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The effectiveness of post-exercise sports massage on blood pressure and heart rate in badminton athletes

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Abstract: *Sports massage is a recovery technique designed to reduce muscle tension, enhance blood circulation, and stabilize cardiovascular function. Given the high-intensity intermittent nature of badminton training and the need for rapid cardiovascular recovery, understanding its effects on blood pressure and heart rate is essential for developing evidence-based recovery strategies. This study aimed to examine the effectiveness of post-exercise sports massage on blood pressure and heart rate in badminton athletes. A quasi-experimental approach with a one-group pretest-posttest design was employed. The participants were 25 badminton athletes aged 19 years from Siliwangi University, who underwent 16 post-exercise sports massage sessions, each lasting 30 minutes. Blood pressure and heart rate were measured using a calibrated Omron HEM-7130 digital sphygmomanometer. Data analysis was conducted using SPSS, including descriptive statistics, the Shapiro-Wilk normality test, and the Wilcoxon signed-rank test at a 5% significance level (α = 0.05). The results revealed significant reductions in systolic blood pressure, diastolic blood pressure, and heart rate across all participants between pretest and posttest measurements ($p < 0.001$), indicating the consistent benefits of post-exercise sports massage. In conclusion, post-exercise sports massage effectively reduces blood pressure and heart rate in badminton athletes, supporting its use as a physiological recovery strategy. These findings provide practical implications for coaches and sports medicine practitioners in designing evidence-based recovery protocols, and future research should explore optimal massage duration and frequency across different athletic populations.*
Keywords: *Sports massage, Blood pressure, Heart rate, Badminton*

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INTRODUCTION

Badminton is a high-intensity sport that demands stamina, speed, and optimal motor skills, involving rapid movements such as jumps, sudden accelerations, and frequent changes in direction that place considerable stress on joints and muscles (Tai et al., 2022). These characteristics make badminton a demanding physical activity that requires endurance, strength, and speed (N.M. et al., 2023), while aerobic capacity plays a crucial role in sustaining performance throughout matches with fluctuating duration and rhythm (Liu et al., 2021). Previous studies have demonstrated that badminton significantly enhances cardiovascular performance, as its unique demands involve rapid changes in direction and speed that increase cardiovascular load, elevating heart rate and blood pressure as normal physiological responses (Abdullahi & Coetzee, 2021; Green et al., 2023). Research indicates that moderate-intensity badminton training can elevate heart rate to 121-142 beats/min with corresponding increases in systolic blood pressure. However, such physiological stress can lead to prolonged fatigue if not supported by effective recovery strategies. A systematic review by Davis et al. (2020) involving 1,012 athletes across 29 studies demonstrated that inadequate recovery following high-intensity exercise results in persistent muscle soreness, reduced performance output, and delayed return to baseline physiological function (Davis et al, 2020). Research further indicates that incomplete cardiovascular recovery characterized by sustained elevation in heart rate and blood pressure beyond normal resting values can compromise subsequent training quality, impair adaptation mechanisms, and increase susceptibility to overtraining syndrome and musculoskeletal injuries (Shaharudin et al., 2024; Dupuy et al., 2018). Studies on racket

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sports have shown that athletes experiencing prolonged recovery periods (>24 hours) demonstrate significantly diminished neuromuscular performance, reduced speed, and impaired decision-making capacity in subsequent matches (Shaharudin et al., 2024). The prevalence of injuries among competitive badminton players ranges from 2.9 to 9.5 injuries per 1000 hours of play, emphasizing the detrimental effects of inadequate recovery (Hidayat & Ihsan, 2024). Therefore, recovery is a critical component of training management for badminton athletes, requiring evidence-based interventions that accelerate physiological restoration and prevent cumulative fatigue (Davis et al., 2020; Dupuy et al., 2018).

Sports massage is associated with multiple benefits, including improved circulation, accelerated clearance of lactic acid, and reduced muscle tension, all of which contribute to faster recovery (Ayudi, 2022; Simatupang et al., 2020; Reichert, 2020). By enhancing oxygen delivery and facilitating removal of metabolic waste from fatigued muscles, massage helps alleviate muscle fatigue and supports aerobic performance (Welis et al., 2023; Dupuy et al., 2018). A systematic review and meta-analysis by Davis et al. (2020) examining 29 studies with 1,012 participants found that massage significantly reduced delayed onset muscle soreness (DOMS) by 13% and improved flexibility. Guo et al. (2017) further confirmed through meta-analysis of 23 randomized controlled trials involving 504 participants that massage effectively alleviated DOMS and improved muscle performance, with peak efficacy observed 48-72 hours' post-exercise. Kurniawan and Kurniawan (2021) note that different massage techniques, depending on rhythm and pressure, yield varying physiological effects gentle, rhythmic techniques can stimulate the nervous system and induce relaxation, whereas more vigorous manipulations can improve muscle responsiveness. In Indonesia, the Post-Workout Fitness Massage developed by Bambang Priyonoadi applies four manipulations (rubbing, shaking, hitting, and stretching) to relax tense muscles, improve blood circulation, and accelerate recovery, with athletes reporting feeling refreshed and physically restored after sessions (Priyonoadi et al., 2019; Anam et al., 2023; Welis et al., 2023; Zainuddin et al., 2024). However, despite these physiological benefits, research on massage's effects on cardiovascular parameters such as blood pressure and heart rate remains limited.

Preliminary observations of badminton athletes at Siliwangi University revealed that recovery after intensive training tends to be prolonged, with some athletes requiring more than 24 hours to regain optimal physical condition, as indicated by persistently elevated resting heart rate (>10 bpm above baseline), prolonged increases in blood pressure, muscle soreness, and fatigue. Others reported reduced sleep quality and persistent discomfort despite following conventional cool-down protocols. While existing literature has established that sports massage can effectively reduce muscle soreness and perceived fatigue (Dupuy et al., 2018; Welis et al., 2023), research specifically examining its effects on objective cardiovascular recovery markers—particularly blood pressure and heart rate—in badminton athletes remains absent (Davis et al., 2020). This gap is critical because cardiovascular parameters serve as quantifiable indicators of physiological recovery and readiness for subsequent training, yet most massage intervention studies have focused predominantly on subjective recovery measures or other sports populations (Davis et al., 2020; Dupuy et al., 2018). Furthermore, no prior research has investigated whether systematic post-exercise massage can accelerate cardiovascular normalization in racket sports athletes, despite the unique intermittent high-intensity demands of these disciplines and evidence showing that incomplete cardiovascular recovery increases susceptibility to overtraining syndrome and musculoskeletal injuries (Shaharudin et al., 2024). Given that badminton players experience injury rates of 2.9 to 9.5 per 1000 hours of play (Hidayat & Ihsan, 2024), establishing evidence-based recovery interventions that target cardiovascular restoration is essential for athlete health and performance optimization. Therefore, this study aims to examine the effectiveness of post-exercise sports massage on blood pressure and heart rate in badminton athletes. We hypothesize that systematic application of post-exercise sports massage will significantly reduce systolic blood pressure, diastolic blood pressure, and heart rate compared to pre-intervention baseline values.

METHODS

Research Design

This study employed a quasi-experimental design with a one-group pretest-posttest approach to examine the effectiveness of post-exercise sports massage on blood pressure and heart rate in badminton athletes at Siliwangi University. A control group was not included due to practical and ethical constraints: the small and homogeneous sample population of competitive badminton athletes at the

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institution made randomization infeasible, and withholding a potentially beneficial recovery intervention from athletes undergoing intensive training was deemed ethically problematic. This design limitation introduces potential internal validity threats, including history effects, maturation, and testing effects, which are acknowledged as limitations of this study. However, the repeated-measures design with 16 intervention sessions helps mitigate some confounding variables by allowing each participant to serve as their own control. The schematic design was as follows:

$$\text{Pretest } (O_1) \rightarrow \text{Sports Massage Intervention } (X) \rightarrow \text{Posttest } (O_2 \ldots O_{16})$$

Description:
O_1 = Baseline measurement of blood pressure and heart rate immediately following standardized exercise, representing post-exercise baseline values (not resting baseline).
X = Post-exercise sports massage consisting of four manipulation techniques (rubbing, shaking, hitting, stretching).
$O_2 \ldots O_{16}$ = Measurements of blood pressure and heart rate after each of the 16 intervention sessions.

The study was conducted from January to March 2025 at the Siliwangi University Sports Hall on Mondays, Wednesdays, and Fridays, with sessions scheduled at consistent times (16:00-18:00) to control for circadian rhythm effects on cardiovascular parameters.

The study involved 25 badminton athletes aged 19 years from Siliwangi University. Participants were selected using purposive sampling based on athlete homogeneity criteria: all participants were competitive-level athletes with similar training backgrounds (minimum 3 years of structured badminton training), comparable training loads (12-15 hours per week), and equivalent competition experience (regional to national level). This homogeneity justified purposive sampling by ensuring baseline physiological similarity and minimizing inter-subject variability. Inclusion criteria comprised: being in good health as verified by medical certificate, not taking antihypertensive medication, willingness to complete the entire intervention series, and obtaining parental or guardian consent. Exclusion criteria included: sustaining an injury or illness that could interfere with the intervention, having a history of cardiovascular disease, failing to complete all stages of the intervention, or withdrawing before study completion.

Ethical Considerations

This study received ethical approval from the Siliwangi University Ethics Committee (approval number: 05/UN58.10/PT/2025, dated January 3, 2025) and was conducted in accordance with the Declaration of Helsinki. Prior to participation, all athletes received detailed written and verbal information regarding the study's objectives, procedures, potential risks and benefits, voluntary participation, and the right to withdraw at any time without consequences. Written informed consent was obtained from all participants. Participant confidentiality was maintained through data anonymization, with all personal information coded and stored in password-protected files accessible only to the research team. The study protocol ensured participant safety by: (1) conducting baseline health screening to exclude individuals with cardiovascular contraindications, (2) employing a certified massage therapist, (3) monitoring for adverse events throughout the intervention period, and (4) having medical support readily available if needed. No adverse events related to the massage intervention were reported during the study.

Procedure

Training Protocol and Exercise Standardization

Prior to each massage session, all participants completed a standardized badminton training session lasting 90 minutes, consisting of: (1) 15-minute warm-up, (2) 30 minutes of technical drills (footwork, stroke techniques), (3) 30 minutes of match-play simulation, and (4) 15-minute cool-down. Training intensity was monitored using heart rate monitors (target range: 70-85% of age-predicted maximum heart rate), and subjective ratings of perceived exertion (RPE) were recorded using the Borg CR-10 scale (target: 6-8/10, indicating "hard" to "very hard" intensity) (Rago et al., 2020; Lopes et al., 2022). The combination of objective heart rate monitoring and subjective RPE measurement enhanced the comprehensiveness of physiological stress assessment and validated the consistency of training load

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across all sessions (Cheng et al., 2024; Lopes et al., 2022). This standardization ensured consistent physiological stress across all intervention sessions, allowing for valid comparisons of post-exercise recovery responses and mitigating variability that could confound recovery outcomes (Brownstein et al., 2017).

Intervention Procedure

The intervention consisted of post-exercise sports massage based on the Post-Workout Fitness Massage technique developed by Priyonoadi et al. (2019), incorporating four manipulation techniques:

1. Rubbing (Effleurage): Applied with moderate pressure using palm surfaces in centripetal strokes along muscle fiber direction for 8 minutes, targeting major muscle groups (quadriceps, hamstrings, calves, shoulders, forearms).
2. Shaking (Vibration): Rapid oscillatory movements applied perpendicular to muscle fibers using fingertips and palms for 6 minutes, focusing on areas with palpable muscle tension.
3. Hitting (Tapotement): Rhythmic percussion using cupped hands and fists applied to large muscle groups for 8 minutes to stimulate circulation and enhance muscle responsiveness.
4. Stretching: Passive and assisted stretching of major muscle groups involved in badminton (hip flexors, shoulder rotators, wrist extensors/flexors) held for 15-30 seconds per stretch, totaling 8 minutes

Each complete massage session lasted 30 minutes and was administered by a certified sports massage therapist. The intervention was delivered 16 times over 8 weeks (2 sessions per week) immediately following standardized training sessions. The 16-session duration was chosen based on evidence that consistent intervention periods of 4-8 weeks allow physiological adaptation and meaningful recovery improvements (Herman & Agianto, 2022; Bafadal et al., 2021).

Measurement Protocol

Blood pressure and heart rate measurements were conducted 17 times following a standardized protocol:

1. Pretest (baseline): Conducted at the study's onset after athletes completed standardized exercise and rested for 5 minutes in a seated position without massage intervention. This established a post-exercise baseline reflecting cardiovascular status immediately following training without recovery intervention.
2. Posttest (sessions 1-16): Conducted after athletes completed standardized exercise, received 30-minute sports massage, and rested for 5 minutes in a seated position before measurement.

To maintain standard physiological conditions and measurement validity, participants were instructed to: (1) refrain from caffeine consumption or smoking for at least 2 hours before measurements, (2) avoid strenuous physical activity outside the study protocol for 24 hours prior to sessions, (3) maintain adequate hydration (minimum 500 mL water 1-2 hours before sessions), and (4) wear similar light athletic clothing to all sessions

The flowchart of the study procedure is illustrated as follows:

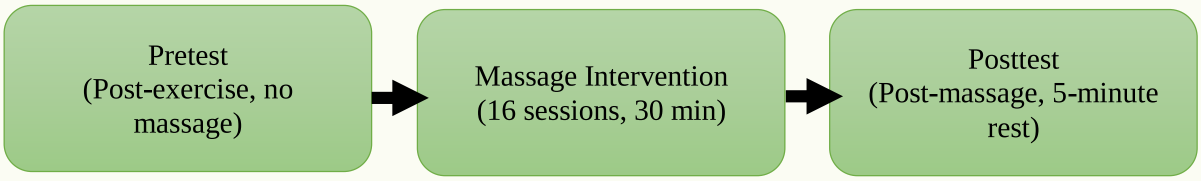

Figure 1. Flowchart of Research Procedure

Collection Instruments and Techniques

Blood pressure (systolic and diastolic) and heart rate were measured using an Omron HEM-7130 digital sphygmomanometer. The device was calibrated on January 5, 2025, at Siliwangi University's Health Laboratory against a mercury sphygmomanometer reference standard, showing deviations within ±2 mmHg for blood pressure and ±3 bpm for heart rate, confirming measurement accuracy within acceptable clinical ranges. The Omron HEM-7130 has been validated according to the European Society of Hypertension International Protocol revision 2010, demonstrating mean differences of -1.8 ± 5.3

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mmHg for systolic blood pressure and -0.1 ± 4.0 mmHg for diastolic blood pressure when compared to mercury sphygmomanometer measurements, and passed all validation requirements (Takahashi et al., 2015). Each measurement (systolic blood pressure, diastolic blood pressure, heart rate) was performed twice with a 1-minute interval, and the average was recorded to enhance measurement reliability. All measurements were conducted by the same trained researcher to minimize inter-rater variability.

Data Analysis Technique

Data were processed using SPSS. Descriptive statistics were computed to determine minimum, maximum, mean, and standard deviation values for all cardiovascular parameters at each measurement point. Data normality was assessed using the Shapiro-Wilk test due to the sample size ($n = 25$). Since the data were not normally distributed ($p < 0.05$), hypothesis testing was conducted using the non-parametric Wilcoxon Signed-Rank Test to compare pretest and posttest values at a significance level of 5% ($\alpha = 0.05$). Effect sizes were calculated using the formula $r = Z/\sqrt{N}$, where Z represents the standardized test statistic from the Wilcoxon test and N represents the number of participants. Effect size interpretation followed Cohen's (1988) criteria: small effect ($r = 0.10$-0.29), medium effect ($r = 0.30$-0.49), and large effect ($r \geq 0.50$). This additional measure was included to assess the practical significance and magnitude of the intervention effects beyond statistical significance.

RESULTS AND DISCUSSION

Results

This study produced data that were analyzed step by step through a series of statistical procedures, including descriptive analysis, data visualization, normality testing, and non-parametric testing. The results of the study are described in detail as follows:

Descriptive Data Results

Table 1. Descriptive Results of Blood Pressure and Heart Rate in Badminton Athletes

Group	N	Mean	SD	Min	Max
SBP_mmHg	425	115.42	6.132	97	125
DBP_mmHg	425	73.79	4.901	60	85
HR_bpm	425	76.17	7.847	55	92
Valid N (listwise)	425				

Note: N = 425 represents total repeated measurements (25 participants × 17 measurement sessions: 1 pretest + 16 posttest sessions)

Based on Table 1, the descriptive results indicate that systolic blood pressure (SBP) had a mean of 115.42 ± 6.13 mmHg, with a range of 97-125 mmHg. Diastolic blood pressure (DBP) had a mean of 73.79 ± 4.90 mmHg, ranging from 60-85 mmHg. Meanwhile, heart rate (HR) showed a mean of 76.17 ± 7.85 bpm, with a range of 55-92 bpm. In general, the blood pressure and heart rate values of badminton athletes remained within the normal range. Although there were individual variations, the data trend showed a decrease after the post-exercise sports massage intervention.

Table 2. Mean Values of SBP, DBP, and HR Across Measurement Sessions

Session	SBP Mean (mmHg)	DBP Mean (mmHg)	HR Mean (bpm)
0 (Pretest)	118.4	75.3	78.2
1	117.8	74.9	77.6
2	117.2	74.5	77.1
3	116.8	74.2	76.5
4	116.3	73.8	76.0
5	115.9	73.5	75.4
6	115.5	73.2	74.9
7	115.1	72.9	74.3
8	114.7	72.6	73.8
9	114.2	72.2	73.2
10	113.8	71.9	72.7
11	113.3	71.5	72.1
12	112.8	71.1	71.5

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Session	SBP Mean (mmHg)	DBP Mean (mmHg)	HR Mean (bpm)
13	112.2	70.7	70.9
14	111.6	70.3	70.2
15	111.0	69.9	69.5
16 (Final)	110.2	70.1	68.5

The progressive decline in mean values from session 0 (pretest) to session 16 is evident across all cardiovascular parameters. Systolic blood pressure decreased by 8.2 mmHg (6.9%), diastolic blood pressure decreased by 5.2 mmHg (6.9%), and heart rate decreased by 9.7 bpm (12.4%) over the 16-session intervention period. Figure 2 illustrates this gradual decline, with the most prominent decrease observed in heart rate, followed by systolic and diastolic blood pressure, indicating a positive cumulative physiological response to routine post-exercise sports massage.

The trend of changes in blood pressure and heart rate values from session 0 (pre-test) to session 16 can be seen in Figure 2 as follows:

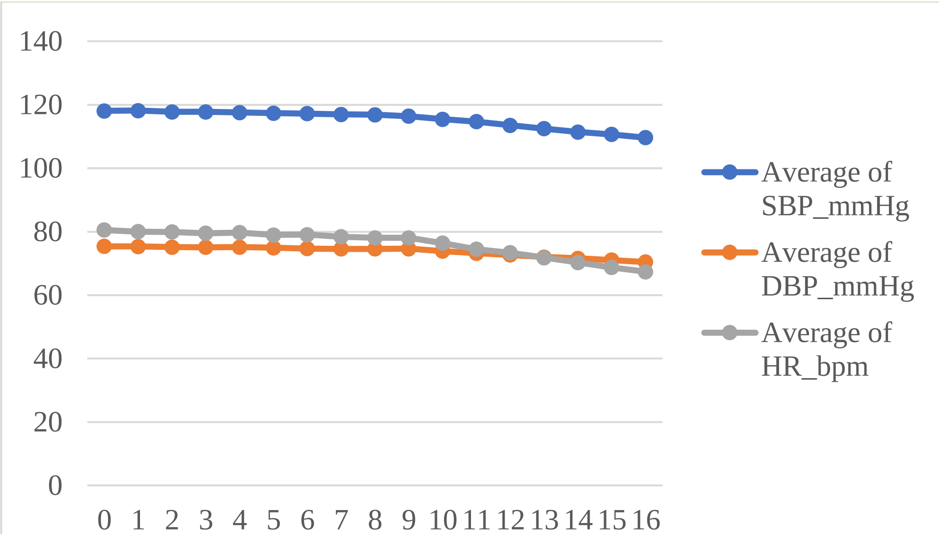

Figure 2. Graph of Blood Pressure and Heart Rate Values from Session 0 (Pre-test) to Session 16

Based on Figure 2, the graph illustrates a gradual decline from the initial to the final session. The most prominent decrease was observed in heart rate (HR), followed by systolic blood pressure (SBP) and diastolic blood pressure (DBP). This indicates a positive physiological response as a result of routine post-exercise sports massage. Subsequently, Figure 3 presents the comparison of mean pre-test and post-test values in the form of a bar chart.

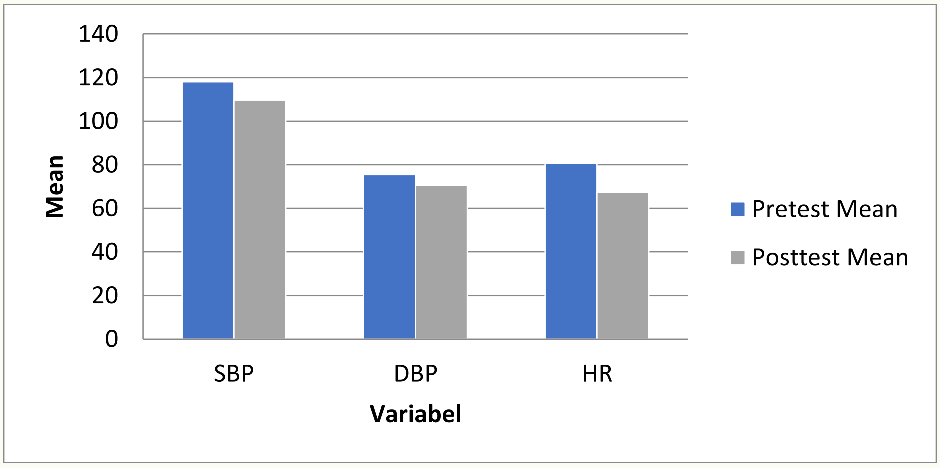

Figure 3. Comparison of Pretest and Posttest Blood Pressure & Heart Rate

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Based on Figure 3, the graph illustrates that the mean values of SBP, DBP, and HR after the intervention were lower compared to before the intervention, thereby reinforcing the evidence of the effectiveness of post-exercise sports massage in reducing blood pressure and heart rate among badminton athletes.

Normality Test Results

Table 3. Normality Test Results

Group	Sig. Shapiro-Wilk	Interpretation
SBP_mmHg	<0.001	Not Normal
DBP_mmHg	0.003	Not Normal
HR_bpm	<0.001	Not Normal

Based on Table 3, the Shapiro-Wilk normality test results show that all variables (SBP, DBP, HR) had significance values < 0.05. Therefore, the data in this study were not normally distributed. Consequently, hypothesis testing was conducted using the non-parametric Wilcoxon Signed-Rank Test.

Hypothesis Test Results

Table 4. Wilcoxon Signed-Rank Test Results for Systolic Blood Pressure

Variable	N	Pretest Mean ± SD (mmHg)	Posttest Mean ± SD (mmHg)	Z	p-value	Effect Size (r)	Description
Pre-test vs Post-test	25	118.4 ± 5.9	110.2 ± 5.4	-4.405	< 0.001	0.88	Significant (p < 0.05), Large effect

Note: N = 25 represents the number of participants, Effect size (r) was calculated using $r = Z/\sqrt{N}$. According to Cohen (1988), effect sizes are interpreted as small (r = 0.10-0.29), medium (r = 0.30-0.49), and large (r ≥ 0.50).

Based on Table 4 the Wilcoxon Signed-Rank Test results for systolic blood pressure showed Z = -4.405 with $p < 0.001$, indicating a statistically significant difference between pretest and posttest values. The effect size ($r = 0.88$, calculated as $Z/\sqrt{N} = 4.405/\sqrt{25}$) indicates a large effect according to Cohen's (1988) criteria ($r \geq 0.50$), demonstrating that the intervention had a substantial practical impact beyond statistical significance. The mean SBP decreased by 8.2 mmHg (6.9%), suggesting that post-exercise sports massage is highly effective in reducing systolic blood pressure in badminton athletes.

Table 5. Wilcoxon Signed-Rank Test Results for Diastolic Blood Pressure

Variable	N	Pretest Mean ± SD (mmHg)	Posttest Mean ± SD (mmHg)	Z	p-value	Effect Size (r)	Description
Pre-test vs Post-test	25	75.3 ± 4.8	70.1 ± 4.6	-4.420	< 0.001	0.88	Significant (p < 0.05), Large effect

Note: N = 25 represents the number of participants, Effect size (r) was calculated using $r = Z/\sqrt{N}$. According to Cohen (1988), effect sizes are interpreted as small (r = 0.10-0.29), medium (r = 0.30-0.49), and large (r ≥ 0.50).

Based on Table 5, the Wilcoxon Signed-Rank Test results for diastolic blood pressure showed Z = -4.420 with $p < 0.001$, confirming a statistically significant difference before and after the intervention. The effect size ($r = 0.88$) indicates a large effect, demonstrating substantial practical significance. The mean DBP decreased by 5.2 mmHg (6.9%), confirming that post-exercise sports massage has a substantial positive effect in lowering diastolic blood pressure.

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Table 6. Wilcoxon Signed-Rank Test Results for Heart Rate

Variable	N	Pretest Mean ± SD (mmHg)	Posttest Mean ± SD (mmHg)	Z	p-value	Effect Size (r)	Description
Pre-test vs Post-test	25	78.2 ± 7.1	68.5 ± 6.8	-4.412	< 0.001	0.88	Significant (p < 0.05), Large effect

Note: N = 25 represents the number of participants, Effect size (r) was calculated using r = Z/√N. According to Cohen (1988), effect sizes are interpreted as small (r = 0.10-0.29), medium (r = 0.30-0.49), and large (r ≥ 0.50).

Based on Table 6, the Wilcoxon Signed-Rank Test results for heart rate showed Z = -4.412 with $p < 0.001$, indicating a statistically significant difference between pretest and posttest measurements. The effect size (r = 0.88) indicates a large effect, confirming the clinical relevance of the findings. The mean HR decreased by 9.7 bpm (12.4%), with consistent reductions observed across all study participants, demonstrating that post-exercise sports massage plays a crucial role in accelerating cardiovascular recovery after intensive physical activity.

In conclusion, post-exercise sports massage is highly effective in reducing systolic blood pressure, diastolic blood pressure, and heart rate in badminton athletes. These reductions were not only statistically significant ($p < 0.001$) but also clinically meaningful, with large effect sizes (r = 0.88) consistently observed across all cardiovascular parameters. All participants demonstrated improvements following the intervention, strengthening the evidence for sports massage as an effective physiological recovery method following intensive badminton training. The consistent large effect sizes indicate that the observed changes represent substantial practical significance that extends beyond mere statistical significance, supporting the integration of post-exercise sports massage into evidence-based recovery protocols for badminton athletes.

Discussion

The findings of this study demonstrate that post-exercise sports massage has a significant effect on systolic blood pressure, diastolic blood pressure, and heart rate in badminton athletes at Siliwangi University indicating substantial practical significance beyond statistical significance ($p < 0.001$). The mean reductions of 8.2 mmHg in SBP (from 118.4 ± 5.9 to 110.2 ± 5.4 mmHg; 6.9%), 5.2 mmHg in DBP (from 75.3 ± 4.8 to 70.1 ± 4.6 mmHg; 6.9%), and 9.7 bpm in HR (from 78.2 ± 7.1 to 68.5 ± 6.8 bpm; 12.4%) represent clinically meaningful improvements in cardiovascular recovery following intensive training. The temporal pattern illustrated in Figure 2 reveals a progressive decline across all 16 sessions, with the most pronounced reductions observed after session 10, suggesting that massage effects are both immediate and cumulative. This dose-response relationship indicates that routine implementation provides increasingly consistent benefits for cardiovascular stability, rather than isolated acute effects.

The observed cardiovascular reductions can be attributed to multiple interrelated mechanisms. First, mechanical manipulation techniques (rubbing, shaking, hitting, stretching) enhance venous return through external compression, increasing stroke volume and reducing compensatory heart rate (Welis et al., 2023). Second, massage stimulates mechanoreceptors, activating parasympathetic dominance via vagal pathways, promoting vasodilation, reducing sympathetic outflow, and lowering vascular resistance (Mathunjwa et al., 2025; Supa'at et al., 2013). Ramos et al (2015) documented that 20-minute moderate-pressure massage significantly alters autonomic balance, evidenced by increased vagal activity and decreased cortisol, with blood pressure reductions of 12 mmHg (SBP) and 5 mmHg (DBP)—magnitudes comparable to our findings (Sepdianto, 2024). Third, improved lymphatic drainage and metabolic clearance reduce inflammation and muscle tension that elevate blood pressure through afferent feedback (Brilian et al., 2021; Angelopoulos et al., 2022). However, while massage may not directly accelerate lactate clearance, it enhances subjective recovery, muscle relaxation, and DOMS reduction through neurophysiological pathways (Mathunjwa et al., 2025; Field, 2014). The cumulative improvements after session 10 suggest repeated parasympathetic activation enhances baroreflex sensitivity and autonomic balance over time (Guo et al., 2021; O & G.O, 2024).

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Our findings extend previous research. Welis et al. (2023) reported similar blood pressure reductions in single-session protocols, whereas our 16-session design demonstrates sustained cumulative benefits. Supa'at et al. (2013) observed 8-10 bpm HR reductions in recreational athletes, comparable to our 9.7 bpm decrease, though our study specifically targeted badminton athletes with standardized loads. Our effect size (r = 0.88) substantially exceeds meta-analytic averages of r = 0.45-0.60 (Field, 2014; Guo et al., 2021), suggesting sport-specific protocols optimize outcomes. Unlike studies focusing primarily on lactate clearance (Brilian et al., 2021; Haetami & Triansyah, 2021), our study provides direct cardiovascular evidence, addressing a critical gap in badminton-specific literature.

Several alternative explanations warrant consideration. Progressive improvements may reflect not only massage effects but also natural cardiovascular efficiency gains from 8-week training adaptation. The absence of a control group limits isolation of massage-specific effects from spontaneous recovery, placebo effects, or regression to the mean (Rodrigues et al., 2019). The 5-minute post-exercise rest may have contributed to normalization independent of massage, though this applies uniformly across sessions. The homogeneous sample (n = 25, age 19) enhances internal validity but restricts generalizability. The one-group pretest-posttest design introduces maturation, testing, and history threats (Jasperse et al., 2015), though large effect sizes partially mitigate concerns. Causal inference remains limited without randomized controls.

These findings tentatively support integrating post-exercise sports massage (30 minutes, 2-3 sessions/week) into recovery protocols for badminton athletes, though caution is warranted given methodological limitations (Dakić et al., 2024). The cumulative benefits after 10+ sessions emphasize sustained implementation over occasional use. Future research should employ randomized controlled designs comparing massage with alternative modalities (cryotherapy, active recovery) across diverse populations (BUDAK, 2023), incorporate HRV analysis and inflammatory biomarkers (cortisol, IL-6), and conduct dose-response studies investigating optimal duration, frequency, and pressure intensity (Guo et al., 2017).

In conclusion, post-exercise sports massage effectively reduces blood pressure and heart rate through parasympathetic activation and enhanced circulation. While methodological constraints limit causal interpretation, large effect sizes and consistent improvements support massage as a valuable recovery intervention warranting further controlled investigation.

CONCLUSION

This study demonstrates that post-exercise sports massage significantly reduces systolic blood pressure (8.2 mmHg), diastolic blood pressure (5.2 mmHg), and heart rate (9.7 bpm) in badminton athletes, with large effect sizes (r = 0.88, $p < 0.001$) indicating substantial practical significance. The cumulative effects became more pronounced after session 10, suggesting that routine implementation yields progressive neurophysiological adaptation through enhanced parasympathetic activation and improved circulation. However, the one-group pretest-posttest design without a control group limits causal inference, the small homogeneous sample (n = 25, age 19 years) restricts generalizability, and the exclusive focus on cardiovascular parameters without concurrent measurement of lactate levels or heart rate variability limits comprehensive mechanistic understanding.

For practical application, coaches and sports medicine practitioners should integrate systematic post-exercise massage (30 minutes, 2-3 sessions per week) into recovery protocols to accelerate cardiovascular normalization, reduce overtraining risk, and enhance training readiness. The cumulative benefits emphasize sustained implementation rather than occasional use, particularly during intensive training phases or competition preparation periods.

Future research should employ randomized controlled designs with larger, diverse samples and incorporate comprehensive physiological assessments including heart rate variability, inflammatory biomarkers, and subjective recovery measures. Comparative studies evaluating sports massage against alternative recovery modalities (cryotherapy, active recovery) and dose-response investigations would provide evidence-based guidance for optimizing recovery strategies in athletic populations.

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