FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 18, No 1, 2020, pp. 65 - 82
https://doi.org/10.22190/FUPES200322007H

Review article

THE EFFECTS OF PHYSICAL ACTIVITY ON OBESITY AMONG THE ELDERLY – A SYSTEMATIC REVIEW

UDC 615:796

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Abstract. *The aim of this review research was to determine the effects of the physical activity (PA) on obesity among the elderly. To compile existing studies on the effects of PA on obese elderly individuals, PubMed, SCIndeks, PEDro, J-GATE, DOAJ and Google Scholar electronic databases were searched. By analyzing and applying the set criteria, the final analysis included 20 studies, and the positive influence of the PA on the obesity of the elderly was confirmed. The greatest effect on the decrease in body mass was achieved by the simultaneous application of a combination of exercise programs and dietary regimen for a period of 6 months. It was concluded that combined programs of aerobics, weight training, flexibility and balance exercises for a period of at least 12 weeks lead to a mild decrease in body mass and the amount of fat mass, while maintaining and increasing lean body mass mostly in the form of muscle tissue. PA is an effective mean in reducing obesity, and thus its use among the elderly is recommended.*

Key words: *Physical Exercise, Ageing, Body Composition, Body Mass Index, Weight Loss.*

INTRODUCTION

Pronounced demographic changes and the increase in the number of the elderly with certain health issues characteristics for their age have been a feature of most countries in the world over the past two decades. Poor habits and lifestyle choices at a young age are described as possible triggers for the health disorders later in life, e.g. diabetes or cardiovascular diseases are the most common health disorders that are caused largely by unhealthy habits (Chan & Woo, 2010; Sourtzi et al., 2019). Obesity, as a consequence of insufficient physical activity (PA) and an inappropriate way of life represents one of the quickest growing trends among the elderly population. As a result, physical exercise (PE) is

Received March 22, 2020/ Accepted May 11, 2020
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recommended as one of the most effective means of solving the aforementioned problem (Han, Tajar, & Lean, 2011; Petrović & Marinković, 2018), as it also contributes to the improvement in quality of life, increase in muscle strength, and endurance (Blair, LaMonte, & Nichaman, 2004). In addition to numerous recommendations regarding the frequency and intensity of the physical activities of the elderly, the effects of the applied exercises, due to great variations in the aging process, according to certain authors, primarily depend on the health status, psychophysical characteristics and functional abilities of each individual (Taylor et al., 2004).

During the normal aging process, changes in body composition occurs in the form of a decrease in muscle mass and increase in fat mass, that is, the development of sarcopenia, which represents an important cause of bone brittleness, instability, the occurrence of disability and loss of independent movement among the elderly (Weinheimer, Sands, & Campbell, 2010). In addition to the effects of PE on the elderly, related to the prevention and eradication of sarcopenia and cachexia through a combination of aerobic and weight training exercises (Scalabrin & Caporossi, 2016), it was determined that PA have a beneficial effect on relieving joint pain among individuals with rheumatoid arthritis, osteoarthritis, osteoarthritis of the knees, chronic obstructive pulmonary disease (Rejeski, Brawley, & Shumaker, 1996), a decrease in fatigue, increase in energy (Cochrane, Munro, Davey, & Nicholl, 1998) and quality of sleep (Singh, Clements, & Fiatarone, 1997). Obesity, accompanied by physical weakness and other health complications due to a decrease in daily PA, represents one of the main causes of the occurrence of disability among the elderly (Villareal, Banks, Siener, Sinacore, & Klein, 2004). This inactivity is related to low percentages of lean body mass (LBM) and increased amount of body fat (BF), a decrease in muscle mass and quality of life. As the number of the elderly in the world population is increasing, and obesity is proving to be one of the greatest problems of modern times, the question is: "What are the effects of the PA on obesity among the elderly, and what type of the PE has the greatest effect?"

The aim of this research is to determine the effects of PA on obesity among the elderly.

METHODS

The tasks that originated from the research aim included: 1) a search of electronic databases; 2) the compilation and translation of existing literature from English; 3) an analysis of the research results; and 4) result representation, that is, determining the effects of exercise programs on obesity among the elderly.

To compile existing studies on the effects of the PA on obesity among the elderly, the following electronic databases were searched: PubMed, SCIndeks, PEDro, J-GATE, DOAJ and Google Scholar. Following the compilation of the relevant data from studies previously carried out from 2000 to 2017, under the assumption that the PA has a positive effect on the reduction of obesity among the elderly, an evaluation of its effects was carried out.

During the database search, the following key words were used: exercise, ageing, body composition, body mass index, weight loss, health promotion. The titles of identified studies, their abstracts and entire texts were read and analyzed. The research was carried out by several authors, and the studies were analyzed in detail based on the set criteria.

Inclusion criteria

In order for a study to be included in the final analysis, it had to satisfy certain criteria:

- that it included obese individuals with a body mass index ≥30 (Body mass index – BMI=kg/m²);
- that it included obese elderly individuals, with an average age ranging from 55 to 80, independent of lifestyle;
- that the experimental group took part in an exercise program as part of which the evaluation of the effects of the PA on obese elderly individuals took place;
- that the study was written in English.

The experimental studies which met the set criteria were analyzed afterwards and presented based on the following parameters: references (the author's initials and date of publication of the study), the sample of participants (health status, age, overall number and subgroups of the participants), the PE program, the duration and frequency of the PE, the research results.

Exclusion criteria

The exclusion criteria included:

- that the study was carried out on a sample of participants whose average age is outside the range of 55 to 80;
- that the study was not published in English.

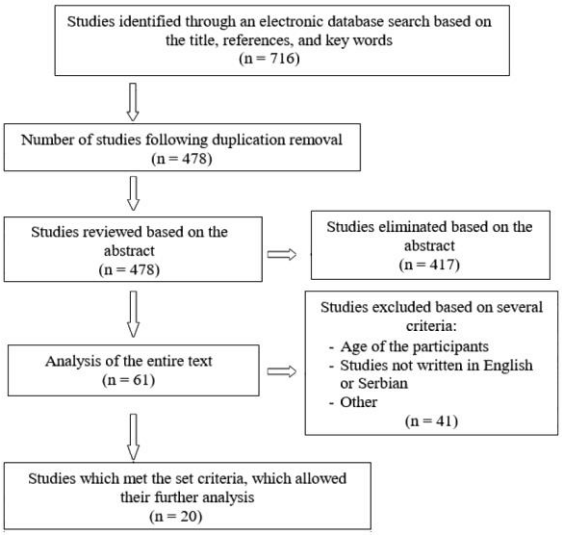

Fig. 1 The flow diagram

RESULTS

The search of the electronic databases identified 716 studies on the relevant topic. Following a further analysis and application of the set criteria, in accordance with the aims of this study, the final analysis included 20 studies, as can be seen from the following Flow diagram 1.

Table 1 A systematic review and the characteristics of the participants included in the studies

Study (year)	Health status	Gender	Age of the participants (Mean±SD)	Sample size (n)	BMI (kg/m²)	Number of participants per group	Duration Frequency (days/ weeks)	Intensity Duration of the training (min)	Type of the activity	Results (p)
Womack et al. (2000)	Obese individuals	M	60 ± 8	n = 81	EG_1 BMI = 30.4 ± 2.5 EG_2 BMI = 29.9 ± 2.8 CG BMI = 31.2 ± 2.4	EG_1 = 35 EG_2 = 38 CG = 8	36 weeks 3 / 7	30-45min. HRR 50-80%	EG_1 – dietary regimen EG_2 – aerobic exercise (running on a treadmill and riding a bicycle ergometer) CG - no physical activity	EG_1 » BW ↓ p<0.05 BMI ↓ p<0.05 BFP% ↓ p<0.05 WC ↓ p<0.05 WHR ↓ p<0.05 FFM ↓ p<0.05 VO_{2max} ↑ ¥ EG_2 » BW ↓ p<0.05 BMI ↓ ¥ BFP% ↓ p<0.05 WC ↓ ¥ WHR ¥ FFM ↓ ¥ VO_{2max} ↑ p<0.05 CG » ¥
Messier et al. (2000)	Obese individuals with osteoarthritis	M = 7 F = 17	EG_1 = 69 ± 5 EG_2 = 67 ± 4	n = 24	EG_1 BMI = 38 ± 6 EG_2 BMI = 35 ± 5	EG_1 = 11 EG_2 = 13	12 weeks 3/7	60min. HRR 50-75%	EG_1 - combined training (aerobic walking + weight training exercises) EG_2 - combined training (aerobic walking + weight training exercises) + dietary regimen (nutrition education 60min per week)	EG_2 » EG_1 BW ↓ p=0.01 EG_1 » BW ↓ (1.8 kg) EG_2 » BW ↓ (8.5 kg)

Dunstan et al. (2002)	Obese individuals with type 2 diabetes (postmenopausal women)	M = 16 F = 17	EG_1 67.6 ± 5.2 EG_2 66.9 ± 5.3	n = 90	EG_1 BMI = 31.5 ± 3.7 EG_2 BMI = 32.5 ± 3.8	EG_1 = 16 EG_2 = 13	6 months 3 / 7	55min. 1RM 50–85%	EG_1 – dietary regimen + progressive high intensity weight training exercise (warm-up and cool down on a stationary bicycle and weight training exercises) EG_2 – controlled program which includes 5 min of exercise on the stationary bicycle without weights and static stretching exercises for 30 min	3 months: EG_1» BW ↓ p<0.01 WC ↓ p<0.01 EG_2» BW ↓ p<0.01 WC ↓ p<0.01 6 months: EG_1» BW ↓ p<0.01 WC ↓ p<0.01 BF_{kg} ↓ p<0.01 LBM ↑ p=0.09 EG_2» BW ↓ p<0.01 WC ↓ p<0.01 BF_{kg} ↓ p<0.01 LBM ↓ ¥ EG_1» EG_2 (ГхВ) LBM ↑ p<0.05
Irwin et al. (2003)	Postmenopausal obese individuals	F	CG = 60.6 EG = 61.0	n = 173	EG BMI = 30.5 CG BMI = 30.6	CG = 86 EG = 87	12 months 5 / 7 I-III months- 3 supervised training sessions at a gym and 2 at home IV-XII months – 1 supervised training session in a gym and 4 at home	45min. HR_{max} 40–75%	CG – only minimal intensity stretching exercises were suggested EG – combined training (moderate intensity aerobic training (walking on a treadmill and riding a stationary bicycle) and supervised weight training with walking, aerobics and cycling recommended as home exercises)	EG»CG BW ↓ p=0.01 BMI ↓ p=0.004 WC ↓ p=0.049 HC↓ p=0.003 BF_{kg} ↓ p=0.001 BFP% ↓ p=0.001 SCF ↓ p=0.003 VCF ↓ p=0.045

You et al. (2006)	Postmenopausal obese individuals	F	58 ± 1	n = 45	BMI = 33.0 ± 0.6	EG_1 = 15 EG_2 = 14 EG_3 = 16	20 weeks 3 / 7	EG_2 55min. HRR 45-50% EG_3 30min. HRR 70-75%	EG_1 – dietary regimen EG_2 – dietary regimen + low intensity aerobic exercise EG_3 – dietary regimen + high intensity aerobic exercise	EG_1» BW ↓ p<0.001 BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 VO_{2max} ↑ p<0.01 EG_2» BW ↓ p<0.001 BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 VO_{2max} ↑ p<0.001 EG_3» BW ↓ p<0.001 BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 VO_{2max} ↑ p<0.01
Villareal et al. (2006)	Obese, physically weak individuals	M = 9 F = 18	CG =71.1±5.1 EG =69.4±4.6	n = 27	BMI ≥ 30 CG BMI = 39.0 ± 5.0 EG BMI = 38.5 ± 5.3	CG = 10 EG = 17	26 weeks 3/7	90min	CG – no physical activities EG – dietary regimen + combined training (flexibility exercises + endurance exercises + weight training exercises+ balance exercises)	EG» BW ↓ p<0.001 BF_{kg} ↓ p<0.001 FFM ↓ p=0.04 PPT ↑ p=0.001 VO_{2max} ↑ p=0.001 FSQ ↑ p=0.005 EG»CG BW ↓ p<0.001 BF_{kg} ↓ p<0.001 FFM ↓ ¥ p=0.75 PPT ↑ p=0.001 VO_{2max} ↑ p=0.02 FSQ ↑ p=0.02
O'Leary et al. (2006)	Obese individuals (postmenopausal women)	M = 5 F = 11	63 ± 1	n = 16	BMI = 33.2 ± 1.4	EG = 16	12 weeks 5 / 7	50-60min HR_{max} 60-85%	EG – aerobic exercise program (riding a bicycle, running on a treadmill and stretching)	EG» BW ↓ p<0.0001 BMI ↓ p<0.0001 BF_{kg} ↓ p<0.005 FFM ↑ ¥ TAF ↓ p<0.003 SCF ↓ p<0.03 VCF ↓ p<0.0001

Lambert et al. (2008)	Obese, physically weak individuals	M = 8 F = 8	69 ± 1	n = 16	BMI = 38 ± 6	EG_1 = 8 EG_2 = 8	12 weeks 3 / 7	90min. HR_{max} 75-90% 1RM 65-80%	EG_1 – dietary regimen EG_2 – combined training (aerobic exercise, weight training exercise, flexibility and balance exercises)	EG_1 » BW ↓ p=0.001 BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 FFM ↓ p=0.01 EG_2 » BW ↓ ¥ BMI ↓ ¥ BF_{kg} ↓ p<0.05 FFM ↑ p=0.03
Frimel et al. (2008)	Obese, physically weak individuals	M = 12 F = 18	70 ± 5	n = 30	EG_1 BMI = 36.9 ± 4.9 EG_2 BMI = 36.7 ± 5.1	EG_1 = 15 EG_2 = 15	24 weeks 3 / 7	90min 1RM 85%	EG_1 – dietary regimen EG_2 – dietary regimen + combined training (flexibility exercises, low intensity aerobic exercises, progressive training with high intensity weight training and balance exercises)	EG_1 » EG_2 BW ↓ ¥ BF_{kg} ↓ ¥ FFM ↓ p<0.05 UELBM ↓ p<0.05 LELBM ↓ p<0.05 EG_2 » UELBM ↓ ¥ p=0.35
Davidson et al. (2009)	Obese individuals	M = 57 F = 79	M = 67.7 ± 5.1 F = 67.5 ± 5.1	n = 136 study completed by n = 84	M BMI = 30.4 ± 2.7 F BMI = 29.5 ± 3.0	CG = 24 EG_1 = 30 EG_2 = 30 EG_3 = 33	6 months EG_1 3 / 7 EG_2 5 / 7 EG_3 3 / 7	EG_1 20min. HR_{max} 45% EG_2 30min HR_{max} 60-75% EG_3 50min. Aerobic exercise HR_{max} 60-75% Weight training HR_{max} 45%	Seminars on nutrition during the exercise program for all groups of participants CG – no physical activity EG_1 –weight training exercises (1 set of 9 exercises) EG_2 – aerobic exercises (moderate intensity walking on a treadmill) EG_3 – combined training (moderate intensity walking on a treadmill + weight training exercises)	EG_1 » CG WC ↓ p<0.05 EG_2 » CG TAF ↓ p<0.05 SCF ↓ p<0.05 VCF ↓ p<0.05 EG_2 » CG, EG_1 BW ↓ p<0.05 BMI ↓ p<0.05 WC ↓ p<0.05 BF_{kg} ↓ p<0.05 EG_3 » EG_1 BW ↓ p<0.05 BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 EG_3 » CG, EG_1 WC ↓ p<0.05 TAF ↓ p<0.05 SCF ↓ p<0.05 VCF ↓ p<0.05

Wycherley et al. (2010)	Obese individual with type 2 diabetes	M / F	56.1 ± 7.5	n = 59	CG_1 BMI = 34.8 ± 4.9 CG_2 BMI = 35.6 ± 3.8 EG_1 BMI = 34.9 ± 4.9 EG_2 BMI = 36.6 ± 5.0	CG_1 = 16 CG_2 = 12 EG_1 = 17 EG_2 = 14	16 weeks 3 / 7	45min. 1RM 70–85%	CG_1 – low protein and no fat diet CG_2 – high protein and low fat diet EG_1 – low protein and no fat diet + weight training exercise program EG_2 – high protein and low fat diet + weight training exercise program	EG_1, EG_2, CG_1, CG_2 » BW ↓ p<0.001 WC ↓ p<0.001 BMI ↓ p<0.001 FFM ↓ p<0.001 EG_2» CG_1, CG_2 BW ↓ p<0.05 WC ↓ p≤0.02 BF_{kg} ↓ p≤0.02 EG_2» EG_1 BW ↓ ¥ WC ↓ ¥ BF_{kg} ↓ p=0.06 FFM ↓ ¥ EG_1, EG_2 » CG_1, CG_2 BW ↓ p=0.02 WC ↓ p<0.01 BF_{kg} ↓ p<0.01 BMI ↓ p=0.03 FFM ↓ ¥ CG_2» CG_1 BW ↓ ¥ BF_{kg} ↓ p=0.06 FFM ↓ ¥
Villareal et al. (2011)	Obese, physically weak individuals	M = 40 F = 67	CG = 69 ± 4 EG_1 = 70 ± 4 EG_2 = 70 ± 4 EG_3 = 70 ± 4	n = 107 study completed by n = 93	CG BMI = 37.3 ± 4.7 EG_1 BMI = 37.2 ± 4.5 EG_2 BMI = 36.9 ± 5.4 EG_3 BMI = 37.2 ± 5.4	CG = 27 EG_1 = 26 EG_2 = 26 EG_3 = 28	52 weeks 3 / 7	EG_2 and EG_3 90min HR_{max} 65-85% 1RM 65-80%	CG – no physical activity EG_1 – dietary regimen EG_2 – combined training (aerobic exercise + weight training exercise + flexibility and balance exercises) EG_3 – dietary regimen + combined training (aerobic exercise + weight training exercise + flexibility and balance exercises)	EG_2 » CG BW ↓ ¥ BF_{kg} ↓ p=0.004 LBM ↑ p<0.001 BMD ↑ p=0.001 EG_3» EG_1 BW ↓ ¥ BFkg ↓ ¥ LBM ↓ p=0.04 BMD ↓ p=0.005 EG_3» EG_2 BW ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.001 BMD ↓ p<0.001

Foster-Schubert et al. (2012)	Menopausal obese individuals	F	58.0 ± 5.0	n = 439 study completed by 399	BMI = 30.9 ± 4.0	CG = 80 EG_1 = 105 EG_2 = 106 EG_3 = 108	12 months EG_2 , EG_3 5 / 7	≥45min HR_{max} 60-85%	CG – no physical activity EG_1 – dietary regimen EG_2 – moderate to high intensity aerobic exercise EG_3 – dietary regimen + moderate to high intensity aerobic exercise	EG_1» CG BW ↓ p<0.0001 BFP% ↓ p<0.0001 BMI ↓ p<0.0001 WC ↓ p<0.0001 EG_2» CG BW ↓ p=0.034 BFP% ↓ p<0.0001 BMI ↓ p=0.01 WC ↓ p=0.0005 LBM ↑ ¥ EG_3» CG BW ↓ p<0.0001 BFP% ↓ p<0.0001 BMI ↓ p<0.0001 WC ↓ p<0.001 EG_2» EG_1 LBM ↑ p<0.0001 EG_2» EG_3 LBM ↑ p<0.003 EG_1» EG_2 BW ↓ p<0.0001 WC ↓ p<0.004 BFP% ↓ p<0.005 EG_3» EG_2 BW ↓ p<0.0001 WC ↓ p<0.0001 BFP% ↓ p<0.005 EG_3» EG_1 BW ↓ ¥ WC ↓ p<0.004 BFP% ↓ p<0.005

Armamento - Villareal et al. (2012)	Obese individuals	M = 40 F = 67	CG = 69 ± 0.8 EG_1 = 70 ±0.8 EG_2 = 70 ±0.8 EG_3 = 70 ±0.8	n = 107	BMI ≥ 30 CG BMI = 37.3 ± 0.9 EG_1 BMI = 37.2 ± 0.9 EG_2 BMI = 36.9 ± 1.1 EG_3 BMI = 37.2 ± 1.0	CG = 27 EG_1 = 26 EG_2 = 26 EG_3 = 28	52 weeks 3/7	EG_2 and EG_3 90min HR_{max} 65-85% 1RM 65-80%	CG – no physical activity EG_1 – dietary regimen EG_2 – combined training (flexibility exercises + aerobic exercises + weight training exercises) EG_3 – dietary regimen + combined training (flexibility exercises + aerobic exercises + weight training exercises)	EG_1, EG_3» CG, EG_2 BW ↓ p<0.001 CG, EG_2» BW ¥ EG_3» LBM ↓ -3.2 ± 0.5% EG_1» LBM ↓ -5.3 ± 0.7% EG_2» LBM ↑ 2.4 ± 0.5% EG_1» LS ↑ p<0.05
Bocalini et al. (2012)	Obese individuals	F = 69	CG_1 = 67 ± 9 EG_1 = 66 ± 4 CG_2 = 63 ± 2 EG_2 = 64 ± 4 CG_3 = 62 ± 1 EG_3 = 62 ± 2	n = 69	CG_1 and EG_1 BMI = 18.5 – 24.9 CG_2 and EG_2 BMI = 25.0 – 29.9 CG_3 and EG_3 BMI >30.0	CG_1 = 9 EG_1 = 18 CG_2 = 10 EG_2 = 14 CG_3 = 9 EG_3 = 9	12 weeks 3/7	50min HR_{max} 70%	CG_1, CG_2, CG_3 – no physical activities EG_1, EG_2, EG_3 -Circuit training (aerobic warm-up, weight training exercises and stretching exercises)	CG_1, CG_2, CG_3, EG_1, EG_2» BW ¥ BF_{kg} ¥ BFP% ¥ LBM ¥ EG_3» CG_3 BW ↓ p<0.05 BF_{kg} ↓ p<0.05 BFP% ↓ p<0.05 LBM ↑ p<0.05 BMI ↓ p<0.05

Amati et al. (2013)	Obese individuals	M = 26 F = 38	67 ± 0.5	n = 64	BMI = 30.7 ± 0.4	EG_1 = 11 EG_2 = 36 EG_3 = 17	16 weeks 3-5/7	45min VO_{2max} 50-75%	EG_1 – dietary regimen EG_2 – moderate intensity aerobic exercises EG_3 - moderate intensity aerobic exercises + dietary regimen	EG_1» BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 LBM ↓ p<0.05 VO_{2max} ↑ ¥ EG_2» BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 LBM ↑ ¥ VO_{2max} ↑ p<0.05 EG_3» BMI ↓ p<0.05 BF_{kg} ↓ p<0.05 LBM ↓ p<0.05 VO_{2max} ↑ p<0.05
Romero-Arenas et al. (2013)	Obese individuals and overweight individuals	M/F	61.6 ± 5.3	n = 37	EG_1 BMI = 29.7 ± 4.1 EG_2 BMI = 30.2 ± 6.0 CG BMI = 29.9 ± 5.8	EG_1 = 16 EG_2 = 14 CG = 7	12 weeks 2 / 7	EG_1 35-47min. 1RM 85-90% EG_2 45-87min. 1RM 85-90%	EG_1 – circuit training with high intensity weight training exercises EG_2 – classic weight training CG – no physical activity Nutrition advice	EG_1» IS ↑ p<0.001 LBM ↑ p<0.001 BMD ↑ p=0.025 BF_{kg} ↓ p=0.011 EG_2» IS ↑ p<0.001 LBM ↑ p=0.025 BMD ↑ p=0.018 EG_1, EG_2» CG IS ↑ p<0.03 EG_1» CG BF_{kg} ↓ p=0.039

Beavers et al. (2014)	Obese indivduals with osteoarthritis of the knee	M = 75 F = 209	66.0 ± 6.2	n = 284	EG_1 BMI = 33.5 ± 3.7 EG_2 BMI = 33.2 ± 3.6 EG_3 BMI = 33.4 ± 3.7	EG_1 = 95 EG_2 = 88 EG_3 = 101	18 months 3 / 7	60min	EG_1 – combined training (walking and weight training exercises) EG_2 – dietary regimen EG_3 – dietary regimen + combined training (walking and strength exercises)	EG_1 » BW ↓ p<0.01 EG_2 » BW ↓ p<0.01 EG_3 » BW ↓ p<0.01 EG_2, EG_3 » EG_1 BMD ↓ p<0.01
Ryan & Harduarsingh -Permaul (2014)	Postmenopausal obese individuals	F	50 - 76	n = 65	EG_1 BMI = 32 ± 1 EG_2 BMI = 34 ± 1	EG_1 = 43 EG_2 = 22	6 months EG_1 3 / 7	60min HRR 50-85%	EG_1 – dietary regimen + aerobic exercise on a treadmill EG_2 – dietary regimen	EG_1 » BW ↓ p<0.001 BMI ↓ p<0.001 WC ↓ p<0.001 WHR ¥ BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.05 FFM ↓ p<0.05 TAF ↓ p<0.001 EG_2 » BW ↓ p<0.001 BMI ↓ p<0.001 WC ↓ p<0.001 WHR ¥ BFP% ↓ p<0.001 BF_{kg} ↓ p<0.001 LBM ↓ p<0.01 FFM ↓ p<0.01 TAF ↓ p<0.001

Villareal et al.(2017)	Obese, physically weak individuals	M = 57 F = 103	CG = 70 ± 5 EG_1 = 70 ± 4 EG_2 = 70 ± 5 EG_3 = 70 ± 5	n = 160	BMI ≥ 30 CG BMI = 37.3 ± 0.9 $E\Gamma_1$ BMI = 35.9 ± 4.4 $E\Gamma_2$ BMI = 36.7 ± 5.8 $E\Gamma_3$ BMI = 35.8 ± 4.5	CG = 40 EG_1 = 40 EG_2 = 40 EG_3 = 40	26 weeks 3/7	EG_1 60min. HR_{max} 65-85% EG_2 60min. 1RM 65-85% EG_3 75-90min. HR_{max} 65-85% 1RM 65-85%	CG – instructions regarding dietary regimens and no physical activity EG_1 – dietary regimen + aerobic training EG_2 – dietary regimen + weight training exercises EG_3 – dietary regimen + combined training (aerobic + weight training exercises)	EG_1, EG_2, EG_3 » CG PPT ↑ p<0.001 EG_3 » EG_1 PPT ↑ p=0.01 EG_3 » EG_2 PPT ↑ p=0.02 EG_1, EG_2 » EG_3 VO_{2max} ↑ p<0.001 EG, EG_3 » EG_1 MS ↑ p<0.001 EG_1, EG_2, EG_3 » BW ↓ 9% CG » BW ↓ ¥ EG_1» EG_2, EG_3 LBM ↓ p<0.05 BMD↓ p<0.05

Legend: M - male; F - female; X - unavailable; n – number of participants; EG-experimental group; CG- control group; PPT – (Physical Performance Test); FSQ – (Functional Status Questionnaire); p – level of statistical significance; ↑- improvement/increase; ↓ - decrease; ‡ - moderate statistical significance; ¥ - no statistical significance; » - differences between the initial and final measurement; (GxT) – significant effect of interaction between the groups and time; BMI – body mass index (kg/m^2); HR_{max} – maximal heart rate frequency; HRR – resting heart rate; EG»CG – differences in favor of the experimental group in relation to the control group following the exercise program; VO_{2max} – maximum oxygen uptake (ml/kg/min); MS – muscle strength; BW- body weight; LBM – lean body mass including essential body fat (kg); UELBM – upper extremities weight without body mass (kg); LELBM – lower extremities weight without body mass (kg); BMD – bone mineral density (g/cm^2); 1RM – 1 repetition maximum; LS – (sclerostin levels); BF_{kg} – amount of body fat (kg); FFM – fat free mass (kg); BFP% - percentage of body mass; WC – waist circumference (cm); HC- hip circumference; WHR – waist to hip ratio; TAF – total abdominal fat (g/cm^2); SCF – subcutaneous fat tissue (g/cm^2); VCF – visceral fat (g/cm^2); IS – isokinetic strength.

DISCUSSION

The research results whose aim was the evaluation of the effects of PE on the changes in body composition and decrease in the body weight among elderly obese individuals are shown in table form (Table 1). They indicate that the most prevalent programs were those that included the simultaneous use of a combined means of exercise (aerobic exercises, weight training exercises, flexibility and balance exercises) and a dietary regimen (Messier et al., 2000; Villareal, Banks, Sinacore, Siener, & Klein, 2006; Frimel, Sinacore, & Villareal, 2008; Davidson et al., 2009; Villareal et al., 2011; Armamento-Villareal et al., 2012; Beavers et al., 2014; Villareal et al., 2017).

The effect of exercise on obesity, on the changes in body weight and other anthropometric data among the elderly, isolated by a combination of exercise programs without a reduction in food intake, was analyzed in seven studies (Messier et al., 2000; Irwin et al., 2003; Lambert, Wright, Finck, & Villareal, 2008; Villareal, et al., 2011; Armamento-Villareal et al., 2012; Bocalini et al., 2012; Beavers et al., 2014). The authors of six studies relied on aerobic exercises in combination with a dietary regimen to induce changes in one of the groups of obese participants (You et al., 2006; Amati, Dubé, Shay, & Goodpaster, 2008; Davidson, et al., 2009; Foster-Schubert et al., 2012; Ryan & Harduarsingh-Permaul, 2014; Villareal et al., 2017), while in four of the studies only an aerobic exercise program was used (Womack et al., 2000; O'Leary et al., 2006; Amati et al., 2008; Foster-Schubert et al., 2012). A combination of a dietary regimen and weight training exercises was prescribed to a group of participants in four studies (Dunstan et al., 2002; Davidson et al., 2009; Wycherley, Noakes, Clifton, Cleanthous, Keogh, & Brinkworth, 2010; Villareal, et al., 2017), and only a weight training exercise program was used in one of the studies (Romero-Arenas et al., 2013).

Seminars on proper nutritional intake during exercise, dietary regimens for the reduction of body weight, and various types of supplements, as well as consultations with nutritionists, were provided to a group of participants in 12 of the included studies (Womack et al., 2000; You et al., 2006; Amati et al., 2008; Frimel et al., 2008; Lambert et al., 2008; Wycherley et al., 2010; Villareal et al., 2011; Armamento-Villareal et al., 2012; Foster-Schubert et al., 2012; Beavers et al., 2014; Ryan & Harduarsingh-Permaul, 2014; Villareal et al., 2017).

The total number of participants included in this systematic review was 2029. In five of the studies the participants were only women (Irwin et al., 2003; You et al., 2006; Bocalini et al., 2012; Foster-Schubert et al., 2012; Ryan & Harduarsingh-Permaul, 2014), that is 791 female participants in total, while in one of the studies only male participants took part, that is 81 male participants (Womack et al., 2000). The remaining 14 studies had mixed samples of participants (n=1157).

The smallest number of obese participants in the experimental group which took part in combined training (aerobic exercises, weight training exercises, flexibility and balance exercises) was eight (Lambert et al., 2008) and the largest was 108, in a study which at the same time was also the study which included the largest sample of participants (n=439). In this study, a group of obese women took part in a combined dietary regimen and moderate to high intensity aerobic exercise (Foster-Schubert et al., 2012).

The duration of the studies differed and ranged from an interval of 12 weeks (Messier et al., 2000; O'Leary et al., 2006; Lambert, et al., 2008; Bocalini et al., 2012; Romero-

Arenas et al., 2013) which also represents the most frequently used duration of the applied program, to 18 months (Beavers et al., 2014). The most frequent weekly rate of training sessions was applied in 16 of the studies, and included three training sessions per week. The shortest duration of individual training sessions was 20 minutes of aerobic exercise (Davidson et al., 2009), and the longest 90 minutes of combined aerobic and weight training exercises (Villareal et al., 2006; Frimel et al., 2008; Lambert et al., 2008; Villareal et al., 2011; Armamento-Villareal et al., 2012).

The intensity of the exercise in the analyzed studies differed and ranged from 40% to 85% of maximum heart rate (HR_{max}) and from 45% to 80% of resting heart rate during aerobic and combined training, while intensity during weight training ranged from 45% to 90% of 1RM. The maximum intensity of the aerobic exercise as part of combined training ranged from 70% to 90% of HR_{max} (Lambert et al., 2008), while in one of the studies which focused on the effects of circuit and classical weight training, the maximum intensity ranged from 85% to 90% of 1RM (Romero-Arenas et al., 2013).

The systematic review of the measurements of the included parameters identified multiple effects of the applied exercise programs on the obesity levels of the elderly in the form of a reduction in body weight. The best statistically significant effects ($p<0.001$) on the reduction in body mass were achieved in studies with a longer duration of the experimental treatment from 26 and 52 weeks, the simultaneous application of a dietary regimen and combined program of aerobic and weight training exercises (Villareal et al., 2006; Villareal et al., 2011; Armamento-Villareal et al., 2012). In addition, a somewhat lower effect on the decrease in body weight was determined for the programs which included a dietary regimen for the reduction of energy intake through food in combination with aerobic exercises of moderate and high intensity over a longer period of time, from 6 and 12 months (You et al., 2006; Foster-Schubert et al., 2012), then independently applied programs of aerobic exercise with a greater weekly frequency (O'Leary et al., 2006), as well as training sessions which included weight training of a moderate to high intensity in combination with a dietary regimen (Dunstan et al., 2002; Wycherley et al., 2010). The results of this study confirmed the claims of authors of previous studies (Villareal, Apovian, Kushner, & Klein, 2005; Jakičić & Otto, 2006), that exercise without a reduction in food intake is less effective when it comes to the decrease in body mass.

The effect of a combined program of exercise with changes in the dietary regimen led to a decrease in the BMI, with a statistically significant difference identified in studies whose PE program lasted for 6 months or longer (Irwin et al., 2003; Davidson et al., 2009; Foster-Schubert et al., 2012; Ryan & Harduarsingh-Permaul, 2014). A significant decrease in the values of BMI was achieved in studies which included aerobic exercise programs without dietary restrictions, but of a shorter duration, of 12 and 16 weeks, and a frequency of exercise of five training sessions a week (O'Leary et al., 2006; Amati et al., 2008).

By comparing the results of the applied programs, the greatest statistically significant reduction ($p<0.001$) in the amount of BF in kg (BF_{kg}), was noted in studies with the simultaneous application of a dietary regimen and combined aerobic and weight training exercises, where the exercise program lasted over a longer period of time, 26 weeks and 52 weeks (Villareal et al., 2006; Villareal et al., 2011), as well as over aerobic exercise programs combined with a dietary regimen which lasted for longer periods of time, 20 weeks and 6 months (You et al., 2006; Ryan & Harduarsingh-Permaul, 2014). The amount of BF in the body decreased in the studies with isolated programs of aerobic and weight training

exercises, without changes in the dietary regimen, but with more training sessions per week. However, these changes were statistically smaller than the ones that occurred in combination with a dietary regimen (Irwin et al., 2003; O'Leary et al., 2006). The greatest noted decrease in percentage of BF (BFP%), compared to the control group of participants, was determined for aerobic exercise programs which lasted for a period of 12 months, in combination with a reduction in food intake (Foster-Schubert et al., 2012).

The effects of the exercise programs, when it comes to the results recorded for LBM, which also included essential BF, indicate that the increase occurred in the studies which used a combination of aerobic and weight training exercises with no dietary regimen (Villareal et al., 2011; Armamento-Villareal et al., 2012; Bocalini et al., 2012). The simultaneous application of combined exercise programs and dietary regimens in most cases leads to a decrease in LBM (Armamento-Villareal et al., 2012; Villareal et al., 2011), while weight training exercises of high intensity combined with a dietary regimen or without a change in diet contribute to an increase in the LBM among obese elderly individuals (Dunstan et al., 2002; Romero-Arenas et al., 2013).

Based on the analysis of the results of the compiled studies, the claims of previous authors could be confirmed (Yassine et al., 2009). The application of an exercise program without a change in the dietary regimen for a period of 12 or more weeks could lead to a slight decrease in body mass, that is, the amount of BF in the body and an increase in fat free and LBM among obese elderly individuals (Lambert et al., 2008; Romero-Arenas et al., 2013). In addition, it should be pointed out that a much greater effect on body composition of obese elderly individuals is achieved by a combined exercise program which includes both weight training exercises and aerobic exercises, with the simultaneous application of dietary regimen, which is reflected in a decrease in energy intake through food and adequate protein intake, in accordance with the claims of previous studies (Villareal et al. 2005; Jakičić & Otto, 2006; Weinheimer et al., 2010; Mathus-Vliegen, 2012; Miller et al., 2013).

CONCLUSION

The research results indicate that there are many studies which analyze the effects of various PA programs either independently or in combination with dietary regimens on the health and obesity levels among the elderly, of an average age of 55 to 80.

The analysis of the compiled studies has confirmed the existence of the positive effect of PA on obesity among the elderly, and led to the conclusion that a combined program of aerobic, weight training, flexibility and balance exercises for a period of at least 12 weeks leads to a mild decrease in body mass and amount of fat mass in the body, while maintaining and increasing LBM, mostly in the form of muscle tissue. However, a much greater effect on the decrease on BF was achieved with the simultaneous application of a combined program of PE and dietary regimens for a period of 6 months.

Finally, following a summation of all the results, we could conclude that PA is an effective means of reducing obesity, and so its use is recommended among the population of the elderly.

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UTICAJ FIZIČKE AKTIVNOSTI NA GOJAZNOST STARIH OSOBA - SISTEMATSKO PREGLEDNO ISTRAŽIVANJE

Cilj ovog preglednog istraživanja bio je da se utvrde efekti fizičke aktivnosti (PA) na gojaznost starih osoba. Za pregled postojećih istraživanja o efektima PA na gojazne stare osobe, pretraživane su elektronske baze PubMed, SCIndeks, PEDro, J-GATE, DOAJ i Google Scholar. Analizom i primenom zadatih kriterijuma, konačna analiza obuhvatila je 20 studija i potvrđen je pozitivan uticaj PA na gojaznost starih osoba. Najveći efekat na smanjenje telesne mase postignut je istovremenom primenom kombinacije programa vežbanja i režima ishrane u trajanju od 6 meseci. Zaključeno je da kombinovani programi aerobika, treninga sa opterećenjem, vežbi fleksibilnosti i ravnoteže tokom perioda od najmanje 12 nedelja dovode do blagog smanjenja telesne mase i količine masne mase, istovremeno održavajući i povećavajući bezmasnu telesnu masu, uglavnom u formi mišićnog tkiva. PA je efikasno sredstvo za smanjenje gojaznosti, pa se stoga preporučuje njena upotreba među starim osobama.

Ključne reči*: fizička vežba, starenje, sastav tela, indeks telesne mase, gubitak mase tela*