International Journal of Sport, Exercise and Health Research

Review Article

IJSEHR 2024; 8(2): 71-76

www.sportscienceresearch.com
Received: 23-05-2024
Accepted: 24-09-2024
DOI: 10.31254/sportmed.8208

Impact of rest interval on post-exercise cardiovascular responses: A brief review

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Abstract

Background: The rest interval is considered a key variable in strength training, due to its direct influence on physiological and training responses. However, most research on rest intervals focuses on performance, strength gains, and muscle hypertrophy. Therefore, analysis of the rest interval in other demands, such as cardiovascular responses, for example, is necessary. Objectives: The objective of this study was to review the impact of rest intervals on cardiovascular responses in the post-exercise period. Methods: The research was developed in the PubMed, BIREME/BVS, Scielo, and Google Scholar databases using the search words: "rest interval", "rest periods", "resistance training", "strength training", "hypotension" and "post-exercise hypotension" in different combinations with the help of the Boolean operators "OR/AND". As inclusion criteria were considered: a) studies in the English language; b) that investigated the hypotensive effect after resistance training sessions and c) that investigated the rest interval variable. Results: After the removal of duplicate studies, of articles excluded based on the title and abstract, in the inclusion and exclusion criteria, 11 articles were included in this review. Conclusion: According to the results found in this review, if the objective is to reduce blood pressure acutely, the rest intervals between 2 and 3 minutes can be considered a safe and efficient option, since short intervals (<1 minute) promote greater cardiac stress. Therefore, individuals who require special care should exercise with caution at short intervals.

Keywords: Resistance training, Blood pressure, Hypotensive effect, Heart rate.

INTRODUCTION

Rest interval is considered one of the main variables of strength training (ST) due to its influence on acute physiological responses (i.e., reestablishment of ATP and CK reserves in the muscle, stimulation of anabolic and catabolic hormones, among others), in training responses (i.e., maintaining the number of repetitions, training loads, increasing and decreasing training intensity, among others), and also in long-term adaptations, such as gains in strength, power and muscular hypertrophy. [1, 2, 3, 4] It can vary according to the objectives and training format; for example, if the objective is to emphasize the ability to exhibit maximum strength, it requires relatively long rest periods. When the aim is to develop the ability to perform high-intensity exercises and increase localized muscular resistance, rest periods between sets can be less than 1 minute. [1, 2] Thus, rest interval analyses are mostly directed toward training demands, such as repetition performance, strength gains, and muscular hypertrophy. [3, 4]

Therefore, investigating the influence of the rest interval on other demands, such as cardiovascular responses, for example, is of great importance, since the number of people diagnosed with arterial hypertension has been increasing in recent years and the ST is an auxiliary option in the control/prevention of arterial hypertension and other cardiovascular diseases. [5, 6]

In general, the literature demonstrates that a single ST session can reduce blood pressure below the values observed in the pre-exercise situation and control session. [5, 7, 8] Therefore, knowing the influence of the variables surrounding the ST is very important for an efficient and safe prescription.

In this regard, because the rest interval between sets is one of the main variables in ST, the objective of this study was to review the impact of the rest interval on cardiovascular responses in the post-exercise period.

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MATERIAL AND METHODS

Article Search

This study is a narrative review of the literature on the effects of rest intervals on cardiovascular responses in the post-exercise period.

The research was carried out in the PubMed, BIREME/BVS, Scielo, and Google Scholar databases, without temporal delimitation to increase the number of studies on this topic.

The following search descriptors were used: "Rest interval" [Title/Abstract] OR "rest periods" [Title/Abstract] AND "resistance training" [Title/Abstract] OR "strength training" [Title/Abstract] AND "Hypotension" [Title/Abstract] OR "Post-Exercise Hypotension" [Title/Abstract].

Criteria for inclusion and exclusion

The studies were included in this review if they met the following inclusion criteria: a) studies in the English language, b) that investigated the hypotensive effect after ST sessions and c) that investigated the rest interval variable. The studies that used other types of methodologies that did not have the rest interval as a variable to be analyzed and that were not available for free access were not considered. The bibliographic survey was carried out in January 2024.

Study coding and data extraction

Using Microsoft Excel software (Microsoft Corporation, USA), the data were tabulated in a spreadsheet and coded into a) authors, year of publication and title, b) descriptive information about the participants, including the number of participants in each group, age, sex and health condition, and c) training characteristics, such as number of repetitions, training load, exercises used, rest interval adopted and the method of assessing blood pressure and heart rate.

RESULTS

Selection of studies and characteristics of interventions

The search identified 1,884 studies (Google Scholar= 1,330; BIREME/BVS= 316; PubMed= 230 and Scielo= 8). After the removal of duplicate studies, of articles excluded based on title and abstract, in the inclusion and exclusion criteria, 11 articles were included in this review.

The temporal distribution of articles included in this study was as follows: 2 articles from 2010, 1 article from 2011, 3 articles from 2013, 2 articles from 2016, 1 article from 2018, 1 article from 2022 and 1 article from 2023. Of these, 8 studies were conducted with young people (between 19 and 26 years old), 3 studies investigated older people (between 61 and 67 years old), 9 studies investigated men, 2 studies analyzed women, 8 studies were conducted with normotensive individuals, 2 studies researched hypertensive individuals and 1 study analyzed pre-hypertensive individuals. The intervals adopted in the studies varied from 30 seconds to 3 minutes in different intervention formats, i.e.: circuit training, passive intervals, active intervals and self-selected. The summary of the main information from the studies selected is described in Table 1. In this study, short intervals < 1 minute, intermediate intervals between 1 and 2 minutes and long intervals ≥ 3 minutes were considered.

Table 1: Characteristics of Training Protocols

Study	Population	Training protocol	Main Results
Veloso et al. (10)	Young men (23 ± 3 years), NT	6 exercises, full body protocol, alternating upper and lower limbs, 3 sets, 8 reps, intensity 80%, 70% and 60% of 1RM, intervals: 1, 2 and 3 minutes.	No reduction in SBP was observed, however, DBP was reduced in the 1- and 3-minute interval protocols.
de Salles et al. (11)	Older men (67.6 ± 2.2 years), NT	7 exercises, full body protocol, alternating upper and lower limbs, 3 sets, 10 reps, intensity 70% of 1RM, intervals: 1 and 2 minutes.	Both intervals were efficient in reducing SBP and DBP. However, the 2-minute interval promoted greater magnitude in results.
Brito et al. (21)	Older women (61.2 ± 2.0 years) HT	6 lower limb exercises (LL) and 6 upper limb exercises (UL), 3 sets, 15 reps, intensity 60% of 1RM, 90-second intervals applied actively (AI) and passively (PI).	The UL exercises promoted PEH more discreetly than LL exercises. The AI promoted more significant HPE than PI.
Arazi et al. (18)	Young men (19.5 ± 1.0 years) NT	6 exercises, circuit training protocol, 3 laps, 10RM, intervals: 30 and 40 seconds.	Both intervals promoted PEH of similar magnitude and duration.
Lima et al. (16)	Young men (23.9 ± 0.7 years) NT	5 exercises, full body protocol, 3 sets, 12 reps, intensity 50% of 1RM, intervals: 30 and 90 seconds.	Intervals did not promote PEH; however, the shorter interval protocol increased HR for one hour post-exercise.
Goessler and Polito (26)	Young men (23.0 ± 2.0 years) NT	4 exercises, alternating upper and lower limbs, 3 sets until muscle failure, intensity 75% of 1RM, intervals: 1, 2 minutes and self-selected.	There was no difference in SBP and HRV between the intervals. DBP reduced from the 10th minute of recovery in all intervals lasting longer in the 2-minute interval. The 1 and 2-minute intervals showed greater sympathetic nervous activity.
Figueiredo et al. (12)	Young men (26.1 ± 3.6 years) PHT	8 exercises, sequence upper limbs towards lower limbs, 3 sets, 8-10 reps, intensity: 70% of 1RM, intervals: 1 and 2 minutes.	Both intervals were efficient in reducing DBP. However, 1 minute of rest was associated with greater cardiac stress.
Abrahin et al. (22)	Older women (64.1 ± 7.9 years) HT	4 exercises, alternating upper and lower limbs, 3 sets, 6-8 reps, intensity: 80% of 1RM, interval: passive (2 minutes) and active (2 minutes).	The active interval promoted greater post-exercise hypotension compared to the passive interval.
Lemos et al. (17)	Young men (25.0 ± 4.5 years) NT	6 exercises, upper limbs, 3 sets, 15RM, interval: 40 and 90 seconds.	The 90-second interval promoted a hypotensive effect on SBP. In contrast, the 40-second interval was associated with greater cardiac stress.
Alemi et al. (13)	Young men (21,6 ± 1,1 anos) NT	4 exercises, 3 sets, 15RM, interval: 1, 2 and 3 minutes.	The results demonstrated that intervals of 2 and 3 minutes promoted a longer duration of the hypotensive effect.
Coles et al. (28)	Young adults NT	The training occurred in three sessions per week for eight weeks, 4 exercises, 3 sets, 10 repetitions, intensity: 65% of 1RM, intervals: 30, 90 and 150 seconds.	The different rest intervals reduced SBP similarly in normotensive young adults.

DISCUSSION

This study aimed to review the impact of rest intervals on cardiovascular responses in the post-exercise period.

This section is structured in two topics for didactic purposes: 1) rest interval and hypotensive effect and 2) rest interval and heart rate variability.

The discussion was also organized considering the proximity of the intervals adopted in the studies and not the temporal sequence of the publications. This presentation format was chosen for better understanding by the reader.

Although there are review studies regarding the effect of ST on post-exercise hypotension, the present study focused on the rest interval variable. Thus, the results found in this review may be important for professionals working in the training field to expand their knowledge specifically about this variable and prescribe training more safely for individuals with cardiovascular disorders.

Rest interval and hypotensive effect

Currently, ST has been recommended by important health entities such as the American College of Sports Medicine and the American Heart Association as an auxiliary option for non-pharmacological treatment against hypertension. [5, 6] This is because the literature has already demonstrated its prolonged effect on acute blood pressure reduction and long-term control. For example, Melo et al.[7] demonstrated a reduction in blood pressure for 10 consecutive hours in hypertensive women using antihypertensive medications compared to a control session (day without physical exercise). Moraes et al.[9] found that 12 weeks of low-intensity ST (12 reps) reduced resting blood pressure similarly to drug treatment in hypertensive men, demonstrating that this training modality is safe and effective for individuals affected by cardiovascular diseases.

As ST involves a variety of prescription variables (i.e., order of exercises, number of sets and repetitions, execution speed, intensity, among others)[2], the trainer must have adequate knowledge about cardiovascular responses when manipulating the training program. Thus, specifically regarding the rest period between sets, Veloso et al.[10] analyzed the effects of three different intervals (1, 2 and 3 minutes) performed in three sets, eight repetitions with a load corresponding to 80%, 70% and 60% of 1RM throughout the series. The results of the study demonstrated no significant changes in systolic blood pressure after the different rest interval protocols. However, a significant reduction in diastolic blood pressure was observed in protocols with 1 and 3-minute intervals, demonstrating that in young normotensive men, the rest interval influenced reducing diastolic blood pressure for 30 minutes.

In the study by de Salles et al.[11], it was observed that both rest intervals investigated (1 and 2 minutes in a protocol with 10 repetitions at 70% of 1RM) were effective in reducing systolic blood pressure (60 minutes duration). However, the 2-minute interval was more effective in the duration of the hypotensive effect on diastolic blood pressure in older men (60 vs. 50 minutes compared to the 1-minute protocol). In contrast, Figueiredo et al.[12], in these same rest intervals (1 and 2 minutes), only found a hypotensive effect in pre-hypertensive men on diastolic blood pressure and without statistical differences between rest intervals between series.

More recently, Alemi et al.[13] found that longer intervals (2 and 3 minutes) were more efficient in reducing blood pressure (systolic and diastolic) than the shorter interval of 1 minute. However, this study adopted a greater number of repetitions (15RM) performed until muscle failure. Thus, periods of short intervals performed with a greater number of repetitions can promote greater cardiovascular demand during training and influence post-exercise behaviour. [14, 15]

Regarding short and intermediate intervals, Lima et al. [16] investigated a protocol of 5 upper and lower limb exercises, 10 repetitions worked at 50% of 1RM and intervals of 30 and 90 seconds. The results of this study did not demonstrate any influence of the rest interval on the hypotensive effect at any time or condition investigated (laboratory and ambulatory). In contrast, Lemos et al. [17] found a hypotensive effect in the training sessions investigated, with a longer duration for the session that was performed with a 90-second interval compared to the training session with a 40-second interval. Thus, the differences in results between these two studies can also be associated with intensity, as in the study by Lima et al. [16], the loads were worked with 50% of 1RM and possibly this intensity was not enough to trigger significant physiological changes, whereas in the study by Lemos et al. [17], the loads were aimed at maximum repetitions (15RM).

When the training program is developed in a circuit format, short intervals (30 vs. 40 seconds) showed similar results in reducing systolic blood pressure in normotensive individuals [18]. Therefore, when choosing to work with short rest intervals, the circuit format can be a good option [18].

As alternative methodologies, it is possible to mention the active and self-selected interval [19, 20]. The active interval is performed with the implementation of some intra-set task/exercise (such as stretching, massage, walking, among other strategies) that is not the passive form of rest [19]. Regarding cardiovascular responses, Brito et al. [21] submitted 21 older hypertensive women to passive interval protocols (rest for 90 seconds), active intervals (walking at low intensity at 40% of maximum HR reserve for 90 seconds between series) and control session (day without exercise). The training sessions were also composed of 3 sets of 15 repetitions at 60% of 1RM. The results demonstrated that both interval protocols were able to promote a reduction in blood pressure in the post-exercise period. However, the magnitude of reduction in blood pressure (systolic and diastolic) was more evident in the active interval protocol. Corroborating these findings, Abrahin et al. [22] observed a 21 mmHg reduction in SBP in the active interval protocol compared to the 10 mmHg observed in the passive interval protocol over 60 minutes. Therefore, the inclusion of walking in intra-set rest intervals can be considered an effective and safe strategy during ST practice. ST can increase cardiac stress (blood pressure, cardiac output) during training, due to muscle contraction providing a hypoxic environment and increasing the production of metabolites, thus causing an increase in sympathetic nervous activity and peripheral vascular resistance [23, 24] and aerobic exercise can increase the bioavailability of vasodilating agents such as nitric oxide, improving vasodilation, sympatho-vagal balance and attenuating these responses [25].

In the self-selected interval, the practitioner perceives/controls the interval time from one series to another. [20, 26] Literature demonstrates that this option presents performance and training efficiency results close to fixed intervals (whether short or long), being an excellent alternative for trained individuals. [20, 26] In the study by Goesler and Polito [26], a greater volume of training was observed in the 2-minute and self-selected intervals (average time of 155 ± 37 seconds) compared to the 1-minute interval. Post-exercise hypotension was only observed in diastolic blood pressure. Although the different training protocols did not present statistical differences, the 2-minute interval promoted a longer duration of the hypotensive effect, demonstrating the influence of training volume.

Most studies investigated the acute responses of the rest interval on the hypotensive effect (Table 1). Although investigating acute effects is clinically important, keeping blood pressure controlled throughout the day in hypertensive individuals can reduce the risk of target organ damage and other complications of hypertension. [27] On the other hand, investigating adaptations after a period of training can prove the effectiveness of the treatment. Thus, Coles et al. [28] analyzed the effects of different rest intervals (30, 90 and 150 seconds) on resting blood pressure in young normotensive individuals. The training protocol consisted of 3 sets, 10 repetitions with a load at 65% of 1RM, 4 exercises and a frequency of 3 times a week. All training groups showed a similar reduction in systolic blood pressure after 8 weeks of training, regardless of the rest interval adopted, however, the longest interval (150 seconds) demonstrated a greater amplitude of reduction compared to the other intervals. These data corroborate acute effect studies, according to which longer rest times were more efficient in promoting the duration of the hypotensive effect.

In general, the results of the studies gathered in this review demonstrated that intermediate and long intervals (between 90 seconds and 3 minutes) had a greater influence on reducing post-exercise blood pressure than shorter intervals (≤ 1 minute). Some observations for these results may be that the longer interval between sets enables a performance of greater training volume and maintaining loads. [20] The literature has already demonstrated that a greater training volume (number of sets, repetitions and exercises) provided a longer duration of the hypotensive effect and, in this case, resting more can favour a better recovery of the energy system and blood pressure. [29, 30, 31]

Rest interval and heart rate variability

It is known that during physical exercise, due to the increase in metabolic demand, there is a redirection of blood flow to the active muscles and an increase in cardiovascular responses (i.e. increase in heart rate, systolic volume, cardiac output, blood pressure etc.). [32] Thus, the assessment of cardiovascular behaviour, especially in the post-exercise period, has been widely studied in the literature. [31, 33, 34]

Due to the simplicity of measurement, heart rate variability (HRV) has been widely used in clinical practice to evaluate the cardiovascular autonomic response to physical training [35, 36, 37, 38], as this measure describes the oscillations of the R-R intervals between heartbeats that are under the influence of the autonomic nervous system (sympathetic or parasympathetic predominance) on the sinus node. [32] In general, in the beginning of exercise, the main mechanism for increasing heart rate (HR) is the decrease in vagal activity and, as exercise continues and intensity increases, increases in HR come from greater sympathetic nervous activity. [39] Therefore, monitoring HR behaviour after physical exercise is simple and low-cost, but with a significant impact on the prevention of cardiac events, since the reduction in vagal activity associated with the increase in sympathetic nervous activity allows an environment for the appearance of lethal arrhythmias. [40, 41]

The studies included in this review demonstrated that short intervals promoted greater cardiac stress during training sessions and remained high in the post-exercise period. For example, Veloso et al. [10] found greater HR responses as the interval reduced: 1 minute promoted higher values than 2 and 3 minutes, and 2 minutes promoted higher values than 3 minutes. However, in the 2 and 3-minute rest interval protocols, HR values recovered faster, a fact that was not observed in the 1-minute rest protocol. Lima et al. [16] found that HR remained elevated for up to 6 hours, with higher values for the 30-second interval compared to the 90-second interval in the first and fourth-hour post-exercise. The double product was also greater in the first-hour post-exercise in the 30-second interval protocol.

Generally, studies demonstrate that HR remains elevated after ST sessions, and this response may be attributed to some physiological factors, such as greater sympathetic nervous activity, lower parasympathetic nervous activity, increased lactate production, increased body temperature, greater activity hormonal, reduction in systolic volume, among others. All of these responses can be influenced by the structure of the training protocol. [31, 32, 33, 39]

Regarding HRV, Figueiredo et al. [12] observed that, in a moderate-intensity protocol (70% of 1RM), a 1-minute interval promoted greater cardiac stress than the 2-minute interval, with a reduction in vagal nervous activity being observed in the first 20 minutes of recovery. Goesler and Polito [26] checked, after 30 minutes of recovery, an increase in the LF/HF ratio in intervals of 1 and 2 minutes, demonstrating a possible sympathetic predominance; that response was not observed in the self-selected interval protocol (interval protocol that presented greater average rest between exercises).

In the study by Lemos et al. [17], although no significant differences were observed, the authors highlighted that the 40-second interval tended to demonstrate a greater negative impact than the 90-second interval, because greater sympathetic nervous activity and lower parasympathetic nervous activity associated with the shorter rest interval were observed. Alemi et al. [13] found different effect sizes in their results. For example, in the high-frequency component (a measure that indicates the action of the vagus nerve on the heart), a greater magnitude of reduction in the post-exercise by 45 minutes in the 1 and 2-minute intervals was observed, compared to the 3-minute interval (interval that did not present this response), demonstrating greater HRV changes over the longer interval. Thus, in addition to the rest interval, it can be highlighted that the structure of the training protocol can also impact cardiovascular responses. For example, when training involves the recruitment of a large muscle mass [42, 43], performed in prolonged or maximal series [14, 44], greater number of sets [31], greater training loads [45], different exercise orders [46] and associated with reduced rest intervals [12, 17] can intensify the increase in cardiovascular responses during training, which in turn influences the delay in recovery in the post-exercise period. This information must be considered when manipulating a training program, especially for individuals with cardiovascular problems.

It is important to mention that even though this study specifically reviewed the effects of rest intervals, the studies that were included in this review presented a diversity of training protocols. For example, full body training protocols (alternating upper and lower limbs); full body in the sequence of upper limbs towards the lower limbs; only upper limb exercises; different training volumes (i.e., the number of exercises varied between 4 and 8); different muscle groups (i.e., the selected exercises involved multiple joints only or multiple joints and single joints), worked with free weights and machines, the percentage of loads varied between 40 and 80% of 1RM between 8 and 15 repetitions (Table 1). Furthermore, the study samples were composed of different profiles (older people, young, women, men, trained and untrained). Thus, these different approaches/methodological structures may have influenced the results of the studies and deserve to be highlighted.

Additionally, most studies were conducted with normotensive individuals, so analyses with hypertensive individuals are limited and necessary. Future studies could also evaluate the long-term impact of rest intervals to elucidate the effects of this training variable.

CONCLUSION

According to the results of this review, if the objective is to reduce blood pressure acutely, rest intervals between 2 and 3 minutes can be considered a safe and efficient option, since short intervals (≤1 minute) provided greater cardiac stress. Therefore, individuals who require special care should exercise with caution at short intervals. Although the literature presents little evidence that explored other interval methodologies adopted, such as active interval and self-selected interval, these approaches are interesting. The active interval can be applied at any level of training and the self-selected interval can be applied to those individuals who have a higher level of experience.

Conflict of interest

The authors reports no conflicts of interest.

Financial Support

None declared.

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