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Original paper

Physical activity, rehabilitation, and lifestyle changes in hypertension

Jędrzej Mikołajczyk[1], Aleksander Joniec[1], Tomasz Fajferek[1], Seweryn Kaczara[1], Lucyna Grelowska[2], Emma Mażul-Kulesza[1], Barbara Pietrzyk[3]

[1]Students' Scientific Club, Department of Medical Biophysics, Faculty of Medical Sciences in Katowice, Medical University of Silesia, Katowice, Poland
[2]Beskidzkie Centrum Onkologii - Szpital Miejski im. Jana Pawła II w Bielsku-Białej / Beskid Oncology Center - John Paul II Municipal Hospital, Bielsko-Biała, Poland
[3]Department of Medical Biophysics, Faculty of Medical Sciences in Katowice, Medical University of Silesia, Katowice, Poland

Address for correspondence:
Aleksander Joniec
Studenckie Koło Naukowe
Katedra i Zakład Biofizyki Lekarskiej
ul. Medyków 18, 40-752 Katowice
tel. +48 32 208 84 24
e-mail: aleksander.joniec@gmail.com

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ABSTRACT

Introduction: Arterial hypertension remains one of the leading risk factors for cardiovascular morbidity and mortality worldwide. Regular physical activity and lifestyle modification are considered essential components of hypertension management alongside pharmacological treatment. This study aimed to evaluate the impact of physical activity and cardiac rehabilitation on blood pressure control, health behaviors, and the effectiveness of pharmacological treatment in patients with arterial hypertension.

Material and methods: The study included 70 patients with arterial hypertension (59% women, 41% men), divided into two age groups: 45–59 and ≥60 years. Conducted at the Municipal Hospital in Bielsko-Biała between May and November 2023, the study used a 36-question survey assessing physical activity, treatment, and anthropometric data. Statistical analysis included ANOVA and Tukey's HSD test, with significance set at $p < 0.05$.

Results: No significant differences were observed in systolic blood pressure reduction between groups ($p = 0.666$). Significant differences were found for diastolic blood pressure reduction ($p = 0.003$; $\eta^2 = 0.22$), with the greatest reduction observed in patients aged 45–59 years combining pharmacotherapy with regular physical activity (5.79 ± 3.22 mmHg). Physically active participants also reported healthier lifestyle behaviors and lower pharmacological burden more frequently.

Conclusions: Regular physical activity was associated with improved diastolic blood pressure control and healthier lifestyle behaviors in hypertensive patients, particularly among younger individuals combining exercise with pharmacotherapy. Further large prospective studies are required to confirm these findings.

KEYWORDS

hypertension, physical activity, blood pressure control, pharmacological treatment, cardiac rehabilitation

INTRODUCTION

Hypertension is a major global health concern and one of the leading risk factors for cardiovascular diseases and premature mortality worldwide. According to the American Heart Association (AHA) [1] hypertension is classified into several stages, including isolated systolic hypertension, which is particularly prevalent among older adults. Similarly, the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH) [2] provide a detailed classification system based on systolic and diastolic blood pressure values, emphasizing early detection and comprehensive management. In Poland, the Polish Society of Hypertension (Polskie Towarzystwo Nadciśnienia Tętniczego – PTNT) [3] follows comparable guidelines, categorizing hypertension into three stages, with specific attention given to risk stratification and individualized treatment plans.

According to the definition and classification of arterial hypertension provided in the PTNT guidelines, three primary grades of hypertension are distinguished: Grade I: threshold value of 140/90 mmHg, Grade II: from 160/100 mmHg, Grade III: above 180/100 mmHg. Additionally, the category of isolated systolic hypertension is considered separately [4].

Lack of treatment or inadequate therapy for this condition may lead to serious complications, the most common of which are myocardial infarction and stroke [5]. Studies indicate that the development of hypertension is influenced by lifestyle, socioeconomic status, and level of education [6]. Scientific reports emphasize the effectiveness of antihypertensive therapy and increasingly highlight the importance of prevention, in which maintaining a healthy lifestyle and engaging in regular physical activity, regardless of age, play a main role [7]. The promotion of health-oriented behaviors and the undertaking of actions in support of one's own health can significantly reduce the risk of complications associated with this disease. The growing interest in physical activity, observed among both younger and older individuals, reflects the increasing awareness of society. Nevertheless, the number of elderly people recognizing the consequences of physical inactivity and the impact of lifestyle on the course of the disease still remains relatively small [8].

Physical activity is defined as any bodily movement involving skeletal muscles that requires energy expenditure. It encompasses not only sports but also everyday activities such as household or occupational tasks. Its absence ranks among the leading causes of mortality and disability, alongside unhealthy diet, smoking, and alcohol consumption [9].

Regular exercise helps reduce blood pressure, decrease the need for pharmacological treatment, and improve overall physical and mental condition [10]. The level of physical activity depends on environmental, economic, and cultural conditions. It is recommended for everyone, regardless of age or functional capacity - both for preventive and therapeutic purposes [7].

A key aspect is tailoring the form of physical activity to the individual preferences and capabilities of the patient [11]. Lifestyle has a significant impact on blood pressure values. Regular, appropriately adjusted physical activity exerts an antihypertensive effect and should constitute an important component of treatment [12]. The selection of physical activity depends on age, health status, prior level of physical activity, and comorbidities. A safe exercise intensity is determined based on maximum heart rate – set at 60%–80% of the value calculated as 220 minus age [13].

According to ESC recommendations, patients should engage in aerobic exercise for a minimum of 150 minutes per week at moderate intensity, or 75 minutes per week at vigorous intensity [14]. Exercises such as brisk walking, cycling, or swimming are best performed at a steady pace for 30–45 minutes daily. Ideally, a target of 300 minutes of moderate or 150 minutes of intense physical activity per week is recommended [15]. Regular physical activity can yield effects akin to invasive treatment, improving cardiac function and reducing the risk of cardiovascular complications [16]. Any form of movement supports exercise capacity, enhances quality of life, and improves exertional tolerance in individuals with hypertension [7].

Health behaviors are attitudes and habits that promote health and prevent disease, whereas health-promoting behaviors are conscious actions aimed at improving health [17].

The aim of this study was to evaluate the impact of the level and type of physical activity in patients with arterial hypertension on blood pressure control, health behaviors and the effectiveness of pharmacological treatment, as well as to obtain preliminary data relevant for planning future population-based studies.

MATERIAL AND METHODS

The study included 70 patients (n = 70). Both women and men were enrolled, divided into two age groups: 45–59 years and ≥60 years. The sex distribution of the cohort comprised 41 women (59%) and 29 men (41%). The study was conducted among patients of the Cardiology Outpatient Clinic at the Municipal Hospital in Bielsko-Biała between May and November 2023. Adult individuals with a confirmed diagnosis of arterial hypertension were included, while patients with severe comorbidities that could affect the outcomes, as well as those who did not consent to participate, were excluded.

The assessment of the role of physical activity and rehabilitation in modifying the lifestyle of patients with arterial hypertension was based on a proprietary survey questionnaire. Participation in the study was voluntary, and completing the questionnaire was considered as consent to participate in the project. The questionnaire consisted of 36 closed-ended questions (single- and multiple-choice), designed to collect anthropometric data (e.g., age, body mass), information regarding the type and duration of physical activity, blood pressure values, and the pharmacological treatment being used.

The observational study was conducted anonymously using a survey administered by medical personnel, without collecting personal data and without referencing medical records or additional interviews. The sole source of information was the voluntarily completed questionnaire, independent of medical consultations. The study was conducted using a self-designed questionnaire and did not meet the criteria of a medical experiment; therefore, it did not require approval by a Bioethics Committee under Polish law. According to the Act on the Professions of Physician and Dentist (consolidated text of August 19, 2024), only medical experiments require such approval.

Table I. Demographic distribution of the study group

Sex	Age range (years)	Number of patients	% of the study population
Women	45–59	19	27.14%
Women	≥60	22	31.43%
Men	45–59	16	22.86%
Men	≥60	13	18.57%

Statistical analysis

The data were analyzed using Microsoft Excel and Python. In Python, an analysis of variance (ANOVA) was performed to compare means between groups, followed by a Tukey's HSD post-hoc test to identify significant differences between individual group pairs. Results are presented as means and percentages for nominal and ordinal data. For age, the arithmetic mean and standard deviation were calculated. Statistical significance was defined as p-values below 0.05 (at a 95% confidence interval).

RESULTS

The study included 70 patients with confirmed arterial hypertension, comprising 41 women (59%) and 29 men (41%), aged 45–87 years. The age distribution was evenly split, with 50% of patients (n = 35) aged 45-59 years and 50% of patients (n = 35) aged 60 years.

Patients were categorized into five groups based on pharmacological treatment status and physical activity level (Table II): G1 (No medication + exercise,45–59 years), G2 (Medication + no exercise, 45–59 years), G3 (Medication + no exercise, ≥60 years), G4 (Medication + exercise, 45–59 years), and G5 (Medication + exercise, ≥60 years). Group sizes were markedly unequal, ranging from n = 3 to n = 30. The 'No medication + exercise (45–59 years)' group (n = 3) is of insufficient size for reliable inferential statistical analysis. Consequently, data from this group are presented descriptively only, and any comparative analyses involving this subgroup are strictly exploratory and should be interpreted with caution.

One-way ANOVA revealed no statistically significant differences in systolic blood pressure (SBP) reduction across the five groups ($F(4.65) = 0.60$; $p = 0.666$; $\eta^2 = 0.04$), indicating a negligible effect size – η^2 values were interpreted according to Cohen's conventional thresholds: 0.01 (small), 0.06 (medium), and 0.14 (large). The explained variance attributable to group membership was approximately 3.6%, consistent with the absence of a clinically or statistically meaningful between-group effect on SBP. Given the non-significant omnibus F-test, post-hoc pairwise comparisons for SBP were not performed.

Mean SBP reductions with 95% confidence intervals per group are presented in Table II. One-way ANOVA revealed statistically significant differences in diastolic blood pressure (DBP) reduction across the five groups ($F(4.65) = 4.46$; $p = 0.003$; $\eta^2 = 0.22$). The effect size corresponds to a large effect by conventional benchmarks ($\eta^2 \geq 0.14$), with approximately 21.5% of variance in DBP reduction attributable to group membership.

Mean DBP reductions and 95% confidence intervals for each group are presented in Table II. The highest mean DBP reduction was observed in the G4 group (5.79 ± 3.22 mmHg; 95% CI: 4.49 to 7.09), whose confidence interval does not include zero, indicating a statistically reliable reduction in this group.

In contrast, the G1 group (n = 3) showed a wide 95% CI spanning zero (3.12 mmHg; 95% CI: −2.42 to 8.66), precluding meaningful inference.

Post-hoc analysis using the Tukey-Kramer Honest Significant Difference (HSD) test was performed on DBP data. The critical value of the Studentized range statistic was $q(\alpha=0.05, k=5, df=65) = 3.97$. The within-group mean square error (MSwithin) was estimated from pooled within-group variance as 7.18. Pairwise comparisons are presented in Table III.

The only pair that narrowly failed to reach statistical significance was the G3 group versus G4 group comparison (mean difference = 1.99 mmHg; SE = 0.51; $q = 3.92$; $p \approx 0.054$), which marginally failed to reach the corrected threshold.

This finding suggests a possible association between combined pharmacotherapy and physical activity in younger patients and a less pronounced response in older medicated sedentary patients; however, this interpretation is tentative given the small margin and the unbalanced group sizes. These non-significant results reflect an exploratory analysis and require validation in adequately powered, balanced cohorts.

The results are summarized in Tables II and III. A graphical comparison of the reductions in systolic and DBP is presented in Figures 1 and 2.

Table II. Mean systolic (SBP) and diastolic (DBP) blood pressure reduction values according to the presence or absence of pharmacological treatment and physical activity in the study group

Study group (age)	Number of patients	Mean SBP reduction (mmHg) ± SD	SBP 95% CI	Mean DBP reduction (mmHg) ± SD	DBP 95% CI
G1 No medication + exercise (45–59 years)	3	6.29 ± 3.98	[−3.60, 16.18]	3.12 ± 2.23	[−2.42, 8.66]
G2 Medication + no exercise (45–59 years)	6	9.66 ± 3.15	[6.35, 12.97]	4.41 ± 3.04	[1.22, 7.60]
G3 Medication + no exercise (≥60 years)	30	10.29 ± 3.73	[8.90, 11.68]	3.80 ± 2.17	[2.99, 4.61]
G4 Medication + exercise (45–59 years)	26	11.39 ± 5.51	[9.16, 13.62]	5.79 ± 3.22	[4.49, 7.09]
G5 Medication + exercise (≥60 years)	5	11.79 ± 4.22	[6.55, 17.03]	3.96 ± 1.91	[1.59, 6.33]

SD (Standard Deviation). 95% CIs calculated using t-distribution with group-specific degrees of freedom (df = n − 1)

Table III. Tukey-Kramer post-hoc pairwise comparisons — DBP reduction. MS_within = 7.18 (pooled within-group variance); q critical (k=5, df=65, α=0.05) = 3.97

Group A	Group B	Mean Difference (mmHg)	SE	q statistic	Significance
G1 (n=3)	G2 (n=6)	1.29	1.34	0.96	ns
G1 (n=3)	G3 (n=30)	0.68	1.15	0.59	ns
G1 (n=3)	G4 (n=26)	2.67	1.16	2.31	ns
G1 (n=3)	G5 (n=5)	0.84	1.38	0.61	ns
G2 (n=6)	G3 (n=30)	0.61	0.85	0.72	ns
G2 (n=6)	G4 (n=26)	1.38	0.86	1.61	ns
G2 (n=6)	G5 (n=5)	0.45	1.15	0.39	ns
G3 (n=30)	G4 (n=26)	1.99	0.51	3.92	~
G3 (n=30)	G5 (n=5)	0.16	0.92	0.18	ns
G4 (n=26)	G5 (n=5)	1.83	0.93	1.98	ns

~ = non-significant (p ≈ 0.054; q marginally below critical threshold)

G1 = No medication + exercise (45–59 years); G2 = Medication + no exercise (45–59 years); G3 = Medication + no exercise (≥60 years); G4 = Medication + exercise (45–59 years); G5 = Medication + exercise (≥60 years).

ANOVA summary: SBP — $F(4,65) = 0.60$, $p = 0.666$, $\eta^2 = 0.04$ (negligible). DBP — $F(4,65) = 4.46$, $p = 0.003$, $\eta^2 = 0.22$ (large).

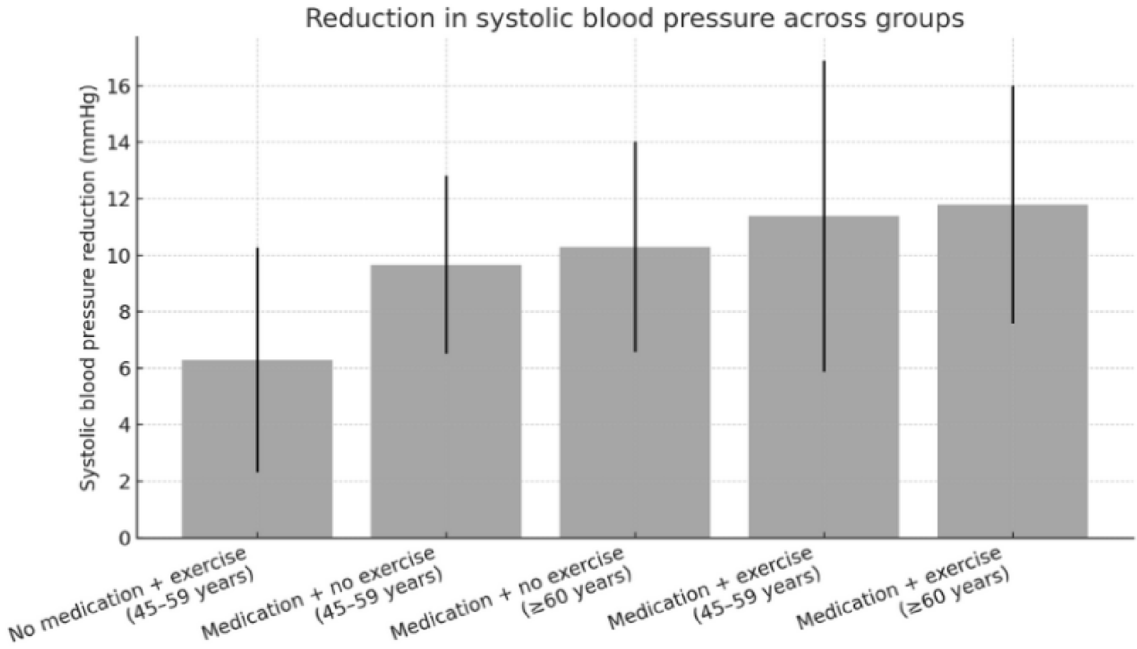

Fig. 1. Reduction in systolic blood pressure (SBP) according to the presence or absence of pharmacological treatment and physical activity in the study groups. (G1: No medication + exercise, 45–59 years; G2: Medication + no exercise, 45–59 years; G3: Medication + no exercise, ≥60 years; G4: Medication + exercise, 45–59 years; G5: Medication + exercise, ≥60 years).

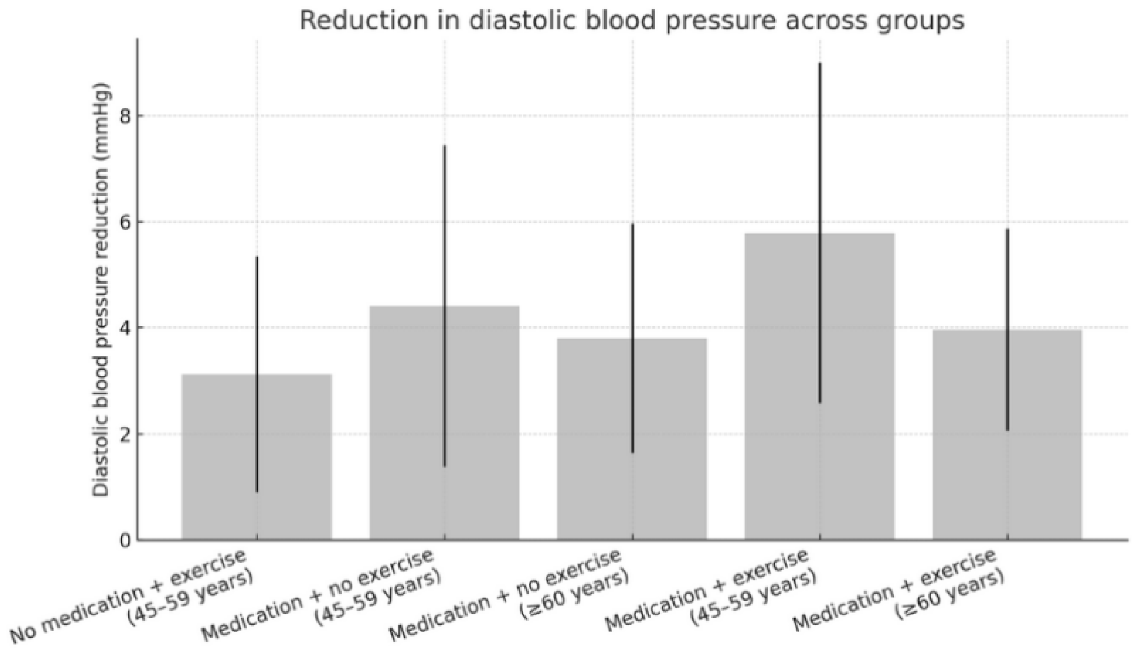

Fig. 2. Reduction in diastolic blood pressure (DBP) according to the presence or absence of pharmacological treatment and physical activity in the study groups (G1: No medication + exercise, 45–59 years; G2: Medication + no exercise, 45–59 years; G3: Medication + no exercise, ≥60 years; G4: Medication + exercise, 45–59 years; G5: Medication + exercise, ≥60 years).

DISCUSSION

Physical activity plays a significant role in the management of arterial hypertension, and its absence is one of the major risk factors for cardiovascular disease. Studies demonstrate that the implementation of systematic physical activity, along with other beneficial lifestyle modifications, can effectively reduce blood pressure, translating into improved quality and longevity of life for patients [7].

In our study, which included 70 patients with arterial hypertension (41 women and 29 men, aged 45–87 years) treated in an outpatient setting, the impact of physical activity on blood pressure was evaluated. Various forms of movement were analyzed, including walking, gardening, Nordic walking, and hiking. Both in our study and in the literature, it has been shown that regular, moderate physical activity leads to a reduction in blood pressure, confirming its significant role in the management of hypertension [18]. The study suggests that regular physical activity contributes to a significant reduction in DBP in patients with arterial hypertension. The greatest therapeutic effect was observed in individuals aged 45–59 years who combined pharmacotherapy with systematic exercise. This highlights the possible synergistic effect of medication and physical activity. Other studies have shown that reductions in DBP associated with exercise programs in hypertensive patients typically range by a few mmHg. In a meta-analysis by Saco-Ledo et al. [19], which included randomized trials, a significant reduction in 24-hour DBP was reported, with a mean decrease of 3.0 mmHg (95% CI 5.4 to 0.6). In a meta-analysis by de Barcelos et al. [20], the reduction in DBP following aerobic training was reported as 5.49 mmHg with structured progression and 6.51 mmHg without progression. For comparison, in our analyzed cohort – patients aged 45–59 years who combined pharmacotherapy with systematic physical activity – a mean reduction in DBP of 5.79 mmHg was observed (Table II). This value is similar to the results reported by de Barcelos et al. [20] and exceeds the effect indicated in the Saco-Ledo at al. [19] analysis, which may reflect, among other factors, differences in the type and intensity of exercise programs, duration of the intervention, baseline blood pressure levels, and the synergistic effect with pharmacotherapy [21]. However, it must be strongly emphasized that due to the highly unequal group size distribution in our cohort, particularly the critically small sample size in the non-medicated exercising group (n = 3), these comparisons are exploratory in nature. The findings serve to generate hypotheses rather than provide definitive clinical conclusions.

The lack of significant differences in SBP reduction may be attributed to the small sample size, particularly in the G1 group (n = 3), G2 group (n = 6), and G5 group (n = 5). The limited size of these subgroups heavily influenced the obtained results [22], reinforcing the exploratory character of this study. Reliable inferences regarding the isolated effect of lifestyle modifications versus pharmacotherapy cannot be definitively drawn from this dataset without a larger, balanced sample. In contrast, Saco-Ledo et al. [19] demonstrated that systematic exercise in patients with hypertension resulted in a mean reduction in SBP of 5.4 mmHg [95% CI, −9.2 to −1.6] and DBP of 3.0 mmHg [95% CI, −5.4 to −0.6]. Data collected in our study also suggest the positive impact of physical activity — 75.0% of women (n = 15) and 71.4% of men (n = 10) who engaged in regular weekly exercise reported that their physical activity enabled them to reduce the doses of antihypertensive medications. Additionally, our observations indicated that physically active patients generally utilized a simpler pharmacological regimen (1–2 medications) compared to the more sedentary group, which required a higher pill burden (3–4 medications). However, the reason for this reduced need for pharmacotherapy remains ambiguous. It could be a direct physiological consequence of exercise-induced blood pressure lowering. Alternatively, it might reflect broader factors among active individuals, such as higher health literacy, better dietary habits, and superior treatment adherence. Disentangling the direct antihypertensive effects of physical exertion from these closely associated behavioral and psychosocial factors is complex and will require further rigorously designed, controlled longitudinal studies to draw definitive conclusions.

These analyses indicate that physical activity plays both a preventive and therapeutic role in the management of arterial hypertension. Unfortunately, 21.4% of respondents still lacked knowledge regarding the importance of physical activity in the treatment of this condition. Furthermore, the observation that a substantial portion of the cohort (42%) had never heard of cardiac rehabilitation highlights a critical gap in patient education. Current literature suggests that such profound unawareness is rarely due to patient disinterest alone, but rather stems from systemic barriers. These frequently include a lack of proactive physician referrals at the primary care level, as well as logistical constraints such as limited geographic access to specialized rehabilitation facilities and insufficient reimbursement frameworks [23]. Addressing these institutional and communication barriers is essential for the effective integration of cardiac rehabilitation into routine hypertension management.

The data collected from our own observations were compared with the results reported by Kebede et al. [24]. Compared to their study, our sample had a lower proportion of completely inactive individuals (~51%). However, low-intensity and easily accessible forms of physical activity predominated. Specifically, walking was preferred by 61% of women and 55.2% of men, while gardening was reported by 51.4% of the population. This suggests the need to implement interventions promoting increased intensity and diversity of physical activity to achieve more comprehensive health benefits.

Based on the proprietary questionnaire, 61.4% (n = 43) of participants reported using their free time for walking. At the same time, 25.2% of men preferred to spend this time passively, e.g., watching television, and 17% of all participants reported engaging in physical exercise. Despite varying opinions regarding the recommended intensity and duration of exercise, moderate physical activity positively affects not only blood pressure reduction but also BMI reduction, as confirmed by both our observations and the literature [15].

For comparison, studies conducted in China by You et al. [25] on a sample of 7113 individuals revealed a substantially higher prevalence of obesity (77.85%) and overweight (39.12%). Such large discrepancies may result from differences in the BMI standards applied and the variability in physical activity levels between regions.

In contrast, our analysis showed that overweight was more frequent among men (70%), whereas obesity was more common in women (63%). One of the main reasons for reduced physical activity – particularly in the 66–80 year age group – was joint and spinal pain (64%), while being overweight was a less frequent factor (7%). In the 45–54 year age group, the predominant barrier was lack of motivation (86%), with 14% citing either unwillingness or pain-related issues as obstacles.

In the study group, 34.1% of women (n = 14) and 37.9% of men (n = 11) reported engaging in physical activity for 30–60 minutes per week. More than 60 minutes of exercise per week was reported by 48.8% of women (n = 20) and 48.3% of men (n = 14), while 15.7% of respondents (n = 11), including 7 women and 4 men, did not engage in any physical activity. Exercise duration was generally longer among men, which corresponds with the findings regarding overweight and obesity. Results from You et al. [25] indicate that 52.42% of patients reported physical activity exceeding 10–20 minutes per week, and over 50% exceeded 30 and 60 minutes.

Our data showed that physical activity performed 1–2 times per week was reported by 22% of women and 20.7% of men. More frequent exercise – over 4 times per week – was reported by 7.3% of women and 13.8% of men. The results of the population-based prospective cohort study "Low-Risk Diet and Lifestyle Habits in the Primary Prevention of Myocardial Infarction in Men" confirm the significant role of lifestyle in the prevention of cardiovascular diseases. The authors suggest that up to 80% of myocardial infarction cases in men could potentially be avoided by adhering to healthy lifestyle principles, including a balanced diet, limited alcohol consumption (10–30 g/day), maintaining a waist circumference below 95 cm, abstaining from tobacco, and engaging in regular physical activity (≥40 minutes daily of walking or cycling and ≥1 hour of exercise per week) [26]. The results of our study showed that 26 patients (43.9%) maintained normal blood pressure values- among them, 18 women and 8 men- while 4.0% of participants had not initiated pharmacological treatment, and 9.0% (n = 6) were unable to clearly define their health status. These findings suggest that physical activity may play an important complementary role alongside pharmacological treatment. However, this cannot be definitively established from the present data alone. Furthermore, exercise is often perceived by patients merely as a form of leisure or a hobby [7].

Subsequent clinical studies have provided evidence that regular physical activity effectively may contribute to blood pressure values reduction in patients with hypertension [27].

From these observations, it can be concluded that systematic physical activity should be recommended to all patients with hypertension, regardless of age. However, the type of exercise, its intensity, and duration should be tailored to each individual's capabilities and health status, and in some cases, consultation with a physician may be necessary [28].

Limitations

This study has several important limitations:

1. The sample size of n = 70 was not calculated to power a multivariable regression analysis; therefore, potential confounding variables including sex distribution, medication class and dose, comorbidity burden, and BMI were not controlled for.
2. Group sizes were markedly unequal (n = 3 to n = 30), and the smallest groups produced wide confidence intervals, limiting the precision and reliability of inference.
3. Additionally, the unequal subgroup sizes and very small sample size of certain groups may have limited the robustness of the parametric analyses and reduced the reliability of the distributional assumptions underlying one-way ANOVA.
4. Blood pressure values were self-reported and not verified against clinical records, introducing potential recall bias and measurement heterogeneity.
5. The cross-sectional design prevents causal inference, as physically active patients may differ systematically from sedentary individuals in unmeasured ways.
6. Finally, single-center recruitment limits the generalizability of the findings.

In view of these constraints, the findings should be interpreted as preliminary and hypothesis-generating, providing a basis for a larger, prospective, adequately powered study with objective blood pressure measurement and multivariable adjustment.

CONCLUSIONS

1. A statistically significant difference in DBP reduction was observed across study groups ($p = 0.003$; $\eta^2 = 0.22$), with the numerically greatest reduction in patients aged 45–59 years combining pharmacotherapy with regular physical activity. These results are exploratory and do not permit causal inference.

2. The observed lack of significant differences in SBP reduction between groups may be attributed to the small sample size and individual variability in treatment response, highlighting the need for further research.
3. In the study group, a low level of physical activity and a lack of awareness of its role in hypertension management were observed, which limits the effectiveness of non-pharmacological treatment methods.
4. Physical activity should be an integral part of hypertension management, individually tailored to the patient, as it is crucial for preventing cardiovascular complications.

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Conflict of interest

The authors declare no conflicts of interest.

Authors' contribution

Study design – J. Mikołajczyk, T. Fajferek, B. Pietrzyk

Data collection – L. Grelowska, E. Mażul-Kulesza

Data interpretation – J. Mikołajczyk, A. Joniec, T. Fajferek

Statistical analysis – A. Joniec, T. Fajferek

Manuscript preparation – J. Mikołajczyk, A. Joniec, T. Fajferek, S. Kaczara, E. Mażul-Kulesza

Literature research – J. Mikołajczyk, S. Kaczara, E. Mażul-Kulesza

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