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# Analysis of Post-Exercise Acute Hemodynamic Sustainability in Different Training Methods in Paralympic Powerlifting Athletes

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**Abstract:** Background: Paralympic powerlifting (PP) is one of the sports modalities that uses strength training with high loads, causing various physiological responses resulting from hemodynamic adaptations. Objective: To evaluate hemodynamic responses after traditional (TT) and eccentric (ET) training sessions in PP athletes. Methods: Twelve national-level PP athletes, aged: (Mean ± SD) 30.8 ± 10.05 years; 70.0 ± 16.1 kg. In the intervention, five sets of five repetitions (5 × 5) of the bench press at 80% of 1 repetition maximum (1RM) were used; in the TT and in the ET, 5 × 5 of the bench press with a load in the eccentric phase of 110% and that in the concentric phase of 80% of 1RM were used. Results: Compared to baseline, heart rate was significantly elevated at various times in the ET, between before and 20 min after ($p = 0.023$), and 40 min after ($p = 0.035$), but decreased to baseline in 24 h ($p = 0.043$, $\eta 2p = 0.395$). In addition, the product pressure rate in the ET had a decrease between the moments before and 60 min after ($p = 0.042$), and before and 24 h after ($p = 0.043$). A high effect on myocardial oxygen volume in ET at 24 h was found ($p = 0.018$; $\eta 2p = 0.393$). Conclusions: One session of traditional and eccentric training methods can be effective in causing significant changes in the cardiovascular system in PP athletes.

**Keywords:** hypotension; strength training; hemodynamics

## 1. Introduction

According to Triani et al. [1], physical exercise causes several physiological responses, resulting from metabolic and hemodynamic adaptations. These physiological responses can be verified through changes in heart rate (HR), blood pressure (BP), among others, which can be used as training evaluation parameters. According to Macdougall et al. [2] and Feriani et al. [3], during strength exercise, both systolic blood pressure (SBP) and diastolic blood pressure (DBP) tend to rise, causing a significant increase in mean arterial pressure (MBP), even for a short period of time. The change in the pressure response occurs because during exercise, cardiac output increases in the systemic attempt to supply the perfusion of the demand needed by the activated muscle [4]. This effect occurs due to the increase in cardiac frequency and contractility, as well as the vasoconstriction of the veins, increasing venous return and, consequently, the systolic volume. Another variable that can be used, as mentioned by Poton and Polito [5], would be the product pressure rate (PPR). The PPR can be considered the best noninvasive indicator, as it serves as a valid predictor of myocardial oxygen consumption during exercise. In stress tests, physiological elevations of PPR may indicate good conditions of coronary irrigation and myocardial function, while low values of PPR are associated with heart disease and a greater propensity to mortality (Antônio and Assis) [6].

With regard to hemodynamic changes, systemic arterial hypertension (SAH) stands out. The treatments for SAH are medication and the adoption of a healthy lifestyle [7]. Among nonpharmacological interventions, physical training programs stand out [8]. In this way, blood pressure (BP) increases during exercise but tends to decrease after its completion [9]. It is believed that post-exercise hypotension (PEH) plays an important role in BP control, as the magnitude of HPE is associated with chronic BP reductions induced by regular exercise programs [10]. However, the body can generate responses from the cardiovascular system, presenting physiological changes in blood pressure and heart rate, due to an acute reaction to the type of training [11]. According to Morais et al. [12], the oscillations in HR and BP would be derived from the sympathetic nervous system (SNS), which tend to influence the excretion of catecholamines, decreasing the sensitivity to sodium and muscle calcium and on the vascular peripheral resistance.

Still in relation to nonpharmacological interventions, sports practice, as mentioned, has been highlighted. Among the sports, in the modalities of strength, we have powerlifting (PWL), which is a sport that uses strength training with high loads, being known worldwide [13]. Paralympic powerlifting (PP) is one of the sports modalities adapted from the PWL. In PP, male and female athletes with lower-limb disabilities compete [14]. The sport is characterized by the movement of the bench press, in which the athlete has three attempts, aiming to lift the highest valid load as a final result [14].

In the same direction, some studies have indicated that wheelchair users tend to have a higher risk of systemic arterial hypertension (SAH) [15,16]. According to the same authors, this trend toward an increase in SAH would be associated with increased body weight, as well as decreased muscle tone and increased body fat in the lower limbs.

In this perspective, PWL training, as well as PP, has used the traditional training (João et al.) [13], and the eccentric training (Taber et al.) [17] has been used to improve strength.

In this sense, the statements regarding hemodynamic responses in relation to training methods for PP athletes are not conclusive [18,19]. In this direction, some previous studies show that when evaluating post-exercise hemodynamic responses in PP athletes from two sessions of high-intensity resistance training, there was no risk of hemodynamic overload and induced moderate PEH, with blood pressure adaptation up to 60 min after exercise [18,19]. Other studies demonstrate that high-intensity physical exercise can cause acute cardiac changes and chronic remodeling of the athlete's heart, and the clinical significance of these changes has remained uncertain [20–23]. Given the above, our study aimed to evaluate the hemodynamic responses after training sessions, in two different methods, traditional (TT) and eccentric (ET), in PP athletes.

## 2. Materials and Methods

### *2.1. Experimental Approach to the Problem*

The study was developed in three weeks, with one session each week (Figure 1). In the first week, the subjects were familiarized, signed the free and informed consent form, and performed the test of 1 maximum repetition (1RM). In the second week, the participants performed a traditional training session (TT) of the system of five sets of five repetitions ($5 \times 5$), with 80% of 1RM [24]. In the third week, an eccentric training (ET) session of the $5 \times 5$ system was used; however, the load in the eccentric phase was 110% and that in the concentric phase was 80% of 1RM [17]. Before and after training, hemodynamic variables were evaluated.

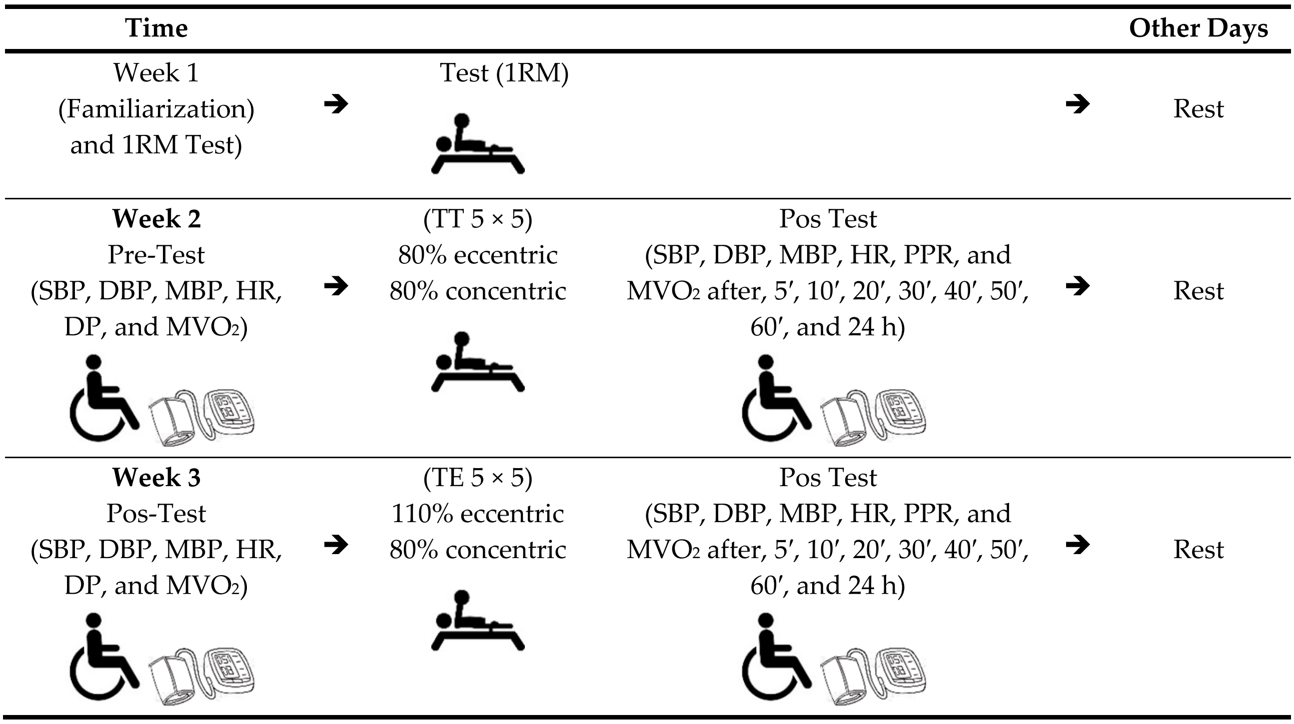


**Figure 1.** Experimental design. TT: Traditional training; TE: Eccentric training; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MBP: Medium blood Pressure; HR: Heart rate; PPR: Product Pressure rate, $MVO_2$: Myocardial oxygen volume: 1RM: one repetition maximum; 5 × 5: five sets of 5 repetitions.

### 2.2. Sample

The sample consisted of 12 male Paralympic Powerlifting athletes, with a mean age of 30.83 ± 10.05 years and body mass of 70.00 ± 16.11 kg, participating in the extension project of the Federal University of Sergipe—Brazil, with at least 12 months of training and who are among the top 10 within the Ranking of their respective categories by body weight at the national level, with 10 male and 10 female body weight categories, where athletes compete with others of a similar weight. Consequently, all participants met the necessary prerequisites of the Brazilian Paralympic Committee and were eligible to compete in the sport [14]. Two athletes had lower-limb amputations; two athletes had spinal cord injuries as a result of accidents with injuries below the eighth thoracic vertebra; two had sequelae of poliomyelitis; two had atrophy in the lower limbs, two had malformation in the lower limbs (arthrogryposis); two had cerebral palsy. The basic characteristics of the sample are described in Table 1.

**Table 1.** Temporal, anthropometric, hemodynamic, and strength characteristics of sample components.

| **Features** | **PP (*n* = 12) (Mean ± SD)** |
|---|---|
| Age (years) | 30.8 ± 10.05 |
| Body mass (kg) | 70.0 ± 16.1 kg |
| Experience (years) | 2.8 ± 1.3 |
| Systolic blood pressure (mmHg) | 125.8 ± 15.7 |
| Diastolic blood pressure (mmHg) | 71.5 ± 12.7 |
| 1RM test (bench press) (kg) | 122.0 ± 38.06 |
| 1RM test/body mass | 1.7 ± 0.4 |

The sample size was determined a priori based on a previous study [18,19], which found a partial eta squared effect size ($\eta 2p$) $\geq 0.5$ for the analysis of hemodynamic aspects in Paralympic Powerlifting athletes. Thus, the open-source G* Power software (Version 3.0; Berlin, Germany) was used in the statistical configuration for family tests "F" (ANOVA two way), considering an $\alpha < 0.05$ and a $\beta = 0.80$. In addition, two groups (traditional training vs. eccentric training) in 10 distinct moments were considered. Thus, a minimum sample size of six subjects was indicated for the present study, with the sample power estimated at 0.80.

The inclusion criteria were to practice and be eligible for the PP modality, for at least 12 months, and to be in the national ranking among the top 10 in their respective categories. The exclusion criteria were not participating in any stage of the collections or using any type of ergogenic resources. The athletes participated in the study voluntarily and signed an informed consent form, in accordance with resolution 466/2012 of the National Research Ethics Commission—CONEP, of the National Health Council, following the ethical principles expressed in the Declaration of Helsinki (1964, reformulated in 1975, 1983, 1989, 1996, 2000, 2008, and 2013) of the World Medical Association. This study was approved by the Research Ethics Committee of the Federal University of Sergipe, CAAE: 2,637,882 (approval date: 7 May 2018).

### *2.3. Instruments*

A digital electronic scale for a Micheletti wheelchair, Model Mic Wheelchair, of the digital electronic platform type (Micheletti, São Paulo, Brazil) with a maximum weight capacity of 300 kg (dimensions of 1.50 × 1.50 m) was used.

To perform the bench press exercise, an official straight bench (Eleiko Sport AB, Halmstad, Sweden) approved by the International Paralympic Committee [14] was used, with a total length of 210 cm. The bar used was a 220 cm Eleiko brand (Eleiko Sport AB, Halmstad, Sweden) weighing 20 kg [14].

For the eccentric training session, weight releasers (Berenice) fixed to the bar were used, which were detached from the bar when it hit the ground, thus allowing the concentric phase of the movement to be performed with a load of 80% of the 1RM and the eccentric phase at a load of 110% of the 1RM [17].

A noninvasive automated blood pressure monitor (Microlife 3AC1-1PC, Widnau, Switzerland) was used to assess resting blood pressure and heart rate [18,25].

### *2.4. Procedures*

#### 2.4.1. Measurement of Blood Pressure and Heart Rate

To measure systolic blood pressure (SBP), diastolic blood pressure (DBP), medium blood pressure (MBP) (calculated using the formula: $MBP = DBP + [SBP - DBP]/3$ [26]), and frequency heart rate (HR) at all relevant test moments (before, immediately after, and at 5′, 10′, 20′, 30′, 40′, 50′, 60′, and 24 h after each training session), a noninvasive automated blood pressure monitor (Microlife 3AC1-1PC, Microlife, Widnau, Switzerland) was used. By convention, all BP measurements were taken on the left arm with the cuff fixed approximately 2.5 cm away between its lower extremity and the antecubital fossa [6].

For control and safety purposes, pre-exercise BP should not exceed 160 and 100 mmHg for SBP and DBP, respectively [27]. This measurement took place with the subjects sitting for 10 min in a calm and mild environment, where they were instructed not to perform muscle contractions, to keep the elbow at 90º with the hand on the chest to avoid interference from gravity, and to avoid the Valsalva maneuver during the entire study procedure, following the guidelines of the American College of Sports Medicine [28].

The product pressure rate (PPR) was evaluated according to the following equation: $SD = HR \times SBP$ [26].

To obtain myocardial oxygen volume ($MVO_2$), a mathematical function based on the high correlation between the heart pressure product and $MVO_2$ was used. To obtain the

$MVO_2$, a mathematical function was used, expressing the result in $mLO_2/100$ g.VE/min: $MVO_2 = (SD \times 0.0014) - 6.37$ [24].

#### 2.4.2. Load Determination

To determine the training load, the test of one repetition maximum (1RM) was performed, where each subject started the attempts with a weight that could be lifted only once using the maximum effort. To reach 1RM, weight increments were added until reaching the maximum load that could be lifted at once; if the practitioner could not perform a single repetition, 2.4 to 2.5% of the load used in the test was subtracted [29]. Subjects rested between 3 and 5 min between trials. The test to determine 1RM was performed at week 1.

#### 2.4.3. Warm-Up

The subjects performed a previous warm-up for the upper limbs, using three exercises: abduction of the shoulders with dumbbells, development of the shoulders in the machine, and external rotation of the shoulders with dumbbells (a series of 20 repetitions for each exercise, totaling approximately 10 min of exercise warm-up). Then, a specific warm-up was performed on the bench press using only the bar (20 kg) without extra weight, with 10 slow repetitions ($3.0 \times 1.0$ s, eccentric vs. concentric) and 10 fast repetitions ($1.0 \times 1.0$ s, eccentric vs. concentric). Then, the subjects performed five repetitions at 30% of 1RM, followed by three repetitions at 50% of 1RM and one repetition at 70% of 1RM. Between sets, subjects rested for at least three minutes [30].

#### 2.4.4. Training Procedures: Resistance, Traditional, and Eccentric

All testing sessions and procedures were performed in the morning (between 9:00 am and 1:00 pm) for all participants. The procedures lasted three weeks with an interval of seven days for each session, using the bench press exercise of five sets of five maximum repetitions ($5 \times 5$) [29,31]. During traditional training, it was directed to athletes who performed at a normal movement speed according to the workouts to which they are frequently submitted, and the maximum concentric and eccentric load was 80% of the 1RM.

The eccentric training method was performed with a load of 110% in the eccentric phase and 80% in the concentric phase. To add supramaximal load, weight releasers were used [32] attached to the bar, which detached from the bar at the moment it hit the ground, thus allowing the concentric phase of the movement to be performed with a load of 80% of the 1RM and the eccentric phase at a load of 110% of the 1RM [17].

### *2.5. Statistics*

Descriptive statistics were performed using measures of central tendency and mean (X) $\pm$ Standard Deviation (SD). To verify the normality of the variables, the Shapiro–Wilk test was used, considering the sample size. To evaluate the results between the conditions, the ANOVA test (Two Way, Training vs. Moment) with Bonferroni's Post Hoc was performed. Statistical analysis was performed using the computerized Statistical Package for the Social Science (SPSS), version 22.0 (IBM Corp., Armonk, NY, USA). The significance level adopted was $p \leq 0.05$. The effect size was determined by the values of partial eta square (η2p), considering values of low effect ($\leq$0.05), medium effect (0.05–0.25), high effect (0.25–0.50), and very high effect (>0.50) [33,34]. The sample size was calculated, a priori, considering the value of "F" 0.4, the value of "α" 0.05, and "1-β" 0.8. A sampling power of 0.97 (high effect) was estimated for a minimum sample of 12 individuals present in the study, using G*Power version 3.1.9.6 (Heinrich Heine University, Düsseldorf, Germany).

## 3. Results

The results of systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP), heart rate (HR), product pressure rate (PPR), and myocardial oxygen ($MVO_2$) are shown in the Figure 2.

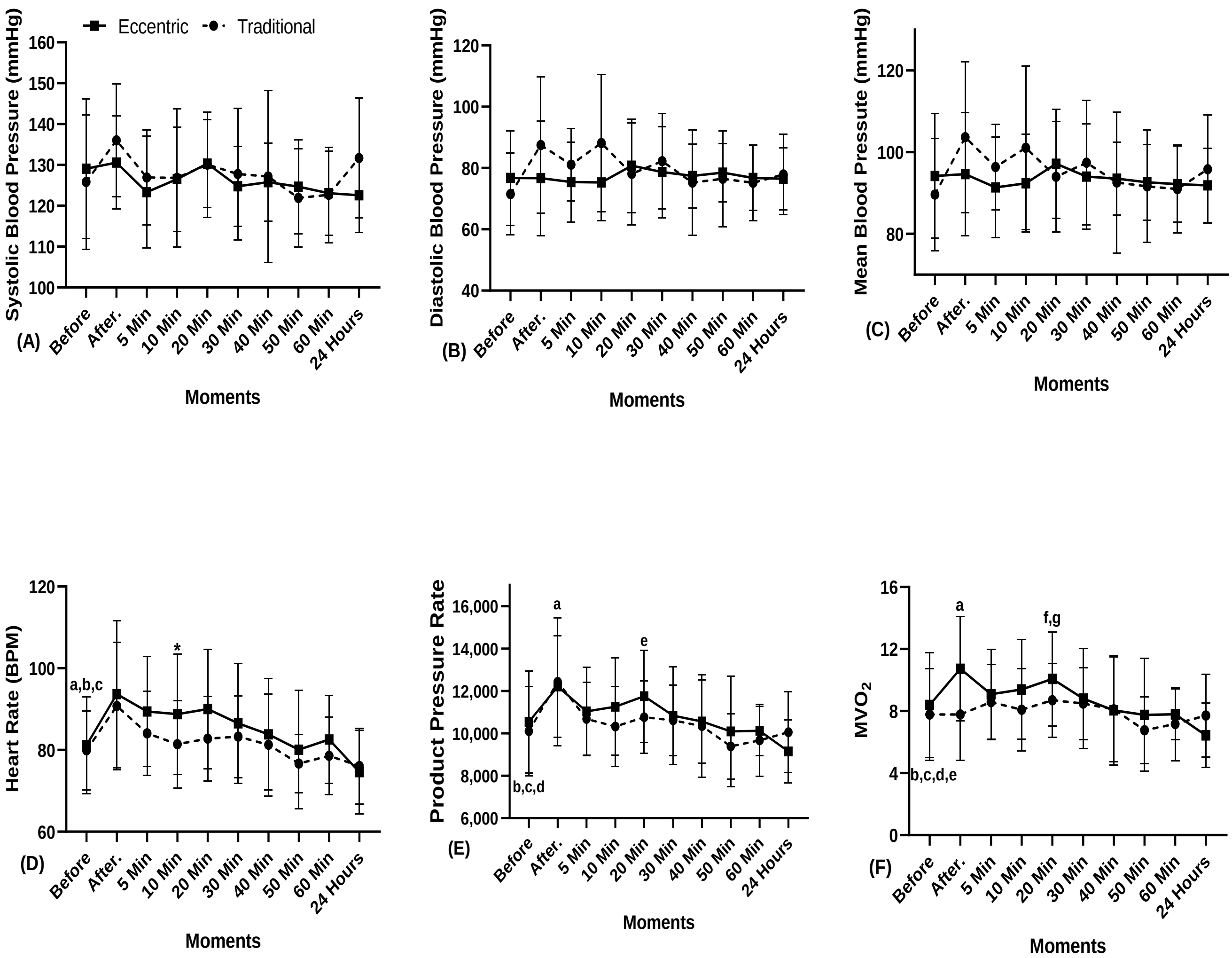


**Figure 2.** (**A**) Systolic Blood Pressure, (**B**) Diastolic Blood Pressure, (**C**) Medium Blood Pressure, (**D**) Heart Rate, (**E**) Product Pressure Rate, and (**F**) $MVO_2$ at different times. Letters (a, b, c, d, e, f, and g) represent moments comparing intra-groups, and (*) represent moments comparing inter-groups.

It was found that there were no significant differences in the traditional (TT) and eccentric (ET) training methods, in relation to blood pressure, systolic (A), diastolic (B), and mean (C). Therefore, in heart rate (D), there was a difference in eccentric training between the moments before and 20 min after ("a" $p = 0.023$), before and 40 min after ("b" $p = 0.035$), and before and 24 h after ("c" $p = 0.043$, η2p = 0.395, high effect). There was a difference between traditional and eccentric training at the moment of 10 min after ("*" $p = 0.049$; η2p = 0.120, mean effect). In the double product (E), there was a difference in the traditional training between the moments immediately after and 60 min after ("a" $p = 0.007$). In the eccentric training, there were differences between before and immediately after ("b" $p = 0.038$), before and 60 min after ("c" $p = 0.042$), and before and 24 h after ("d" $p = 0.043$); there was also a difference between 20 min and 24 h after ("e" 0.018; η2p = 0.400, large effect). There were also significant differences in $MVO_2$ (F) and a difference in traditional training between the moment after and 60 min after ("a" $p = 0.007$). In the eccentric training, there were differences between before and immediately after ("b" $p = 0.037$), before and 40 min after ("c" $p = 0.029$), before and 60 min after ("d" $p = 0.042$), and before and 24 h after ("e" $p = 0.043$). There were still differences in eccentric training in relation to 20 min and 40 min after ("f" $p = 0.017$), and 24 h after ("g" $p = 0.018$; η2p = 0.393, high effect).

## 4. Discussion

This study aimed to analyze the hemodynamic effects in relation to traditional resistance training with a load of 80% of 1RM and eccentric training with a load of 110% in the eccentric phase and 80% in the concentric phase in Paralympic powerlifting athletes, using the method of five sets of five repetitions in the adapted bench press, evaluating the hemodynamic variables (SBP, DBP, MBP, HR, PPR, and $MVO_2$) in the following moments: before, immediately after, and 5′, 10′, 20′, 30′, 40′, 50′, 60 min, and 24 h after the end of the training session.

Some studies support the cardiovascular health benefits of resistance exercise. In this sense, Wewege et al. [35] and Alpsoy [36] carried out studies indicating that hypertensive individuals may have a cardiovascular risk minimized by regular resistance exercises. This could be explained by the significant reduction in systolic blood pressure, diastolic blood pressure, and mean blood pressure after resistance training sessions. A physiological mechanism that could explain the adaptation-reducing effect on BP after an exercise program is an improvement in the baroreflex control of muscular sympathetic nerve activity [37]. However, even though our study did not show a statistically significant reduction in systolic, diastolic, and mean blood pressures between the training conditions, traditional and eccentric, there was a clinically noticeable reduction in relation to the eccentric method.

The clinical values found a reduction of 6.0 and 6.5 mmHg in SBP when compared with rest at 60′ and 24 h, respectively. There was also a reduction in MBP by 2.0 and 2.3 mmHg when compared with rest at 60′ and 24 h, in relation to the same method. This effect may have been caused by the inflammatory process promoted by eccentric training stimulating the immune system. Although the overall impact of immune responses on PEH is unclear, some research indicates that eccentric exercise results in decreased plasma STNFR1 concentrations, which has been positively correlated with reduced BP [38].

In diastolic blood pressure, we found that traditional training maintained absolute levels higher than in eccentric training. In the literature, according to Paz et al. [17], with a sample similar to that of our study, male Paralympic powerlifting athletes, through one of the training methods of our study—traditional training, with applied intensities of 90% to 95% 1RM, however—caused the EHP. The fact that the training intensity of the present study was lower may have been the determining factor for not having PHE. In addition, hemodynamic responses are directly linked to intensity or to the number of series or recovery intervals, which are important components for HPS [39].

In contrast, in Dos Santos et al. [40], after analyzing 60 individuals with hypertension, the sample used was not composed of weightlifters. This relationship is possible because the authors obtained the same training methods, traditional and eccentric, but with different series numbers and repetitions; 3 series of 8 to 12 repetitions at 60 to 80% of 1RM resulted in reduced BP with both training types.

João et al. [13] found a hypotensive effect at 60 min after the training session, with an intensity of 95%, in normotensive men, in the squat, bench press, and deadlift exercises with 2 to 5 repetitions. It should be noted that our study did not present the EHP, but it was composed of Paralympic athletes (trained and normotensive men) and only the bench press was used. The explanation for these results is probably due to the fact that high-performance athletes, including those in our study, tend to present less physiological changes during training. In the same vein, João et al. [13] mentioned that with trained individuals, hemodynamic responses tend to improve; thus, the decrease in stroke volume compensates for the increase in HR, caused by increased sympathetic activity and reduced parasympathetic activity in the heart.

From the results verified in our study, the heart rate referring to the eccentric training showed an increase in relation to rest (moment before) and 20 min after, as well as related to 40 min later; however, there was a reduction between rest and 24 h later. However, eccentric training is considered an alternative recognized for reducing cardiorespiratory effort due to the lower metabolic cost of producing a mechanical output, compared to combined load training [41]. It should be noted that this method generates greater muscle damage and, consequently, a greater possibility of an inflammatory process, which would justify the high HR levels. On the other hand, Aidar et al. [18], when evaluating traditional training, with samples similar to our study, found a reduction in heart rate, where the PP group had a lower HR than the healthy ones.

Duncan et al. [42] found that men trained at 80% intensity (using squats, bench presses, and deadlifts) resulted in significantly elevated HR immediately after exercise, returning to resting levels 60 min after the session of training. These results are also similar to those of the present study; however, our study was composed of Paralympic athletes and only the bench press was used with the same intensity.

Even though HR was recorded significantly elevated at 20 min and 40 min later, HR levels returned to baseline values 60 min later, coinciding with the aforementioned study. Furthermore, the magnitude of the hemodynamic variables studied was relatively low, 24 h after the training session. Corroborating this, a decrease in heart rate was also shown in those evaluated after the traditional training session. Compared to the methods, the HR in the traditional was significantly lower at 10 min later in relation to the eccentric training, showing a greater recovery for this method [43].

The product pressure rate (PPR) is the best indirect predictor of myocardial work during exercise, being of great importance for the prescription and monitoring of these activities for healthy individuals or those with cardiovascular problems [44]. In our study, in traditional training, there was a decrease between the moment immediately after and 60 min after, and in the eccentric training, there was an increase between before and immediately after. However, there was a decrease between before and 60 min after, before and 24 h after, and even between 20 min and 24 h after. However, there were no differences in this indicator between the traditional and eccentric methods. However, differences were observed in each method in relation to the different moments, as mentioned above. João et al. [13] showed a decrease in PPR in nine traditional powerlifting athletes, using 95% of 1RM. Consequently, the PPR can suffer interference in relation to the type of exercise, the anatomical position, and the rest time [45].

Our study found no differences between training methods. It is noteworthy that despite not having statistically significant differences, in absolute terms, there was a drop in the eccentric method in relation to the traditional one, 24 h later, a fact that drew the attention of our findings. On the other hand, Aidar et al. [18], when evaluating the PPR in PP and healthy athletes, found differences between the analyzed groups.

If we consider that the definition of PPR is systolic blood pressure multiplied by heart rate, which is closely related to ventricular function and myocardial oxygen consumption [46], we can say that the training methodologies used in our study were safe. This statement is based on typical values for PPR presented by Mcardle et al. [5], 40,000 mmHg.bpm (millimeters of mercury/beats per minute), (HR = 200 bpm; SBP = 200 mmHg) or more, depending on the intensity and type of physical activity, and also according to the ACSM [47], presenting values up to 30,000 mmHg.bpm of PD as a possible risk limiter. In other words, the present study did not present cardiovascular risks to athletes, where the maximum mean values of the PPR presented in the traditional training were 12,434 mmHg.bpm, and in the eccentric training, the maximum values were 12,211 mmHg.bpm. These values are important measures to predict the absence of cardiovascular problems.

When evaluating the Myocardial Oxygen Volume ($MVO_2$), we found results similar to PPR. This is an expected result given that the PPR has a high correlation between the $MVO_2$, as the $MVO_2$ values were obtained through the PPR conversion formula: $MVO_2 = (PPR \times 0.0014) - 6.3$ [29]. Regarding our findings during the traditional training, there was a decrease in $MVO_2$ and PPR between the moment immediately after and 60 min after. In this sense, our results are similar to those of Paz et al. [17], where they found a significant increase in $MVO_2$ and DP in the moments before, after, and 5 min after traditional training.

The same happened with João et al. [13]; when evaluating acute cardiovascular overload and post-powerlifting hypotension in subjects with experience in the modality, they found results similar to ours in the PPR and $MVO_2$ variables. Corroborating this, Aidar et al. [18], when analyzing the hemodynamic responses generated in PP compared to healthy ones after training with high intensity with 5 × 5 in relation to PPR and $MVO_2$, there were differences between before and immediately after in both groups.

According to our findings during eccentric training, $MVO_2$ obtained similar results from PPR. Regarding the $MVO_2$, differences were observed in each method in relation to the different moments, as mentioned above. Thus, the results presented in relation to eccentric training present less cardiovascular stress than in traditional training. This reduced stress in eccentric training may have occurred due to the lower recruitment of motor units and lower energy expenditure, in addition to improved contractile efficiency and reduced inhibitions, as well as the possible increase in the amount of muscle fibers involved in the training method [48].

## 5. Study Limitations

Our study has some limitations, despite the relevance of the results found. The possible mechanisms that promote hypotension were not investigated. We did not assess peripheral vascular resistance, sympathetic activity, stroke volume, beta-adrenergic receptors, or endothelial factors; however, the method used to assess blood pressure was through validated devices. This method, although universally used, has some limitations in relation to invasive methods, such as intra-arterial catheterization. The nutritional history of the analyzed subjects was not controlled. The sample consisted of national athletes with different disabilities eligible for the modality. In this sense, the findings are for Paralympic powerlifting practitioners, not seeking the specifics of the different physical disabilities eligible for the modality. However, the findings are relevant for coaches and researchers to better understand strength training in relation to the type of training method to be applied to Paralympic powerlifting athletes and its effects on athletes' cardiovascular health. Thus, as far as possible and considering the methods used, every effort has been made to ensure that these measurements are obtained consistently, reliably, and accurately.

## 6. Conclusions

Data from this study indicate that one session of traditional and eccentric training methods can be effective in causing significant changes in the cardiovascular system. The application of the methods did not present a risk of hemodynamic overload for powerlifting athletes with intensities from 80% to 110% (1RM). The methods also did not promote a statistically significant hypotensive effect; however, according to the absolute values found, this effect should be clinically considered. The relevance of eccentric training is also highlighted, as it presents differences in the analyzed variables (HR, PPR, and $MVO_2$). Thus, eccentric training, despite having higher absolute values, did not present risky cardiovascular effort for Paralympic powerlifting athletes. In this vein, both the traditional method and the eccentric method are safe in cardiovascular terms for athletes in the modality.

**Author Contributions:** Conceptualization, J.B.d.J. and F.J.A.; methodology, S.C. and G.G.; software, L.P.; validation, J.A.d.S.L.J., J.L.M., A.F.S. and R.C.; formal analysis, J.A.d.S.L.J., J.L.M. and A.F.S.; investigation, J.B.d.J. and R.C.; resources, S.C. and T.L.B.F.; data curation, L.P. and G.G.; writing—original draft preparation, J.B.d.J. and F.J.A.; writing—review and editing, G.M., G.G. and F.F.; visualization, G.M. and T.L.B.F.; supervision, F.J.A., G.G. and F.F.; project administration, F.J.A. All authors have read and agreed to the published version of the manuscript.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data that support this study can be obtained from the address: Available in: www.ufs.br/ Department of Physical Education, accessed on 29 July 2022.

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