controlled trial	32 obese women	This study examined the effect of Pilates training under hypoxia, a novel treatment method, for obesity.	Nomotoxic Pilates training (NPTG) <i>n</i> = 10 Hypotoxic Pilates training (HPTG) <i>n</i> = 12 Control group (CON) <i>n</i> = 10 12 weeks Tubing band Pilates 3 × week 50'	Body composition, blood pressure, arterial stiffness, vascular endothelial function, cardiometabolic biomarker, hemorheological function, and aerobic performance measurements	The HPTG showed a significant improvement in diastolic blood pressure, total cholesterol and triglyceride concentrations, flow-mediated dilation, and erythrocyte deformability and aggregation (all $p < 0.05$) compared with the CON and PTG. However, compared with the CON and NPTG, the HPTG did not show improvements in other parameters.	Hypoxic Pilates intervention is a novel and successful method for promoting endothelial and hemorheological functions in women with obesity.
25	Pekel, H.A., Aydos, L., Uzun, A., Bozoglu, M.S., Demirel, M. (2020) [41]	The effect of Zumba® and reformer exercises on female body composition	31 sedentary women	The aim of this study was to investigate the effects of Zumba® and reformer training on body composition and regional anthropometric features in sedentary women.	Reformer (Pilates apparatus) group <i>n</i> = 18 Zumba® group <i>n</i> = 13 10 weeks 3 × week 60'	Body composition, waist thickness, arm, chest, abdomen, butt, hip, leg, BMI, and waist/hip ratio	The final test values of body weight, BMI, waist thickness, arm, chest, abdomen, butt, hip, and leg environment for the Zumba® and reformer groups were statistically significant according to preliminary test results ($p < 0.05$). In addition, there was no difference between Zumba® and Pilates groups in any parameters compared to recent test comparisons ($p > 0.05$).	It was determined that Zumba® and reformer exercises have positive effects on body composition, BMI, and some anthropometric variables in women. It was concluded that fat burning is particularly effective in triggering reduced waist thickness, and reformer exercises are more effective on arm circumference.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
26	Martínez-Sánchez, S., Martínez-García, T.E., Bueno-Antequera, J., Munguía-Izquierdo, D. (2020) [42]	Feasibility and effect of a Pilates program on the clinical, physical, and sleep parameters of adolescents with anorexia nervosa	12 female adolescents with AN	This study evaluated the safety of a Pilates program and investigated the feasibility and effect in adolescents with anorexia nervosa (AN).	10 weeks 3× week 60'	Body composition, blood analysis, sedentary time, physical activity, time of sleep, and physical fitness	There were significant increases in height, plasma calcium, and sleep efficiency. Significant decreases in plasma follitropin, sleep duration, and duration and number of night perturbations were observed.	The Pilates program was safe and feasible in adolescents with AN when they had a controlled and stable weight, and such a program could be a viable alternative among treatment programs to achieve better sleep quality.
27	Nogueira Haas, A.; Bulso-Júnior, O.; Meurer, J.; Pinto, F. (2020) [43]	Características antropométricas de mulheres saudáveis praticantes do método Pilates clássico na cidade de Porto Alegre (Brasil)	58 healthy females (mean age 37)	The aim of this study was to describe the anthropometric characteristics of classical Pilates method (CPM) women practitioners in Porto Alegre (Brazil) and to associate the age range and practice time with the adipose mass (AM), muscle mass (MM), and mass index body (BMI) variables.	Pilates practitioners more than 6 months	Body mass, height, cephalic trunk height, wingspan, nine skinfolds, 17 perimeters, nine diameters, and nine lengths	The mean value of AM (25.03 ± 4.81 kg) was higher than that of MM (23.14 ± 3.36 kg). However, the BMI classification of the sample majority (79%) was inside the appropriate range. There was no significant association between any of the variables ($p > 0.05$).	The practice of CPM allows the maintenance of adequate BMI. However, the greater mean in AM than MM is worrying, as well as the large number of women who practice only PM and do not reach the physical activity minimum of minutes weekly to get out of a sedentary lifestyle.
28	Pires, F.O., Pinto, L.M., Costa, H.A., Brito-Monzani, J.O., Sevilho, M.O., Castro, H.O., Gadelha, A.B., Mostarda, C.T., Ferreira, A.C., Dibai-Filho, A.V., Dias, C.J., Martins, D.S. (2021) [10]	Cardiac autonomy modulation response and functional capacity in older women	75 older women	The aim of this study was to analyze cardiac autonomic modulation response and functional capacity in physically active older women.	PG $n = 19$ Hydro-gymnastics group (HG) $n = 18$ Dance group (DG) $n = 19$ CG $n = 19$	Blood pressure, body composition, heart rate variability, and functional capacity	The sedentary group presented higher waist-to-hip ratio, diastolic blood pressure, and resting heart rate compared to the other groups ($p < 0.05$).	These results conclude that physically active elderly women, practicing hydro-gymnastics, Pilates, or dance, presented physiological benefits, such as better functional capacity and improvements in hemodynamic variables and autonomic cardiac modulation. In addition, the group that practiced dance presented greater parasympathetic modulation, as well as greater functional capacity, when compared to the other modalities.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
29	Nasiri, E.; Harsini, A.G.; Arabi, F.; Samadi, A.; Rashki, Z. (2021) [44]	Eight weeks of Pilates exercise improved physical performance of overweight and obese women without significant changes in body composition and serum myokines	26 females (mean age = 26 years)	The aim of the present study was to investigate the effect of 8 weeks of Pilates exercise on physical performance, body composition, and serum myokines level of overweight and obese women.	PG <i>n</i> = 13 CG <i>n</i> = 13 8 weeks 3 × week 60'–90'	Muscular strength and endurance, static and dynamic balance, flexibility, and serum levels of Follistatin, Decorin, and Myostatin	Pilates exercise led to a significant increase in upper body (MD 3.9 kg (CI 95%, 1.54–6.3), <i>p</i> < 0.001) and lower body (MD 31.6 kg (CI 95%, 16.9–46.3), <i>p</i> = 0.003) strength compared to the CG. Pilates exercise resulted in a significant improvement in upper body (MD 3.7 n (CI 95%, 1–6.3), <i>p</i> = 0.01) and core (MD 3.1 n (CI 95%, 1.2–5.05), <i>p</i> = 0.03) endurance in comparison with the CG. Additionally, Pilates exercise led to a significant improvement in static balance (MD 1.4 s (CI 95%, 0.55–2.15), <i>p</i> = 0.002) and dynamic balance (MD—4.16 s (CI 95%, –6.9 to –1.3), <i>p</i> = 0.005) compared to the control group. There was no significant difference between groups in flexibility, body composition, and serum levels of Decorin, Follistatin, and Myostatin (<i>p</i> > 0.05).	Eight weeks of Pilates exercise could improve the physical performance of sedentary overweight and obese women. However, it seems that higher intensities or frequencies/volumes of exercise may be needed to induce significant changes in myokine levels and body composition in this population.
30	Shadmehri, S.; Kazemi, N. (2021) [45]	The effect of Pilates training on changes in hematological parameters in women with breast cancer	24 females	This study aimed to investigate the effect of Pilates training on changes in hematological parameters in women with breast cancer.	PG <i>n</i> = 12 CG <i>n</i> = 12 10 weeks 3 × week 60'	Blood sampling: number of red blood cells (RBCs), white blood cells (WBCs), and platelets (PLTs), percentage of hematocrit (Hct), amount of hemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) Anthropometric measurements: height, weight, BMI, and waist-to-hip ratio	The results showed that 10 weeks of Pilates training had no significant effect on weight, BMI, and waist-to-hip ratio in women with breast cancer. Pilates training had no significant effect on white blood cell count, red blood cells (mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration), hemoglobin, hematocrit, and platelets in women with breast cancer.	It seems that more research is needed to investigate the effects of this type of exercise to achieve beneficial changes in hematological parameters and the immune system.

Table 1. Cont.

n	Author	Title	T Subjects/Group	Objective	Intervention	Outcomes	Results	Conclusion(s)
31	Evangelou, C., Sakkas, G., Hadjicharalambous, M., Aphasios, G., Petrou, P., Giannaki, C. (2021) [46]	The effect of a three month, low-load high-repetition group-based exercise program versus Pilates on physical fitness and body composition in inactive women	42 middle-aged inactive women	The aim of this study was to examine the effects of both programs on physical fitness and body composition of previously inactive adult women.	Pilates group <i>n</i> = 16 Low-load high-repetition group <i>n</i> = 26 12 weeks 3 × week 60'	Aerobic fitness flexibility, handgrip strength, lower-extremity explosiveness, total body fat, trunk fat levels, and heart rate response during exercise	Aerobic fitness, lower-extremity explosive power, left-arm handgrip strength, and body composition significantly improved in the LLHR group, while flexibility significantly improved only in the Pilates group, following the intervention period ($p < 0.05$). LLHR was superior to the Pilates program in improving aerobic fitness and body composition, whilst Pilates was superior in improving flexibility ($p < 0.05$).	LLHR group-based exercise programs may improve various aspects of physical fitness, including aerobic fitness, in inactive adult women. This medium-intensity form of exercise is generally well tolerated and might be used as an option for women who cannot perform training at higher intensities. In contrast, the Pilates program failed to improve physical fitness-related parameters except flexibility levels.
32	Khajehlandi, M., Mohammadi, R. (2021) [47]	The effect of Pilates training on body composition, lipid profile, and serum 25-hydroxy vitamin D levels in inactive overweight women	28 (14 + 14) overweight women	This study examined the effect of Pilates training on body composition, lipid profile, and serum 25-hydroxy vitamin D levels in inactive overweight women.	Pilates group Control group 12 weeks 3 × week 60'	Weight, BMI, waist-to-hip ratio, serum 25-hydroxy vitamin D levels, cholesterol, triglycerides, LDL, and HDL-C	After 12 weeks of Pilates training in the training group compared to the control group, there was a significant decrease in the BMI ($p = 0.005$), cholesterol ($p = 0.001$), and triglyceride ($p = 0.001$) values, as well as serum 25-hydroxy vitamin D levels ($p = 0.005$), while high-density lipoprotein ($p = 0.028$) increased significantly. However, no significant change was observed in low-density lipoprotein levels ($p = 0.435$).	According to the results, 12 weeks of Pilates training improved serum 25-hydroxy vitamin D levels, as well as changed the anthropometry and lipid profile, in inactive overweight women.
33	Mathucheski, B., Junior, O., Pinto, F., Dias, A., Gaya, A., Haas, A. (2021) [48]	Body composition and body mass index in women Pilates practitioners from two Brazilian cities	30 middle-aged women Pilates practitioners (>3 months)	The aim of this study was to evaluate and compare the BMI and body composition of PM women practitioners from two Brazilian South Region cities.	Pilates from Encruzilhada do Sul city <i>n</i> = 15 Pilates from Viamão city <i>n</i> = 15	Six skinfolds, six circumferences, nine diameters, nine lengths, weight, height, and BMI	No statistical differences between the two groups in the body composition and BMI were found. A statistical difference between the two groups in terms of practice time was found ($p = 0.01$).	BMI and body composition were similar in both groups. However, Viamão practitioners showed higher levels of body fat, due to the shorter practice time.

The first set of studies pointed to the efficacy of PM in FBC [19–21,24], even in a 4 week program [23]. Serbescu et al. (2017), in a longitudinal study, although they found no differences between the PG and the CG after 12 months of Pilates, they found that bone density values in menopausal women were higher than expected for their age after exercise for 5 years. We highlight the efficiency of Pilates practice in terms of related FBC matters and the relative short period of 4 weeks to feel these effects.

In a second study group, the benefits of Pilates in improving FBC were again highlighted [25–28,30]. The exception is presented in the study by Haas et al. (2018), who, when comparing Pilates practitioners in two Brazilian cities, did not find any difference between the groups concerning the variables related to FBC.

In a third block of studies, we can find evidence pointing to gains in muscle mass [32], decreased adipose tissue, FM [33,36], and waist-to-hip ratio [35], or increased SIRT1 [31].

Benefits for the cardiovascular system, with direct influence on the FBC, are supported by three studies in this third block [4,37,40], which also presented advantages in BMI and BW [39].

Improvements related to Pilates type and intensity, linked to pelvic floor strength and stability, were presented by Hyun and Jeon (2020). A decrease in muscle damage after training was also identified by these authors. A reduction in associations with nonalcoholic fatty liver disease (NAFLD) was also recorded [12].

Advancing to another block of studies, some results emerge that pointed to the need for more research to validate the benefits of Pilates in FBC, in terms of hematological changes [45], myosin, and BC levels [44]. In the opposite direction, advantages were presented in FBC [10,41] and in weight control and sleep quality of adolescents with anorexia nervosa [42].

The final block of studies presented that pointed to the advantage of Pilates practice in some variables of physical fitness and FBC [46], as well as some hematological variables (cholesterol and triglycerides) and lipids [47]. In the opposite direction, Mathucheski et al. (2021) found no differences between the two groups (Pilates and control) in the FBC variables studied between two groups of Pilates practitioners in two different cities in Brazil.

It is important to point out that there is a great scarcity of studies at the level of the male population in terms of analysis of physical fitness variables and FBC, preventing further scientific development in this aspect.

It is also important to highlight that we chose to carry out an effect size study without meta-analysis given the multiplicity of the selected results. Accordingly, the limitations of meta-analyses with a small number of studies were avoided. Thus, in Table 2 [49], we present the trends in the results of the analyzed articles. In addition, the main categories of collected results were selected, and studies that did not demonstrate results in these categories are not presented. The results are summarized using green upward-pointing arrows for advantages in Pilates practice and yellow side-pointing arrows to indicate results without differences. The size of the arrows is proportional to the size of the sample under study.

In Table 2, we can emphasize the existence of a block of studies in which the results did not significantly validate the practice of Pilates for benefits at the FBC level [28,29,43,48]. There were similarities in terms of the methodology and results in three of these studies [29,43,48]. In fact, they compared two groups of women practicing Pilates in different cities in Brazil. The same form of analysis of BC was used (48 anthropometric variables and BMI calculation). In none of these studies was a significant difference found between the two sample groups, except for the time of practice in one [48]. The absence of a control group or pre–post intervention measures makes it difficult to establish the cause and effect of the Pilates intervention in CC. For this reason, we believe that they may have somehow influenced the outcome of this review. In addition, a set of seven studies revealed advantages in the practice of Pilates for some variables, whereas advantages were not identified in others [20,22,38,40,44,46]. In the other eligible articles, the results presented an




association between Pilates practice and improvements in the selected categories of the FBC. The signal test results showed a significant value ($p = 0.008$) for BFP. Thus, BFP presents itself as a predictor variable of efficiency of Pilates practice in FBC. From a functional point of view, this variable can influence other variables in the study, such as LM ($p = 0.109$) and HC ($p = 0.180$). We believe that more studies and standardized criteria and methodologies should confirm this trend.

Table 2. Effect direction plot and signal test.

n	Authors	Body Mass Index (BMI)	Body Fat Percentage (BFP)	Weight	Lean Mass	Waist Circumference	Hip Circumference	Waist–Hip Ratio	Body Mass Density	Cholesterol/Triglycerides
1	Aguado-Henche et al. (2017) [19]		▲		▲					
2	Savkin et al. (2017) [20]	▲	▲	▲		▲	▲			
3	Andrei-Marius et al. (2017) [21]	▲	▲	▲	▲					
4	Serbescu et al. (2017) [22]								▲	
5	Sevimli et al. (2017) [23]		▲	▲		▲	▲			
6	Eftekhari et al. (2018) [24]	▲	▲	▲		▲	▲			
7	Leal et al. (2018) [25]	▲	▲		▲					
8	Lee, J.C. (2018) [26]	▲	▲		▲					
9	Özcan et al. (2018) [27]	▲	▲	▲						
10	Welter et al. (2018) [28]							◀▶		
11	Haas et al. (2018) [29]	◀▶				◀▶	◀▶			
12	Widanita et al. (2019) [30]	▲								
13	Amirsasan et al. (2019) [31]		▲	▲						
14	Carrasco-Poyatos et al. (2019) [32]				▲					
15	Ghazali et al. (2019) [33]	▲				▲	▲			
16	Feldner et al. (2019) [34]	◀▶	▲	◀▶		▲	◀▶			
17	Bastik, C. & Cicioglu, H. (2020) [35]	▲	▲		▲			▲		
18	Correio et al. (2020) [36]		▲							
19	Wong et al. (2020) [4]		▲							
20	Baek, S.G. (2020) [37]	▲	▲	▲	▲					▲
21	Hyun, A.H. & Jeon, Y.J. (2020) [38]				▲					
22	Bayram, L. & Keskin, D.Y. (2020) [39]	▲		▲		▲				

Table 2. Cont.

n	Authors	Body Mass Index (BMI)	Body Fat Percentage (BFP)	Weight	Lean Mass	Waist Circumference	Hip Circumference	Waist–Hip Ratio	Body Mass Density	Cholesterol/Triglycerides
23	Keymasi et al. (2020) [12]	▲	▲	▲				▲		
24	Jung et al. (2020) [40]									▲
25	Ahmet Pekel et al. (2020) [41]	▲		▲		▲	▲			
26	Martínez-Sánchez et al. (2020) [42]	◀▶	◀▶	▲						
27	Nogueira Haas et al. (2020) [43]	◀▶	◀▶		◀▶					
28	Pires et al. (2021) [10]							▲		
29	Nasiri et al. (2021) [44]	◀▶	◀▶	◀▶	◀▶	◀▶				
30	Shadmehri, S. & Kazemi, N. (2021) [45]	◀▶		◀▶				◀▶		
31	Evangelou et al. (2021) [46]		▲	◀▶						
32	Khajehlandi & Mohammadi (2021) [47]	▲								▲
33	Mathucheski et al. (2021) [48]	◀▶								
	Signal test	$p = 0.189$	$p = 0.008$	$p = 0.210$	$p = 0.109$	$p = 0.180$	$p = 0.453$		Not calculated	

Legend: Sample size  $n = 60$,  $n = 40$,  $n = 20$; (▲): studies that found benefits of Pilates practice; (◀▶): studies with unfavorable and other inconclusive results about Pilates; (sig. = $p > 0.05$).

4. Discussion

Obesity, defined as the accumulation of body fat, is a health issue that increases the risk of death associated with cardiovascular and metabolic diseases [40]. Thus, the practice of physical activity assumes a leading role in food balance and promotes healthy lifestyles that fight excess weight [3]. In the last few years, the number of Pilates practitioners [50] and the knowledge of its benefits have been increasing [9]. Therefore, our review of studies is in line with the trend of seeking the benefits of this method in the area of FBC. No differences between genders are expected, whether in these variables [12] or other variables traditionally associated with the practice of Pilates [13]. Even in traditional female pathologies, such as pelvic floor problems, advantages were found for males in neoplasms in post-prostatectomy incontinence [16].

Therefore, Aguado-Henche et al. (2017), using the dual X-ray photon absorptiometry (DXA) method to assess the FBC, regarded a lean mass increase and noted an increase in muscle mass in the trunk ($p = 0.028$), abdomen ($p = 0.010$), and arms ($p = 0.042$). As for FM, a decrease in the lower limbs was identified. Lastly, an increase in bone density was noticed in the lumbar spine, specifically in L2, L3, and L4. This benefit should be highlighted since the sample included menopausal and sedentary women.

Using another technique, the bioimpedance method, a significant decrease was identified in the values of weight, BMI, fat percentage, waist diameter, and hip and abdomen circumferences [20]. In another study using bioimpedance (Omron BF511 body composition monitor) to assess changes in the body composition of 20 adult women, improvements were observed in all measured indicators, namely, weight and FM [21]. In another study

with menopausal women practicing Pilates over 6 years, it was found that bone mineral density was higher in the Pilates group and greater than expected considering the age of participants [22]. In an intervention based on Pilates, named “cardio-Pilates”, significant differences in fat mass percentage, fat mass weight, and hip and waist circumferences were identified [23]. The effect size of these changes was rated as moderate. In an 8 week intervention with a sample with multiple sclerosis, significant decreases were recorded in BW, BMI, FP, FM, WHC, and mid-arm muscle circumferences, as well as in the chest, abdominal, triceps, and supra-iliac skinfolds [24]. These results point to evidence that the practice of Pilates positively influences the factors related to FBC, even when considered as a broad concept.

Moreover, significant differences in BMI and FM, as well as significant increases in lean mass and metabolic rate, were obtained in patients at cardiovascular risk. The effect size was rated as high for weight, BMI, FM, lean mass, and basal metabolic rate, despite the small sample size [25]. We highlight the fact that Pilates influences the basal metabolic rate, given that it can have control over weight. Another study that used the bioimpedance technique found a significant decrease in body fat percentage and in abdominal fat percentage [26]. In this group of young university students, an increase in lean mass was also identified in the group that had Pilates intervention. In a variant of Pilates using an aquatic environment, there were also significant advantages in weight and BMI, with a small effect size, and in FM percentage, where the effect was moderate [27]. In addition to the positive results of Pilates in the different parameters of the FBC, the size of the effect of the indicated evidence is highlighted.

Additionally, a 21-week follow-up study with adolescents found that the WHR was maintained in the group that practiced Pilates, while the control group increased that measure [28]. In another study, a set of anthropometric and BMI measurements were compared between groups practicing Pilates in two Brazilian cities—the city of Osório and the city of Canoas. The study, which involved 50 women, found no significant differences between the participants of two cities in any of the measures collected [29]. In contrast, in another study using overweight women, it was concluded that there was a significant effect in reducing BMI. The same authors also indicated that the Pilates training model tends to be effective in altering BMI and muscle mass [30].

In the molecular field, evidence also seems to point to the efficiency of Pilates in FBC. Accordingly, it was observed that 3 months of Pilates practice produced a significant increase in Sirtuin 1 protein [31]. The authors used a saffron supplement, and significant advantages were found in both Pilates groups (with or without this supplement). Advantages were also identified in the results obtained for the BFP. In terms of physical capacities, namely, in strength, muscle strength, and muscle mass, in a sample of elderly women, significant increases were observed in the Pilates practitioners group and in the muscle strength training group, when compared to the control group ($p < 0.001$ and $p = 0.05$, respectively) [32]. Similarly, in the analysis of the Pilates method for overweight people, a normative value of “good” was assigned to this method, as a strategy to improve BMI [33]. This study also proposed a series of methodological suggestions to improve its effectiveness and keep it attractive to practitioners. Furthermore, the results obtained in another study [34], with a sample of men and women, pointed to a reduction in waist circumference, systolic and diastolic pressure, fat mass, and fat percentage. The broad spectrum of results in the different components of the FBC, from physical capacities to metabolic rate or cardiac issues, seems to consolidate the validity of the influence of Pilates in this domain.

Regarding Pilates on an apparatus, in a sample of women, after 8 weeks of practice, mat Pilates and reformer Pilates also brought benefits in FBC and the WHR [35]. Mat Pilates was more effective in reducing WHR and increasing muscle mass. Reformer Pilates, on the other hand, was more efficient in BMI and decreasing FM. These results are interesting in the sense of being able to characterize the types of Pilates and their influences. Regarding the effect of Pilates practice on the measurement of six skinfolds and the BFP, in a sample of 41 men and women, significant differences were obtained between the Pilates practitioner group (during

20 weeks) and the control group [36]. Focusing again on cardiac variables, the advantages in terms of Pilates practice were similar. For 12 weeks, 38 obese women with high blood pressure attended Pilates training, and the results showed the effectiveness of this method in improving vascular function and BFP [4]. The same line of results was obtained in a male sample study on Pilates and its benefit on risk factors for coronary infection [51]. In fact, resting heart rate, VO_2 max, and cholesterol were positively influenced by Pilates practice. As outlined in our review, the metabolic values of 19 obese, middle-aged women were analyzed over a period of 12 weeks of mat/floor Pilates. There was a positive effect on BW, skeletal muscle mass, FM, BFP, and BMI values [33].

Furthermore, in terms of lipid metabolism, this practice had a positive effect on total cholesterol, triglycerides, HDL-C, LDL-C, and fatty acids, thus promoting the prevention of chronic cardiovascular diseases in obese women. In another study carried out with 16 pregnant women, it was found through blood tests that both groups (Pilates and control) showed improvements in BW, FM, and BFP [38]. Even so, the authors considered, due to the balance of water in the tissues, that Pilates strengthened the pelvic floor stabilization muscles, especially when practiced with adequate and effective intensity.

However, concerning the self-esteem component and its influence on FBC, there was no effect of Pilates (mat or with small equipment) for 12 weeks in 10 young women [39]. In the analysis of the differences between pre- and post-intervention, significant values were registered in the levels of physical fitness, but not in the levels of self-esteem.

Regarding the control of fatty liver disease of nonalcoholic origin, it was found that an 8-week mat Pilates program could play an important role in improving this condition [12]. In this case, 20 men who suffered from this pathology saw their anthropometric measurements, BFC, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) levels, reduced with this practice.

Similarly, in the analysis of the effect of Pilates practice under hypoxic conditions, 32 women were distributed in groups practicing Pilates under normal oxygen conditions, another group with Pilates practice under hypoxic conditions, and a control group [40]. Obese women who performed Pilates under hypoxic conditions had significant improvements in diastolic blood pressure, triglycerides, and total cholesterol. The flow-mediated dilation and deformability and aggregation of erythrocytes were also significant in comparison with the control group and Pilates practiced under normal conditions. Thus, the range of benefits and the influence of Pilates were shown through biological mechanisms and processes.

In a study with 31 sedentary women, the effect of Pilates on a reformer and Zumba[®] was compared [41]. After 10 weeks, the authors concluded that both practices were effective in improving FBC, while decreasing BMI and some anthropometric measurements. This study also associated the Zumba[®] modality with greater effectiveness in reducing the WC than Pilates, with a better condition of the upper limbs.

On the other hand, the safety and feasibility of Pilates practice were analyzed as an influencing factor for FBC and sleep quality in 12 adolescents with anorexia nervosa [42]. Both conditions were improved and led the authors to indicate that Pilates is a safe practice for weight-controlled, anorexic adolescents. In addition, it could also have positive results as an alternative treatment for increasing sleep quality.

The effects of Pilates on practitioners with more than 6 months of experience in classic Pilates were also studied, and it was identified that this practice allowed the maintenance of a correct BMI [43]. In a cross-sectional study, with 75 elderly women, distributed among practitioners of Pilates, water aerobics, dance, and control groups, the highest values of WHR, diastolic blood pressure, and resting heart rate [10] were attributed to the control group. In a study of males, the resting heart rate and blood pressure improved as a function of Pilates [51].

Returning to the molecular topic, serum levels of Decorin, Follistatin, and Myostatin [44] were also investigated. In this case, the practice of Pilates did not promote significant changes ($p > 0.05$) in these proteins and, consequently, in FBC. The authors

indicated that a greater intensity or longer duration of intervention was required to bring about the levels of protection projected in this study. There were gains in muscle strength and endurance compared to the control group. In the same sense/set of results, a study was developed with women with breast cancer, which also did not find differences between the Pilates practitioner group and the control group in the variables of BW, BMI, and WHR [45]. The findings of another study comparing the practice of low-intensity, high-repetition exercises versus the practice of Pilates indicated an improvement in some aspects of the physical fitness of low-intensity, high-repetition exercise practitioners [46]. As far as Pilates is concerned, its practice was associated with increased flexibility. In these studies, the issue of intensity stood out, which should be further studied to understand its influence on the FBC. To wrap up this molecular topic, a combined procedure testing FBC and blood tests on 28 overweight women who performed mat Pilates for 12 weeks revealed significant in BMI, cholesterol, and triglycerides [47]. Additionally, 25-hydroxy vitamin D levels, as well as HDL levels, showed positive improvements associated with this practice.

In a final study, no significant differences were registered between two groups of Pilates practice over a period longer than 3 months. However, higher levels of body fat were associated with the group that had the least amount of practice time [48].

Overall, in the present review, a wide range of benefits and the influence of the Pilates method were collected with respect to FBC. This can be better seen in Table 2, with the majority of studies pointing to a positive trend between Pilates and FBC. On a final note, we consider limitations of this review in the period defined (5 years) and in the number of databases searched. Both factors may have decreased the number of eligible studies on this topic, which should be considered in a future review.

5. Conclusions

The more restricted concept of BC is linked to two variables: fat mass and lean mass. In a broader concept, the metabolic, biochemical, and physiological areas index this theme more toward the area of physical activity and health. Joseph Hubertus Pilates created this method initially due to poor physical and health conditions. Throughout his life, and in the evolution of his method, several concerns went beyond the muscular or physical dimension [52]. Therefore, it seems natural that this concern is being highlighted with new research projects covering dimensions other than muscular (especially postural muscles), including physical capacity (strength or flexibility) and wellbeing (quality of life, sleep quality, self-image) [53,54].

Pilates practice does not have a competitive aspect. There are no records to beat. Therefore, it does not end in itself. In contrast, it exists within a functional dimension, because it is in this “function” that the body performs—at home, at work, or at leisure—the movements that this method requires. At the same time, given the studies analyzed, we can conclude that FBC reflects knowledge in the health area in harmony with the biological organism, not as an end in itself, but rather as an application to a global concept of health that starts with the BFP or BMI, which goes through cholesterol and blood glucose levels, while also crossing endothelial function and diastolic pressure in a duality and harmony recognized in the functioning of the human body. It is here that the two themes perhaps intersect better in view of the studies analyzed.

To sum up, this systematic review showed a marked trend toward the benefits of Pilates with respect to the FBC, which is in line with other systematic reviews carried out on this topic [9] in terms of BC (BW and BMI) and in a reduction in BFP. Hence, the available evidence seems to indicate that, in BC and FBC, Pilates practice tends to be effective in reducing obesity as a multifactorial condition.

The limitations of this systematic review can be overcome with studies bringing together multidisciplinary aspects of FBC and covering all forms of Pilates through better designed and more robust methodologies, thus allowing more reliable analyses of this method. Furthermore, searches in other databases may expand the number of eligible studies in the future. In addition, it is suggested to carry out research with similar method-

ologies in the process of data collection and intervention but applied to larger samples and with higher percentages in terms of male samples.

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