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Original Article

Multicomponent physical training increases strength, agility and dynamic balance in middle-aged women

Treinamento físico multicomponente aumenta a força, agilidade e equilíbrio dinâmico em mulheres de meia idade

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ABSTRACT

Aim: The present study aimed to verify the effects of a multicomponent physical training program on the functional capacity of middle-aged women. **Methods:** Thirty-five women (51.8 ± 5.4 years) underwent a multicomponent physical training program for 16 weeks. The volunteers were submitted to anthropometric measurements and a battery of tests adapted to assess their functional capacity. To verify the normality of the data, the Shapiro Wilk test was used and to compare the values before and after the intervention, a paired t test was used. The effect size was also calculated, using $\alpha = 0.05$ for all analyzes. **Results:** increase in upper limb strength (pre: 18.9 ± 4.3 *vs* post: 22.8 ± 7.9 repetitions) with medium effect size, in lower limbs strength (pre: 14.9 ± 2.8 *vs* post: 17.3 ± 2.6 repetitions) with large effect size, as well as improved agility and dynamic balance (pre: 5.4 ± 0.8 *vs* post: 4.6 ± 0.5 seconds) with large effect size. **Conclusion:** the multicomponent physical training program increased the strength, agility and dynamic balance of middle-aged women, improving their functional capacity.

Key-words: Physical exercise, Aging, Functional capacity, Menopause.

RESUMO

Objetivo: verificar os efeitos de um programa de treinamento físico multicomponente sobre a capacidade funcional de mulheres de meia idade. **Métodos:**Trinta e cinco mulheres (51,8 ± 5,4 anos) foram submetidas a um programa de treinamento físico multicomponente durante 16 semanas. As voluntárias foram submetidas a medidas antropométricas e a uma bateria de testes adaptada para avaliar a capacidade funcional delas. Para verificar a normalidade dos dados adotou-se o teste Shapiro Wilk e para comparar os valores antes e após intervenção adotou-se teste t pareado. Calculou-se também o tamanho do efeito, sendo adotado $\alpha = 0,05$ para todas as análises. **Resultados:** houve aumento na força de membros superiores (pré: 18,9 ± 4,3 *vs* pós: 22,8 ± 7,9 repetições) com tamanho do efeito médio, na força de membros inferiores (pré: 14,9 ± 2,8 *vs* pós: 17,3 ± 2,6 repetições) com tamanho do efeito grande, assim como melhora na agilidade e equilíbrio dinâmico (pré: 5,4 ± 0,8 *vs* pós: 4,6 ± 0,5 segundos) com tamanho do efeito grande. **Conclusão:** o programa de treinamento físico multicomponente aumentou a força, agilidade e equilíbrio dinâmico de mulheres de meia idade, melhorando a capacidade funcional.

Palavras-chave: Exercício físico, Envelhecimento, Capacidade funcional, Menopausa.

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Introduction

Aging is a dynamic, progressive, and irreversible process that causes a series of changes at the molecular and systemic levels related to biological, psychological, and social factors [1,2]. These modifications can lead to a reduction in the individual's functional capacity, making it difficult/impossible to perform activities of daily living such as getting up from a chair, moving from place to place, carrying groceries, among others [3,4].

Many of the declines inherent in aging are known to begin in adulthood. The best levels of aerobic fitness and strength are reached around the third decade of life. From then on, there is a gradual reduction in the strength levels, increasing mainly from the fifth decade onwards [5,6]. Many studies have been carried out to verify the effectiveness of the systematic and guided practice of physical exercises on the functional capacity of older women, but not of middle-aged women [7-11]. Entities like the American College of Sports Medicine, the American Heart Association, and the World Health Organization recommend that health-focused exercise programs should address aerobic exercise, strength, balance, and flexibility [12,13]. These components are considered essential for maintaining health-related physical fitness at adequate levels, especially considering the losses related to aging. Multicomponent training (MCT) covers aerobic exercise, strength, balance, and flexibility. MCT improves the functional capacity of older women, positively affecting the performance of basic, instrumental, and advanced activities of daily life [14,15].

Although the literature shows that the declines in several functions are accentuated from the third decade onwards, most intervention studies with MCT are carried out with the aging people [7-11]. Selbac et al. [16] point to the climacteric as the period in which the ovarian follicles are depleted, leading to estrogen deficiency, causing biological changes that reflect in all dimensions of women's lives. Menopause, the stage in which ovarian failure occurs, causing a reduction in estrogen levels, implies morphophysiological and cellular changes that cause a decline in muscle strength and bone mass, in addition to changes in the repair of damage to neural cells and activity enzyme related to neural synthesis [16]. All these changes due to climacteric and menopause can cause a reduction in the functional capacity of women in menopause.

Thus, it is important to verify the effects of supervised MCT on the functional capacity of middle-aged women, which will allow a better understanding of how possible physical/functional changes may influence the health and behavioral variations of individuals. The adoption of active habits in earlier stages of life can be crucial for maintaining an autonomous and independent old age [17,18]. The study hypothesizes that 16 weeks of MCT may improve the functional capacity of middle-aged women. The present study aimed to verify the effects of a 16-week supervised MCT program on the functional capacity of middle-aged women.

Methods

Experimental design

The present research is a quasi-experimental study that assessed the effect of a 16-week MCT program on the functional capacity of middle-aged women. The Ethics Committee on Research Involving Human of the Federal University of Viçosa approved the study (CAAE: 60303716.1.0000.5153). All volunteers signed a free and informed consent form and were informed that they could leave the research at any time without charge. Anthropometric and functional capacity measurements were obtained through a battery of tests that assessed aerobic fitness, strength, agility, dynamic balance, and flexibility. These measures were collected before and after a 16-week MCT program, to which the volunteers were submitted (Figure 1). The volunteers went through familiarization with the battery of tests before data collection.

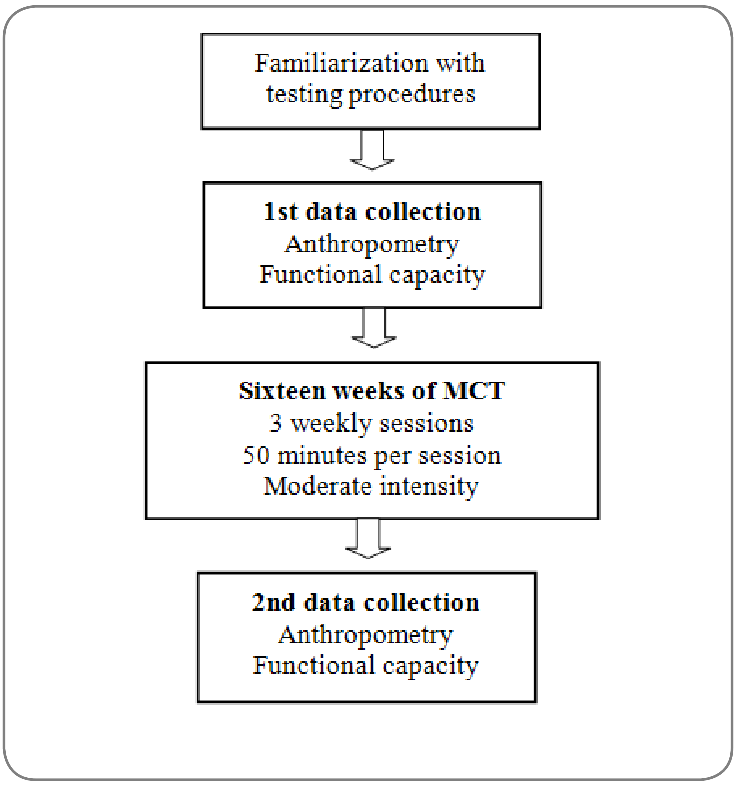

Figure 1 – Study design.

Participants

Participated in the present study 35 healthy middle-aged women, selected for convenience, aged 51.8 ± 5.4 years, who attend an extension project developed at the Federal University of Viçosa, Viçosa/MG, which offers physical exercises for middle and third age individuals from the Viçosa community. Inclusion criteria were: women aged 40-59 years, presenting a medical certificate clearing to practice physical exercises, accepting to participate in the study by signing the free and informed consent form, participating in interventions frequently (minimum 75% participation of the total sessions) and perform the battery of tests in both moments, pre and post-intervention.

Anthropometric assessment

Body mass (kg) and height (m) were collected using a mechanical scale with a precision of 0.1 kg and a stadiometer with an accuracy of 1 mm (Filizola, São Paulo, Brazil). From these measurements, the values of the body mass index (BMI = weight/height^2) were obtained. The anthropometric assessment in both moments was performed by the same Physical Education professional, properly trained.

Assessment of functional capacity

Table I shows the components of the functional capacity evaluated and the tests used. The battery was developed by the extension project team based on the choice of tests consolidated in the literature [3,19-21]. The test battery was applied 48 hours before starting training and repeated 48 hours after the intervention period. The functional capacity assessment battery was applied, at both times, by the same trained Physical Education professionals. During the tests, there was verbal encouragement from the evaluators to the volunteers. The expressions *"It's going well!"*, *"Keep it up!"*, *"Don't let the pace drop!"*, and *"Come on, you can do it!"* were used during the evaluations.

Table I - Battery of tests to assess functional capacity.

Physical capacity assessed	Test used	References
Aerobic fitness	1600-meter walk	Kline et al. [19]
Strength	Abdominal resistance in 1 minute	Gaya et al. [21]
	Sitting and getting up from a chair	Rikli and Jones [3]
	Elbow flexion	Rikli and Jones [3]
Agility and dynamic balance	Get up from the ground	Andreotti and Okuma [20]
	Get up from the chair and move	Rikli and Jones [3]
	Put on socks	Andreotti and Okuma [20]
Flexibility	Sit and reach on the Wells bench	Gaya et al. [21]

Source: Prepared by the authors.

Multicomponent training program

The MCT program consisted of 3 weekly interventions lasting 50 minutes each, structured as follows: 5 minutes of warm-up (all together), 40 minutes of a circuit with 4 multicomponent stations (4 subgroups): 1) aerobic fitness, 2) muscle strength and endurance, 3) agility and balance and 4) flexibility, lasting 10 minutes each season, and finally 5 minutes of relaxation (all together). The volunteers were divided equally into subgroups in the 4 stations, and every 10 minutes they changed, until training all the programmed physical skills. They performed as many repetitions of the physical exercises as possible in each season, according to the determined time and the individual perception of the effort. The volunteers were explained and asked to maintain a perception of effort between 3 and 7, which corresponds, respectively, to a moderate and very strong effort on Borg's CR10 subjective perception of effort (SPE) scale [22]. The training was applied to all volunteers at the same place and time of day, in joint sessions, in which they performed the exercises respecting the biological individuality and physical fitness of each participant, seeking to maintain the intensity within the requested effort zone. The training sessions were accompanied by duly trained teachers, who supervised the performance of physical exercises in each station.

During the training program, the progression of the exercises occurred according to the principle of biological individuality. There was an increase in the complexity of the activities, always respecting the perception of the volunteers involved. The volume was regularly 50 minutes per session with a weekly frequency of 3 times and an interval of at least 24 hours between sessions. The exercises were performed without the use of machines, with bodyweight and implements such as mattresses, dumbbells, shin pads, and 1-3 kg sticks, Pilates ball, Swedish gymnastic bench, trampoline, and stepper.

The progression of MCT occurred in the same way for practiced physical capacities. In weeks 1 to 5, exercises with an initial degree of complexity were applied, with a duration of 30 seconds and a rest interval of 30 seconds. In weeks 6 to 11, exercises with an intermediate degree of complexity, with a duration of 40 seconds and a rest interval of 20 seconds. In the weeks from 12 to 16, exercises with an advanced degree of complexity, lasting 60 seconds, with a pause of 20 seconds. All exercises were applied to respect the capabilities and limitations of each volunteer.

The elaboration of this MCT program was based on the position of the American College of Sports Medicine for older adults [23]. The exercises were chosen considering the participants' functional demands to perform basic, instrumental, and advanced activities of daily living. Table II shows the physical exercises performed during the MCT.

Table II – Exercises performed in the MCT program.

Training weeks	Aerobic fitness	Muscle strength / endurance	Agility and balance	Flexibility
1-5	Stationary running, jumping jacks and trampoline	Squat, push-up, and abdominal plank	Single-leg deadlift, single-leg support, and balance on the ball	Static and active stretches
6-11	*Stepper, walking and running*	Biceps curl, pelvic and abdominal lift with ball	Balance circuit, Tandem gait, and balance on Swedish gymnastic bench	Dynamic and active stretches
12-16	Shifts, trampoline and rhythms	Squat, crucifix, bench press, and sit-up	Agility ladder, balance on the ball, and single leg support	Dynamic and passive stretches

Source: Prepared by the authors.

Statistical analysis

Initially, the normality of the data was verified using the Shapiro-Wilk test, as well as graphical methods and asymmetry coefficient. Then the paired t-test was applied. The level of significance adopted was 5%. Data analysis was performed using the Statistical Package for the Social Sciences version 21.0 (SPSS Inc., Chicago, United States).

The adopted formula to estimate the effect size of the intervention was: $r = \sqrt{t^2/t^2+df}$, where t - t-score and df - degrees of freedom. The values of r = 0.10, 0.30 and 0.50 were considered, respectively, small, medium and large effect [24].

Results

Table III shows the anthropometric characteristics of the volunteers before and after the 16 weeks of MCT. The results showed no differences found between the two assessment moments for anthropometric characteristics.

Table III - Anthropometric characteristics of the sample, before and after 16 weeks of MCT.

	T1	T2	p	r
Body mass (kg)	68.6 ± 10.9	67.3 ± 11.5	0.24	0.22
Height (m)	1.55 ± 0.5	1.55 ± 0.5	0.57	0.11
BMI (kg/m²)	28.1 ± 4.2	27.3 ± 4.5	0.12	0.29

T1 = 1st evaluation; T2 = 2nd evaluation; p = p-value for paired t-test; r = effect size; BMI = Body Mass Index; Data are mean ± standard deviation; Source: Prepared by the authors.

Table IV shows the results of tests for assessing functional capacity before and after the intervention. A percentage increase of 20.6% in upper limb strength was observed, with medium effect size, and 16.1% in lower limb strength, with large effect size, assessed using the elbow flexion test and the sit-to-stand test, respectively. There was a 14.8% improvement in agility and dynamic balance, assessed using the stand-up and move test, with a large effect size. No differences were found in the abdominal resistance test, in the stand-up test, in the sock test, and the sit and reach test.

Table IV – Results of functional tests.

		T1	T2	p	r
Aerobic fitness	1600-meter walk (ml/kg/min)	31.0 ± 6.1	32.0 ± 6.4	0.61	0.18
Muscle strength / endurance	Sit-ups (reps)	10.2 ± 8.4	11.9 ± 9.9	0.10	0.28
	Elbow flexion (reps)	18.9 ± 4.3	22.8 ± 7.9	<0.01	0.46
	Sit-to-stand (reps)	14.9 ± 2.8	17.3 ± 2.6	<0.01	0.74
Agility and balance	Get up from the ground (sec)	4.1 ± 2.6	3.8 ± 0.9	0.41	0.14
	Stand-up and move (sec)	5.4 ± 0.8	4.6 ± 0.5	<0.01	0.67
	Put on socks (sec)	5.4 ± 2.8	4.8 ± 1.1	0.21	0.23
Flexibility	Sit and reach (cm)	25.4 ± 10.1	26.8 ± 8.0	0.53	0.15

T1 = 1st evaluation; T2 = 2nd evaluation; p = p-value for paired t-test; r = effect size; min = minutes; kg = kilograms; ml = milliliters; reps = repetitions; sec = seconds; cm = centimeters; Data are mean ± standard deviation; Source: Prepared by the authors.

Discussion

The present study aimed to verify whether an MCT program could influence the functional capacity of middle-aged women. The main findings indicated that there was an improvement in the strength of the lower and upper limbs, as assessed by the elbow flexion and the sitting and standing tests, improvement in agility and dynamic balance evaluated by the standing and moving test. The findings of this study show MCT as a relevant strategy for improving the functional capacity of middle-aged women during the aging process.

From the third decade of life, declines in the functional capacity of individuals begin, such as decreased aerobic fitness, muscle strength and endurance, flexibility and balance, which over time begins to limit the individual in carrying out the activities of the daily life and contributes to a sedentary lifestyle [1,2,6]. Among the factors that explain this reduction in functional capacity with aging are structural and functional changes in the cardiac system, such as thickening and dilation of large arteries, which can result in hypertrophy and altered left ventricular function

[25,26]. There is a reduction in muscle mass and function, in the cross-sectional area and the number and activity of motor units [27,28], as well as changes in the vestibular system [29], lower levels of joint amplitude, and changes in connective tissue, tendons, ligaments and joint capsules [30].

The practice of exercises throughout life, on a regular and permanent basis, can contribute to a more active and healthy old age [31]. MCT has been identified in the literature as an efficient approach to improve functional capacity, mitigating the declines inherent to aging [8,10,14,15]. However, there is a gap in the literature of studies that evaluated the effects of MCT on the functional capacity of middle-aged women.

The results of the present study show an improvement, with medium and large effect size, in the strength of the upper and lower limbs, assessed by the elbow flexion and sitting and standing tests, respectively (Table IV). The results of the study by Kang et al. [32] corroborate these findings. The authors found that 4 weeks of MCT were effective in improving the strength of upper limbs (pre: 15.1 ± 5.4 vs. post: 18.5 ± 5.1 repetitions) and lower (pre: 12.3 ± 3.8 vs. post: 18.8 ± 4.3 repetitions) in older women. In the study by Heubel et al. [33], improvements were also found in upper limb strength (pre: 16.6 ± 3.4 repetitions vs. post: 19.4 ± 4.2 repetitions), but not in lower limbs (pre: 12.8 ± 2.8 repetitions vs. post: 13.7 ± 2.8 repetitions) of the aging people, after 16 weeks of MCT.

The increase in upper and lower limb strength found in this study highlights the role of MCT in improving the functional capacity of middle-aged women. These changes can be explained by morphological and metabolic adaptations that occur in skeletal muscle tissue in response to physical exercise (increased cross-sectional area, improved recruitment of motor units, reduced activation of antagonistic muscles, changes in muscle architecture, etc.) [34]. They can generate benefits to the individual, facilitating the performance of activities of daily living, such as walking, crouching to pick up objects, carrying supplies, among others. Besides, these changes can contribute to the prevention of diseases such as sarcopenia, osteoporosis, and obesity, in addition to improving the movement pattern and reducing the risk of falls [9,15,26].

The results of the present study showed improvement in agility and dynamic balance, with a large effect size (pre: 5.4 ± 0.8 seconds vs. post: 4.6 ± 0.5 seconds), assessed by the stand-up and move test. The results of the study by Kang et al. [32] corroborate these findings since the research showed that 4 weeks of MCT were efficient for improving the agility and dynamic balance of older women (pre: 7.2 ± 1.9 seconds vs. post: 6.1 ± 1.2 seconds). In the study by Resende-Neto et al. [35], improvements in agility and dynamic balance (pre: 5.3 ± 0.6 seconds vs. post: 4.4 ± 0.3 seconds) were also found after 12 weeks of MCT.

The result found in the stand-up and move test indicates an improvement in the levels of agility and dynamic balance, and this finding should be considered positive since, with advancing age, there is a reduction in these physical capacities [2,29]. Better levels of balance and agility can contribute to the maintenance of functional capacity, allowing that even with advancing age, it is possible to perform basic tasks such as walking, dodging objects, or climbing the stairs when getting on the bus, for example. Plus, better balance levels are essential to reduce the risk of falls, which can have serious consequences, such as bone fractures that limit the performance of activities of daily living, end up reducing the individual's functional capacity, as well as increasing the risk of diseases such as sarcopenia and obesity [36,37].

These findings together can be seen as positive from the point of view of public health since aging declines in strength and balance are evidenced by the literature [1,2,26,29].

There were no changes in the 1600-meter walk test, abdominal resistance in 1 minute, standing up from the ground and putting on socks, and sitting and reaching. Such findings indicate that 16 weeks of MCT helped to maintain these parameters of functional capacity, which can be considered positive since, with aging, there is a tendency to reduce these capacities [1,2,26,29,38,39]. From the third decade of life, it is possible to notice biofunctional changes in the body, such as reduced locomotor function and flexibility, the decline in aerobic fitness, changes in the vestibular system, reduced postural stability, and decreased strength levels, even in healthy subjects [1,2,6,38,39].

The findings of our study demonstrated that this protocol was effective in improving the strength of upper and lower limbs and in agility and dynamic balance. As practical applicability, we highlight the effectiveness of a sixteen-week MCT program, with three weekly sessions of 50 minutes each, divided into a warm-up, four multi-component stations, and relaxation, with exercises aimed at improving everyday movements, without using machines, using simple implements and body weight, of low cost, with moderate intensity and that meets the global recommendations on physical exercise and aging for health.

Although this study has some limitations (the absence of a control group, relatively small sample size, evaluation by the same professionals who applied the intervention, lack of control of the level of physical activity outside the training period, and absence of restriction of eating habits), the hypothesis was confirmed, since the MCT program was effective in improving the functional capacity of middle-aged women. In this research, we adopted MCT with moderate intensity. It may be that in new studies that carry out MCT with greater intensities, other capacities can also be improved. Such findings must be considered preliminary, and future studies that meet the above limitations are essential to contribute to the understanding of this type of training for middle-aged women.

Conclusion

The results of this study revealed that 16 weeks of MCT increased the strength, agility, and dynamic balance of middle-aged women. Therefore, the practice of MCT by middle-aged women is fundamental to promote improvements in their functional capacity, enabling them to become physically active aging people and capable of carrying out their daily life activities with autonomy and independence.

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Potential conflict of interest
No conflicts of interest have been reported for this article.

Academic affiliation
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Authors' contributions
Conception and design of the research: Caldas LRR, Carneiro-Júnior, MA. **Obtaining data and conducting the intervention:** Caldas LRR, Lopes E, Moreira AC. **Analysis and interpretation of data:** Caldas LRR, Albuquerque MR, Ribeiro AQ, Carneiro-Júnior MA. **Statistical analysis:** Caldas LRR, Albuquerque MR, Ribeiro AQ, Carneiro-Júnior MA. **Obtaining financing:** Caldas LRR, Carneiro-Júnior MA. **Writing of the paper:** Caldas LRR, Albuquerque MR, Ribeiro AQ, Carneiro-Júnior MA. **Critical review of the paper for important intellectual content:** Caldas LRR, Albuquerque MR, Ribeiro AQ, Carneiro-Júnior MA.

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