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Review article

EFFECTS OF DIFFERENT TYPES OF EXERCISE PROGRAMS ON ARTERIAL BLOOD PRESSURE OF THE ELDERLY

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Abstract. *The value of arterial blood pressure is variable. It depends on the time of the day, external and internal factors such as genetics and lifestyle. Moderate and regular physical activity, as well as weight reduction, can affect the reduction of high arterial blood pressure (ABP). The influence of physical activity on the health of the elderly is not well researched. The objective of this systematic review study is to collect and analyze studies of the effects of different types of exercise programs on arterial blood pressure of the elderly. Based on an analysis of electronic databases and the inclusion criteria set, 21 studies were included in the analysis. Performing only one exercise training program with the elderly leads to a fall of systolic blood pressure (SBP) from 7 to 30 mm Hg and of diastolic blood pressure (DBP) from 3 to 17 mm Hg, whereas a long-term training program reduces SBP by 17 and DBP by 7mm Hg. The combination of aerobic training (AT) and resistance training (RT) with the elderly gives the best results in reducing ABP, increasing arterial elasticity, thus reducing the chance of getting a cardiovascular disease.*

Key words: *hypertension, arterial elasticity, physical activity, aerobic training, resistance training*

INTRODUCTION

The value of arterial blood pressure (ABP) is variable. It depends on the time of the day, external and internal factors such as genetics and lifestyle (Chobanian et al., 2003). Among adults aged 60, the average value of systolic blood pressure (SBP) is 140, whereas among 80-year-olds it is 160 mm Hg (De Buyzere, & Rietzschel, 2018). People

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with SBP between 120-139 mm Hg or diastolic blood pressure (DBP) between 80 and 89 mm Hg should be considered as hypertensive and recommendations should be given to promote health changes to prevent cardiovascular diseases (Chobanian et al., 2003). Hypertension occurs in more than 2/3 of people after the age of 65 (Chobanian et al., 2003). It is a prevalent cardiovascular risk factor in Europe, with values between 30% and 45% which increase with age (Mancia et al., 2013). In the United States, hypertension affects 76.1% of older adults (Gillespie, Hurvitz, & CDC, 2013), in Portugal 74.9% (Polonia, Martins, Pinto, & Nazare, 2014). In Serbia, the average blood pressure is 132.5 mm Hg (van den Hoogen et al., 2000). From 1975 to 2015, the value of blood pressure had significantly increased and it is assumed that by 2025 it will have increased by 25% more. High blood pressure is a worldwide problem, with the highest increase in low and middle income countries belonging to the parts of Central and Eastern Europe (Slovenia, Lithuania and Croatia), Oceania, sub-Saharan Africa and East Asia, where the average value of SBP noted in 2015 was 137.5 mm Hg (NCD Risk Factor Collaboration, 2017). Obesity can accelerate vascular aging and it is associated with an increase in arterial stiffness (Sutton-Tyrrell et al., 2001; Wildman, Mackey, Bostom, Thompson, & Sutton-Tyrrell, 2003). Lifestyle changes can help with reducing arterial blood pressure, increasing antihypertensive efficacy of drug use and reducing the risk of cardiovascular diseases. By combining two or more life changes, better results can be achieved (Chobanian et al., 2003). Regular physical activity displays a positive effect on laboratory test results as well as on clinical manifestations in many chronic non-infective diseases such as cardiovascular disease, hypertension, obesity, etc. (Isaković, Janković, Mazić, Stanojević, & Nešić, 2018). There are two important forms of exercise, aerobic training-AT and resistance training-RT (Garber et al., 2011). The American College of Sports and Medicine (ACSM) points to the training programs that include exercises that increase endurance, strength, flexibility and aerobic capacity as basic training for healthy aging of the elderly (Bentes et al., 2015; Pescatello et al., 2004). Based on the abovementioned, the aim of this paper is to analyze recent research that examined the impact of different types of exercise programs on arterial blood pressure of the elderly.

METHODS

Research strategy

The search was conducted via following electronic databases: Medline/Pub Med, Kobson and Google Academy. The following key words were used: arterial blood pressure or high blood pressure, body mass index or obesity, physical activity or exercise and AT or RT.

Selection of the research and qualification criteria

The final analysis includes all the studies published during the last 10 years, namely between 2008 and 2017, whose samples were extracted from the population of the elderly. The research had to meet the following criteria: 1) the participants belonging to the group of the elderly, 2) the participants' arterial blood pressure values, and 3) their exercise training program had to be analyzed.

Data analysis

Table 1 provides a chronological overview of close analyses of the 21 studies that met the set criteria. Following the conventions for systematic reviews, the table presents the following parameters: groups, participant's sample information (number of participants, gender and age), health status, type of program, experimental sessions, program duration, frequency, individual session duration, results and conclusion.

Table 1 Summary of characteristics of all studies meeting the inclusion criteria

Author (-s), year	Groups	Sample (number, gender and age)	Health status (BMI, BP)	Program type, experimental seasons, program duration, weekly frequency, individual session duration	Results (M±SD)	Conclusion
Terra *et al.* (2008)	EG: 1 CG: 1	N:52 G: F Y: 66,8 ± 5.6 (E) 65.3 ± 3.4 (C)	BMI: 28.3±5.8 BP: P	PT: RT; ES: exercise 60 %, 70 % and 80 % 1RM; PD: 12 weeks, FD: 3 x week, 3x12,10,8 rep., 10 exercises	SBP_{E}: - 9,2 % ↓**	Progressive RT reduced SBP during rest period in old hypertensive women.
Costa *et al.* (2010)	EG: 2 CG: 2	N: 15 G: F Y: 66.3 ± 4	BMI: 26.4 ± 2.8 BP: P	PT: RT; ES: control, exercise 10-15 RM; ISD: 7 exercises, 2 x 10-15 reps.	$SBP_{Etreind,notrein}$(30min) ↓* $SBP_{Enotreind}$ (15,30,45,60 min) ↓° $DBP_{Enotreind}$ (15,30min)↓*	A single resistance exercise session can reduce blood pressure in hypertensive elderly women, especially in a non-trained group.
Gomes *et al.* (2011)	EG: 2 CG: 2	N: 13 G: F Y: 66 ±6 / 64 ± 4	BP: N / H	PT: AT; ES: control, water and land exercise 70 % *VO2max*; ISD: 5 exercises, 10 minutes	$SBP_{norm,water(6,10min)}$: 150 ± 3.6; 159 ± 3.0↓[a] $SBP_{hyper,water(6,10min)}$: 155 ± 2.4; 157 ± 1.8 ↑[a]	The systolic blood pressure has a differential control during aquatic exercise in hypertensive elderly.
Lacombe *et al.* (2011)	EG: 2 CG: 1	N:13 G: M Y: 57 ± 4	BMI: 28.6 ± 2.3 BP: P	PT: AT; ES: inter. exercise (IE) 85% and 40% *VO2max*, steady state (SS) 60% *VO2max*; ISD: 40 minutes	SBP_{EIE}: 4 ± 6 ↓* SBP_{ESS}: 3 ± 4↓* $SBP_{EIE\&SS}$: 4 ± 4↑*	Older pre-hypertensive adults experience similar PEH following equicaloric bouts of IE and SS exercise.

Cunha & Jardim (2012)	EG: 1 CG: 1	N: 30 G: F Y: 66.9 ± 4.63	BMI: 25.41 ± 2.99 P: H	PT: RT; ES: control, exercise 10-15 RM; ISD: 5 exercises, 3 x 8-10 reps.	$SBP_{E(30mi)}$: 123,36 ± 17,33 ↓* $SBP_{C(40min)}$: 121,16 ± 13,11 ↓* $DBP_{E(40min)}$: 74,20 ± 10,58 ↓* $DBP_{C(20min)}$: 77.16 ± 9.47 ↓*	The pressure reduction appears to be influenced by the rest that occurred after the protocols and not by exercise.
Cunha *et al.* (2012)	EG: 1 CG: 1	N: 16 G: F Y: 66 ± 2.94	BMI: 27.32 ± 4.3 BP: H	PT: AT; ES: control, moderately and predominately intense water exercise; ISD: 40 min	$SBP_{E\ (0min)}$: 149.37 ±13.51↑* $SBP_{E(30min)}$: 126.93 ± 11.51 ↓* $DBP_{E(10,20,30\ min)}$: 74.81 ± 7.33. 72.56 ± 8.09. 72.84 ± 5.08 ↓*	The inclusion of water exercise can be carried out in relative safety and systolic blood pressure tended to decrease.
Ho, Radavelli-Bagatini, Dhaliwal, Hills, & Pal (2012)	EG: 3 CG: 1	N: 97 G: M/F Y: 40-66	BMI: 23.4 - 48 BP: H	PT: AT / RT / CT; ES: treadmill walking, exercise 10RM, its comb. PD: 8 and 12 w, FD: 5 x week, 5 exercises, 4 x 8 – 12 repetitions, 2 x 15min AT / RT	In 8th week: SBP_{AT}: - 4 % ↓* SBP_{RT}: - 5.1 % ↓* SBP_{CT}: - 6.3 % ↓* In 12th week: SBP_{CT}: -6.3 % ↓*	Some of the overweight and obese people can improve BP with a regular exercise combination workout and thus reduce the risk of getting cardiovascular disease.
Kawano *et al.* (2012)	EG: 1 CG: 1	N: 22 G: M Y: (E) 68 ± 1.5; (C) 65 ± 1,1	BMI: 68 ± 3 BP: N	PT: AT / RT; ES: rowing ex. PD: 5 years, FD: 2 x week, 90-120 min (12-16 km)	Arterial stiffness ↑*	Rowing exercise in older men is associated with high muscle power and aerobic capacity without affecting arterial stiffness.
Heffernan *et al.* (2013)	EG: 1 CG: 1	N: 21 G: M/F Y: 61 ± 1	BMI: 29.2 BP: P	PT: RT; ES: control, upper body 40 %, lower body 60 % 1 RM; PD: 12 weeks, FD: 3 times per week, 2 x 12-15 r. (on 3rd weeks 5 % ↑)	SBP_E: ~ 6 ↓* DBP_E: ~ 7 ↓*	RET may reduce central BP in older adults with hypertension and prehypertension.

Mota *et al.* (2013)	EG: 1 CG: 1	N:64 G: F Y: 67.1 ± 6.2	BMI: 27.8 ± 5.5 (E) 29.4 ± 4.6 (C) BP: H	PT: RT; ES: exercise 60 %, 70 % and 80 % 1 RM; PD: 1 adaptation month, 3 exercise months, FD: 1st month 12 times per week, 2nd -4th month 16 times per week, 1 x 10-12 reps., pause 30-60 s.	2nd $SBP_{E(45min)}$: 121.5 ± 14.8 ↓* $DBP_{E(30min)}$: 73.2 ± 9.5 ↓* 3rd $SBP_{E(30min)}$: 119.3 ± 13.0 ↓* 4th $SBP_{E(30min)}$: 117.5 ± 12.1 ↓* $DBP_{E(30min)}$: 69.7 ± 9.2 ↓* Reduction after 4th SBP_E: 120.2 ± 11.8 ↓* DBP_E: 72.4 ± 9.3 ↓*	The occurrence of chronic reduction of blood pressure and PEH through EG may have a protective effect on the cardiovascular system.
Brito *et al.* (2014)	EG: 2 CG: 1	N: 10 G: / Y: 65 ± 3	BMI: 28.7 ± 3 BP: H	PT: RT; ES: control, exercise 50 % and 80 % of 1RM ISD: 10 exercises, 3 x 10 reps.	SBP_{E1}: 124 ± 5 ↓* SBP_{E2}: 115 ± 3 ↓* DBP_{E1}: 86 ± 5 ↓* DBP_{E2}: 75 ± 5 ↓* SBP, DBP_{E2} ↓[a]	High-intensity resistance exercise was effective in promoting PEH.
de Freitas Brito, de Oliveira, do Socorro Brasileiro-Santos, & da Cruz Santos (2014)	EG: 2 CG: 1	N: 10 G:M/F Y: 65 ± 3	BMI: 28.7 ± 3 BP: H	PT: RT; ES: control, exercise w/a set and w/three sets of 50% 1RM; ISD: 10 exercises, 1x10 and 3x10 reps.	SBP_{E1}: 17.9 ± 4.7 ↓* SBP_{E2}: 26.5±4.2↓* DBP_{E1}: 7.7 ± 5↓* DBP_{E2}: 13.8 ± 4.9 ↓* SBP, DBP_{E2} ↓[a]	Resistance exercise with higher volume were more effective in causing post exercise hypotension.
Yasuda *et al.* (2014)	EG: 1 CG: 1	N:19 G: M/F Y: 71.3 ± 7.1 (E) 67.7 ± 6.0 (C)	BMI: 20.8 ± 2.6 (E) 21.3 ± 2.9 (C) BP: H	PT: RT; ES: exercise 20% and 30% 1RM; PD: 12 weeks, FD: 2 exercises, 2 times per week, 1x75 (30,20,15 and 10 reps., 30 and 90 s pause)	SBP_E: 143 ± 20 ↓*	RT does not negatively affect arterial stiffness.

Cavalcante *et al.* (2015)	EG: 2 CG: 1	N: 20 G: F Y: 65 ± 3	BMI: 30 ± 5 BP: H	PT: RT; ES: control, exercise 40 % and 80 % of 1RM; ISD: 8 exercises, 3 x 10-12 reps.	$SBP_{E1(30,45,60\ min)}$: 113 ± 2.112 ± 4.110 ± 3 ↓ º $SBP_{E2(30,45,60\ min)}$: 111 ± 3.111 ± 4.110 ± 4 ↓** SBP_{E1}: 11 % ± 1.0 % ↓* SBP_{E2}: 13 % ± 3.4 % ↓*	Hypertensive older women exhibit post-exercise hypotension independently of exercise intensity without expressed cardiovascular overload.
Jefferson *et al.* (2015)	EG: 2 CG: 2	N: 32 G: F Y: 68 ± 3	BMI: 31.1 ± 2.7 BP: H	PT: RT; ES: ex. 70 % 1RM and RT + caloric restriction (600 kcal/day); PD: 5 months, FD: 3 x week, 8 ex., 3x10 reps.	BMI_{RT+CR}: 2,2 ± 1.7 ↓*[a]	The mean change in BP was not significant.
Gambassi *et al.* (2016)	EG: 1 CG: 1	N: 6 G: F Y: 65 ± 3	BP: N	PT: RT; ES: control, exercise 1 RM; ISD: 4 exercises, 3 x 8 reps.	$SBP_{E(20min)}$: 110.16 ± 10.90 ↓* $DBP_{E\ (0,20min)}$: 66.66 ± 9.09; 66.66 ± 8.93 ↓*	There was an acute reduction in BP after the resistance exercise without any recovery.
Gomes *et al.* (2016)	EG: 2 CG: 1	N: 18 G: F Y: 67 ± 3.5	BMI: 29.2 BP: H	PT: AT; ES: inactive cont., water and land ex. 85 % *VO2max*; ISD: 20 min	DBP_{water}: - 4 ± 3.5 ↓[a]	DPB decrease during the water-based exercise.
Oliveira, Mesquita-Bastos, de Melo, & Ribeiro (2016)	EG: 1 CG: 1	N:18 G: M/F Y: 83.4 ± 3.2 (E) 82.7 ± 2.5 (C)	BMI: 28.5 ± 2.0 (E) 28.0 ± 2.5 (C) BP: H	PT: AT; ES: control, exercise 40 to 60 % *HRR*, ISD: 2x10min, 5 min pause	$SBP_{E(20min)}$: 127.3 ± 20.9 ↓* $SBP_{E(40min)}$: 123.7 ± 21.0 ↓*	A single session of aerobic exercise reduces BP in very old adults with hypertension.
Thiebaud *et al.* (2016)	EG: 1 CG: 1	N:10 G: M Y: 67.4 ± 6.3	BMI: 24,8 ± 3.4 BP: P	PT: RT; ES: control, exercise 65 % 1RM; ISD: 5 exercises, 3 x 10	$SBP_{E(0min)}$: 5 ± 6 ↑* $DBP_{E(0min)}$: 3 ± 5 ↓*	Performing whole body moderate resistance exercise bouts minimally affects changes in arterial stiffness and blood pressure.

Ubolsakka-Jones *et al.* (2016)	EG: 2 CG: 1	N:38 G: F Y: 66 ± 5	BP: H / N	PT: RT / AT; ES: exercise 30 % MVC and 60 % HRR; ISD: 2 min for RT, 5 min for AT	$SBP_{Ecycling(0min)}$: 194 ± 18 ↑ º $SBP_{Ehandgrip(0min)}$: 168 ± 19 ↑ º	Despite being well controlled and normotensive at rest, ISH patients had high sBP responses to both dynamic and static exercise.
Cunha *et al.* (2017)	EG: 1 Cg: 1	N: 50 G: F Y: 67.8 ± 4.1	BMI: 28.6 ± 3.9 BP: H	PT: AT; ES: control, water exercise 70 % - 75 % HRmax; ISD: 45 min	$SBP_{E(0min)}$: 17.4 (14.3 %) ↑º $DBP_{E(0min)}$: 5.4 (7.8 %) ↑º $SBP_{E(10min)}$: 7.5 (6.2 %) ↓* $DBP_{E(30min)}$: 3.8 (5,5 %) ↓*	Blood pressure changed after exercise; there was a safe rise of small magnitude for hypertensive people.

Legend: EG - experimental group; CG - control group; M – male; F – female; BMI – body mass index (kg/m²); BP - blood pressure; SBP - systolic blood pressure; DBP - diastolic blood pressure; PEH – post exercise hypotension; H – hypertensive; P – prehypertensive; N - normotensive; RT - resistance training; AT - aerobic training; CT - combination of AT/RT; * statistical significance < 0.05 compared to initial measurement; [a] statistical significance < 0.05 between groups; ** statistical significance < 0.01; º statistical significance < 0.001; ↑- high; ↓ - low; reps - repetitions

RESULTS

Study selection

The database searches returned 305 studies. After eliminating all duplicated papers and analyzing titles and abstracts, 37 studies entered the next stage of analysis. Only studies that had included relevant outcomes were considered. The number of studies in the final analysis was 21 (presented in Table 1).

Study characteristics

The first study in this group was published in 2008 by Terra et al., and the last in 2017 (Cunha et al., 2012). The number of participants in the analyzed studies ranged from at least six in the study carried out by Gambassi et al. (2016), while the study carried out by Mota et al. (2013) had the highest number of participants, 64. The participants mostly belonged to the older age group (65-79). In the study carried out by Ho et al. (2012), the participants belonged to the middle-aged group (40-64) and in the study of Oliveira et al., (2016) to the very old group (>80) according to the division of ACSM. In the research conducted by Thiebaud et al. (2016) all age groups were included, and for this review, only the age group that met the criterion was taken into consideration. Gender-wise, women were the more represented group, with 13 studies including only female participants, five including both sexes (de Freitas Brito et al., 2014; Heffernan et al., 2013; Ho et al., 2012; Oliveira et al., 2016; Yasuda et al., 2014), whereas in three studies the participants were only male (Kawano et al., 2012; Lacombe et al., 2011; Thiebaud et al., 2016). In 15 analyzed studies, the participants had a previous history of prehypertension, in four studies participants had a previous history of hypertension (Brito et al., 2014; de Freitas Brito et al., 2014; Kawano et al., 2012; Yasuda et al., 2014) and two studies contained a sample of normotensive and prehypertensive participants (Gomes, Almeida, Silva, & Becker, 2011; Ubolsakka-Jones et al., 2016).

The influence of resistance training (RT) on blood pressure was examined in 12 studies, while the influence of AT was examined in six of them (Cunha & Jardim, 2012; Cunha et al., 2017; Gomes et al., 2011, 2016; Lacombe et al., 2011; Oliveira et al., 2016) and three studies focused on their combination (Ho et al., 2012; Kawano et al., 2012; Ubolsakka-Jones et al., 2016). Experimental programs ranged from one training (14 studies), eight- and 12-week training programs (Ho et al., 2012), 12-week training programs (Heffernan et al., 2013; Terra et al., 2008; Yasuda et al. 2014), four-month training programs (Mota et al., 2013) and five-month training programs (Jefferson et al., 2015).

Based on the applied training programs and the health status of the participants, all the collected results of the targeted research have been classified into two groups:

1. Influence of one training exercise on the ABP of the elderly;
2. Influence of different experimental training programs on the ABP of the elderly.

Influence of one training exercise on the ABP of the elderly

Systematization of the studies revealed seven which investigated the effects of one resistance training, six studies which investigated the effects of one aerobic exercise and two studies which investigated the effects of one resistance training compared to AT. The intensity of the exercise varied from 40% to a maximum of 1RM for resistance training which included machine-based resistance exercises and 70-85% VO2max and 40-60% heart rate reserve (HRR) for aerobic exercise which included water and land exercises for upper and lower limbs and cycling on a bicycle ergometer.

High intensity resistance training (RT) caused post-exercise hypotension of previously active participants (Costa et al., 2010; Brito et al., 2014; de Freitas Brito et al., 2014; Thiebaud et al., 2016) and inactive elderly (Costa et al., 2010; Cavalcante et al., 2015; Gambasi et al., 2016). In the research of Costa et al. (2010) the results showed that hypotension was higher with previously physically inactive participants, compared to the active ones. Brito et al. (2014) and de Freitas Brito et al. (2014) found that resistance training with high-intensity resistance exercises was effective in promoting PEH compared to moderate ones (SBP 30/20 mm Hg and DBP 17/6 mm Hg), higher volume training (a training with three sets of exercise compared to one set) was more effective, too (SBP 27/18 mm Hg and DBP 14/8 mm Hg). On the other hand, the results of the research conducted by Cunha & Jardim (2012) with inactive elderly indicate that 60 minutes of rest after the protocol, rather than the RT itself, was probably responsible for the decrease in BP. SBP was reduced for 9 mm Hg in experimentals and 7 mm Hg in controls and DBP 7 mm Hg and 3 mm Hg.

Training programs that included water (Cunha, & Jardim, 2012; Cunha et al., 2017; Gomes et al., 2011, 2016) and land (Oliveira et al., 2016; Lacombe et al., 2011; Gomes et al., 2011, 2016) aerobic exercises caused post-exercise hypotension. Gomes et al. (2011) found that the SBP during exercise performed on land was lower for hypertensive participants compared to normotensives, while during aquatic exercises the SBP of hypertensives was significantly higher.

In the research of Ubolsakka-Jones et al. (2016), which included both normotensive and systolic hypertensive elderly, and applied exercising on a bicycle ergometer and assessing handgrip strength, there is an increase in the SBP, especially of systolic hypertensive participants.

Influence of different experimental training programs on the ABP of the elderly

Systematization of the studies revealed five which investigated the effects of long term experimental programs on arterial blood pressure. The length of the training program ranged from eight to 12 weeks (Ho et al., 2012), 12 weeks (Terra et al., 2008; Heffernan et al., 2013; Yasuda et al., 2014) four months (Mota et al., 2013) and five months (Jefferson et al., 2015). Frequency was two or three times per week in five studies (Heffernan et al., 2013; Jefferson et al., 2015; Kawano et al., 2012; Terra et al., 2008; Yasuda et al., 2014), in the study of Ho et al. (2012) frequency was five and in the study of Mota et al. (2013) it ranged from 12 up to 16 times per week. Session duration for the AT ranged from 5 minutes (Ubolsakka-Jones et al., 2016) to 90-120 minutes (Kawano et al., 2012) and for the RT it ranged from two to ten exercises with one to four sets with eight to 75 repetitions and 30-12's of inter-set rest, with an intensity of 40-80% 1RM and 40 - 85% VO2max.

A long term resistance exercise program caused a reduction both in SBP (Terra et al., 2008; Yasuda at al., 2014; Heffernan et al., 2013; Mota et al., 2013; Jefferson et al., 2015) and DBP (Heffernan et al., 2013; Mota et al., 2013; Jefferson et al., 2015). Ho et al. (2012) found in their research that an eight-week aerobic exercise program reduces the SBP by 4%, resistance by 5.1% and the combination of aerobic and resistance by 6.3%, while 12-week programs reduce SBP by 12%, 9.5% and 12.5%.

DISCUSSION

In most of the analyzed studies, there was a decline in blood pressure during the resting phase of the participants after a one-exercise session. Post-exercise hypotension (PEH) after resistance training was found in normotensive (Fisher, 2001) and hypertensive individuals (Melo et al., 2006) which is in agreement with the analyzed research in this paper (Costa et al., 2010; Brito et al., 2014: de Freitas Brito, 2014; Thiebaud et al., 2016; Cavalcante et al., 2015; Gambasi et al., 2016). In previous studies with hypertensive participants, the decrease of arterial blood pressure ranged from 2 to 13 mm Hg in systolic and from 2 to 7.9 mm Hg in diastolic blood pressure (Mota et al., 2013; Rezk, Marrache, Tinucci, Mion, & Forjaz, 2006). In the studies analyzed in this paper, the decrease of SBP ranged from 7 to 30 mm Hg and in DBP from 3 to 17 mm Hg. On the other hand, Thiebaud et al. (2016) found that resistance exercises could increase SBP immediately after an exercise (5 mm Hg), which Fahs, Heffernan, & Fernhall (2009) also observed in their research, with an increase of 10 mm Hg after high intensity training for the upper muscle group. The reason for this discrepancy may be the difference between the times when the pressure was measured or the use of different measuring instruments, as well as the number and type of exercises or the difference in the intensity of training. An increase has been found in SBP immediately after exercise in an aquatic environment with a decline in the rest phase but without conducted

PEH (Gomes et al., 2011). Every type of physical exercise can increase blood pressure (MacDougall, Tuxen, Sale, Moroz, & Sutton, 1985), which is a possible risk factor for hypertensive individuals. Although the increase is not high, and it was safe for participants in the analyzed studies, this indicates the importance of measuring blood pressure and paying attention to blood pressure after doing exercises both in water and on land too.

The reduction of ABP after long term physical activity is taken as the main non-pharmacological method for controlling blood pressure, and it is especially beneficial for hypertensive individuals (Halliwill, 2001). In the study conducted by Stamler (1991), there was evidence that even the slightest reductions in blood pressure can protect the cardiovascular system. A reduction of SBP by 2-5 mm Hg can reduce the risk of a heart attack by 6-14%, of coronary heart disease by 4-9%, and it can also reduce all the causes of mortality by 3-7%. Another research showed that people who perform RT for 30 minutes during one training session may reduce the risk from acute myocardial infarction (AMI) and fatal cardiovascular disease by 23%, compared to inactive ones (Tanasescu et al., 2000). Overweight individuals (BMI>25.0) can reduce systolic arterial blood pressure from 5 to 20 mm Hg with every loss of 10 kg of body weight (Trials of Collaborative Research Group, 1997; He, Whelton, Appel, Charleston, & Klag, 2000). In the analyzed research in this paper the reduction in body weight and arterial elasticity was due to the RT combined with the calorie intake reduction (Jefferson et al., 2015). In some other studies, weight loss also showed a link with ABP reduction, too (Dengo et al., 2012; Figueroa et al., 2013; Hughes et al., 2012; Goldberg, Boaz, Matas, Goldberg, & Shargorodsky, 2009; Miyaki et al., 2009). In the analyzed studies in this paper the reduction of SBP was mostly achieved by using resistance training programs (Heffernan et al., 2013; Terra et al., 2008; Mota et al., 2013). These results are in agreement with other studies as well (Macaluso & De Vito, 2004). On the other hand, previous studies have shown that through regular aerobic exercise, such as a quick walk for at least 30 minutes a day most of the week, we can reduce systolic arterial blood pressure from 4 to 9 mm Hg (Kelley & Kelley, 2000; Whelton, Chin, Xin, & He, 2002), which was concluded in the study observed in this paper where the decrease of SBP ranged from 4 to 12 mm Hg (Ho et al., 2012). All in all, the results showed that all types of exercise (AT, RT and their combination) can reduce arterial blood pressure, but the highest effects on ABP reduction had the combination of RT and AT (Ho et al., 2012).

Adapting the elderly to healthy lifestyle habits is one of the first steps in reducing high arterial blood pressure. Some of the major recommendations are moderate physical activity combined with diet changes. Daily training of moderate intensity can lead to a significant reduction in arterial blood pressure of the elderly.

CONCLUSION

Based on the analysis of the results and conclusions reached by the authors in the abovementioned research, it can be concluded that physical exercise can successfully reduce arterial blood pressure, thus avoiding cardiovascular diseases. With the elderly, two types of training were used the most, training with resistance and aerobic exercises, as well a combination of the two. In conclusion, regular exercise, especially combinations of AT and RT, can lead to the reduction of body weight, muscle strength, an increase in arterial elasticity, as well as a reduction in the arterial blood pressure of the elderly.

Considering it explicitly, physical exercise of the elderly should be under the constant control of professional medical personnel in order to protect possible uncontrolled blood pressure growth.

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UTICAJ RAZLIČITIH PROGRAMA VEŽBANJA NA ARTERIJALNI KRVNI PRITISAK STARIJIH OSOBA

Vrednosti arterijskog krvnog pritiska su promenljive. Zavise od doba dana, spoljašnjih i unutrašnjih faktora kao što su genetika i način života. Umerena i redovna fizička aktivnost, kao i redukovanje telesne mase, mogu da utiču na smanjenje povišenog arterijskog krvnog pritiska (ABP). Uticaj fizičke aktivnosti na zdravlje starih osoba nije dovoljno istraživan. Cilj ovog sistematskog preglednog rada je bio prikupljanje i analiza istraživanja povezanih sa uticajem različitih tipova programa vežbanja na arterijski krvni pritisak kod starih osoba. Analizom pretraživačkih baza i ulaznih kriterijuma, 21 istraživanje je uključeno u konačnu analizu. Izvođenje samo jednog treninga vežbanja sa starim osobama dovodi do pada sistolnog krvnog pritiska (SBP) od 7 do 30 mm Hg i dijastolnog (DBP) od 3 do 17 mm Hg, dok dužim trenažnim programom dolazi do smanjenja SBP za 17 i DBP za 7mm Hg. Kombinacija aerobnog treninga (AT) i treninga sa opterećenjem (RT) kod starih osoba daje najbolje efekte u redukovanju ABP, povećanju arterijske elastičnosti, a samim tim i smanjuju mogućnosti za dobijanje kardiovaskularnih oboljenja.

Ključne reči: *hipertenzija, arterijska elastičnost, fizička aktivnost, aerobni trening, trening sa opterećenjem.*