

Physical activity, rehabilitation, and lifestyle changes in hypertension

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Abstract

Aim of the research: This study aimed to assess the impact of the level and type of physical activity in hypertensive patients on health behaviours, blood pressure control, and pharmacological treatment, as well as to provide preliminary data for future population-based research.

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 old. Conducted at the Municipal Hospital in Bielsko-Biala (May–November 2023), the study used a 36-question survey addressing physical activity, treatment, and anthropometric data. Data were analysed using Microsoft Excel and Python, with ANOVA and Tukey's HSD tests; significance was set at $p < 0.05$.

Results and conclusions: The effect of physical activity and pharmacotherapy on blood pressure was evaluated in 5 patient groups. ANOVA showed no significant differences in systolic pressure reduction ($p = 0.666$) but revealed significant differences for diastolic pressure ($p = 0.003$). The greatest diastolic pressure reduction occurred in younger patients combining pharmacological treatment with physical activity. Participation in cardiac rehabilitation significantly improved blood pressure control and encouraged healthier lifestyle behaviours among hypertensive patients.

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, emphasising early detection and comprehensive management. In Poland, the Polish Society of Hypertension (PTNT) [3] follows comparable guidelines, categorising hypertension into three stages, with specific attention given to risk stratification and individualised 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 mm Hg, Grade II: from 160/100 mm Hg, and Grade III: above 180/100 mm Hg. 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 emphasise 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 the main role [7]. The promotion of health-oriented behaviours 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 recognising 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 which 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

Table 1. Demographic distribution of the study group

Sex	Age range [years]	Number of patients	% of the study population
Women	45–59	16	22.86%
	≥ 60	25	35.71%
Men	45–59	13	18.57%
	≥ 60	16	22.86%

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

Aim of the research

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 behaviours 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 old and ≥ 60 years old. The sex distribution of the cohort comprised 41 (59%) women and 29 (41%) men. The study was conducted among patients of the Cardiology Outpatient Clinic at the Municipal Hospital in Bielsko-Biala 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 (Table 1).

The assessment of the role of physical activity and rehabilitation in modifying the lifestyle of patients with arterial hypertension was based on a self-designed survey questionnaire 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 any Bioethics Committee under Polish law. According to the Act on the Professions of Physician and Dentist (consolidated text of 19 August 2024), only medical experiments require such approval.

Statistical analysis

The data were analysed using Microsoft Excel and Python. In Python, an analysis of variance (ANOVA) was performed to compare means between groups, followed by the 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).

Table 2. 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 $\pm$ SD [mm Hg]	SBP [95% CI]	Mean DBP reduction $\pm$ SD [mm Hg]	DBP [95% CI]
No medication + exercise (45–59 years)	3	6.29 $\pm$ 3.98	[–3.60, 16.18]	3.12 $\pm$ 2.23	[–2.42, 8.66]
Medication + no exercise (45–59 years)	6	9.66 $\pm$ 3.15	[6.35, 12.97]	4.41 $\pm$ 3.04	[1.22, 7.60]
Medication + no exercise ($\geq$ 60 years)	30	10.29 $\pm$ 3.73	[8.90, 11.68]	3.80 $\pm$ 2.17	[2.99, 4.61]
Medication + exercise (45–59 years)	26	11.39 $\pm$ 5.51	[9.16, 13.62]	5.79 $\pm$ 3.22	[4.49, 7.09]
Medication + exercise ($\geq$ 60 years)	5	11.79 $\pm$ 4.22	[6.55, 17.03]	3.96 $\pm$ 1.91	[1.59, 6.33]

SD – standard deviation. 95% CIs calculated using *t*-distribution with group-specific degrees of freedom ($df = n - 1$).

Results

The study included 70 patients with confirmed arterial hypertension, comprising 41 (59%) women and 29 (41%) men, aged 45–87 years. The age distribution was as follows: 21% ($n = 15$) aged 45–54 years, 33% ($n = 23$) aged 55–65 years, 41% ($n = 29$) aged 66–80 years, and 4% ($n = 3$) aged over 80 years.

Patients were categorised into five groups based on pharmacological treatment status and physical activity level (Table 2). 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; data from this group are presented descriptively only.

One-way ANOVA revealed no statistically significant differences in systolic blood pressure (SBP) reduction across the five groups ($F(4.65) = 0.60$; $p = 0.666$; $\eta^2 = 0.036$), indicating a negligible effect size. 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 2. One-way ANOVA revealed statistically significant differences in diastolic blood pressure (DBP) reduction across the five groups ($F(4.65) = 4.46$; $p = 0.003$; $\eta^2 = 0.215$). 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 2. The high-

est mean DBP reduction was observed in the ‘Medication + exercise (45–59 years)’ group (5.79 $\pm$ 3.22 mm Hg; 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 ‘No medication + exercise (45–59 years)’ group ($n = 3$) showed a wide 95% CI spanning zero (3.12 mm Hg; 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 (MS_within) was estimated from pooled within-group variance as 7.18. Pairwise comparisons are presented in Table 3.

The only pair approaching statistical significance was the ‘Medication + no exercise ($\geq$ 60 years)’ versus ‘Medication + exercise (45–59 years)’ comparison (mean difference = 1.99 mm Hg; SE = 0.508; $q = 3.921$; $p \approx 0.054$), 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.

The results are summarised in Tables 2 and 3. A graphical comparison of the reductions in systolic and diastolic blood pressure is presented in Figures 1 and 2.

Discussion

Physical activity plays a significant role in the management of arterial hypertension, and its absence

Table 3. Tukey-Kramer post-hoc pairwise comparisons – DBP reduction. MS_within = 7.18 (pooled within-group variance); q critical ($k = 5$, $df = 65$, $\alpha = 0.05$) = 3.97

Group A	Group B	Mean difference [mm Hg]	SE	Q statistic	vs. q critical = 3.97	Significance
G1 ($n = 3$)	G2 ($n = 6$)	1.290	1.340	0.963	< Critical	ns
G1 ($n = 3$)	G3 ($n = 30$)	0.680	1.147	0.593	< Critical	ns
G1 ($n = 3$)	G4 ($n = 26$)	2.670	1.155	2.312	< Critical	ns
G1 ($n = 3$)	G5 ($n = 5$)	0.840	1.383	0.607	< Critical	ns
G2 ($n = 6$)	G3 ($n = 30$)	0.610	0.847	0.720	< Critical	ns
G2 ($n = 6$)	G4 ($n = 26$)	1.380	0.858	1.608	< Critical	ns
G2 ($n = 6$)	G5 ($n = 5$)	0.450	1.147	0.392	< Critical	ns
G3 ($n = 30$)	G4 ($n = 26$)	1.990	0.508	3.921	$\approx$ Critical ($p \approx 0.054$)	~
G3 ($n = 30$)	G5 ($n = 5$)	0.160	0.915	0.175	< Critical	ns
G4 ($n = 26$)	G5 ($n = 5$)	1.830	0.925	1.978	< Critical	ns

~ – approaching significance (q within 2% of critical value, $p \approx 0.054$). ns – not significant.

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

ANOVA summary: SBP – $F(4.65) = 0.60$, $p = 0.666$, $\eta^2 = 0.036$ (negligible). DBP – $F(4.65) = 4.46$, $p = 0.003$, $\eta^2 = 0.215$ (large).

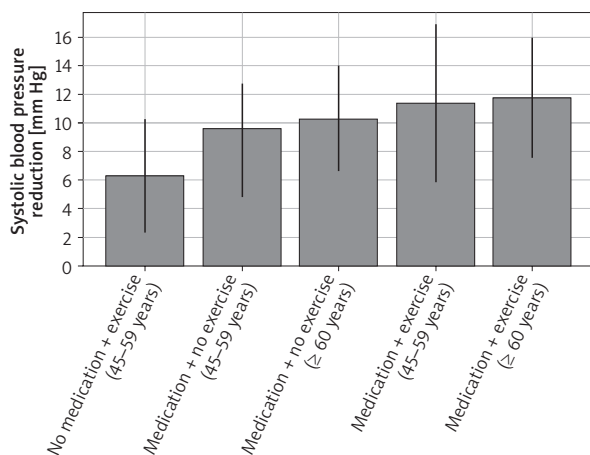


Figure 1. Reduction in systolic blood pressure (SBP) according to the presence or absence of pharmacological treatment and physical activity in the study groups

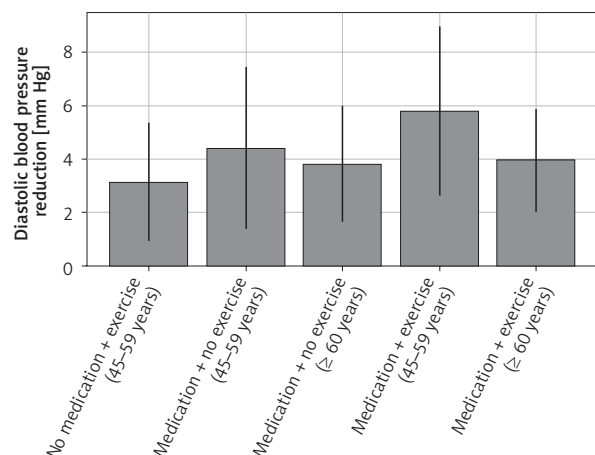


Figure 2. Reduction in diastolic blood pressure (DBP) according to the presence or absence of pharmacological treatment and physical activity in the study groups

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 analysed, 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 confirmed that regular physical activity significantly reduces diastolic blood pressure in patients with arterial hypertension, with the greatest therapeutic effect observed in individuals aged 45–59 years who combined pharmacotherapy with systematic exercise, highlighting the possible synergistic effect of medication and physical activity. Other studies have shown that reductions in diastolic blood pressure associated with exercise programs in hypertensive patients typically range by a few mm Hg. In a meta-analysis by Saco-Ledo *et al.*, which included randomised trials, a significant reduction in 24-hour diastolic blood pressure was reported, with a mean decrease of 3.0 mm Hg (95% CI: 5.4 to 0.6) [19]. In a me-

ta-analysis by de Barcelos *et al.*, the reduction in diastolic blood pressure (DBP) following aerobic training was reported as 5.49 mm Hg with structured progression and 6.51 mm Hg without progression [20]. For comparison, in our analysed cohort – patients aged 45–59 years who combined pharmacotherapy with systematic physical activity – a mean reduction in diastolic blood pressure of 5.79 mm Hg was observed (Table 2). This value is similar to the results reported by de Barcelos *et al.* and exceeds the effect indicated in the Saco-Ledo *et al.* 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].

The lack of significant differences in systolic blood pressure reduction may be attributed to the small sample size, particularly in the groups of individuals under 60 years not receiving medication but engaging in physical activity, individuals under 60 years receiving medication but not exercising, and individuals over 60 years receiving medication and remaining physically active. The limited size of these subgroups may have influenced the obtained results [22]. In contrast, Saco-Ledo *et al.* demonstrated that systematic exercise in patients with hypertension resulted in a mean reduction in systolic blood pressure of 5.4 mm Hg (95% CI: –9.2 to –1.6) and diastolic blood pressure of 3.0 mm Hg (95% CI: –5.4 to –0.6) [19]. 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 utilised a simpler pharmacological regimen (1–2 medications) compared to the more sedentary group, which required a higher pill burden (3–4 medications). However, it remains ambiguous whether this reduced need for pharmacotherapy is a direct physiological consequence of exercise-induced blood pressure lowering, or whether it reflects a broader phenomenon of higher health literacy, better dietary habits, and overall superior treatment adherence among active individuals. Disentangling the direct antihypertensive effects of physical exertion from these closely associated behavioural and psychosocial factors is complex and will require further rigorously designed, controlled longitudinal studies to draw definitive conclusions.

The conclusions from 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 specialised 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]. It was shown that, despite a lower proportion of individuals completely inactive in our sample (~51%) compared to the Kebede *et al.* study, low-intensity, easily accessible forms of physical activity – such as walking (61% of women and 55.2% of men) and gardening (51.4%) – predominated in our 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 self-designed questionnaire, 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.* on a sample of 7,113 individuals revealed a substantially higher prevalence of obesity (77.85%) and overweight (39.12%) [25]. 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 ($n = 11$), includ-

ing 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.* indicate that 52.42% of patients reported physical activity exceeding 10–20 minutes per week, and over 50% exceeded 30 and 60 minutes [25].

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 (43.9%) patients 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 are consistent with the notion that physical activity may play an important complementary role alongside pharmacological treatment, though this cannot be established from the present data alone, often perceived by patients as a form of leisure or a hobby [7].

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

These observations demonstrate 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].

This study has several important limitations:

- 1) The sample size of $n = 70$ was not calculated to power a multivariable regression analysis; 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 $n = 30$), with the smallest group producing 95% CIs spanning zero, rendering inference unreliable.
- 3) Blood pressure values were self-reported and not verified against clinical records, introducing potential recall bias and measurement heterogeneity.

- 4) The cross-sectional design prevents causal inference, as physically active patients may differ systematically from sedentary ones in unmeasured ways.
- 5) Single-centre recruitment limits generalisability.

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

A statistically significant difference in diastolic blood pressure reduction was observed across study groups ($p = 0.003$; $\eta^2 = 0.215$), 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.

The observed lack of significant differences in systolic blood pressure reduction between groups may be attributed to the small sample size and individual variability in treatment response, highlighting the need for further research.

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.

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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Ethical approval

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Conflict of interest

The authors declare no conflict of interest.

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