The Effects of Palmar Heat Extraction During Upper Body Conditioning and Strength Training

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INTRODUCTION

Heat can limit one's ability to do work. Maximum force production and voluntary activation of skeletal muscles are impaired when core temperature rises (Morrison, et al., 2008). A tremendous amount of heat is generated by active muscles during weight training. If internal heat production is performance limiting, removal of heat generated during exercise should attenuate heat-related performance decays.

The human body has unique vascular structures that serve as the body's radiator. These vascular structures enable a large volume of blood to flow directly beneath the non-hairy skin surfaces (e.g., the palms of the hands). A simple method for efficient heat extraction through the palms of the hands has recently been developed. This method uses a cold surface to draw heat out of the circulating blood in the palms in combination with the application of a local sub-atmospheric environment to distend the heat exchange vascular structures and, thus, enhance heat transfer. This heat extraction method has been reported to provide a substantial aerobic performance benefit (Grahn, et al., 2005).

The hypothesis tested here was that removal of heat from the body between sets of resistance weight training exercise would increase workout capacity and thereby enhance the conditioning effect of a multi-week training regime. Two separate bench press exercise studies were conducted: 1) A conditioning study - the total number of repetitions performed during fixed weight exercise and 2) A strength study - changes in the maximum weight lifting capacity. We predicted that, in 4 weeks of training, cooling would significantly improve work capacity, and that effects of cooling on strength gain would be similar to – or better than – the effects of steroid-use during a similar training regime.

METHODS

- An IRB approved protocol.
- Subject informed consent obtained prior to participation.
- Study design: Crossover (4 weeks control, 4 weeks cooling). Order randomized in conditioning study.
- Exercise: Bench press (3 minute rest between sets).
- Treatment: cooling during 3 minutes rest between sets.

Conditioning

- 14 male subjects with varying lifting experience.
- 10 sets per workout, 2 workouts per week.
- Weight: 70% of subject's 1-repetition maximum (1-RM).
- Repetitions to failure each set.
- Total repetitions per set tabulated.

Strength

- 25 male subjects with varying lifting experience.
- 6-set pyramid strength workout (set weights as %1-RM): 1^{st}, 40%; 2^{nd},60%; 3^{rd}, 80%; 4^{th}, 95%; 5^{th}, 60%; 6^{th}, 40%.
- 2 workouts per week.
- All subjects began with control phase.
- Performance of 2 reps in Set 4, resulted in an increase in weights by 5 lbs. in subsequent workouts.
- Top weights tabulated.
- Initial and final 1-RMs measured.

Data Analysis

Conditioning: Total reps per workout were calculated and plotted against date. Regression analysis determined rate of change. Relative treatment effects were determined from regression data (cooling slope – control slope) and plotted.

Strength: Inclusion criteria for data: stable performance during control phase, complete data set. Data from 7 of the 25 subjects met the inclusion criteria. Top weight vs. trial date were plotted for each subject and rates of change calculated. Descriptive statistics (mean and standard deviation) were calculated for the group data.

1-RM changes were determined (weight: final – initial). % improvement in 1-RM was also calculated (change / initial).

Steroid-use data from the various studies in the literature were plotted as % improvement vs. duration of the study (review by Hartgens and Kuipers, 2004). Regression analysis determined the slope of improvement/training period duration. Expected improvements over an eight week training period were calculated using the regression formula.

RESULTS

Conditioning

Examples of the two types of responses to cooling treatment are presented in Figures 2 (an effect) and 3 (no effect). Based on the treatment effect, the subjects were categorized as responders or non-responders. When the treatment effect comparisons of the individual subjects were plotted, there was a linear distribution of effect rather than a clustering of the data (Figure 4). Therefore, the response categorization was based on an arbitrary cutoff line. Treatment order, age, strength, and experience were not factors in distinguishing responsiveness.

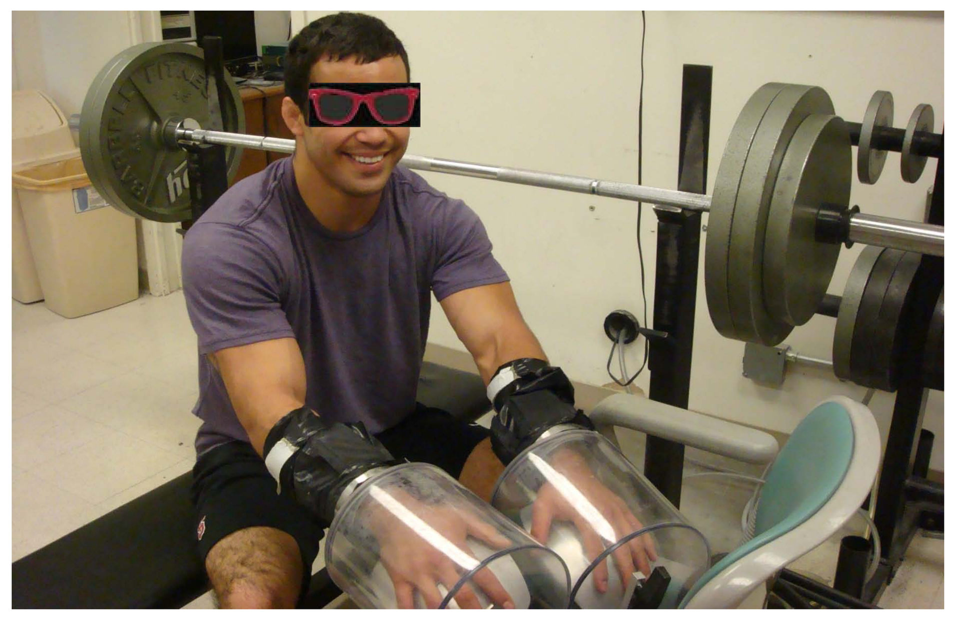

Figure 1: Subject cooling between bench press sets.

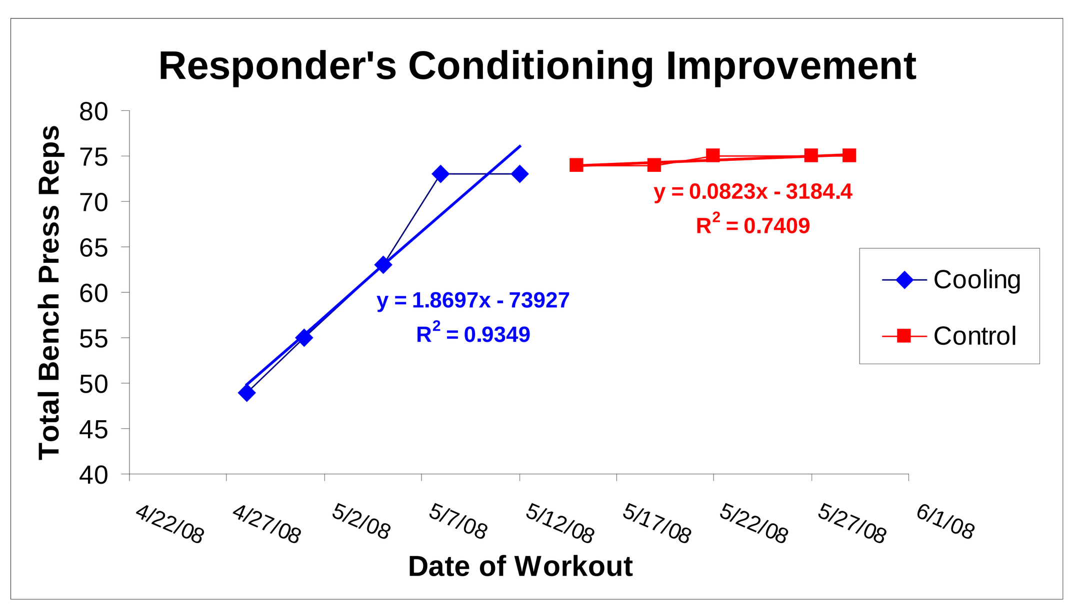

Figure 2: Effect of treatment on bench press conditioning gains (total reps vs. trial date) in a single subject deemed responsive to cooling. Rate of conditioning gains (total reps per day): cooling, 1.9; control, 0.1.

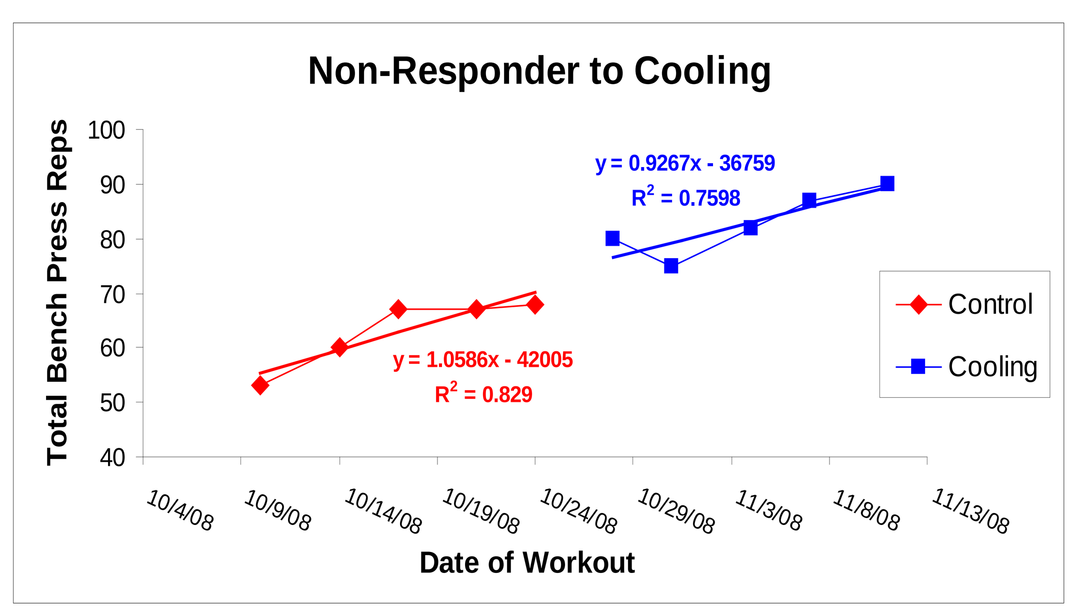

Figure 3: Effect of treatment on bench press performance gains (total reps vs. trial date) in a single subject deemed non-responsive. Rate of conditioning gains (total reps per day): cooling, 0.9; control, 1.0.

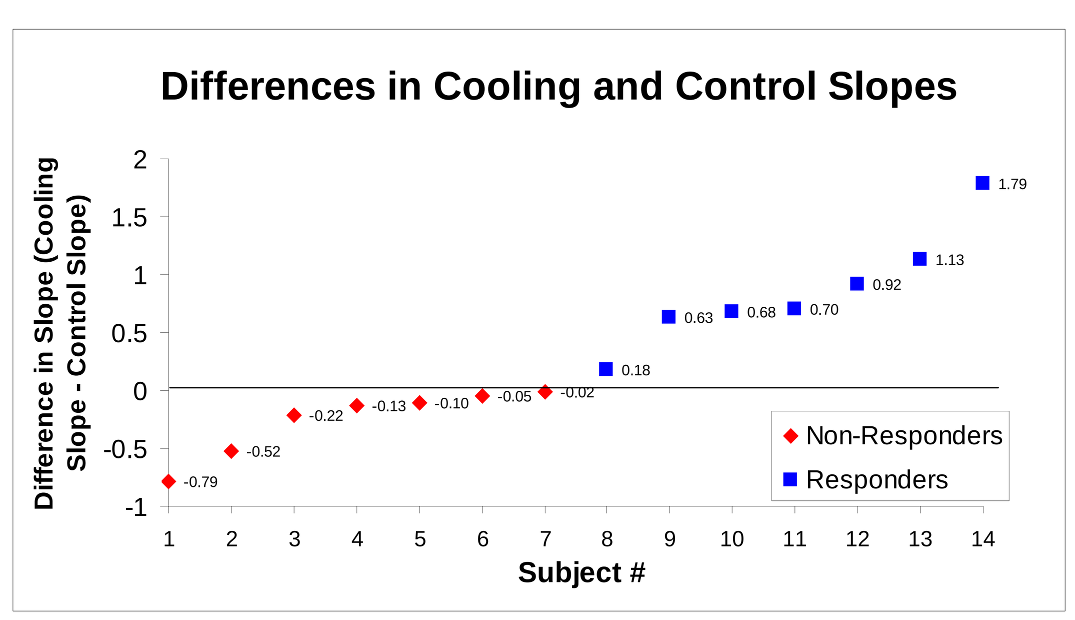

Figure 4: The relative effect of treatments on rate of improvement in bench press of the individual subjects (cooling slope - control slope). Seven of the 14 subjects experienced a performance decay or no improvements with cooling.

Strength

In 7 of the 25 subjects, there was no change in the top weights throughout the control trial period (Figure 5, individual subject example). In those 7 subjects, subsequent cooling trials resulted in increases in top weight and, thus, an increase in the rate of gain (Figure 6). Associated with the increase in strength gain was an increase in weight lifted in 1-RMs (Figure 7). Subjects averaged a 16% increase in strength over the eight week training period (16.07% ± 5.91). The strength gain associated with cooling is near double that expected with steroid augmentation (8.31%) during an eight week training session (Figure 8).

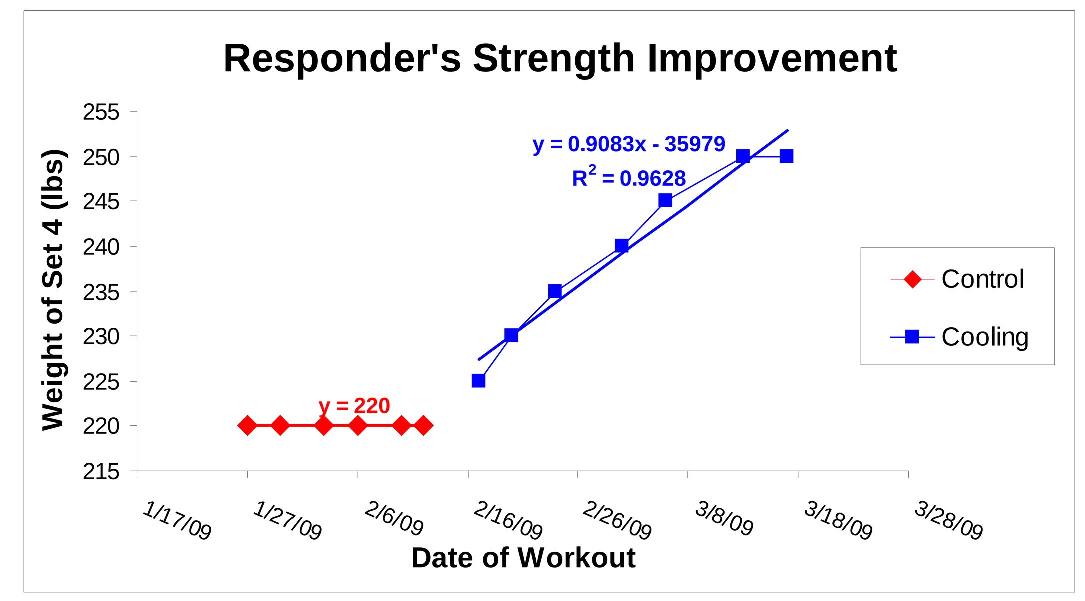

Figure 5: An example data set of top weight achieved in each workout. Red = control, Blue = cooling.

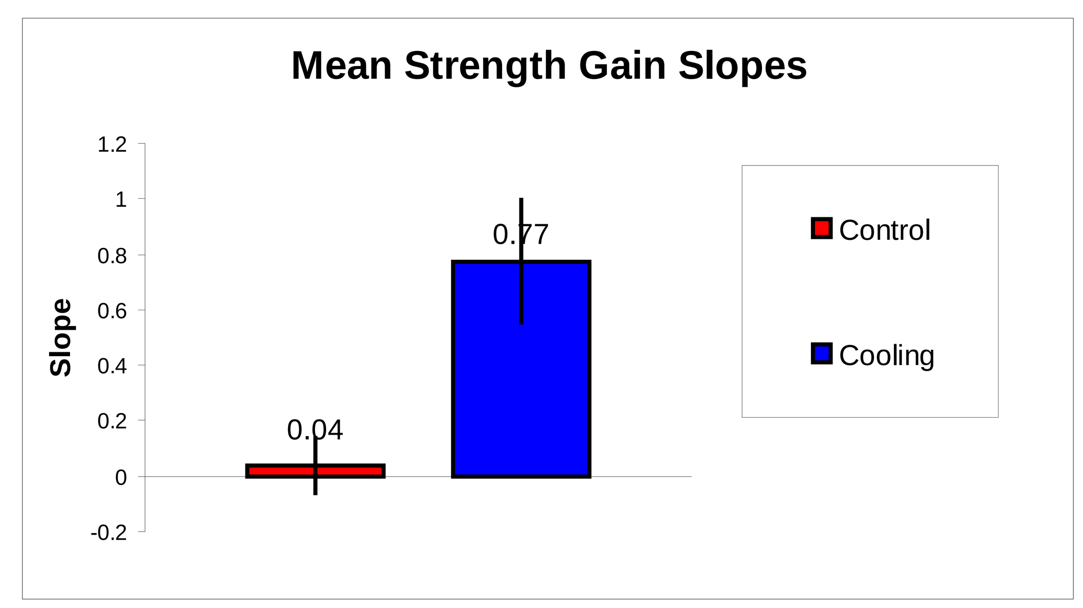

Figure 6: The mean control slope for the 7 subjects is in red, while the mean cooling slopes for the same subjects is in blue, ($p < 0.001$, paired t-test).

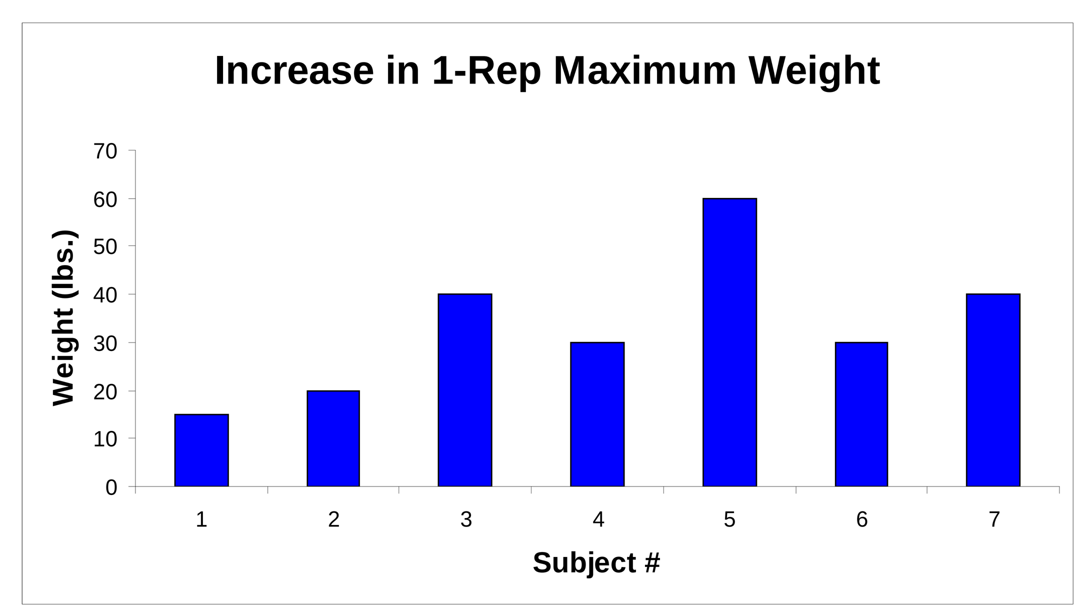

Figure 7: Increases in 1-RM weight in lbs. across the 8 weeks (Final 1-RM – Initial 1-RM).

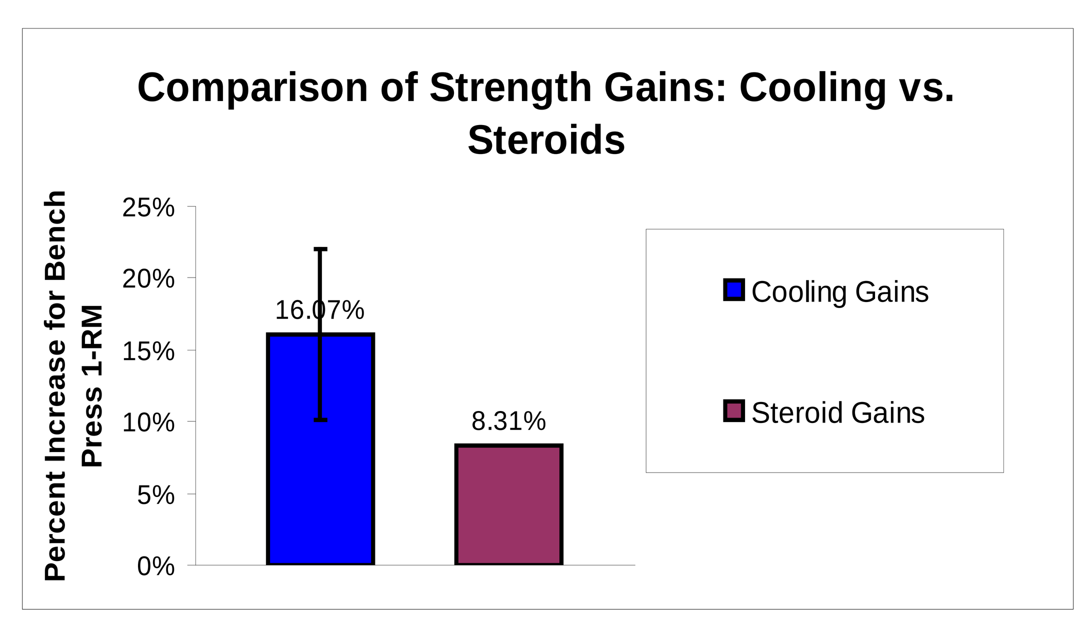

Figure 8: Comparison 1-RM bench press gains with cooling and steroid use for an eight week training period. Note that the cooling trials were limited to the last 4 weeks of the training period. Steroid data obtained by an analysis of results from 7 published studies. Cooling results empirically derived.

DISCUSSION

Conditioning

One possible explanation for the variability in responses to cooling is vasomotor tone. Some subjects are vasoconstricted when they come into the lab and local skin cooling can also trigger vasoconstriction. Vasoconstriction reduces blood flow through the radiator structures which, in turn, will compromise heat transfer. When the skin is below a threshold temperature, blood flow through the subcutaneous vasculatures is reduced. There is substantial variability in vasoconstriction thresholds between individuals (Taylor, et al., 2008). A simple means of eliminating that variable would be to measure either local blood flow or heat transfer during treatment to detect whether or not heat transfer is optimal.

Another possible confound is the fitness level of the subject. When a novice begins a conditioning program, improvements are usually seen and the level of performance may not produce enough heat to make heat a limiting factor. This confound could be reduced by imposing a stricter set of inclusion criteria for participation in the study.

Strength

A common phenomenon in experienced weight lifters is that they reach a plateau of performance. Our goal was to see if heat extraction could get such individuals off their plateaus and continue to condition. Since 18 of the subjects had not reached a plateau in the control trials, they were not included in the cooling experiment.

It is assumed that the positive effects observed in the 7 subjects who were cooled was due to effective cooling treatment and that the strength gains as reflected in the 1-RM weights occurred during the 4 weeks of cooling treatment. If true, the strength gains during 4 weeks of cooling treatment are almost double the strength gains attributed to 8 weeks of training with anabolic steroids. These data suggest that heat extraction is significantly more effective for increasing strength in experienced weight lifters than is the use of steroids. Additionally, there are no known side effects to heat extraction augmentation of weight training.

CONCLUSIONS

Conditioning

- Core temperature cooling significantly enhances muscular conditioning in some, but not all subjects (50% responders, 50% non-responders).

Strength

- Palmar heat extraction is an effective method for increasing the maximum strength in subjects experiencing a plateau in their strength gains.
- For maximizing on strength gains, cooling is equivalent to, or more effective than, anabolic steroids use.

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