Exploring the impact of strength training methods on blood pressure and heart rate variability: a comparative analysis of traditional, superset, and tri-set approaches

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Keywords: Resistance training, Post-exercise hypotension, Autonomic nervous system, Hypotension, Sympathetic modulation, Parasympathetic modulation.

Abstract

Objective: **We compared the effects of three strength training (ST) methods – traditional, superset, and tri-set – on blood pressure (BP) and heart rate variability (HRV) to determine the optimal approach for maximizing cardiovascular benefits.**

Patients and Methods: **Nine men participated, completing three ST sessions consisting of 3 sets of 8-10 repetitions at 70% of their one-repetition maximum (1RM), with 90-second rest intervals. BP and HRV were assessed before and after each session.**

Results: **Findings revealed that systolic blood pressure (SBP) decreased for up to 60 minutes following the traditional method, while both the superset and tri-set methods exhibited decreases at 30- and 40-minutes post-session ($p \leq 0.05$). Diastolic blood pressure (DBP) showed declines at 10 and 30 minutes after the superset and tri-set methods, and mean blood pressure (MBP) experienced decreases at 10, 30, and 40 minutes following both methods ($p \leq 0.05$). A consistent sympathetic predominance was observed across all ST methods ($p \leq 0.05$), indicating substantial cardiovascular stress during sessions. Differences in heart rate variability (HRV) metrics were noted between the traditional and tri-set methods, specifically in the standard deviation of all NN intervals (SDNN) at 10 and 40 minutes ($p = 0.036$) and the root mean square of successive RR intervals (RMSSD) at 30 minutes ($p = 0.037$).**

Conclusions: **These findings offer valuable insights to professionals in strength training for optimizing BP reduction and minimizing cardiac stress in customized ST programs.**

Introduction

Strength training (ST) plays a crucial role in any comprehensive exercise program, as emphasized by the American College of Sports Medicine (ACSM)[1]. It can have positive impacts on several health-related outcomes, including the control of blood pressure[1], through a variety of mechanisms, which include reducing resting blood pressure, enhancing blood vessel function at the endothelial level, increasing arterial flexibility, counteracting arterial stiffness, enhancing metabolism, improving overall fitness, reducing body fat as well as the risk of hypertension, and improving overall cardiovascular health. However, despite the growing body of scholarly evidence, further research is needed to investigate the specific effects of different ST methods on blood pressure regulation and the autonomic nervous system (ANS). Remarkably, the focus lies on the potential of ST to aid in blood pressure control through the occurrence of post-exercise hypotension (PEH), which refers to a reduction in blood pressure values following an exercise session compared to resting levels[1,2]. Notably, PEH has significant clinical implications, especially when it occurs with greater magnitude and duration[3]. Under such conditions, PEH has been associated[4,5] wi th long-term blood pressure control in individuals with hypertension as well as normotensive subjects.

Effective management of ST variables is a crucial strategy for eliciting various physiological adaptations[6] and achieving differential blood pressure responses following ST sessions. Previous studies[7-13] have demonstrated the influence of different ST variables on blood pressure, including training intensity[7], volume[7], rest interval[8], exercise order[9], and methods[10-13]. Superset (SS) refers to a combination of exercises, typically two, performed successively, targeting different muscle groups[13], while tri-set (TS) involves the performance of three consecutive exercises followed by a rest period[14]. Studies[13] comparing SS, TS, and the traditional method (TD), which consists of a single set followed by a rest, have already been conducted. However, given the numerous possibilities for combining these methods with other ST variables to optimize PEH, further investigation is necessary.

The existing literature lacks consensus on the influence of different ST methods on PEH or the underlying mechanisms that may mediate the variable blood pressure responses. One possible mechanism that merits consideration is heart rate (HR) variability (HRV). HRV serves as a physiological marker that can be influenced by an ST session[13,15]. It offers a non-invasive means of assessing the cardiovascular system and interactions with the ANS at rest, during exercise, and in the post-exercise period[16]. Increased sympathetic activity following an ST session[17] is associated with elevated mortality risk, even in healthy individuals[18]. Furthermore, HRV assessment can provide valuable insights into the mechanisms underlying PEH[19].

Previous studies[11,13,20,21] have examined the effects of SS and TS methods on blood pressure and HRV. In these investigations, upper limb exercises were predominantly employed in the SS protocols with an agonist-antagonist order, while the TS protocols involved exercises targeting the same muscle group. However, a recent study[22] demonstrated that a whole-body ST protocol elicited more pronounced PEH compared to protocols focusing on either upper or lower limbs. Additionally, a study[9] revealed that exercise order within an ST session influences blood pressure and HRV responses. Consequently, additional information regarding blood pressure and HRV responses following an ST session with exercise order variations not previously explored would aid in the design of effective ST sessions. Hence, the aim of this study was to compare the responses of blood pressure, HRV, training volume (TV), and training efficiency (TE) following an ST session performed using the traditional (TD), superset (SS), and tri-set (TS) methods. The hypothesis posits that TD, SS, and TS methods would all induce PEH, resulting in reduced HRV, with no significant differences observed between the methods.

Patients and Methods

Prior to the commencement of the ST sessions, several measurements were taken to assess systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), HR, and HRV in both frequency and time domains. These measurements were conducted after a 10-minute passive rest period upon the subjects' arrival at the laboratory and, then, at 10-minute intervals for a total duration of 60 minutes following each experimental condition. The blood pressure and HRV assessments began promptly, within 1 minute after the completion of the ST session.

To establish a robust research design, a within-subject repeated-measures approach was adopted, allowing each subject to serve as their own control. This necessitated a total of 5 visits to the laboratory, which were scheduled on nonconsecutive days. During the first and second visits, anthropometric measurements were obtained, and the subjects underwent the one-repetition maximum (1RM) test and retest to ensure the reproducibility of the loads. Subsequently, from the third to the fifth visit, the subjects were randomly assigned to three different experimental conditions: TD, SS, and TS.

The experimental sessions encompassed specific exercises, namely Bench Press (BP), 45° Angled

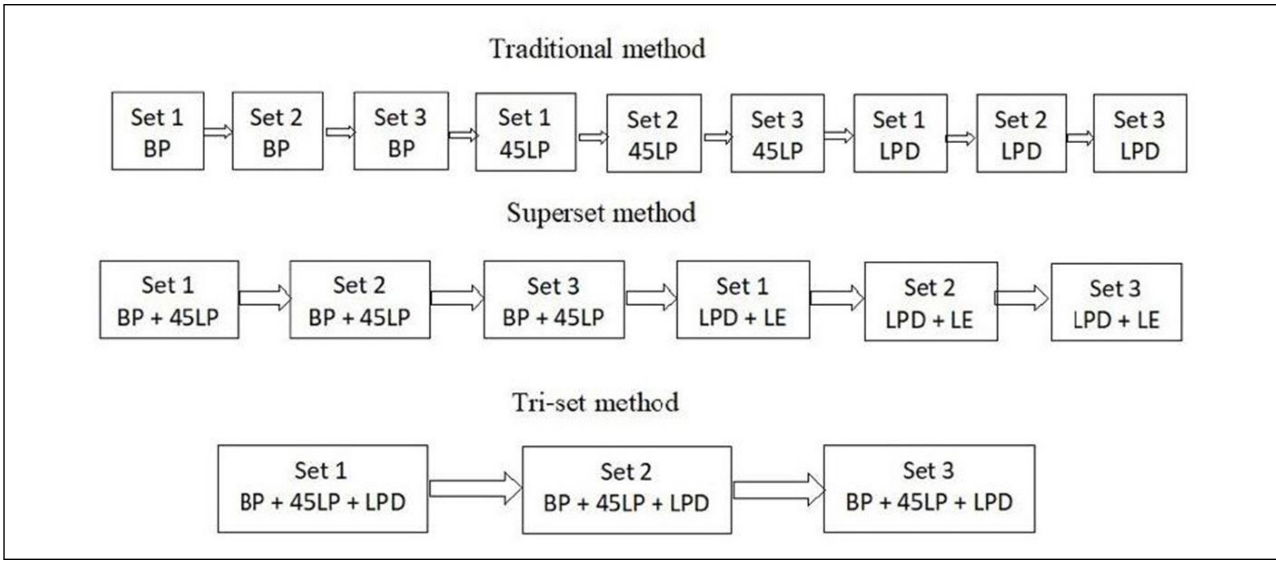

Figure 1. Study design using an example in the first exercises performed during each protocol.
BP: bench press, 45LP: 45 angled leg press, LPD: lat pulldown, LE: leg extension, SP: shoulder press, LC: leg curl, arrows: 90 seconds rest period.

Leg Press (45LP), Lat Pulldown (LPD), Leg Extension (LE), Shoulder Press (SP), and Leg Curl (LC). It is worth noting that the subjects were instructed to abstain from consuming any caffeinated or alcoholic beverages throughout the study period while maintaining their regular dietary habits. For a visual representation of the study design, see Figure 1.

Study Population

Nine normotensive men with a minimum of five years of experience in recreational ST voluntarily participated in this study. Table 1 presents the characteristics of the subjects. To determine the appropriate sample size and minimize the likeli-

Table 1. Physical and functional characteristics of the subjects.

Variables	Mean ± SD	Variables	Mean ± SD
n = 9			
Age (y.)	30.78 ± 4.18	HFnu	29.93 ± 14.12
Body mass (Kg)	78.22 ± 12.48	LF/HF	2.84 ± 1.36
Height (m)	1.75 ± 0.09	SDNN (ms)	49.89 ± 27.02
BMI (Kg/m^2)	25.37 ± 1.96	RMSSD (ms)	47.42 ± 40.36
ST experience (y)	3.17 ± 2.52	HR (bpm)	69.15 ± 14.34
ST frequency (d.w)	3.89 ± 0.78	1-RM BP (Kg)	64.56 ± 20.97
SBP (mmHg)	114.56 ± 5.85	1-RM 45LP (Kg)	280.00 ± 82.16
DBP (mmHg)	66.19 ± 8.76	1-RM LPD (Kg)	61.78 ± 18.16
MBP (mmHg)	77.67 ± 5.36	1-RM LE (Kg)	100.89 ± 2.67
VLF (ms^2)	180.67 ± 130.48	1-RM SP (Kg)	45.33 ± 8.94
LFnu	70.01 ± 14.17	1-RM LC (Kg)	83.99 ± 9.28

BMI: body mass index; ST: strength training; SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; VLF: very low frequency; LF: low frequency; HF: high-frequency; LF/HF: low frequency to high-frequency ratio; SDNN: standard deviation of NN intervals; RMSSD: root mean square of successive RR interval differences; HR: heart rate; BP: bench press; 45LPD: 45 angled leg press; LPD: lat pulldown; LE: leg extension; SP: shoulder press; LC: leg curl; y.: years; d.w: days a week; Kg: kilograms; m: meters; nu: normalized units; ms: milliseconds; bpm: beats per minute; SD: standard deviation.

hood of a type II error, a post-hoc statistical power analysis was conducted using G*Power software (version 3.1.94, Heinrich-Heine-Universität, Düsseldorf, Germany). The analysis was based on the effect size calculated from the criterion with Pillai's trace = 1.964. The parameters used were as follows: effect size = 7.38, $\alpha = 0.05$, total sample size = 9, number of groups = 3, and number of measurements = 8. The calculated sample size provided more than 80% statistical power, indicating sufficient participant numbers.

Participants were selected based on the following inclusion criteria: (a) nonsmokers, (b) absence of metabolic disease, (c) negative Physical Activity Readiness Questionnaire (PARQ)[1], (d) not taking any medication, and (e) no use of steroids. The study received approval from the Ethics Committee of Rio de Janeiro Federal University (number: 86506318.0.0000.5257). Prior to participation, all individuals were fully informed about the study procedures, potential risks, and benefits, and they provided informed consent by signing a consent form.

1RM Testing

During the initial laboratory visit, the participant's height and body mass were measured using a scale and stadiometer (Welmy, Brazil). Subsequently, the 1RM testing was conducted according to the procedures outlined by past research[23]. The 1RM test began with a warm-up set at 50% of the predicted 1RM. Following the warm-up, the load was progressively increased to the predicted 1RM for the first attempt. If a participant failed to achieve the 1RM, an additional attempt was allowed after a five-minute rest period. Each participant had a maximum of three attempts during the 1RM testing session. The highest load successfully lifted was recorded as the 1RM. To establish the reliability of the 1RM values, the same protocol was repeated in the same exercise order and conditions during a second laboratory visit scheduled 48 to 72 hours later[23].

The data obtained from the 1RM test and re-test days were analyzed using intraclass correlation coefficients (ICCs) to assess the reliability. The results showed high reliability for most exercises, as indicated by the following ICC values: BP, $r = 0.996$; LP45, $r = 0.995$; LPD, $r = 0.998$; SP, $r = 0.983$; LC, $r = 0.945$. However, the ICC for LE demonstrated lower reliability ($r = 0.457$). Several strategies were employed to minimize potential errors.

Participants were provided with detailed information regarding the procedures beforehand.

Standardized instructions regarding proper technique were given to the participants prior to the testing.

Verbal encouragement was provided to the participants during the testing process.

The accuracy of the bars and weights used in the testing was ensured.

The technique and range of motion for the exercises followed the guidelines set by the National Strength and Conditioning Association[23].

ST Sessions

Each ST session was meticulously designed and executed in a randomized order to ensure unbiased results. The ST protocol consisted of the following exercises: BP, 45LP, LPD, LE, SP, and LC. Free weights were utilized for BP and SP exercises, while resistance machines were employed for 45LP, LPD, LE, and LC exercises.

After the initial rest period for blood pressure and HRV assessment, the participants commenced their warm-up, which involved one set of 10 repetitions for both BP and 45LP exercises, performed at 50% of their respective 1RM, with a one-minute rest interval between sets. Subsequently, all exercises were performed for three sets, consisting of 8 to 10 repetitions each, at an intensity of 70% of the 1RM. A rest interval of 90 seconds was allowed between sets and exercises. This ST protocol[7], previously utilized, aligns with the recommended ST prescription for managing blood pressure[1]. The transition between eccentric and concentric phases of each exercise was performed without any pause, and a rest interval was provided after each set and exercise during the TD session. In the SS and TS sessions, the rest interval was implemented after each group of exercises: SS involved BP + 45LP, LPD + LE, and SP + LC, while TS included BP + 45LP + LPD and LE + SP + LC (Figure 1).

The number of repetitions performed during each exercise was meticulously recorded to calculate the TV of work, which is the product of the load and the total number of repetitions. To assess TE in terms of kilograms per minute ($kg.min^{-1}$), the TV was divided by the duration of the training session in minutes, following the methodology outlined by a preceding study[14]. A timer was initiated at the beginning of the warm-up and ceased at the completion of the final repetition of the last exercise. Participants were strictly instructed not to employ the Valsalva maneuver during the sessions. The experimental sessions were separated by a 48- to 72-hour period and were conducted on the same day, in accordance with previous studies[8,24].

Blood Pressure Assessment

To measure SBP, DBP, and MBP, an oscillometric device (Contec, PM50 NIBP/Spo2, Qinhuangdao, Hebei, China) was employed. The blood pressure measurements adhered to the guidelines and recommendations set forth by the American College of Cardiology and the American Heart Association[25]. All blood pressure assessments were conducted in a quiet and temperature-controlled environment, maintained at 21-23° Celsius.

The blood pressure evaluation involved a standardized protocol. After a 10-minute period of passive rest in a seated position, the resting blood pressure value (Pre) was determined by averaging three consecutive measurements taken at five-minute intervals. Following each ST session, the blood pressure was assessed under the same conditions. Immediately after the session (post-0), blood pressure measurements were obtained, and subsequently, additional measurements were taken at 10-minute intervals over a duration of 60 minutes (post-10, post-20, post-30, post-40, post-50, and post-60). This allowed for a comprehensive evaluation of the post-exercise blood pressure response.

Measures of Heart Rate Variability and Heart Rate

A Polar® RS800cx heart rate monitor from Finland was employed to collect HR data[26]. HR measurements were taken for a duration of 10 minutes before and 60 minutes after each ST protocol. The recorded HR data were then downloaded and exported as a text file for subsequent analysis using the Kubios heart rate variability software (version 3.1, University of Eastern Finland, Kuopio, Finland). The HRV analysis followed the recommendations outlined[26].

The HRV analysis encompassed two primary parameters: (1) time-domain analysis, which included the standard deviation of all NN intervals (SDNN) and the root mean square of successive RR intervals (RMSSD), and (2) frequency-domain analysis, utilizing the Fast Fourier Transform algorithm. The frequency bands analyzed included the very-low-frequency (VLF) band (0.0033-0.04 Hz), which is associated with thermoregulation and hormonal responses; the low-frequency band in normalized units (LF-nu) (0.04-0.15 Hz), indicative of sympathetic modulation; the high-frequency band in normalized units (HF-nu) (0.15-0.4 Hz), reflective of parasympathetic modulation; and the low-frequency to high-frequency ratio (LF/HF), representing the absolute and relative changes between the ANS components[16,26]. In the time domain, SDNN is correlated with VLF and LF-nu, while RMSSD is correlated with the HF band[16,26].

For data analysis, eight samples were utilized at specific time points. These time points included pre (0-10 minutes before each ST session) and post (post-0: 0-1 minutes; post-10: 1-10 minutes; post-20: 10-20 minutes; post-30: 20-30 minutes; post-40: 30-40 minutes; post-50: 40-50 minutes; post-60: 50-60 minutes). The duration of the recording aligns with previous descriptions[16,26]. Mean HR values obtained at each time point were adopted for the HR analysis.

Statistical Analysis

Normality and homoscedasticity were assessed using the Shapiro-Wilk and Levene's tests, respectively. Descriptive statistics, including the mean and standard deviation (SD), were used to summarize the variables. The test-retest reliability of the 1RM loads was assessed using the intraclass correlation coefficient. To calculate the TV, the workload for each exercise was computed, and the sum of the workloads for all exercises comprised the TV of the protocol. The TV was divided by the time spent in each ST session to calculate the TE. A one-way analysis of variance (ANOVA) was conducted to compare the TV and TE among the different protocols. For the comparison of the resting values and post-exercise measures, multivariate ANOVA (MANOVA) with repeated measures was employed within and between sessions.

To identify statistically significant differences, the post hoc LSD test was utilized. Effect sizes (ESs) and delta values (Δ = pre-post) were calculated for SBP, DBP, MAP, and only ES for VLF, LF-nu, HF-nu, LF/HF, SDNN, RMSSD, and HR across all exercise sequences. ESs were categorized using the following scale: trivial (< 0.35), small (0.35-0.80), moderate (0.80-1.50), and large (> 1.5). The significance level (alpha) was set at $p \leq 0.05$, and all statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS version 24.0, IBM Corp., Armonk, NY, USA).

Results

According to the Shapiro-Wilk test, the 1RM data followed a parametric distribution, except for the LPD test and retest, LE test and retest, and SP retest. The blood pressure measures before the protocols showed a normal distribution. The HRV measures also exhibited a normal distribution, except for SDNN and RMSSD in TD, VLF, LF-nu, HF-nu, and RMSSD in SS, and VLF, LF-nu, HF-nu, SDNN, and RMSSD in TS. Homogeneity of variance was observed, except for VLF, LF/HF, and RMSSD in TD, VLF, LF-nu, HF-nu, SDNN, and RMSSD in SS, and VLF, SDNN, and RMSSD in TS, based on Levene's test.

Total Volume and Training Efficiency

The TV performed was as follows: TD = 13,454.00 ± 2,600.45 Kg; SS = 13,468.22 ± 2,597.42 Kg; TS = 13,456.33 ± 2,552.63 Kg. One-way ANOVA revealed no significant differences in TV between TD and SS (p = 0.991), TD and TS (p = 0.998), and SS and TS (p = 0.992). The TE was as follows: TD = 351.17 ± 71.85 $Kg.min^{-1}$; SS = 484.17 ± 95.81 $Kg.min^{-1}$; TS = 542.48 ± 96.27 $Kg.min^{-1}$. Significant differences were found in TE between TD and SS (p = 0.004) and TD and TS ($p < 0.001$). No differences were observed in TE between SS and TS (p = 0.176).

Systolic Blood Pressure

For SBP, significant reductions compared to Pre were observed at post-10 (p = 0.05), post-20 (p = 0.008), post-40 (p = 0.011), post-50 (p = 0.025), and post-60 (p = 0.046) in the TD method. The effect size (ES) data indicated that the most significant magnitude was observed at post-20 and classified as "moderate" (ES = -1.29; Δ = -8.33 mmHg). Following the SS method, SBP was significantly reduced compared to Pre from post-30 to post-40 (p = 0.019 and p = 0.037, respectively). The highest magnitude was observed at post-30 (moderate, ES = -1.09; Δ = -9.44 mmHg). After the TS method, SBP was significantly higher at post-0 than Pre (p = 0.05; ES = 0.87 – moderate; Δ = 6.89 mmHg). No PEH in SBP was observed after the TS method. There were no significant differences among the methods in SBP (Figure 2 and Table 2).

Diastolic Blood Pressure

For DBP, no significant differences were found after the TD method. The ES showed a "small" reduction at post-50 (ES = -0.71; Δ = -6.11 mmHg). Significant reductions at post-10 (p = 0.010) and post-30 (p = 0.030) compared to Pre were observed after the SS method. The highest magnitude was observed at post-10 (moderate, ES = -0.95; Δ = -8.89 mmHg). After the TS method, a significant reduction was found at the same time points as in the SS method (p = 0.015 and p = 0.045, respectively). The highest magnitude was observed at post-10 (moderate, ES = -1.65; Δ = 10.33 mmHg). There were no significant differences among the methods in DBP (Figure 2 and Table 2).

Mean Blood Pressure

For MBP, no significant differences were found after the TD method. The ES was "trivial" at post-50 (ES = -0.25; Δ = -2.44 mmHg). Significant reductions at post-10 (p = 0.010), post-30 (p = 0.030), and post-40 (p = 0.041) were observed after the SS method. The highest ES was observed at post-30 (moderate; ES = -1.02; Δ = -7.74 mmHg). After the TS method, a significant reduction was found at post-10 (p = 0.05) with a "moderate" magnitude (ES = -1.15; Δ = -7.72 mmHg). There were no significant differences among the methods in MBP (Figure 2 and Table 2).

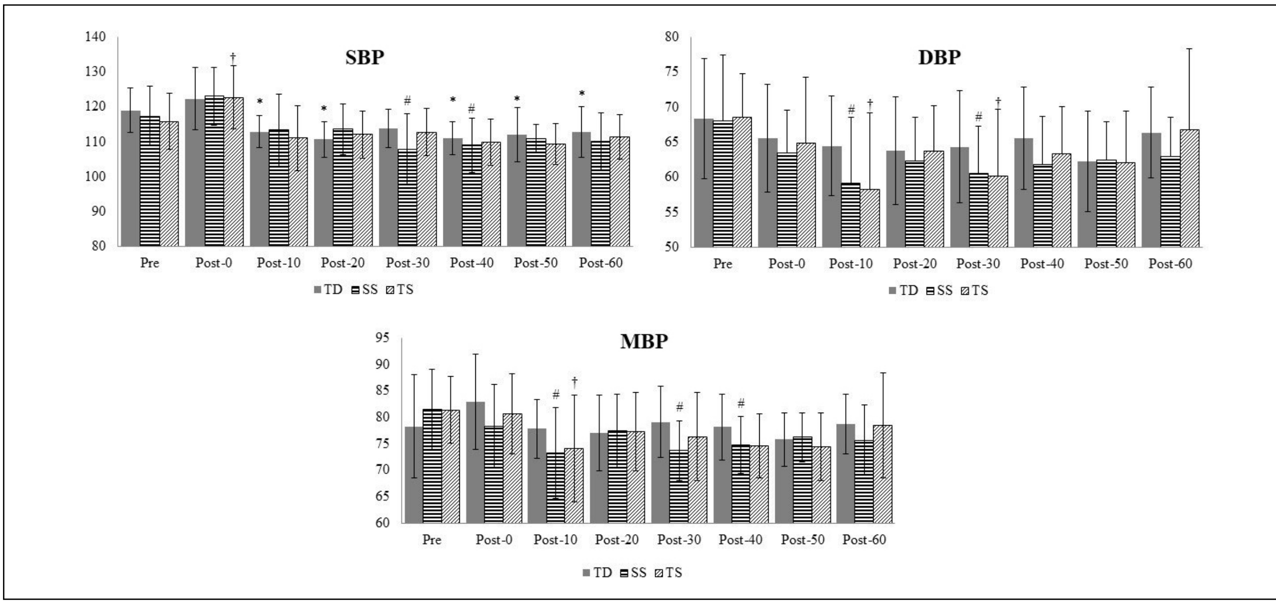

Figure 2. Systolic, diastolic, and mean blood pressure responses after traditional (TD), superset (SS), and tri-set (TS) methods (mean ± SD). Blood pressure: mmHg. *Significant difference from Pre in TD at that time point. #Significant difference from Pre in SS at that time point. † Significant difference from Pre in TS at that time point.

Table 2. Effect size and delta value: systolic, diastolic, and mean blood pressure after traditional, super set and tri-set.

		Post-0	Post-10	Post-20	Post-30	Post-40	Post-50	Post-60
SBP								
	ES	0.50	-0.94	-1,29	-0.81	-1.23	-1.08	-0.96
TD	Magnitude	Small	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.
	Δ	3.22	-6.11	-8.33	-5.22	-8.00	-7.00	-6.22
	ES	0.66	-0.46	-0.44	-1.09	-0.97	-0.76	-0.85
SS	Magnitude	Small	Small	Small	Mod.	Mod.	Small	Mod.
	Δ	5.67	-4.00	-3.78	-9.44	-8.33	-6.56	-7.33
	ES	0.87	-0.60	-0.48	-0.39	-0.75	-0.81	-0.56
TS	Magnitude	Mod.	Small	Small	Small	Small	Mod.	Small
	Δ	6.89	-4.78	-3.78	-3.11	-6.00	-6.44	-4.44
DBP								
	ES	-0.32	-0.45	-0.53	-0.46	-0.32	-0.71	-0.23
TD	Magnitude	Triv.	Small	Small	Small	Triv.	Small	Triv.
	Δ	-2.78	-3.89	-4.56	-4.00	-2.78	-6.11	-2.00
	ES	-0.48	-0.95	-0.60	-0.79	-0.66	-0.59	-0.53
SS	Magnitude	Small	Mod.	Small	Small	Small	Small	Small
	Δ	-4.56	-8.89	-5.67	-7.44	-6.22	-5.56	-5.00
	ES	-0.59	-1.65	-0.78	-1.35	-0.84	-1.05	-0.28
TS	Magnitude	Small	Large	Small	Mod.	Mod.	Mod.	Triv.
	Δ	-3.67	-10.33	-4.89	-8.44	-5.22	-6.56	-1.78
MBP								
	ES	0.48	-0.05	-0.13	0.09	-0.01	-0.25	0.05
TD	Magnitude	Small	Triv.	Triv.	Triv.	Triv.	Triv.	Triv.
	Δ	4.67	-0.44	-1.22	0.89	-0.11	-2.44	0.44
	ES	-0.40	-1.08	-0.52	-1.02	-0.87	-0.68	-0.76
SS	Magnitude	Small	Mod.	Small	Mod.	Mod.	Small	Small
	Δ	-3.07	-5.11	-3.96	-7.74	-6.63	-5.19	-5.74
	ES	-0.12	-1.15	-0.65	-0.79	-1.08	-1.09	-0.46
TS	Magnitude	Triv.	Mod.	Small	Small	Mod.	Mod.	Small
	Δ	-0.78	-7.22	-4.11	-5.00	-6.78	-6.89	-2.89

SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; TD: traditional; SS: superset; TS: tri-set; ES: effect size; Δ: delta value mmHg; Mod: moderate; Triv: trivial.

Heart Rate Variability – Frequency-Domain

In the HRV analysis by the frequency domain, there were no significant differences in VLF after the TD method. Significant reductions were observed in VLF after the SS compared to Pre from post-0 (p = 0.010) to post-10 (p = 0.019). After the TS method, significant reductions compared to Pre were found at post-0 (p = 0.002), post-10 (p = 0.003), post-20 (p = 0.004), post-30 (p = 0.012), and post-40 (p = 0.013). The highest magnitude in VLF was observed at post-0 in TD, SS, and TS (moderate, ES = -1.12; small, ES = -0.77; and moderate, ES = -0.80, respectively). The methods had no significant differences (Figure 3 and Table 3).

LF-nu increased significantly compared to Pre at all-time points after the TD method (post-0: p = 0.004; post-10: $p < 0.001$; post-20: $p < 0.001$; post-30: p = 0.001; post-40: $p < 0.001$; post-50: p = 0.005; post-60: p = 0.006). The highest magnitude was observed at post-20 (moderate; ES = 1.20). After the SS method, a significant increase compared to Pre was found at post-0 (p = 0.010), post-10 (p = 0.055), post-20 (p = 0.024), post-30 (p = 0.006), post-40 (p = 0.012), and post-50 (p = 0.016). The same pattern was observed after the TS method (post-0: p = 0.048; post-10: p = 0.037; post-20: p = 0.005; post-30: p = 0.001; post-40: p = 0.011; post-50: p = 0.034). The ES showed the highest magnitude at post-30 in the SS and TS methods (small, ES = 0.63; moderate, ES = 0.91, respectively). There were no significant differences among the methods (Figure 3 and Table 3).

For HF-nu, a significant reduction compared to Pre was observed at all-time points after the TD method (post-0: p = 0.004; post-10: $p < 0.001$; post-20: $p < 0.001$; post-30: p = 0.001; post-40: $p < 0.001$; post-50: p = 0.004; post-60: p = 0.006). The ES was "moderate" at post-20 (ES = -1.20). After the SS method, significant reductions related to Pre were found at post-0 (p = 0.010), post-10 (p = 0.055), post-20 (p = 0.023), post-30 (p = 0.006), post-40 (p = 0.012), and post-50 (p = 0.015). After the TS method, a significant reduction occurred at the same time points as in the SS method (post-0: p = 0.048; post-10: p = 0.036; post-20: p = 0.005; post-30: p = 0.001; post-40: p = 0.011; post-50: p = 0.035). The highest magnitude was also observed at post-30, with a "small" magnitude (ES = -0.63)

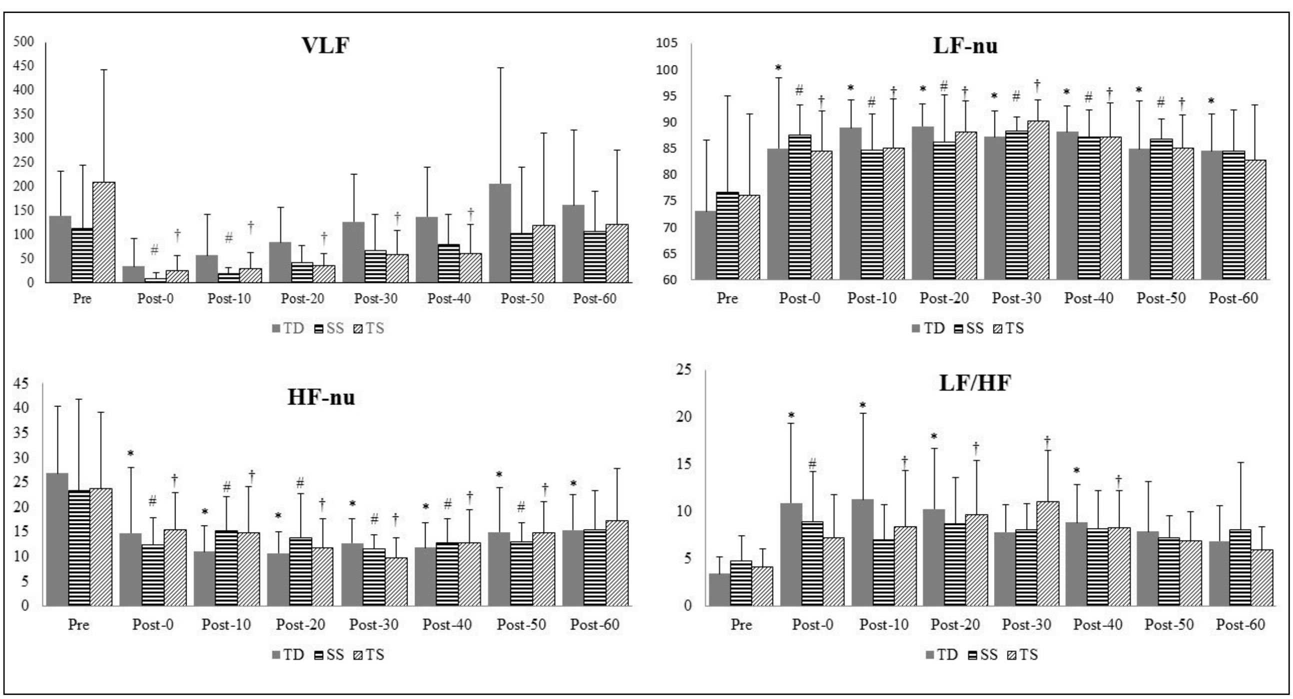

Figure 3. Very low frequency (VLF), low frequency (LF-nu), high frequency (HF-nu), and low frequency to high frequency ratio (LF/HF) after traditional (TD), superset (SS), and tri-set (TS) methods (mean ± SD).
*Significant difference from Pre in the TD method at that time point. #Significant difference from Pre in the SS at that time point. †Significant difference from Pre in the TS at that time point.

Table 3. Effect size: heart rate variability in the frequency domain.

		Post-0	Post-10	Post-20	Post-30	Post-40	Post-50	Post-60
VLF								
TD	ES	-1.12	-0.88	-0.59	-0.13	-0.02	0.72	0.24
	Magnitude	Mod	Mod.	Small	Trivial	Trivial	Small	Trivial
SS	ES	-0.77	-0.70	-0.53	-0.34	-0.25	-0.07	-0.04
	Magnitude	Small	Small	Small	Trivial	Trivial	Trivial	Trivial
TS	ES	-0.80	-0.77	-0.75	-0.65	-0.64	-0.39	-0.38
	Magnitude	Mod.	Small	Small	Mod.	Small	Small	Small
LF-nu								
TD	ES	0.89	1.17	1.20	1.05	1.12	0.88	0.85
	Magnitude	Mod.	Mod.	Mod	Mod	Mod	Mod	Mod
SS	ES	0.59	0.44	0.52	0.63	0.58	0.55	0.42
	Magnitude	Small	Small	Small	Small	Small	Small	Small
TS	ES	0.54	0.58	0.78	0.91	0.71	0.58	0.43
	Magnitude	Small	Small	Small	Mod.	Small	Small	Small
HF-nu								
TD	ES	-0.90	-1.18	-1.20	-1.05	-1.12	-0.88	-0.85
	Magnitude	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.
SS	ES	-0.59	-0.44	-0.52	-0.63	-0.57	-0.55	-0.42
	Magnitude	Small	Small	Small	Small	Small	Small	Small
TS	ES	-0.55	-0.58	-0.78	-0.91	-0.71	-0.59	-0.43
	Magnitude	Small	Small	Small	Mod.	Small	Small	Small
LF/HF								
TD	ES	4.21	4.43	3.85	2.47	3.05	2.50	1.94
	Magnitude	Large	Large	Large	Large	Large	Large	Large
SS	ES	1.55	0.81	1.46	1.24	1.26	0.90	1.23
	Magnitude	Large	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.
TS	ES	1.67	2.29	2.97	3.70	2.22	1.45	0.96
	Magnitude	Large	Large	Large	Large	Large	Mod.	Mod.

TD: traditional; SS: superset; TS: tri-set; VLF: very-low frequency; LF-nu: low frequency; HF-nu: high frequency; LF/HF: low frequency to high-frequency ratio; ES: effect size; Mod: moderate.

and a "moderate" magnitude (ES = -0.91) in the SS and TS methods, respectively. The methods had no significant differences (Figure 3 and Table 3).

LF/HF was significantly higher at post-0 (p = 0.008), post-10 (p = 0.005), post-20 (p = 0.014), and post-40 (p = 0.05) compared to Pre after the TD method. The magnitude was "large" (ES = 4.94). After the SS method, a significant increase was found only at post-0 (p = 0.049). The ES data demonstrated the highest magnitude (large; ES = 1.55). The same pattern was observed after the TS method. LF/HF significantly increased compared to Pre at post-10 (p = 0.041), post-20 (p = 0.009), post-30 (p = 0.001), and post-40 (p = 0.048). The most significant magnitude was observed at post-30 and classified as "large" (ES = 3.70). There were no significant differences among the methods (Figure 3 and Table 3).

Heart Rate Variability – Time-Domain

In the HRV analysis by the time domain, significant increases compared to Pre were found in SDNN at post-0 ($p < 0.001$), post-10 (p = 0.003), and post-20 (p = 0.05) after the TD method. After the SS method, a significant increase was observed at post-0 ($p < 0.001$), post-10 (p = 0.003), and post-20 (p = 0.05). After the TS method, SDNN increased significantly compared to Pre at post-0 ($p < 0.001$), post-10 ($p < 0.001$), post-20 (p = 0.001), post-30 (p = 0.004), post-40 (p = 0.011), and post-50 (p = 0.029). There was a significant difference between TD and TS at post-10 (23.85 ± 3.69 and 17.67 ± 12.47, respectively; p = 0.036) and post-40 (41.93 ± 16.95 and 31.44 ± 15.65, respectively; p = 0.038). The ES showed a "moderate" magnitude at post-0

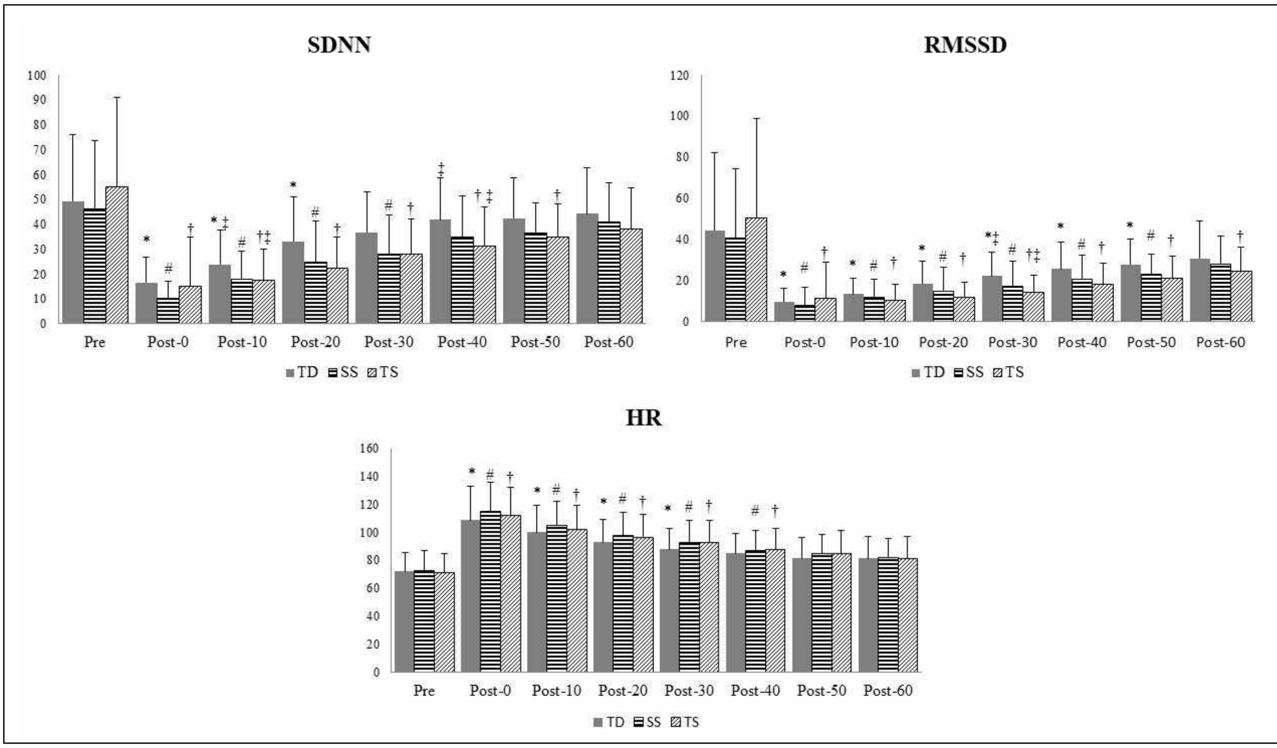

Figure 4. Standard deviation of all R-R intervals (SDNN), root mean square of successive differences (RMSSD), and heart rate (HR) responses after Traditional (TD), Superset (SS), and Tri-set (TS) methods (mean ± SD). *Significant difference from Pre in TD at that time point. #Significant difference from Pre in SS at that time point. †Significant difference from Pre in TS at that time point. ‡Significant difference between TD and TS at that time point.

in TD (ES = -1.22), SS (ES = -1.32), and TS (ES = -1.10) (Figure 4 and Table 4).

RMSSD reduced significantly compared to Pre after all methods. After the TD method, a significant difference was found at post-0 ($p < 0.001$), post-10 ($p < 0.001$), post-20 ($p = 0.003$), post-30 ($p = 0.004$), post-40 ($p = 0.026$), and post-50 ($p = 0.05$). After the SS method, significant differences were found at the same time points observed in the TD method (post-0: $p < 0.001$; post-10: $p < 0.001$; post-20: $p = 0.001$; post-30: $p = 0.002$; post-40: $p = 0.008$; post-50: $p = 0.020$). After the TS method, there was a significant reduction compared to Pre at all-time points (post-0: $p < 0.001$; post-10: $p < 0.001$; post-20: $p < 0.001$; post-30: $p < 0.001$; post-40: $p = 0.001$; post-50: $p = 0.003$; post-60: $p = 0.007$). Significant differences were found between TD and TS at post-30 (21.99 ± 11.71 and 14.35 ± 8.27, respectively; $p = 0.037$). The ES was "moderate" in all three methods. The highest magnitude was demonstrated at post-0 in TD (ES=-0.91) and SS (ES=-0.98), and at post-10 in TS (ES=-0.83) (Figure 4 and Table 4).

Heart Rate

HR was significantly increased at post-0 ($p < 0.001$), post-10 ($p = 0.001$), post-20 ($p = 0.011$), and post-30 ($p = 0.052$) after the TD method, at post-0 ($p < 0.001$), post-10 ($p < 0.001$), post-20 ($p = 0.001$), post-30 ($p = 0.009$), and post-40 ($p = 0.052$) after the SS method, and at the same time points after the TS method (post-0: $p < 0.001$; post-10: $p < 0.001$; post-20: $p = 0.002$; post-30: $p = 0.007$; post-40: $p = 0.035$). The highest magnitude in HR was "large" at post-0 after all methods (TD, ES = 2.73; SS, ES = 2.85; TS, ES = 3.03) (Figure 4 and Table 4).

Discussion

The aim of this study was to compare the effects of different ST methods, namely TD, SS, and TS, on blood pressure, HR, HRV, TV, and TE. The key findings of this study are as follows:

Table 4. Effect size: heart rate variability in the time domain.

		Post-0	Post-10	Post-20	Post-30	Post-40	Post-50	Post-60
SDNN								
TD	ES	-1.22	-0.81	-0.68	-0.59	-0.50	-0.44	-0.36
	Magnitude	Mod	Mod.	Small	Small	Small	Small	Small
SS	ES	-1.32	-0.86	-0.78	-0.71	-0.61	-0.53	-0.39
	Magnitude	Mod	Mod.	Mod.	Small	Small	Small	Small
TS	ES	-1.10	-0.83	-0.80	-0.75	-0.67	-0.60	-0.54
	Magnitude	Mod	Mod.	Mod.	Small	Small	Small	Small
RMSSD								
TD	ES	-0.91	-0.81	-0.68	-0.59	-0.50	-0.44	-0.36
	Magnitude	Mod.	Mod.	Small	Small	Small	Small	Small
SS	ES	-0.98	-0.86	-0.78	-0.71	-0.61	-0.53	-0.39
	Magnitude	Mod.	Mod.	Small	Small	Small	Small	Small
TS	ES	-0.81	-0.83	-0.80	-0.75	-0.67	-0.60	-0.54
	Magnitude	Mod.	Mod.	Mod.	Small	Small	Small	Small
HR								
TD	ES	2.73	2.09	1.56	1.18	0.96	0.70	0.69
	Magnitude	Large	Large	Large	Mod.	Mod.	Small	Small
SS	ES	2.85	2.18	1.69	1.38	1.01	0.82	0.65
	Magnitude	Large	Large	Large	Mod.	Mod.	Mod.	Small
TS	ES	3.03	2.29	1.85	1.57	1.22	1.00	0.75
	Magnitude	Large	Large	Large	Large	Mod.	Mod.	Small

TD: traditional; SS: superset; TS tri-set; SDNN: standard deviation of all R–R intervals; RMSSD: root mean square of successive differences; HR: heart rate; ES: effect size; Mod: moderate.

1) Blood pressure: ST sessions using TD and SS methods resulted in reductions in SBP at different durations, with TD showing a longer duration of reduction (60 minutes *vs*. 40 minutes). SS and TS methods led to reductions in DBP at the same time points (10 and 30 minutes). MBP was reduced with SS and TS methods, with SS showing a longer duration of reduction (40 minutes *vs*. 10 minutes).
2) HRV: After each ST session, a sympathetic predominance was observed in HRV measures. Significant differences were found between TD and TS methods in SDNN after 10 minutes and 40 minutes (TD < TS) and in RMSSD after 30 minutes (TD < TS), indicating greater cardiovascular stress at these time points after the TS method.
3) TV and TE: The alternation of upper and lower limb exercises in SS and TS methods proved to be an effective strategy for maintaining the TV with a higher TE compared to the TD method. The results partially confirmed the hypothesis. PEH with a sympathetic predominance was observed after all methods, with a significant difference in the time-domain HRV between TD and TS (TD < TS). However, the TS method was found to be more time-efficient than the TD method.
4) Blood pressure and HRV results: TD and SS methods demonstrated reductions in SBP with a longer duration after TD (60 minutes *vs*. 40 minutes). Additionally, reductions in DBP and MBP were observed with SS and TS methods, with a longer duration of reduction observed after SS (40 minutes *vs*. 10 minutes). The HRV analysis in the frequency domain showed a sympathetic predominance with a greater magnitude in TD compared to the SS method (LF-nu and HF-nu index in Table 2). PEH primarily occurs through a reduction in cardiac output, which is attributed to a decrease in stroke volume and systemic circulation. The withdrawal of vagal tone observed in the HRV analysis of this study was insufficient to compensate for the reduction in cardiac output despite the significant increase in HR observed for at least 30 minutes after TD and 40 minutes after SS and TS (HR index in Figure 4 and Table 3). The attenuated cardiovas-

cular baroreflex sensitivity inhibits the capacity of baroreceptors to compensate for these reductions in blood pressure, suggesting that blood pressure control mechanisms after ST sessions occur through central adjustments.

In this study, the variables were equalized, and it was found that SS and TS methods were more efficient than TD. These findings align partially with previous research conducted by Paz et al[13] (2019), who compared blood pressure and HRV responses after TD, paired agonist-antagonist set, and SS methods in trained men. They observed PEH with a sympathetic predominance independent of the method, along with significant differences in TV. The differences in TV may explain these results, as ST sessions with high TV reduce blood flow in active muscles, leading to greater activation of metaboreceptors, mechanoreceptors, and the arterial baroreflex.

The alternation of upper and lower limb exercises in the present study, along with longer rest intervals between sets and exercises for specific muscle groups, could explain the observed results by attenuating fatigue during subsequent sets and exercises. A study by other authors[27] evaluated men with experience in ST and focused on upper limb exercises, which resulted in no significant reductions in SBP, DBP, or MBP after a TS session compared to TD. On the other hand, past studies[22] demonstrated that a full-body protocol involving greater muscle mass elicited a greater magnitude of PEH. Although the present study did not show significant reductions in SBP after the TS method, the effect size was moderate after 50 minutes, indicating clinical relevance. Long-term studies[5] have established an association between PEH and blood pressure control in both hypertensive and normotensive individuals, highlighting the potential benefits of a long-term decrease in BP for reducing mortality from stroke and coronary disease.

The present study also revealed a sympathetic predominance after the TS method compared to TD, as evidenced by the differences in SDNN after 10 minutes and 40 minutes and RMSSD after 30 minutes (Figure 4). The greater lactate and creatine kinase concentration observed after TS sessions may contribute to a more significant contribution of anaerobic metabolism, contraction of fast-twitch muscle fibers, release of catecholamines, and accumulation of hydrogen ions, factors that rely on a marked sympathetic response. This is further supported by the significant differences observed in VLF until 40 minutes after the TS method (Figure 3). Thermoregulation plays a role in maintaining homeostasis during physiological stress, and the increase in sympathetic modulation and decrease in parasympathetic modulation observed after all sessions, regardless of the method, align with existing literature. This finding is clinically relevant as an increase in sympathetic activation combined with a reduction in parasympathetic tone may elevate the risk of cardiovascular events in patients with cardiovascular disease.

However, it is essential to consider the limitations of this study. Some individuals may exhibit varied responses to physical exercise, categorized as responsive or nonresponsive. Nonresponsive subjects may have influenced the analysis, which is dependent on mean and standard deviation. Additionally, the blood pressure response to exercise can be influenced differently by supine and seated positions due to orthostatic stress. Prolonged seated positions can affect HRV due to altered venous return and increased baroreflex activity. Although the seated position was adopted in previous studies[28], it is crucial to acknowledge its potential influence. Lastly, the study participants were normotensive and healthy individuals, and therefore, caution should be exercised when extrapolating the results to other populations, such as hypertensive or chronic disease patients.

Conclusions

In conclusion, this study demonstrated that the TD, SS, and TS methods, when incorporated in a full-body protocol with alternating upper and lower limb exercises, are effective for maintaining TV. Furthermore, the SS and TS methods proved to be more efficient than TD, as they allowed for the same load, number of sets, and repetitions to be performed in less time. However, it is important to note that the duration of the ST session, as observed in the TD method, plays a crucial role in achieving longer-lasting PEH in SBP. To promote longer PEH, increasing the number of sets and exercises in SS or TS protocols may be a viable strategy.

The findings of this study also indicated a significant withdrawal in vagal tone after each ST session, highlighting the role of sympathetic activation in mediating PEH. This suggests that the mechanisms underlying the reduction in blood pressure are dependent on central adjustments. Nonetheless, it is recommended that long-term studies be conducted to determine if this acute physiological adaptation persists throughout an ST program. Additionally, the greater sympathetic activation observed after TS compared to TD indicated a higher level of cardiac stress during the post-exercise period in TS sessions. To the best of the authors' knowledge, this was the first study to investigate the effects of the TS method on autonomic modulation.

Therefore, further research is warranted to examine the repercussions of the TS method in populations with different characteristics, such as individuals with chronic conditions. Additionally, manipulating methodological variables while utilizing the TS method should be explored. These results hold practical implications for strength and conditioning professionals working in gyms and conditioning centers. They can now prescribe ST exercises more accurately, considering the desired outcome of PEH and reduced cardiac stress post-exercise

Authors' Contributions:

Conceptualization, M.L.S.C.; methodology, M.L.S.C., T.C.F., B.M., C.J.B., and D.I.V.P.; software, M.L.S.C.; validation, E.A., B.F.S., R.S., and I.D.; formal analysis, M.L.S.C., T.C.F., B.M., C.J.B., D.I.V.P.; investigation, M.L.S.C.; resources, M.L.S.C.; data curation, M.L.S.C.; writing–original draft preparation, M.L.S.C., T.C.F., B.M., C.J.B., and D.I.V.P.; writing–review and editing, M.L.S.C., T.C.F., B.M., C.J.B., D.I.V.P., N.B., M.S., H.Z., E.A., B.F.S., R.S., and I.D.; project administration, M.L.S.C.; funding acquisition, M.L.S.C.; All authors have read and agreed to the published version of the manuscript.

Funding:

This research was funded by Taif University, Saudi Arabia, Project No. (TU-DSPP-2024-301).

Ethics Approval:

The investigation was conducted in accordance with the guidelines of the Declaration of Helsinki and received approval from the Ethics Committee of Rio de Janeiro Federal University (number: 86506318.0.0000.5257).

Informed Consent:

Informed consent was obtained from all the subjects involved in the study.

Data Availability:

Data generated by the investigation are included in the manuscript. Further data can be obtained upon request to the Corresponding Author.

Acknowledgments:

The authors extend their appreciation to Taif University, Saudi Arabia, for supporting this work through project number (TU-DSPP-2024-301).

Conflicts of Interest:

The authors declare no conflict of interest.

AI Disclosure:

The authors declare that no artificial intelligence was used in writing the text of this article.

References

1. American College of Sports Medicine. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc 2011; 43: 1334-1359.
2. Halliwill JR, Buck TM, Lacewell AN, Romero SA. postexercise hypotension and sustained postexercise vasodilatation: what happens after we exercise? Exp Physiol 2013; 98: 7-18.
3. Brito LC, de Fecchio RY, Peçanha T, Lima A, Halliwill J, Forjaz CLDM. Recommendations in post-exercise hypotension: concerns, best practices and interpretation. Int J Sports Med 2019; 40: 487-497.
4. Mota MR, Oliveira RJ, Dutra MT, Pardono E, Terra DF, Lima RM, Simões HG, Silva FM. Acute and Chronic effects of resistive exercise on blood pressure in hypertensive elderly women. J Strength Cond Res 2013; 27: 3475-3480.
5. Tibana RA, de Sousa NMF, Nascimento DDC, Pereira GB, Thomas SG, Balsamo S, Simões HG, Prestes J. Correlation between acute and chronic 24-hour blood pressure response to resistance training in adult women. Int J Sports Med 2015; 36: 82-89.
6. Schoenfeld BJ, Grgic J, Ogborn D, Krieger JW. Strength and hypertrophy adaptations between low- vs. high-load resistance training: a systematic review and meta-analysis. J Strength Cond Res 2017; 31: 3508-3523.
7. Figueiredo T, Rhea MR, Peterson M, Miranda H, Bentes CM, Reis VMdeR, Simão R. Influence of number of sets on blood pressure and heart rate variability after a strength training session. J Strength Cond Res 2015; 29: 1556-1563.
8. Figueiredo T, Willardson JM, Miranda H, Bentes CM, Reis VM, de Salles BF, Simão R. Influence of rest interval length between sets on blood pressure and heart rate variability after a strength training session performed by prehypertensive men. J Strength Cond Res 2016; 30: 1813-1824.
9. Figueiredo T, Menezes P, Kattenbraker MS, Polito MD, Reis VM, Simão R. influence of exercise order on blood pressure and heart rate variability after a strength training session. J Sport Med Phys Fit 2013; 53: 12-17.
10. Washio T, Vranish JR, Kaur J, Young BE, Katayama K, Fadel PJ, Ogoh S. Acute reduction in posterior cerebral blood flow following isometric handgrip exercise is augmented by lower body negative pressure. Physiol Rep 2018; 6: e13886.

11. Ghroubi S, Kossemtini W, Mahersi S, Elleuch W, Chaabene M, Elleuch MH. Contribution of isokinetic muscle strengthening in the rehabilitation of obese subjects. Ann Phys Rehabil Med 2016; 59: 87-93.
12. Gepfert M, Krzysztofik M, Kostrzewa M, Jarosz J, Trybulski R, Zajac A, Wilk M. The acute impact of external compression on back squat performance in competitive athletes. Int J Environ Res Public Health 2020; 17: 4674.
13. Paz GA, Iglesias-Soler E, Willardson JM, Maia MdF, Miranda H. Postexercise hypotension and heart rate variability responses subsequent to traditional, paired set, and superset training methods. J Strength Cond Res 2019; 33: 2433-2442.
14. Weakley JJS, Till K, Read DB, Roe GAB, Darrall-Jones J, Phibbs PJ, Jones B. The effects of traditional, superset, and tri-set resistance training structures on perceived intensity and physiological responses. Eur J Appl Physiol 2017; 117: 1877-1889.
15. Podstawski R, Bielec G, Borysławski K, Alföldi Z, Marzec A. Changes in the blood pressure, heart rate and body mass of physically active men in response to thermal stress. Cent Eur J Sport Sci Med 2022; 37: 65-76.
16. Shaffer F, Ginsberg JP. An Overview of heart rate variability metrics and norms. Front Public Heal 2017; 5: 1-17.
17. Farinatti P, Polito MD, Massaferri R, Monteiro WD, Vasconcelos D, Johnson BT, Pescatello LS, Postexercise hypotension due to resistance exercise is not mediated by autonomic control: a systematic review and meta-analysis. Auton Neurosci Basic Clin 2021; 234: 102825.
18. Prinsloo GE, Laurie Rauch HG, Derman WE. A brief review and clinical application of heart rate variability biofeedback in sports, exercise, and rehabilitation medicine. Phys Sportsmed 2014; 42: 88-99.
19. Romero SA, Minson CT, Halliwill JR. The cardiovascular system after exercise. J Appl Physiol 2017; 122: 925-932.
20. Audette JF, Jin YS, Newcomer R, Stein L, Duncan G, Frontera WR. Tai Chi versus brisk walking in elderly women. Age Ageing 2006; 35: 388-393.
21. Ficarra S, Thomas E, Pillitteri G, Migliore D, Gómez-López M, Palma A, Bianco A. Changes in quality of life, strength and heart rate variability after 4-weeks of supervised online burpees training during the covid-19 quarantine in healthy young adults: a pilot study. Kinesiology (Zagreb) 2022; 54: 116-125.
22. de Freitas MC, Ricci-Vitor AL, Quizzini GH, de Oliveira JVNS, Vanderlei LCM, Lira FS, Rossi FE. Postexercise hypotension and autonomic modulation response after full versus split body resistance exercise in trained men. J Exerc Rehabil 2018; 14: 399-406.
23. Brown L. Strength training/national strength and conditioning association. Human Kinetics Publishers 2017.
24. Sousa AC, Fernandes RJ, Boas JPV, Figueiredo P. High-intensity interval training in different exercise modes: lessons from time to exhaustion. Int J Sports Med 2018; 39: 668-673.
25. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, Ovbiagele B, Smith SC, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA, Williamson JD, Wright JT. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical. Pr J Am Coll Cardiol 2018; 71: e127-e248.
26. Laborde S, Mosley E, Thayer JF. Heart rate variability and cardiac vagal tone in psychophysiological research - recommendations for experiment planning, data analysis, and data reporting. Front Psychol 2017; 8: 1-18.
27. Rodriguez D, Polito MD, Bacurau RFP, Prestes J, Pontes JrFL. Effect of different resistance exercise methods on post-exercise blood pressure. Int J Exerc Sci 2008; 1: 153-116
28. Holmes CJ, Winchester LJ, MacDonald HV, Fedewa MV, Wind SA, Esco MR. Changes in Heart Rate Variability and Fatigue Measures Following Moderate Load Resistance Exercise. J Exerc Physiol Online 2020; 23: 24-35.