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Research article

The role of a medium-term physical exercise program in improving cardiovascular parameters in hypertensive patients

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Abstract: The objective of our study was to evaluate the changes in cardiovascular parameters in patients with hypertension who completed a 3-month physical exercise program. 229 subjects with high normal values of blood pressure and stage 1 hypertension (group 1) and 120 patients with stage 2 hypertension (group 2) followed a 3-month physical exercise program. The following parameters were measured: systolic blood pressure, diastolic blood pressure, pulse pressure, heart rate, pulse wave velocity. For group 1 there were sta-tistically significant differences for all the tested parameters after the 3-month program (decreased systolic blood pressure, heart rate, pulse pressure and pulse wave velocity, $p< 0.0001$; lower diastolic blood pressure, $p=0.018$)). In group 2 all the tested parameters had decreased values after the 3-month rehabilitation program. However, only for the pulse wave velocity there was recorded a statistically significant reduction after the exercise program ($p< 0.001$). There were significant direct correlations between total cholesterol and pulse wave velocity for group 1 at both initial ($p=0.024$) and final assessments ($p=0.03$), and for group 2 patients at the 3-month assessment ($p=0.001$). A medium-term physical exercise program improved the cardiovascular parameters (blood pressure, arte-rial stiffness) in hypertensive patients.

Keywords: hypertension, physical exercise, arterial stiffness

1. Introduction

Detection of risk factors for cardiovascular disease is essential in identifying individuals who are more likely to develop cardiovascular disease. Interventional strategies must be used to address the risk factors and adjust their effects on cardiovascular disease risk [1]. Hypertension and lack of exercise or physical activities were associated with a population-attributable risk of 30% or more [2].

Arterial stiffness is an important risk marker in hypertension. The current gold standard clinical metric of central artery stiffness is the pulse wave velocity (PWV) [3,4]. The meta-analysis of Lopes et al. supports that exercise interventions based on aerobic,

combined or isometric exercise are suitable to reduce PWV in adults with hypertension [5]. A recent systematic review showed that chronic or acute aerobic exercise (long-term or short-term), either alone or as combined with different sessions and programs can reduce systolic and diastolic blood pressure in normotensive, prehypertensive or primary hypertensive subjects [6].

The main objective of our study was to evaluate the changes in cardiovascular parameters (blood pressure, heart rate, pulse pressure and PWV) in patients with hypertension who completed a 3-month physical exercise program. We targeted two groups of patients (with high normal values of blood pressure and stage 1 hypertension, as well as patients with stage 2 hypertension) who started the program in a rehabilitation center and continued with a medium-term home-based exercise program. The second objective of the research was to analyze the changes of the cardiovascular risk factors (body mass index, waist circumference, total cholesterol, SCORE risk) in the two study groups.

We hypothesized that the physical exercise program will have beneficial effects on cardiovascular parameters, as well as on cardiovascular risk factors. If performed correctly and followed constantly as recommended by the medical team the home-based exercise program could add valuable effects on reducing the blood pressure and PWV in hypertensive patients.

2. Materials and Methods

2.1. Participants

The study included two groups: group 1 (patients with high normal values of blood pressure and stage 1 hypertension without hypotensive medication) and group 2 (patients with stage 2 hypertension with hypotensive medication and controlled values of blood pressure).

The inclusion criteria for group 1 were: systolic blood pressure of 130-139 mmHg and diastolic blood pressure of 85-89 mmHg for participants with high normal blood pressure; systolic blood pressure of 140-159 mmHg and diastolic blood pressure of 90-99 mmHg for participants with stage 1 hypertension, without complications for at least 3 months. The inclusion criteria for group 2 were: systolic blood pressure of 160-179 mmHg and diastolic blood pressure of 100-109 mmHg who were regularly using antihypertensive medication, without complications for at least 3 months. In addition to the blood pressure, the inclusion criteria for both groups were: patients between 40 and 75 years old, patients with no more than two cardiovascular risk factors according to 2018 ESC/ESH guidelines (usual or low additional risk factors) [7]. Subjects were recruited from the outpatient departments and randomized into two groups according to the blood pressure values and diagnosis of hypertension.

The exclusion criteria were: additional cardiovascular disorders (cardiac failure, heart arrythmias, cardiomiopathies, congenital heart disorders), musculoskeletal problems that interfere with performance of physical exercise, respiratory problems that would contraindicate or limit the practice of physical exercise, patients with psychiatric disorders (dementia or other disorders that affect rationality due to the fact that these patients are not able to follow and perform adequately the physical exercise program), subjects participating in regular physical activity (more than once a week) for the previous 3 months.

229 patients in group 1 and 120 patients in group 2 completed the study and their data were analysed (Figure 1).

Participation in the study was voluntary. Written informed consent was obtained from all the participants. The study was approved by the Ethics Committee of "Victor Babes" University of Medicine and Pharmacy, Timisoara, Romania, and was in accordance with the Helsinki Declaration (No. 32/15.06.2023).

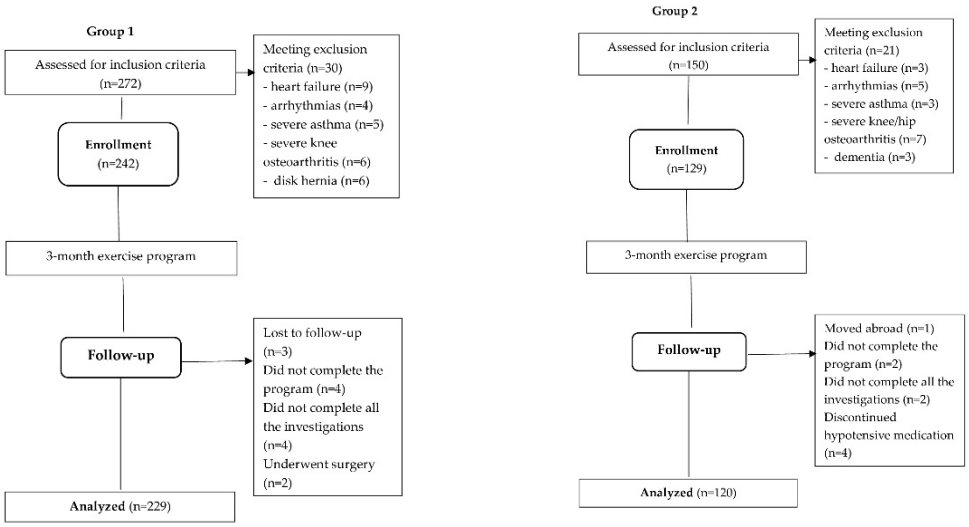


Figure 1. Flowchart of the study design

The characteristics of the two study groups are presented in Table 1.

Table 1. Characteristics of the two study groups

Parameters	Group 1 (n=229)	Group 2 (n=120)
Age (mean ± SD)	58.6 ± 10.16 years	61.59 ± 8.59 years
Gender		
- Males (%)	157 (68.5%)	85 (70.8%)
- Females (%)	72 (31.5%)	35 (29.2%)
Smokers (%)	70 (30.5%)	39 (32.5%)
BMI (mean ± SD)	28.62 ± 5.23 kg/m^2	27.5 ± 5.47 kg/m^2
Total cholesterol (mean ± SD)	192.17 ± 44.91 mg/dl	194.65 ± 38.4 mg/dl

n: number of patients; SD: standard deviation; BMI: body mass index

2.2. Physical exercise program

All the patients in the two groups followed the same physical exercise program. The program was started in a rehabilitation center (first 2 weeks, 10 daily sessions, 30 minutes per session) under the supervision of a physical therapist. After 2 weeks it was continued at home (5 sessions per week, 30 minutes per session). The entire duration of the physical exercise program was of 3 months. The program included exercises without weights: mobilization of the upper extremities with breathing (sitting on a chair flexion of the upper extremities with inspiration and then back to the initial position with expiration; abduction of the upper extremities with inspiration and then back to the initial position with expiration; the same exercises in standing; 5 repetitions for each exercise), movements of the head with breathing (extension with inspiration, flexion with expiration, 10 repetitions; right and left lateral movements, 10 repetitions), semisquads (with the support of hands on a chair, starting with 5 repetitions and then progress gradually to 10 repetitions), walking. The aerobic training was performed 5 sessions per week. 2 of these sessions also included strengthening exercises. This type of exercises used low weights (1-2 kg) and targeted arm strengthening and breathing increase (flexion and extension of the elbows with dumbbells in the hands, 10 repetitions; sitting on a chair, lifting the upper extremities with dumbbells in the hands with

inspiration and back to the initial position with expiration, 10 repetitions; supine, with dumbbells in the hands, arms in abduction, extension of the elbows with inspiration, then flexion of the elbows with expiration, 10 repetitions). The entire physical exercise program was of low intensity.

2.3. Assessment

The patients were assessed at the beginning of the physical exercise program and after 3 months of being involved in the exercise program. The following measurements were recorded: systolic blood pressure, diastolic blood pressure, pulse pressure (the difference between systolic and diastolic blood pressures), heart rate.

The pulse wave velocity was determined by using Complior; the device records simultaneously pressure signals from the carotid and radial arteries to measure pulse wave velocity. For measuring the pulse waves on the carotid artery, a clip containing a piezoelectric sensor was placed on the left side of the neck. For measuring the pulse waves on the radial artery, a clip containing a piezoelectric sensor was placed on the left wrist. The distance between the sensors was measured in a straight line from the sternoclavicular joint to the styloid process of the radius; it was used to approximate the arterial distance travelled by the pulse waves.

Waist circumference was measured using a flexible tape meter at the umbilical level while the participants were standing. The most commonly used waist circumference cut-off point for white Caucasian population is ≥ 102 cm for men and ≥ 88 cm for women [8].

The Systematic Coronary Risk Evaluation (SCORE) is the preferred scoring system to estimate the 10-year risk of a first fatal atherosclerotic cardiovascular event, in relation to age, gender, smoking, total cholesterol, and systolic blood pressure. A calculated SCORE ≥ 10% indicates patients at very high risk, a SCORE ≥ 5% and ≤ 10% indicates patients at high risk, a SCORE ≥ 1% and < 5% indicates patients at moderate risk, and a SCORE < 1% indicates patients at low risk [7,9].

2.4. Statistical analysis

The statistical analysis was performed using the MedCalc version 17.8. Descriptive statistics were calculated for patients' characteristics as mean and standard deviation. Before statistical applications, the normal distribution of values in this study was verified by the D'Agostino–Pearson normality test. For the correlations, for testing the relationship between variables, we used Pearson correlation. A p value less than 0.05 was considered statistically significant.

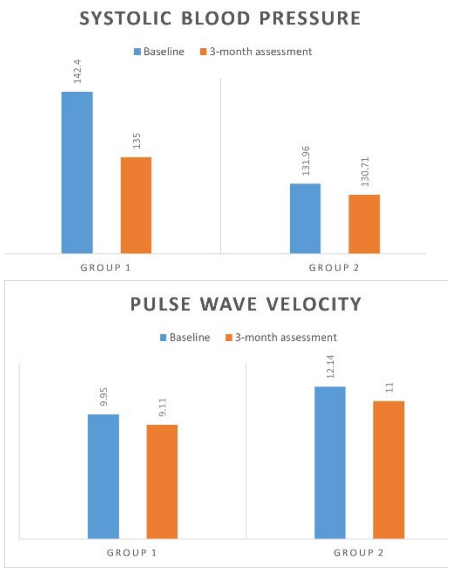
3. Results

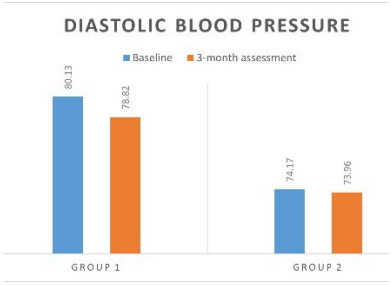
Table 2 presents the cardiovascular parameters (systolic blood pressure, diastolic blood pressure, pulse pressure, heart rate and pulse wave velocity) of the two study groups at the beginning of the physical exercise program and after the 3-month exercise program. For group 1 there were statistically significant differences for all the tested parameters after the 3-month program (lower values of the cardiovascular parameters at final assessment). In group 2 all the tested parameters had decreased values after the 3-month rehabilitation program. However, only for the pulse wave velocity there was recorded a statistically significant reduction after the exercise program. Figures 2-4 present the comparisons of the systolic blood pressure, diastolic blood pressure and pulse wave velocity in the two study groups.

Table 2. Cardiovascular parameters at the beginning of the study and after 3-month exercise program

Cardiovascular parameters	Group 1 (n=229) 1st assessment	3-month assessment	p-value	Group 2 (n=120) 1st assessment	3-month assessment	p-value
SBP (mean ± SD)	142.40 ± 7.52 mmHg	135.00 ± 8.62 mmHg	**< 0.0001**	131.96 ± 6.39 mmHg	130.71 ± 5.36 mmHg	0.06
DBP (mean ± SD)	80.13 ± 6.50 mmHg	78.82 ± 5.25 mmHg	**0.018**	74.17 ± 10.13 mmHg	73.96 ± 7.87 mmHg	0.3
PP (mean ± SD)	62.27 ± 8.01 mmHg	56.18 ± 8.24 mmHg	**< 0.0001**	57.79 ± 8.79 mmHg	57.33 ± 7.72 mmHg	0.08
HR (mean ± SD)	80.48 ± 6.1 bpm	73.51 ± 6.2 bpm	**< 0.0001**	67.45 ± 7.23 bpm	65.21 ± 7.3 bpm	0.067
PWV (mean ± SD)	9.95 ± 2.08 m/s	9.11 ± 1.52 m/s	**< 0.0001**	12.14 ± 2.35 m/s	11.00 ± 2.00 m/s	**< 0.001**

n: number of patients; SD: standard deviation; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; HR: heart rate; PWV: pulse wave velocity. The bolded p-values indicate significant differences.





Figures 2-4. Comparisons of systolic blood pressure, diastolic blood pressure and pulse wave velocity in the two study groups

The comparison of cardiovascular risk factors in the study groups is presented in Table 3. We noticed a significant reduction of all the assessed cardiovascular risk factors (body mass index, waist circumference, total cholesterol, SCORE risk) in both study groups after the physical exercise program. 69.8% of the group 1 participants had an increased waist circumference (≥ 102 cm for men and ≥ 88 cm for women); after the exercise program the percentage of subjects with higher than cut-off point waist circumference was of 51%. 58.3% of the group 2 participants had an increased waist circumference; after the exercise program 50% of patients had still a higher than cut-off point waist circumference.

Table 3. Comparisson of the cardiovascular risk factors in the two study groups

Cardiovascular risk factors	Group 1 (n=229)			Group 2 (n=120)		
	1st assessment	3-month assessment	p-value	1st assessment	3-month assessment	p-value
BMI (mean ± SD)	28.62 ± 5.23 kg/m²	27.85 ± 4.90 kg/m²	**0.019**	27.5 ± 5.47 kg/m²	26.38 ± 3.90 kg/m²	**0.01**
Waist circumference higher than cut-off point (n)						
Total -Males (%) -Females (%)	160(69.8%) 103(44.9%) 57 (24.8%)	117 (51%) 72(31.4%) 45 (19.6%)	**< 0.0001**	70 (58.3%) 42 (35%) 28 (23.3%)	60 (50%) 36 (30%) 24 (20%)	**0.044**
Total cholesterol (mean ± SD)	192.17 ± 44.91 mg/dl	179.50 ± 27.65 mg/dl	**0.0003**	194.66 ± 38.41 mg/dl	176.18 ± 29.28 mg/dl	**< 0.0001**
SCORE risk (mean ± SD)	5.22 ± 3.29 %	3.94 ± 2.71 %	**< 0.0001**	7.26 ± 4.70 %	5.84 ± 4.06 %	**0.013**

n: number of patients; SD: standard deviation; BMI: body mass index. The bolded p-values indicate significant differences.

The correlations between the pulse wave velocity and total cholesterol are presented in Table 4. There were significant direct correlations between the two parameters for group 1 at both initial and final assessments, and for group 2 patients at the 3-month assessment. The higher the total cholesterol is, the more increased is the arterial stiffness.

Table 4. Correlations between pulse wave velocity and total cholesterol

	1st assessment		3-month assessment	
	r	p-value	r	p-value
Group 1 (n=229)	0.17	**0.024**	0.604	**0.03**
Group 2 (n=120)	0.67	0.07	0.51	**0.001**

r: rank correlation coefficient. The bolded p-values indicate significant differences.

4. Discussion

The current study aimed to assess the cardiovascular parameters in patients with different stages of hypertension after performing a 3-month physical exercise program. The two study groups followed the same exercise program (same exercises, same frequency, duration and intensity).

The systematic review of Saco-Ledo et al. pointed out that exercise training results in significant reductions of all ambulatory blood pressure measures (24-hour, daytime, and nighttime blood pressure) in individuals with hypertension [10]. In our study both patients' groups had lower blood pressure values after the 3-month exercise program. However, the decrease was statistically significant only for group 1 patients (patients with high normal values of blood pressure and stage 1 hypertension).

The Consensus Document from the European Association of Preventive Cardiology and the European Society of Cardiology Council on Hypertension state that aero-

bic exercise is a first-line exercise therapy for patients with hypertension [11]. The prescription of a personalized exercise regimen should be according to each patient's background [12]. We proposed an exercise program that is easy to be learnt and performed at home, being adequate also for participants that are not used with any type of physical activity.

Physiological response to short-term exercise refers to functional adaptations that occur during and for some time following an isolated exercise session [13]. Studies showed that blood pressure benefit can be attributed to aerobic exercise training as an acute response related to recent exercise or postexercise hypotension [14]. In our research we proposed a medium-term physical exercise program with beneficial effects on cardiovascular parameters (blood pressure, heart rate, pulse pressure and PWV), as well as on cardiovascular risk factors (body mass index, waist circumference, total cholesterol, SCORE risk).

In hypertensive patients physical exercise has also shown efficacy in reducing arterial stiffness. Park et al. pointed out that consistency and regularity of exercise are more critical in lowering arterial stiffness than the specific type or intensity of the workout [15]. The meta-analysis of Lopes et al. showed that exercise interventions based on aerobic, combined or isometric exercise significantly reduced PWV value in patients with hypertension [5]. In our study the patients followed a 3-month exercise program of low intensity; the aerobic training was combined with low-weight resistance exercises. The patients with stage 2 hypertension had higher PWV both at baseline and at the 3-month assessments in comparison to subjects with high normal values of blood pressure and stage 1 hypertension. The decrease of PWV was significant for both groups of patients after the physical exercise program.

The study of Chen et al. on a large community-based population showed that total cholesterol was positively correlated with brachial-ankle PWV [16]. We found positive correlations between total cholesterol and carotid-radial PWV for both study groups. However, the correlation was not significant for patients with stage 2 hypertension at the beginning of the physical exercise program.

In our research we also aimed to compare some modifiable cardiovascular risk factors due to engagement in a medium-term exercise program. At 3-month assessment all the analyzed factors (body mass index, waist circumference, total cholesterol, SCORE risk) decreased significantly in both study groups.

The different sample size in the two groups can be considered a limitation of our study. We aim to enroll more patients with stage 2 hypertension in order to have similar number of patients in the two study groups. The inclusion of the subjects from the outpatient departments is a bias that limited the number of the study participants. The comparison between different types of physical exercise programs (individual versus group programs) with supervision of the specialized medical staff, continued with a home-based exercise program, is another future direction plan. We are aware that the second evaluation (after a 3-month physical exercise program) is a relatively medium-term analysis. We intend to compare the cardiovascular parameters in hypertensive patients before starting the physical exercise program and after longer periods (6 months and one year).

5. Conclusions

A medium-term physical exercise program improved the cardiovascular parameters (blood pressure, arterial stiffness) in hypertensive patients. The engagement of the participants in a longer physical exercise program (even as a lifestyle change) can add beneficial effects on cardiovascular parameters, also reducing the cardiovascular modifiable risk factors.

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A.C.N., E.A., T.O., A.H.S., R.C.A., R.A.P. and S.I.; writing—review and editing, A.C.N., E.A., T.O., A.H.S., R.C.A., R.A.P. and S.I.; visualization, A.C.N., E.A., T.O., A.H.S., R.C.A., R.A.P. and S.I.; supervision,S.I. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: In conformity with the ethical standards, participation in the study was voluntary, and participants were informed about the testing procedure. All participants in the study consented, in written form, to data processing and the scientific use of data. The study was approved by the Ethical Committee of Victor Babes University of Medicine and Pharmacy, Timisoara, Romania, Ethical Notification No. 32/15.06.2023, and is in conformity with the Helsinki Declaration.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent was obtained from the patients to publish this paper.
Data Availability Statement: Supplementary data available at request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Teo, K.K.; Rafiq, T. Cardiovascular Risk Factors and Prevention: A Perspective From Developing Countries. Can J Cardiol 2021, 37(5), 733-743.
2. O'Donnell, M.J.; Chin, S.L.; Rangarajan, S. et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. Lancet 2016, 388(10046), 761-775.
3. Kaess, B.M.; Rong, J.; Larson, M.G. et al. Relations of Central Hemodynamics and Aortic Stiffness with Left Ventricular Structure and Function: The Framingham Heart Study. J Am Heart Assoc 2016, 5(3), e002693.
4. Townsend, R.R.; Wilkinson, I.B.; Schiffrin, E.L. et al. Recommendations for improving and standardizing vascular research on arterial stiffness: a scientific statement from the American Heart Association. Hypertension 2015, 66, 698–722.
5. Lopes, S.; Afreixo, V.; Teixeira, M. et al. Exercise training reduces arterial stiffness in adults with hypertension: a systematic review and meta-analysis. J Hypertens 2021, 39(2), 214-222.
6. Esmailiyan, M.; Amerizadeh, A.; Vahdat, S.; Ghodsi, M.; Doewes, R.I.; Sundram, Y. Effect of Different Types of Aerobic Exercise on Individuals With and Without Hypertension: An Updated Systematic Review. Curr Probl Cardiol 2023, 48(3), 101034.
7. Williams, B.; Mancia, G.; Spiering, W. et al. Authors/Task Force Members:, ESC Scientific Document Group . 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J 2018, 39(33): 3021–3104.
8. Lean, M.; Han, T.; Morrison, C. Waist circumference as a measure for indicating need for weight management. BMJ 1995, 311(6998), 158–161.
9. Conroy, R.M.; Pyörälä, K.; Fitzgerald, A.P. et al. SCORE project group. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. Eur Heart J 2003, 24(11), 987–1003.
10. Saco-Ledo, G.; Valenzuela, P.L.; Ruiz-Hurtado, G.; Ruilope, L.M.; Lucia, A. Exercise Reduces Ambulatory Blood Pressure in Patients With Hypertension: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Am Heart Assoc 2020, 9(24), e018487.
11. Hanssen, H.; Boardman, H.; Deiseroth, A.; Moholdt, T.; Simonenko, M.; Kränkel, N. et al. Personalized exercise prescription in the prevention and treatment of arterial hypertension: a Consensus Document from the European Association of Preventive Cardiology (EAPC) and the ESC Council on Hypertension. Eur J Prev Cardiol 2022, 29, 205–215.
12. Miura, S.I. Exercise prescription in the treatment of hypertension. Hypertens Res 2023, 46(2), 521-522.
13. Haskell, W.L.; J.B. Wolffe Memorial Lecture. Health consequences of physical activity: Understanding and challenges regarding dose-response. Medicine & Science in Sports & Exercise 1994, 26, 649-660.
14. Pescatello, L. S. Effects of exercise on hypertension. From cells to physiological systems. Humana Press, Springer 2015
15. Park, W.; Jung, W.S.; Hong, K.; Kim, Y.Y.; Kim, S.W.; Park, H.Y. Efects of moderate combined resistance- and aerobic-exercise for 12 weeks on body composition, cardiometabolic risk factors, blood pressure, arterial stiffness, and physical functions, among obese older men: a pilot study. Int J Environ Res Public Health 2020, 17(19), 7233.
16. Chen, H.; Chen, Y.; Wu, W.; Cai, Z.; Chen, Z. et al. Total cholesterol, arterial stiffness, and systolic blood pressure: a mediation analysis. Sci Rep 2021, 11(1), 1330.