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Original Research

Different Cooling Strategies Applied During Inter-Set Rest Intervals in High-Intensity Resistance Training

GILMAR J. ESTEVES†[1,2], RENATO A. GARCIA‡[1], and PAULO H. S. M. AZEVEDO‡[1,3]

[1]Group of Studies and Research in Exercise Physiology, Federal University of São Paulo, Santos, SP, BRAZIL; [2]Postgraduate Program in Human Movement Sciences and Rehabilitation, Federal University of São Paulo, Santos, SP, BRAZIL; [3]Department of Human Movement Sciences, Federal University of São Paulo, Santos, SP, BRAZIL

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 14(2): 295-303, 2021. The purpose of this study was to verify whether cooling between sets during high-intensity resistance exercise improves physical performance and to compare performance among different sites of cooling. It is important because delaying the muscular fatigue could improve total volume at a training session which could lead to greater hypertrophy. Nine healthy and recreational resistance training experienced men, performed six tests of a biceps curl exercise on different days. The first test was the one-repetition maximum test (1RM). Following, we applied five sessions, in crossover and randomized (counter-balanced) design. The subjects received different cooling strategies in each session for 1-min (inter-set rest interval): Control (C) (no Cooling); Palm Cooling (PC); Neck Cooling (NC); Local Cooling (LC) or Tunnel Temperature Cooling (TTC). We analyzed the maximum number of repetitions and the rating of perceived exertion (RPE). The Bayesian analysis showed that no cooling strategy was able to improve performance compared to control, and just NC, when compared to control, showed a 71% probability of increasing the total volume of repetitions. Also, RPE was not modulated by any cooling strategy compared to control, but NC has a chance to reduce individuals' RPE by 52%. In conclusion, no cooling strategy was efficient to improve physical performance during a high-intensity resistance exercise.

KEY WORDS: Fatigue, sports science, strength

INTRODUCTION

Training volume, commonly defined as sets × reps × load (24), is one of the resistance training variables that can be manipulated to impose mechanical and metabolic stresses aiming to stimulate muscle hypertrophy and strength (15). During a high-intensity resistance training session, like a bodybuilding routine, a set is made until failure (25). This fact leads to a decrease in the number of repetitions in subsequent sets as a result of accumulated fatigue (1), especially when rest between sets is short (i.e., 1 minute) (25). Thus, delaying the fatigue process could improve total volume at a training session which could lead to greater hypertrophy (24, 29).

There is an association between body temperature increase and fatigue during physical exercise (19). Aiming to lower body temperature during exercise, scientists have been studying the effects of body cooling on improving physical performance (23). Cooling strategies can be applied at different times, before (3), during (26), or after (16) exercise. Moreover, the cooling technique applied in non-specific locations (11, 12) and local exercised muscle (9, 30) has been used to delay fatigue. During a resistance exercise session, a cooling strategy has been used between sets to maintain a high number of repetitions (i.e., volume) (9). Although there are some conflicts in the literature, studies have shown that cooling could improve performance (2, 7).

When applying cooling on exercised muscle (local) (9), or far from it (11), we can observe a performance improvement. Galoza et al. (9) compared performance in resistance-trained subjects through a cooling and a non-cooling group. They performed four sets of biceps curls until muscle failure with 70% of 1 maximal repetition (1RM) and 1 min inter-set rest interval. During rest intervals, the cooling group had the ice bag applied to each brachial biceps muscle. The researchers concluded that the use of local cooling improved performance when compared to the control group. In another study (11), researchers applied palm cooling between sets during high-intensity bench press exercise in sixteen trained individuals. The results showed that the cooling strategy increased the number of repetitions to exhaustion when compared with palm heating and control conditions.

Different sites of cooling have distinct assumptions to explain how the cooling strategies delay fatigue and improve performance during exercise (2, 7). In local cooling, the performance improvement could be explained by a decrease in local pain (30). When applying cooling far from the exercised muscle, a mechanism that could explain the fatigue delay is the modulation of the central nervous system (CNS). Here we considered fatigue in two ways (8): 1) as a physical component, when contraction apparatus are harmed (e.g., cellular acidification), verified by the number of repetitions; 2) as a cognitive component, when muscle pain sensation increases, leading to exercise cessation, verified by Rating of Perceived Exertion (RPE).

In this present study, we used different cooling strategies aiming to delay fatigue and improve performance during an acute session of high-intensity resistance exercise (biceps curl). We cooled local and distant sites to test the possible superiority of one strategy over the other when compared to the control. We hypothesized that cooling strategies would increase the total number of repetitions (volume) during high-intensity resistance exercise compared with no cooling condition and that different cooling sites affect performance differently.

METHODS

Participants

We recruited nine healthy men (25 ± 4.2 years old; height 175 ± 5.6 cm; weight 74.4 ± 5.3 kg; 1RM 44 ± 4.6 kg), with a minimum recreational resistance training experience of six months. We informed the volunteers about the procedures, possible discomforts, and risks involved in this study. All participants signed a free and informed consent. Volunteers were instructed to keep a similar diet 24 hours before each test, not consume any supplements during all intervention period, not include additional training during data collection, and not perform any resistance training for upper limbs 72 hours before the training sessions. A Research Ethics Committee approved the experimental procedures of this study which is following the Declaration of Helsinki. This research was carried out fully following the ethical standards of the International Journal of Exercise Science (18).

Protocol

The participants performed six training sessions of biceps curl exercise, separated by 6 to 8 days. In the first session, the subjects performed a 1RM test and their descriptive characteristics (height and weight) were measured by a single researcher who used a mechanical scale with a stadiometer (Filizola®). In the following sessions, tests were conducted in crossover and randomized (counter-balanced) design. In each session, we applied one of the following cooling strategies: Control (C); Palm Cooling (PC); Neck Cooling (NC); Local Cooling (LC); or Tunnel Temperature Cooling (TTC). Tests were performed at the same time of the day to not interfere with the circadian cycle, according to the volunteers' availability. Laboratory temperature was maintained at 21ºC.

We evaluated maximum strength through the 1RM test. Participants performed a warm-up consisting of 2 sets. The first set (5 to 10 repetitions) using 40-60% of the participants perceived 1RM and after 1 minute of rest interval, they performed a second set (3 to 5 repetitions) using 60-80% of the participants' perceived 1RM. Subsequently, 3 to 5 sets and 4-minute rest intervals between sets were performed to determine the 1RM. The participants were instructed to perform two repetitions during each attempt; whenever possible, we increased the external load, and the subjects repeated until they were able to perform a single repetition.

The exercise protocol was composed of four sets of biceps curl at 80% of 1RM, with a 1-min inter-set rest interval. Participants performed each set until muscle failure or when the participant could not maintain movement velocity for two consecutive repetitions. The cooling strategy was applied during inter-set rest intervals (figure 1). The volunteers were instructed to keep the movement velocity in the concentric and eccentric phases, lasting 2 seconds each, controlled by a metronome. Participants were verbally encouraged to do maximal repetitions as they could during the exercise. The Control intervention was performed with the same exercise procedures, but during the inter-set rest interval, no cooling strategy was applied. The maximum number of repetitions achieved during each set was counted, and the RPE of the participants through the OMNI-RES scale immediately after each set (22).

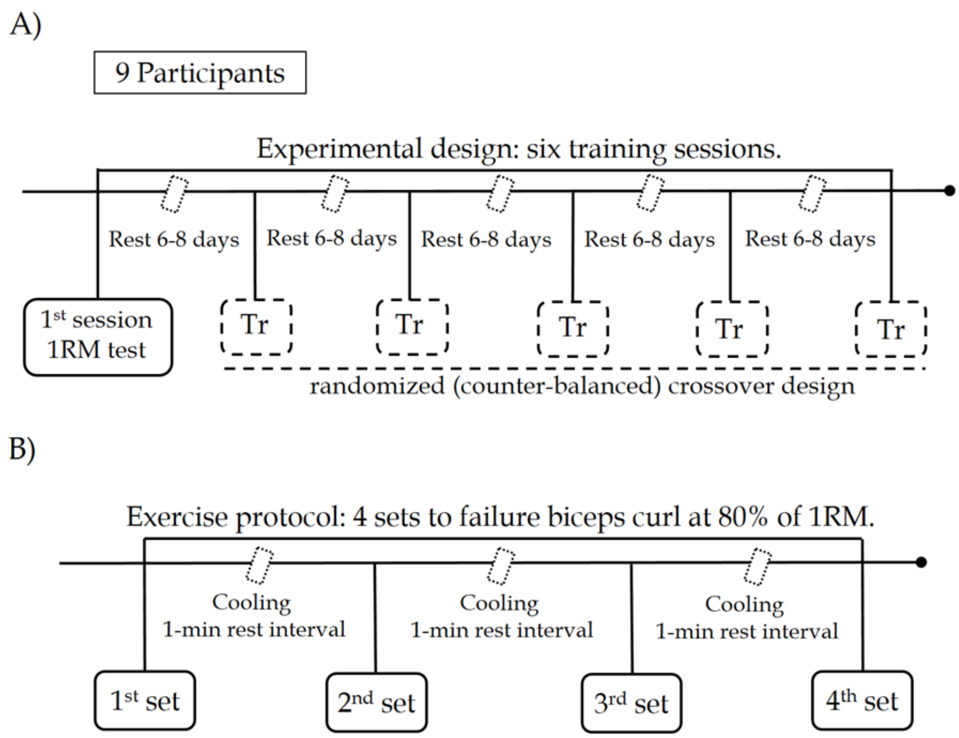

Figure 1. A) Laboratory visit timeline; B) Schematic showing exercise protocol. For each visit, the treatment (Tr) included either palm cooling; neck cooling; local cooling; tunnel temperature cooling; or control (no cooling). We applied these conditions on randomized (counter-balanced) and crossover design.

The cooling strategy was undertaken using two rigid ice bags (20 cm × 10 cm) on the proposed areas. In the PC procedure, the ice bags covered the whole palm to cool it. In the neck region, an ice bag was placed between the posterior cervical region and the occipital bone of the skull. For LC in the active muscles, the ice bags were placed in the mid-portion of the brachial biceps muscle of both arms (located visually). For TTC, the ice bags were placed near the nasal bone and tear duct. During the cooling process, the subjects remained seated on a chair. The time without cooling during the rest interval was ~3 - 5 seconds, a period in which the participant stopped doing the exercise to begin cooling and then returned to complete the next set. Before cooling application, the ice bags were placed in a freezer at -17ºC for a minimum of 24 hours.

Statistical Analysis

Descriptive data are reported as a mean and standard deviation. To check the qualitative outcomes and probability to find the same results again in the future (i.e., the magnitude of the evidence), we applied the Bayes Factor hypothesis testing analyses. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (31). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt (2)) prior. The "U" in the Bayes factor denotes that it is uncorrected (10, 28, 31). The outcomes were classified as anecdotal (BF_{10} = 1 to 3), moderate (3 to 10), strong (10 to 30), very strong (30 to 100), and extreme (> 100) favoring the alternative hypothesis; or anecdotal (BF_{10} = 1 to 0.33), moderate (0.33 to 0.1), strong (0.1 to 0.03), very strong (0.03 to 0.01) and extreme

(< 0.01) favoring the null hypothesis (Lee and Wagenmakers' classification) (14, 21). To calculate the probability to find the same results again, we divided the actual BF_{10} value by $BF_{10} + 1$. We made all analysis through the JAMOVI®.

RESULTS

Figure 2 shows the mean of the maximum repetitions performed in each series for each cooling procedure.

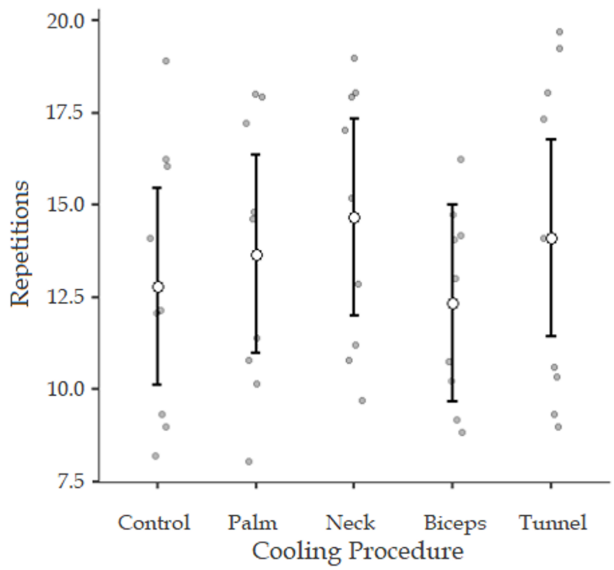

Figure 2. Total exercise volume in each cooling procedure.

No cooling strategy was able to improve performance compared to control. However, neck cooling compared to control showed a 71% probability of increasing the total volume of repetitions (figure 3).

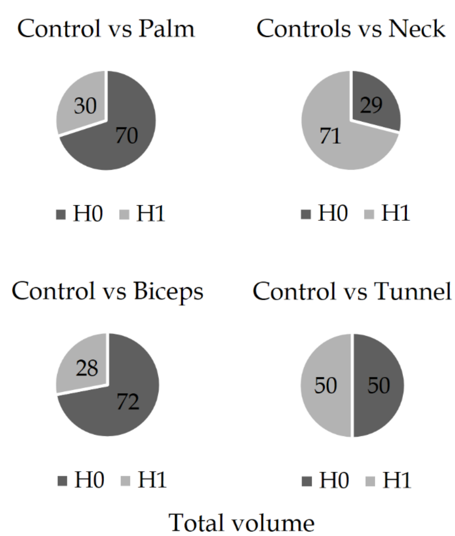

Figure 3. The probability that the null hypothesis holds across all cooling procedures to the exercise total volume.

Rating of perceived exertion was not modulated by any cooling strategy compared to control. The mean (± SD) among series to the RPE was 8.2 ± 0.9 for C; 8.2 ± 0.8 for PC; 7.7 ± 0.9 for NC; 8.1 ± 0.9 for LC and 8.1 ± 0.9 for TTC (figure 4).

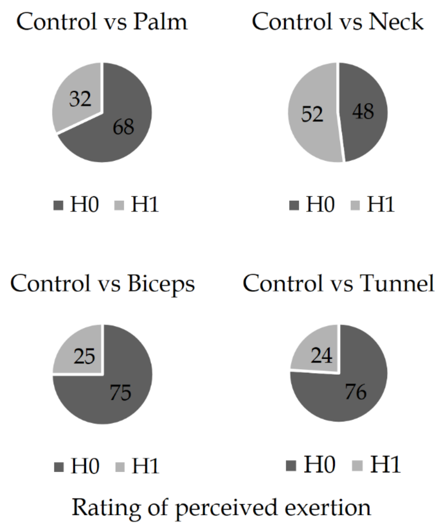

Figure 4. The probability that the null hypothesis holds across all cooling procedures to the rating of perceived exertion.

DISCUSSION

In this study, we compared the efficacy of four different cooling strategies to improve performance during a high-intensity resistance exercise session. Our data shows that no cooling strategy tested here is efficient to improve physical performance during a high-intensity resistance exercise. The RPE response was similar among all cooling procedures and control.

A higher exercise volume to all cooling strategies was expected when compared to control, as showed by previous studies with PC (11), NC (27), and LC (13). The exception is the cooling on tunnel temperature because this is the first study considering this place. Although we have found that cooling strategies could not improve performance, NC had a 71% probability of having a positive effect, while TTC, PC and LC had a chance of recurrence of less than 51% (figure 3). It was hypothesized that TTC could enhance performance with cooling strategies because face regions presents higher thermosensitivity neurons than other body segments (4). Therefore, when cooling these sites, signals regarding the thermal state might be sent to the thermoregulation area concerning a refreshing feeling, improving performance. The same stated before is true to NC. Differently, PC and LC strategies had a negative magnitude of the evidence, indicating that these cooling sites, far from the temperature control center, do not allow a fast response and performance improvement.

We hypothesized that cooling areas near the hypothalamus (temperature control center) (17), as neck cooling, can delay fatigue. In a study completed by Sunderland and co-workers (27), seven recreationally active men participated in an experiment involving NC or control during exercise in a hot environment. The authors verified that cooling in the neck region during exercise can improve repeated sprint performance and they suggested that NC can improve the thermal comfort at the site of cooling and improve performance by reducing the body thermal strain. We argue that although our study was performed at room temperature 21°C, and body temperature probably did not reach high values that would impair performance, the CNS may have interpreted the thermal comfort sensation closer to the hypothalamus increased neural activity and best chance to improve performance when cooling was done in the neck region.

Studies with LC are controversial about the improvement (9, 30) or detrimental performance response (5, 20). We showed that LC has a negative effect when compared to control. We have previously argued about the cooling site being near or far from the temperature control center area. Besides that, perhaps, the time of exercised muscle exposure to the cooling process could explain this result. Here, one minute of LC caused a possible impairment or trivial effect in performance, but some studies had shown an improvement of performance when 3 minutes of exposure were applied (9, 13). Therefore, this site of cooling had no advantage to be used when recovery and cooling are too short.

The RPE response among interventions was similar (Figure 4). There is an association between lower values of RPE and better physical performance (6). Kwon et al. (11) investigated the efficacy of PC during 3-min rest intervals between sets on the physical performance in resistance-trained subjects exercising in the thermoneutral environment. The researchers showed a performance improvement together with a lower RPE. They attributed the performance improvement concerning the CNS response (lower RPE) to the altered signals sent by palm and blood cooling, not to cellular alterations. Our data neither support nor refute the assumptions of CNS as a modulator of performance because we did not observe a performance improvement and RPE decrease.

Our findings support that different cooling sites do not affect physical performance differently, although the NC seems to have the best chance to improve performance. Despite the small sample size and few variables analyzed being a possible limitation, we performed an analysis model (Bayesian analysis) which is not affected by sample size. Other limitations of the study were, not controlling the training routine and eating habits of the participants during the intervention period. Cooling techniques are commonly used in sports and by resistance training practitioners to delay fatigue and improve performance. However, some of these techniques used do not seem to promote the expected performance improvement. Therefore, our results provide a new perspective on the use of the cooling strategy by exercise practitioners and professionals. Researchers should investigate the effect of cooling at different sites on exercise performance including more physiological and neuromuscular variables.

In conclusion, cooling technique applied in different sites does not promote performance enhancement in a high-intensity session of resistance training. Physical performance was modulated positively only when the ice was applied at the neck. However, the probability to achieve performance enhancement again is only 71%.

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