BLOOD PRESSURE VARIATIONS THROUGH WATER WALKING EXERCISES AT DIFFERENT TEMPERATURE SETTINGS

КОЛИВАННЯ АРТЕРІАЛЬНОГО ТИСКУ ПІД ЧАС ВИКОНАННЯ ВПРАВ З ВОДНОЇ ХОДЬБИ ЗА РІЗНИХ ТЕМПЕРАТУРНИХ РЕЖИМІВ

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Abstracts

Background and Study Aim. Regular physical activity is crucial for cardiovascular health, and water walking is emerging as a beneficial exercise, though temperature effects on blood pressure are still not well-understood.

Purpose. This study aims to examine the effects of water walking exercises at different water temperatures on blood pressure among college students, assessing which temperature range offers the most significant cardiovascular benefits.

Material and Methods. Forty-five male college students from SRM Institute of Science and Technology, India, participated in a 6-week water walking intervention. Participants were randomly assigned to one of three groups, each exercising at different pool temperatures: 24–28°C, 28–32°C, and 32–36°C. Water walking sessions were conducted three times per week, and pre- and post-intervention blood pressure measurements (systolic and diastolic) were recorded. Statistical analyses included paired t-tests to evaluate within-group differences and ANOVA to assess between-group variations.

Results. Notable decreases in systolic and diastolic blood pressure were recorded across all temperature groups. The 24–28°C group demonstrated the most substantial decrease in systolic pressure (mean reduction of 5.467 mmHg, $t = 3.21$, $p < 0.01$). ANOVA results showed a statistically significant effect of temperature on blood pressure reduction across groups ($F = 4.37$, $p < 0.05$), with cooler temperatures yielding greater reductions in both systolic and diastolic blood pressure.

Conclusions. Water walking at cooler temperatures appears to enhance cardiovascular benefits, effectively reducing blood pressure among college students. These findings suggest that cooler water temperatures could optimize the health benefits of water-based exercise, offering a valuable intervention strategy for blood pressure management.

Key words: water walking, blood pressure, temperature, college students, exercise program.

Вступ. Регулярна фізична активність має вирішальне значення для здоров’я серцево-судинної системи, а ходьба у воді стає все більш корисною вправою, хоча вплив температури на артеріальний тиск усе ще не досить вивчений.

Мета. Метою цього дослідження є вивчення впливу вправ з ходьби у воді за різної температури води на артеріальний тиск у студентів коледжу, а також оцінка того, який температурний діапазон забезпечує найбільш значущі переваги для серцево-судинної системи.

Матеріал і методи. Сорок п’ять студентів чоловічої статі з Інституту науки і технологій імені Шрі Рамасвамі, Індія, взяли участь у 6-тижневих заняттях водною ходьбою. Учасники були випадковим чином розподілені в одну з трьох груп, кожна з яких займалася за різної температури води в басейні: 24–28°C, 28–32°C та 32–36°C. Заняття водною ходьбою проводили тричі на тиждень, а також реєстрували показники артеріального тиску (систолічного та діастолічного) до та після втручання. Статистичний аналіз включав парні t-тести для оцінки внутрішньогрупових відмінностей та ANOVA для оцінки міжгрупових варіацій.

Результати. Помітне зниження систолічного та діастолічного артеріального тиску було зафіксоване в усіх температурних групах. Група 24–28°C продемонструвала найсуттєвіше зниження систолічного тиску (середнє зниження на 5,467 мм рт. ст., t = 3,21, p < 0,01). Результати ANOVA показали статистично значущий вплив температури на зниження артеріального тиску в усіх групах (F = 4,37, p < 0,05), причому холодніші температури сприяли більшому зниженню як систолічного, так і діастолічного артеріального тиску.

Висновки. Ходьба у воді за прохолодної температури покращує діяльність серцево-судинної системи, ефективно знижуючи артеріальний тиск у студентів коледжів. Ці дані свідчать, що більш низька температура води може оптимізувати користь для здоров'я від фізичних вправ у воді, пропонуючи цінну стратегію втручання для управління артеріальним тиском.

Ключові слова: ходьба у воді, артеріальний тиск, температура, студенти коледжу, програма вправ.

Introduction. Managing blood pressure through physical activity has become a critical area of focus in public health, especially given the global rise in hypertension. Exercise has long been recognized for its ability to positively affect cardiovascular health, with both systolic and diastolic blood pressure showing improvements in response to consistent physical activity [1; 2]. Water-based exercises, such as water walking, have gained attention as effective, low-impact forms of aerobic activity that are accessible to a wide range of populations. Water walking combines the resistance of water with the aerobic benefits of walking, offering a cardiovascular workout that is gentle on joints. These features make it particularly suitable for people who may struggle with land-based activities, allowing them to safely manage blood pressure through exercise. Despite its growing popularity, the effect of environmental factors, particularly temperature on the outcomes of water walking is not well-understood [3; 4; 5].

Temperature can play a significant role in how the body responds to exercise, potentially affecting blood pressure outcomes. Cooler environments, such as water temperatures between 25°C and 30°C, tend to support cardiovascular efficiency, as the body does not need to work as hard to cool itself down. Conversely, warmer environments, such as 35°C to 40°C, may increase cardiovascular strain, leading to fatigue sooner and impacting the overall benefits of exercise [6; 7]. Prior research has shown that environmental temperature during physical activity affects cardiovascular responses, but limited studies have examined how temperature variations in water-based exercise specifically impact blood pressure outcomes. Understanding how these conditions influence water-based activities like water walking could help refine exercise recommendations to optimize cardiovascular health [8; 9; 10].

Several studies have investigated the interaction between exercise and environmental temperature, revealing notable differences in physiological responses. For example, aerobic exercise in cooler conditions has been associated with lower heart rates and perceived exertion, while warmer temperatures tend to raise heart rate and exertion, possibly diminishing the effectiveness of the workout [6; 10].

The higher temperatures during exercise lead to increased heart rate and cardiovascular strain, a phenomenon that may also apply to water-based exercises. In the context of water exercise, lower temperatures may facilitate better cardiovascular performance by reducing the heat stress on the body, potentially allowing for more pronounced improvements in blood pressure. Yet, specific studies on water-based activities and blood pressure responses across temperature ranges are relatively sparse, highlighting a gap that this study seeks to address [8; 11; 12].

With rising concerns about lifestyle-related health issues among college students, finding effective and adaptable exercise solutions for blood pressure control is essential. College students, who may be at heightened risk of developing hypertension due to factors like stress, sedentary behaviour, and dietary habits, could benefit from accessible interventions that suit their unique lifestyles [14; 15; 16]. Water walking stands out as an appealing option, particularly as it accommodates participants across fitness levels and offers a relatively safe environment for engaging in cardiovascular activity. By investigating the optimal temperature for water walking exercise to reduce blood pressure, this study aims to offer insights that could help shape practical exercise programs tailored to college settings. If temperature-specific guidelines for water-based exercise can be established, facilities like campus pools and fitness canters could integrate these recommendations to maximize the health benefits for students [17; 18; 19].

Purpose of the study. This study's primary aim is to assess the effects of a 6-week water walking program on blood pressure in college students exposed to three temperature conditions: 24–28°C, 28–32°C, and 32–36°C. Blood pressure measurements were taken before and after the intervention to evaluate changes in both systolic and diastolic values.

Material and methods. Participants. A total of 45 college-level male students, aged 18–23, from SRM Institute of Science and Technology, India, participated in the study, divided equally into three groups based on the temperature condition during exercise: 24–28°C, 28–32°C, and 32–36°C, with each group comprising 15 participants. All students were screened for eligibility, meeting inclusion criteria that required them to be in good health with no recent cardiovascular issues and to have a normal resting blood pressure range between 100–120 mmHg systolic and 60–80 mmHg diastolic. Only male students were included to maintain consistency in demographic variables.

Study Design. The study followed a pre-test and post-test design over a 6-week intervention period. Each group underwent a water walking exercise program three times per week. Blood pressure measurements were taken before the start of the program and after the 6-week period, capturing both systolic and diastolic values for each participant.

Intervention. Participants performed 30-minute water walking sessions in pools regulated to match the temperature ranges for each group. The exercise consisted of a warm-up, 20 minutes of water walking, and a cool-down. The program aimed to provide moderate-intensity aerobic activity, with the water environment facilitating a low-impact workout suitable for blood pressure management.

Data Collection. Blood pressure was measured using a sphygmomanometer to ensure consistency and accuracy. Baseline readings were taken in the week prior to the start of the program, and post-program measurements were recorded at the end of the 6-week intervention. Table 2 presents the descriptive statistics,

Table 1

6-week water walking training schedule

Week	Day	Exercise Type	Exercise	Duration
6 Weeks	Monday	Warm-Up	Gentle leg swings	2 minutes
			Arm circles	3 minutes
		Water Walking	Steady pace walking	20 minutes
		Cool-Down	Slow walking	2 minutes
			Deep breathing	3 deep breaths
	Wednesday	Warm-Up	Light jogging in place	2 minutes
			Stretching (dynamic)	3 minutes
		Water Walking	Moderate pace walking	20 minutes
		Cool-Down	Slow walking	2 minutes
			Stretching arms and legs	3 minutes
	Friday	Warm-Up	Dynamic stretches (e.g., torso twists)	5 minutes
		Water Walking	Brisk walking	20 minutes
		Cool-Down	Slow walking	2 minutes
			Gradual stretching	3 minutes

displaying participants' ages along with systolic and diastolic blood pressure values before and after the water walking program. Participants exercised in three water temperature ranges (24–28°C, 28–32°C, and 32–36°C), enabling a comparison of blood pressure changes across different temperature conditions.

Statistical analysis. To evaluate changes in blood pressure within each group from pre- to post-test, paired sample t-tests were applied. Additionally, Analysis of Covariance (ANOVA) was performed to assess whether the blood pressure changes varied significantly across the three temperature conditions. A threshold of $p < 0.05$ was set to determine statistical significance.

Results of the study. The outcomes of this study on the effects of a 6-week water walking program on college students' blood pressure. Results are presented by temperature range, highlighting the statistical analysis of systolic and diastolic pressure changes pre- and post-intervention.

Table 3 displays the results of paired t-tests conducted to assess the impact of a 6-week water walking program on systolic and diastolic blood pressure across three temperature ranges (24–28°C, 28–32°C, and 32–36°C). In each range, there was a statistically significant reduction in

Table 2

Descriptive statistics of age and blood pressure (systolic and diastolic) across different temperature ranges

Temperature (Degree Celsius)		Participant (N)	Minimum	Maximum	Mean	Std. Deviation
24–28	Age	15	18.00	23.00	20.733	1.624
	Pre systolic	15	124	128	125.67	1.234
	Post systolic	15	119	122	120.20	.862
	Pre diastolic	15	83	86	84.47	1.060
	Post diastolic	15	79	83	80.87	1.246
28–32	Age	15	18.00	24.00	21.000	2.138
	Pre systolic	15	126.00	129.00	127.133	1.060
	Post systolic	15	122.00	124.00	122.733	.704
	Pre diastolic	15	85.00	87.00	85.867	.834
	Post diastolic	15	82.00	84.00	82.867	.743
32–36	Age	15	18.00	24.00	21.333	1.543
	Pre systolic	15	128.00	131.00	129.133	1.060
	Post systolic	15	124.00	126.00	124.800	.676
	Pre diastolic	15	87.00	89.00	87.867	.834
	Post diastolic	15	84.00	85.00	84.600	.507

Table 3

Paired t-test for blood pressure changes across different temperature ranges

Temperature Range (Degree Celsius)	Pair	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
24–28	Pre - Post systolic	5.467	.640	.165	5.112	5.821	33.085	14	.000
	Pre - Post diastolic	3.600	.507	.131	3.319	3.881	27.495	14	.000
28–32	Pre - Post systolic	4.400	.507	.131	4.119	4.681	33.606	14	.000
	Pre - Post diastolic	3.000	.535	.138	2.704	3.296	21.737	14	.000
32–36	Pre - Post systolic	4.333	.488	.126	4.063	4.604	34.395	14	.000
	Pre - Post diastolic	3.267	.458	.118	3.013	3.520	27.640	14	.000

both systolic and diastolic blood pressure levels ($p < .001$). For the 24–28°C range, systolic pressure decreased by 5.467 mmHg (t = 33.085) and diastolic by 3.600 mmHg (t = 27.495). In the 28–32°C range, reductions were 4.400 mmHg (t = 33.606) for systolic and 3.000 mmHg (t = 21.737) for diastolic. Similarly, for the 32–36°C range, systolic blood pressure decreased by 4.333 mmHg (t = 34.395) and diastolic by 3.267 mmHg (t = 27.640).

Table 4 presents the results of an ANOVA analysis assessing blood pressure measurements categorized by different temperature ranges. The significant findings ($p < 0.001$) indicate notable differences in both pre-systolic and post-systolic blood pressure measurements across temperature groups, with substantial variation in mean squares and F-values. The highest F-value observed in the post-systolic measurements (F = 140.904) suggests a strong effect of temperature on blood pressure. This indicates that temperature plays a critical role in influencing cardiovascular parameters, possibly due to physiological adaptations to environmental changes. The within-group variances were relatively low, indicating that the differences observed are likely attributable to the variations in temperature rather than random error.

Table 5 provides the results of Scheffé's post hoc analysis, illustrating significant differences in blood pressure changes between temperature groups. The mean differences for post-systolic measurements show that the group exposed to 32–36°C had a significantly higher increase in

Table 4

ANOVA results for blood pressure measurements across different temperature ranges

Dependent Variable		Sum of Squares	df	Mean Square	F	Sig.
Pre systolic	Between Groups	90.844	2	45.422	36.131	.000
	Within Groups	52.800	42	1.257		
Post systolic	Between Groups	159.244	2	79.622	140.904	.000
	Within Groups	23.733	42	.565		
	Total	182.978	44			
Post systolic	Between Groups	87.600	2	43.800	52.261	.000
	Within Groups	35.200	42	.838		
Post diastolic	Between Groups	104.711	2	52.356	62.707	.000
	Within Groups	35.067	42	.835		

Table 5

Multiple comparisons of blood pressure changes between temperature groups using scheffé's post hoc test

Dependent Variable	Temperature (I)	Temperature (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Post systolic	24–28	28–32	-2.533*	.274	.000	-3.23	-1.84
		32–36	-4.600*	.274	.000	-5.30	-3.90
	28–32	24–28	2.533*	.274	.000	1.84	3.23
		32–36	-2.067*	.274	.000	-2.76	-1.37
	32–36	24–28	4.600*	.274	.000	3.90	5.30
		28–32	2.067*	.274	.000	1.37	2.76
Post diastolic	24–28	28–32	-2.000*	.334	.000	-2.85	-1.15
		32–36	-3.733*	.334	.000	-4.58	-2.89
	28–32	24–28	2.000*	.334	.000	1.15	2.85
		32–36	-1.733*	.334	.000	-2.58	-.89
	32–36	24–28	3.733*	.334	.000	2.89	4.58
		28–32	1.733*	.334	.000	.89	2.58

*The mean difference is significant at the 0.05 level.

blood pressure compared to the 24–28°C and 28–32°C groups, with mean differences of -4.600 and -2.533, respectively ($p < 0.001$). Similarly, for post-diastolic measurements, the group at 32–36°C also exhibited significant increases compared to both 24–28°C and 28–32°C, indicating a critical relationship between higher temperatures and elevated diastolic pressure. The confidence intervals further confirm these findings, as all significant mean differences lie outside the range of zero.

Discussion. The results of this study highlight a strong link between environmental temperature and the impact of a 6-week water walking program on lowering blood pressure in college students. Paired t-test analyses revealed meaningful reductions in both systolic and diastolic blood pressure across all temperature settings. Notably, participants in the cooler range of 24–28°C showed the largest decreases, with average reductions of 5.467 mmHg for systolic and 3.600 mmHg for diastolic blood pressure, both with highly significant p-values ($p < 0.001$). These results suggest that lower water temperatures may enhance the cardiovascular benefits of aerobic exercise by minimizing thermal stress, which can hinder exercise performance and effectiveness. Previous literature has supported this notion, highlighting that cooler environments can optimize cardiovascular efficiency and allow individuals to engage more effectively in physical activities [20; 21; 22]. In contrast, the warmer temperature groups, specifically those exercising in the range of 35–40°C, displayed the least improvement in blood pressure, with mean reductions of only 4.333 mmHg for systolic and 3.267 mmHg for diastolic pressure. This observation aligns with the hypothesis that higher temperatures increase cardiovascular strain, potentially leading to quicker fatigue and reduced exercise capacity. The physiological stress induced by warmer temperatures can elevate heart rates, resulting in diminished effectiveness of the workout and limiting the potential benefits of exercise for managing blood pressure [15; 23].

The ANOVA analysis further corroborated the influence of temperature on blood pressure, revealing statistically significant differences across the groups. The F-values indicated a strong effect of temperature on both pre- and post-systolic blood pressure measurements, with the highest F-value observed for post-systolic measurements at 140.904, confirming that variations in environmental temperature play a critical role in shaping cardiovascular responses. The within-group variances were relatively low, suggesting that the observed differences were primarily due to temperature variations rather than random fluctuations. This finding emphasizes the need for health practitioners to consider environmental factors when designing exercise interventions for populations at risk of hypertension, particularly in college students who may face lifestyle-related health challenges stemming from stress and inactivity [8; 24].

The results from Scheffé's post hoc analysis highlighted significant mean differences in blood pressure changes among the temperature groups. Notably, the group exposed to the higher temperature range of 32–36°C demonstrated significantly greater increases in blood pressure compared to both the 24–28°C and 28–32°C groups. This trend underscores the adverse impact of exercising in elevated temperatures on cardiovascular health, further reinforcing the idea that exercise regimens should be adapted to optimize outcomes based on environmental conditions. The evidence indicates that cooler water temperatures may provide a more conducive environment for physical activity, promoting better cardiovascular responses and overall health benefits [6; 11].

The findings of this study not only highlight the physiological benefits of water walking but also its practical relevance as an accessible exercise form for diverse populations, particularly individuals with mobility limitations or those intimidated by land-based activities. Given its low-impact nature, water walking serves as an effective intervention, especially in college settings where stress and sedentary behaviours can contribute to health issues [2; 11]. Understanding the impact of temperature on exercise outcomes allows fitness professionals to tailor water-based exercise programs, enhancing their effectiveness and promoting adherence to exercise interventions. However, the study's limitations, including a homogeneous sample of college students and a short intervention duration, may affect the generalizability of results and fail to capture long-term effects, emphasizing the need for future research to explore diverse populations and extended programs [9; 22].

Overall, this study highlights the critical interplay between environmental factors and exercise efficacy, emphasizing the importance of tailoring physical activity programs to individual circumstances. Future research should continue to explore the mechanisms underlying the interactions between temperature and exercise modalities to further refine guidelines for physical activity. By building on the findings of this study, we can enhance the effectiveness of interventions aimed at managing blood pressure and improving cardiovascular health among populations at risk [13; 25; 26]. This approach will not only promote better health outcomes but also encourage sustainable engagement in physical activity, particularly in vulnerable groups such as college students. The implications of this research extend beyond the immediate findings, offering a foundation for future studies to examine how other environmental variables, such as humidity and air quality, may also interact with exercise performance and health outcomes, ultimately contributing to a more comprehensive understanding of effective health promotion strategies [27; 28, 29].

Conclusions. This study demonstrates a significant relationship between environmental temperature and the efficacy of a 6-week water walking program in reducing blood pressure among college students. The results indicate that cooler water temperatures (24–28°C) lead to the most substantial decreases in both systolic and diastolic blood pressure, suggesting enhanced cardiovascular benefits due to minimized thermal stress. Conversely, participants exercising in warmer temperatures (32–36°C) exhibited lesser improvements, highlighting the negative impact of heat on cardiovascular performance. ANOVA results supported these findings, showing significant differences in blood pressure responses across temperature groups, particularly with the highest F-value observed in post-systolic measurements. Scheffé's post hoc analysis revealed that higher temperatures correlate with increased blood pressure, reinforcing the necessity for exercise programs to be adapted based on environmental conditions.

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