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PREVENTION & REHABILITATION: SYSTEMATIC REVIEW

The effect of Pilates exercises on body composition: A systematic review

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Summary *Objective:* The purpose of this systematic review was to determine how Pilates exercises have impacted body composition (BC) on selected populations.
Methods: A comprehensive literature search was performed using the keywords 'Pilates, body composition, systematic review, literature review, overweight, obesity, healthy weight, underweight' and their combination.
Results: Seven studies met the inclusion criteria and after further quality analyses it was determined that there is currently poor empirical quantitative evidence indicating a positive effect of Pilates exercises on BC. Several methodological flaws were observed in the studies analyzed, including few full-text published studies looking into the effects of Pilates exercises on BC, a lack of true experimental research designs, limited standardization in measurement techniques, insufficient or no control of the nutritional status, and inconsistent instructor qualifications.
Conclusion: Well-designed research is needed to determine how Pilates exercises impact BC on selected populations.

Introduction

Measurement, assessment and monitoring of BC in humans have been three of the main challenges for health sciences professionals. Human body mass or weight is the broadest measure of body size and gives no information about metabolically active tissue such as muscle mass. Therefore,

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human BC refers to the assessment of the absolute and relative amounts of bone, muscle, and fat mass measured by different methods depending on the technology at hand (e.g., skinfold calipers, hydrostatic weighing, Dual-emission X-ray absorptiometry). From these variables, fat mass or body fat percentage has been the most important estimate for health purposes given the strong correlation with cardiovascular diseases (Heyward and Wagner, 2004; Wang et al., 1995; Yasumura et al., 2000). Genetics, behavior (e.g., sedentary lifestyle, tobacco and alcohol consumption), and several diseases (e.g., bulimia, anorexia), may negatively impact BC, where overweight, obesity, or a dramatic reduction of muscle mass, are some consequences of these conditions. For instance, children diagnosed with genetic nervous anorexia have shown anxious behavior associated with caloric restriction and low body mass index (BMI) (Dellava et al., 2010). More than 50% of the anorexic patients present with osteopenia at the time of examination (Fernández Soto et al., 2010). Also, a recent study by Thibault et al. (2010), links parental physical activity behavior to their offspring's increased risk for becoming overweight and obese adolescents. Indeed, the risk decreases when at least one of the parents has a physically active lifestyle.

These findings emerge after more than 80 years devoted to the study of overweight and obesity (Hartman and Ghrist, 1929; Prble, 1923; Terriy, 1923). Today, researchers continue in their efforts to understand how new exercise techniques might impact BC in humans. Although control or modification of the BC was not the primary motivation for Joseph Pilates in the early 30's; recently, his exercises and methods have become popular. Pilates created a body conditioning method first called 'Contrology' (Pilates and Miller, 1945). Pilates introduced this method in the United States between 1930 and 1940 (Anderson and Spector, 2000), attracting choreographers and dance instructors who used his exercises for rehabilitation. After Pilates' death in 1967, the method became more widely spread and was introduced to other areas, under the name 'Pilates' (Latey, 2001). Today, dancers, athletes, and other population use Pilates for rehabilitation and to increase their physical activity and fitness (Latey, 2001; von Sperling and Brum, 2006).

Pilates designed a comprehensive method of muscle stretching and strengthening with the goal of building a strong body under the philosophy of mind-over-body control. According to Lange et al. (2000), Pilates exercises provides benefits in physiological (e.g., resistance, strength, muscle power), psychological (e.g., mood, attention, motivation), and motor functions (balance, static and dynamic posture, general coordination). In spite of these purported effects, researchers have questioned the lack of scientific evidence supporting the use of this method for fitness and rehabilitation (Curnow et al., 2009; Da Fonseca et al., 2009; Sorosky et al., 2008; Sekendiz et al., 2007, von Sperling and Brum, 2006; Maher, 2004).

A review by Bernardo and Nagle (2006), demonstrated the effectiveness of Pilates exercises on strength and body alignment in dancers and gymnasts. Bernardo (2007), also showed Pilates effectiveness on flexibility, transversus abdominis activation, pelvic-lumbar stability, and muscular activity in healthy adults. However, this effectiveness might be spurious due to methodological weaknesses, such as small sample size, the lack of true experimental research designs, selection bias, a poor validity and reliability of measurement instruments, as well as the lack of specific parameters for the application and description in the Pilates exercises used (i.e., description of the method). La Touche et al. (2008), found positive effects of Pilates exercises such as increased general function and pain reduction in patients with nonspecific low-back pain, and concludes that further research is needed to better understand what is the best combination of exercises and whether a dose—response relationship exists.

In a survey by von Sperling and Brum (2006), 18.4% of the subjects believed that regular practice of the Pilates method would increase lean mass and thus muscle tone. However, published scientific evidence on the effects of Pilates exercises on BC are scarce. Therefore, the purpose of this review is to determine the effectiveness of Pilates exercises on BC.

Material and methods

Literature search and inclusion criteria

A search concluded on March 20, 2010 using the following databases: PubMed, Medline, SporDiscus, EbscoHost, ScienceDirect, and Google Scholar. In addition, a manual search was done in journals such as *Journal of Bodywork and Movement Therapies*, *Medicine & Science in Sports & Exercise*, and the *International Journal of Obesity*. The keywords used were Pilates, body composition, systematic review, literature review, overweight, obesity, healthy weight, underweight, and their combination. A total of eight potential studies were located and reviewed for title, keywords and summary. These articles were further analyzed using either their full-texts or abstracts if that was the only available information.

Studies selected for analyses met the following criteria: a) BC changes (i.e., adipose tissue mass or body fat, muscle mass or fat free-mass, bone mass, residual mass and skin mass) determined by an intervention based on Pilates exercises; b) diverse populations; c) studies published before March 2010; d) unpublished documents such as thesis, dissertations, and presentations in congresses; e) peer-reviewed articles; and f) no language restriction.

Evaluation of study methodology

Methodological quality of the studies included in this review was determined by the Jadad Scale (Jadad et al., 1996). Two independent reviewers evaluated the quality of the studies using the same methodology. Disagreements between reviewers were resolved by a third reviewer.

Results

Studies selection

Eight studies were located that evaluated the effect of Pilates exercises on BC. The study by Rice (2009), was a narrative review, and was therefore excluded from this review. From the seven studies remaining, one (14.3%) was a thesis written in Chinese (Pan, 2006), with the summary in English, and three (42.8%) were presented as abstracts in scientific meetings (i.e., Baltaci et al., 2005; Carvalho et al., 2009; Rogers and Gibson, 2006). Finally, three (42.8%) full-text articles were published in scientific journals (Jago et al., 2006; Sekendiz et al., 2007; Segal et al., 2004).

Design, demographics, and main results

Research design for the studies evaluated included randomization, control group, pre- and post-test measurements. The study by Rogers and Gibson (2006) was a controlled trial; however, randomization was unreported. The study by Segal et al. (2004), did not have a control group (Table 1) and used a smaller sample size ($n = 22$) compared to the rest of the studies in which $\geq$30 participants performed Pilates exercises. Only four males participated across all studies reviewed (Rogers and Gibson, 2006; Segal et al., 2004).

The key components of BC evaluated were body and limbs fat, fat free-mass trunk and limbs. BMI was considered as pre-participation adiposity in most studies. Overweight and healthy-weight subjects participated in two studies and obese subjects participated in one study. Initial BMI was unreported in the studies by Carvalho et al. (2009) and Rogers and Gibson (2006). Adolescents were subjects in only one study (Jago et al., 2006) (Table 1).

Limb and total body fat content was reduced following Pilates exercises in the studies by Baltaci et al. (2005) and Pan (2006); whilst Rogers and Gibson (2006) reported similar results without changes in total body mass. Carvalho et al. (2009) also showed similar results with an additional increase in lean mass. A decrease of 3.1 points in BMI percentile was reported by Jago et al. (2006) in healthy adolescents. Unlike the other studies, Sekendiz et al. (2007) and Segal et al. (2004) did not report changes in any of the BC components (Table 1).

The Pilates method characteristics varied among studies (Table 2). The typical session length was usually between 45 and 60 min, 2–5 times/wk, for 4–12 wk. The Pilates method used by Segal et al. (2004) was once a week for 24 wk. The use of certified instructors was unreported in three (42.8%) studies. Exercise sessions included in this review were performed on mats (i.e., Pilates matwork) as opposed to studio equipment (i.e., Pilates studio apparatus).

In only two studies reviewed (Segal et al., 2004; Sekendiz et al., 2007), were described the features of the

Table 1 Demographics characteristics, designs and main results of the included studies.

Study	Design	Sample	Results
Baltaci et al. (2005)	Randomized. Pre and post intervention GE and CG	$N = 34$ (17 CG and 17 EG). OW. Age: CG, 53.3 ± 8.9 y. EG, 50.4 ± 6.21 y Sex: F	↓weight and SS differences between groups (EG: 2.27% - CG: 1.58%). Greater ↓ SS in %body fat (EG).
Carvalho et al. (2009)	Randomized. Pre and post intervention GE and CG	$N = 68$ (25 CG y 43 EG). NR. Age : CG 40.0 ± 7.7 y. EG 41 ± 7.2 y Sex: F	↑ SS fat free-mass ↓ %body fat and limb fat, without changes SS in body mass (EG).
Jago et al. (2006)	Randomized. Pre and post intervention GE and CG	$N = 30$ (14 CG and 16 EG). HW Age: 11.2 ± 0.6 y Sex: F	↓ 3.1 BMI percentile (EG).
Pan (2006)	Randomized. Pre and post intervention GE and CG	$N = 47$ (CG and EG: NS). OB Age: >40 y Sex: NS	↓ SS waist and gluteus circumference, weight and %body fat (EG). EG SS different CG.
Rogers and Gibson (2006)	Randomized: NR Pre and post intervention GE and CG	$N = 22$ (13 CG and 9 EG). NR Age: NR Sex: CG, F 12, M 1 and EG, F 8, M 1.	↓ SS %body fat, waist, thorax and arm circumference (EG). = body weight, hips and thighs circumference. = CG.
Sekendiz et al. (2007)	Randomized Pre and post intervention GE and CG	$N = 38$ (17 CG and 21 EG). HW Age: CG 30 ± 8.6 y. EG 30 ± 6.6 y Sex: F	=BMI, %body fat (EG and CG).
Segal et al. (2004)	Not randomized. Pre and post intervention	N=47 EG, OW. Age: F 41 y. M 42 y Sex: F 45, M 2	=body mass, %body fat, segmental fat, fat free-mass, trunk and limbs.

Note: N: Sample size; NS: Not specified; NR: Not reported; SS: Statistically significant; F: Female; M: Male; EG: Experimental group; CG: Control group; y: years; OW: Overweight; HW: Healthy weight; OB: Obesity; ↓: Decrease; ↑: Increase; = : No changes.

Table 2 Intervention characteristics of the included studies.

Experimental group intervention with Pilates Mat	Study
45—60 min 5 t/wk for 4 wk	Baltaci et al. (2005), Jago et al. (2006)
60 min 2 t/wk for 8—12 wk	Carvalho et al. (2009), Pan (2006)
60 min 3 t/wk for 5—8 wk	Rogers and Gibson (2006), Sekendiz et al. (2007)
60 min 1 t/wk for 24 wk	Segal et al. (2004)
Certified instructors	
Reported k = 4 (57.1%)	Jago et al. (2006), Rogers and Gibson (2006), Sekendiz et al. (2007), Segal et al. (2004)
Unreported k = 3 (42.8%)	Baltaci et al. (2005), Carvalho et al. (2009), Pan (2006)
Nutritional status control	
Unreported k = 5 (71.4%)	Baltaci et al. (2005), Jago et al. (2006), Rogers and Gibson (2006), Sekendiz et al. (2007), Segal et al. (2004)
Undeclared k = 2 (28.5%)	Carvalho et al. (2009), Pan (2006)

Note: t/wk: frequency in times per week; k: study sample size.

exercises in the Stott Pilates matwork program; although in none of them were described any kind of adjustments that might enhance BC changes such as exercise intensity or adaptations for participant's functional of physical limitations.

Methodological quality of the full-text studies

Due to the incomplete information provided in abstracts, only full-text studies were assessed for methodological quality. Important research design weaknesses were evident as determined by the Jadad Scale (Jadad et al., 1996); therefore, participation of a third reviewer due to disagreements was seemed unnecessary (Table 3).

Discussion

The purpose of this review was to determine the effectiveness of Pilates exercises on BC. Only seven papers were located and the methodological quality of these studies prevented us from performing a meta-analysis. For instance, only four males participated across these studies. However, a plausible reason may be that females are more likely to practice Pilates exercises. Aaron et al. (2006), demonstrated that there is a higher probability of women practicing Pilates compared to males (88% vs. 60%); therefore, male subjects are not considered a representative sample that allow for comparisons or for conclusions to be drawn as to the overall effects of Pilates on BC.

Current research has demonstrated that regular participation in a physical exercise program is likely to induce positive changes in the BC profile (e.g., reduced percentage body fat, increased lean body mass). The magnitude of these changes is mediated, among others, by the exercise volume performed (i.e., frequency, intensity, duration) (Jakicic et al., 2001). According to Olson et al. (2004), completion of 30—45 min Pilates mat exercise program elicited sufficient stimuli to induce positive changes in energy expenditure (EE) in kilojoules per minute (kJ/min) to reduce BC. Therefore, Pilates studies where BC did not change might have not provided sufficient training stimuli (Segal et al., 2004). Perhaps in some of the studies reviewed (Jago et al., 2006; Segal et al., 2004), the optimal exercise intensity was not reached. Olson et al. (2004), reported that an 'advanced work' level in Pilates mat produced an EE = 33.49 kJ/min, whereas 'basic work' elicited an EE = 19.26 kJ/min.

A possible explanation for the lack of positive changes in body weight or fat reduction observed in some studies is that subjects with healthy weight tend to lose weight at a slower rate than obese and overweight participants (Jakicic et al., 2001). This agrees with a trend observed in the healthy-weight participants in the study by Sekendiz et al. (2007), where changes in BC were not found.

Although insufficient research has been done regarding the potential benefits of Pilates in the several areas (e.g., rehabilitation, physical activity/fitness, strengthening, body alignment, athletic performance) and its relation with some specific characteristics of exercise prescription, Rice (2009) suggests possible uses of this method in obese subjects.

Instrument characteristics

Although widely used, indirect BC measurement techniques (i.e., skinfold technique) are known to increase the

Table 3 Results of the methodological quality of full-text studies according to the Jadad Scale (Jadad et al., 1996).

Authors (year)	1	2	3	4	5	Total
Jago et al. (2006)	1	0	0	0	0	1
Sekendiz et al. (2007)	1	0	1	0	0	2
Segal et al. (2004)	0	1	1	0	0	2

standard error of the estimate due to large variability in technician skills and instrument validity and reliability. It follows that the results of the studies by Baltaci et al. (2005), Jago et al. (2006), and Rogers and Gibson (2006), where different indirect methods were used to predict BC, tend to be inaccurate. In contrast, Carvalho et al. (2009), used Dual-emission X-ray absorptiometry (DXA), a technique shown to have high accuracy (i.e., error $< 2\%$) (Saris et al., 2003).

Methodological quality of the studies

Several methodological issues are taken into consideration when designing research studies, for instance, sample size, randomization, measurement instruments, procedures, blinding to treatments, experimental mortality, and statistical analysis, among others. These factors have a direct impact in external and internal validity (Campbell and Stanley, 1963). According to the Jadad score (Jadad et al., 1996), the study by Segal et al. (2004), was considered the weakest due to a lack of control group and randomization, affecting both, internal and external validity. It is widely known that randomization is used to reduce bias, and it is the most reliable method of creating homogeneous treatment groups (Campbell and Stanley, 1963). Experimental mortality was reported only by Segal et al. (2004); however, no possible explanations or impact in the overall results of the study were given.

Other potential drawbacks

One of the main shortcomings of the studies reviewed was a lack of control in the nutritional status of the experimental subjects (Table 2). Research has shown that changes in BC are better accomplished with the combined effects of EE (i.e., exercise) and a reduction in energy intake (i.e., diet). Therefore, it makes sense to control for the nutritional status of participants performing Pilates exercise aimed to achieve changes in BC (Jakicic et al., 2001).

Another weakness found for these studies was a lack of the proper use of certified instructors. According to Anderson and Spector (2000), Pilates instructors must provide verbal and tactile commands during the exercise routine, facilitating participant's feedback to correct improper or unsafe movement patterns (Keays et al., 2008). The effects of properly trained instructors (i.e., knowledge, experience) on the sense of safety, motivation and other variables in participants of a Pilates class, remains to be elucidated. However, positive results had been obtained in the studies by Baltaci et al. (2005), Carvalho et al. (2009), and Pan (2006), when certified instructors executed the Pilates routines.

Conclusion

This systematic review suggests that there is poor empirical evidence indicating a conclusive effect of Pilates exercises on BC. The main reason that might explain this finding is the lack of methodological quality of the studies published. Among the most relevant drawbacks of these studies are the lack of rigorous experimental designs that allow for truly reliable and accurate conclusions, limited standardization in the measurement techniques, which do not allow for suitable consistency of these results, insufficient or no control of the nutritional regime of the subjects, and the lack of properly certified Pilates instructors.

Pilates mat practice for 60 min, 5 times/wk, for 4 wk (intervention type I), and 2–3 times/wk, for 8–12 wk (intervention type II), tend to be the most positive interventions for changing BC. There was also a trend toward reductions in body weight and percentage body fat in most systematic interventions (type I) as far as more practice hours per week, as opposed to longer interventions with fewer practice hours per week (type II), where body weight and fat mass tended to increase.

Further studies on Pilates training will require randomized controlled experimental trials to determine the best exercise combination/routine that positively affects BC. Researchers must describe more accurately the exercise programs as far as intensity, frequency, and duration and measure these variables accurately. The use of sensitive measurement BC techniques such as DXA (i.e., low measurement error) are strongly encouraged since the use of popular broad estimates such as BMI or body weight might hinder a real and chronic effect of a Pilates workout. Also, different populations such as the elderly, athletes and the obese need to be further analyzed since body fat accumulates differently in these groups.

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