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Effects of three different recovery methods in decreasing blood lactate in collegiate baseball pitchers post pitching.

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Effects of three different recovery methods in decreasing blood lactate in collegiate baseball pitchers post pitching.

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**Effects of Three Different Recovery Methods in Decreasing Blood Lactate in Collegiate Baseball Pitchers Post Pitching**

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**Purpose:** The purpose of this study was to determine the effectiveness of a low volume anaerobic training session, electrical stimulation, cupping therapy, and sequential compression for decreasing blood lactate in collegiate pitchers after pitching. **Methods:** 20 healthy collegiate baseball pitchers consented to participate in this study as a convenience sample (age 21.6 ± 1.90 years; height 175.61 ± 21.41 cm; mass 80.33 ± 8.07 kg). A total of 17 participants completed the study. Subjects were randomly assigned to one of the four interventions and rotated between interventions in one-week increments. The interventions used were a low volume anaerobic training session, electrical stimulation, cupping therapy, and sequential compression. The low volume anaerobic training session, electrical stimulation, cupping therapy, and sequential compression for decreasing blood lactate in collegiate pitchers after pitching was assessed using a factorial repeated measures ANOVA (with two within-subject factors: treatment and time of measurement). The assumption for sphericity was examined based on Mauchly’s test, and where the assumption was violated ANOVA output was assessed based on Greenhouse-Geisser’s correction (For epsilon <=0.75) or Huynh-Feldt’s correction (for epsilon>0.75). Post-hoc pairwise analyses with Bonferroni corrections were performed for statistically significant findings, with all assessments based on the 5% significance level. **Results:** While blood lactate levels increased with a low volume anaerobic training session (mean difference = 0.7120 p=0.57), there were statistically significant decreases immediately after the intervention for sequential (mean difference =-2.64, p=0.03) and cupping therapy (mean difference =-2.94, p=0.001). While there was a decrease in blood lactate levels following electrical stimulation, this decrease was not statistically significant (mean difference =-0.712, p=0.26). **Conclusion:** Blood lactate levels decreased in the period immediately following pitching with the use of cupping and sequential compression. These benefits were not seen with a low volume anaerobic training session and electrical stimulation. **Key Words:** therapeutic modalities, overhead throwing, recovery

**INTRODUCTION**

Ligament and muscle damage at the elbow and shoulder is associated with the repeated microtrauma sustained during the demands of high-speed throwing and pitching. In recent years, it has been noted that the prevalence of shoulder and elbow injuries has continued to rise at all levels of baseball. At the high school level alone, athletes in the United States sustain around 116,000 shoulder injuries yearly, of which 39% are musculoskeletal strains or sprains. Following injury, a baseball player may be concerned with loss of financial compensation or adverse effect on throwing mechanics. As such, injuries to the shoulder and elbow in baseball pitchers can create a multifactorial problem. Given these concerns, there have been efforts to decrease the risk of shoulder and elbow injuries in baseball pitchers. The majority of these interventions have focused on limiting the number of pitches thrown in games and the types of pitches thrown. In addition to these restrictions, several leagues have instituted mandatory rest days following a pitching appearance. Unfortunately, even with these efforts, shoulder and elbow injury prevalence continues to rise. As such, there have been efforts to identify other risk factors for shoulder and elbow injury in baseball.
pitchers. Within the literature, height, mass, and fatigue have been identified as independent risk factors for injury.9

As pitchers become fatigued, it is established in the literature that there is an increased risk of injury.10 It has been documented that pitchers’ blood lactate levels increase after performing the repetitive, high-intensity motions involved in pitching.11 As blood lactate accumulates within muscles, there is a decrease in pH.12 This low pH within the muscle can impair motor control during pitching thereby increasing the risk of injury.12 Given this information, recovery following vigorous physical activity such as pitching in a competition is of utmost importance. Recovery becomes a more significant concern when working with high-level baseball leagues, where there may be fewer rest days and instances in which pitchers may compete more than once in 24 hours.

Previous research on determining the best method for lactate removal in pitchers has focused primarily on comparing passive rest to physical activity.11,12 Within the study, the researchers assessed the effect of electrical stimulation performed on the anterior and posterior deltoid muscle on lactate removal when compared to active or passive recovery.11 These studies showed mixed results, but all previously reviewed studies have shown that increasing blood flow may assist with restoring normal pH levels, mitigating some of the deleterious effects of muscle fatigue.11,12 Studies have shown that cupping therapy and sequential compression increase blood flow to the targeted tissues.13-15 However, no studies examine the effectiveness of cupping therapy and sequential compression on decreasing blood lactate levels in competitive baseball pitchers. Thus, this study aimed to determine the effectiveness of a low volume anaerobic training session, electrical stimulation, cupping therapy, and sequential compression for decreasing blood lactate in collegiate pitchers after pitching.

METHODS
Participants
Twenty healthy collegiate baseball pitchers consented to participate in this study as a convenience sample. All participants were informed of the study’s purpose, and informed consent was obtained. A random number generator was used to assign participants to the treatment group or the sham group. All participants had an in-person interview with the primary investigator. During the interview, the procedures and purpose of the study were explained, along with the potential risks and benefits of participation. Participants were informed that they were not required to participate in this study and were free to discontinue the study at any time. After an opportunity to have questions answered about the study, participants read and signed a university institutional review board approved informed consent document. Throughout the data collection, three participants could not complete the study. One participant withdrew from the study due to scheduling conflicts, and two other participants were removed from the study due to musculoskeletal injuries unrelated to the data collection or therapeutic intervention process.

Approach
Each participant underwent the same procedures in a repeated-measures design. Based on random allocation, the participants began the study with one of the four interventions. The design of the pitching format was congruous with the regular non-traditional pitching routine employed by the pitching coach. Participants would pitch once a week, either in a bullpen or to batters. There was no control over the number of pitches thrown, the type of pitches thrown, or the amount of time for recovery between pitches. This structure was intended to provide a more accurate simulation of a bullpen or pitching
out and prevent participants from performing in a manner that was outside of their routine. Pitching took place outdoors and in warm to cool weather. Baseline blood lactate measurements were taken at approximately the same time every day on pitching days before the participant began their warmup routine. Another blood lactate measure was taken immediately after pitching. All participants would then complete a low volume anaerobic training session routine described later in the manuscript to maintain their normal practice schedule and not introduce confounding variables. This methodology was chosen to mirror a normal progression following a bullpen in many competitive baseball programs. Following the low volume anaerobic training session routine, participants would then complete their assigned intervention. If the participant was in the low volume anaerobic training session group that week, the participant did not receive any therapeutic modalities until after their final blood lactate measure for the week. A third blood lactate measure was taken immediately after the intervention. If the participant were assigned to the low volume anaerobic training session routine, they would rest quietly for 20 minutes before their blood lactate level was measured. Participants would then return roughly 24 hours later for a follow-up blood lactate measurement. The following week, the participant would rotate to the subsequent intervention until they had been in all four groups as shown in Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anaerobic Training Only</td>
<td>Cupping Therapy</td>
<td>Electrical Stimulation</td>
<td>Sequential Compression</td>
</tr>
<tr>
<td>2</td>
<td>Cupping Therapy</td>
<td>Electrical Stimulation</td>
<td>Sequential Compression</td>
<td>Anaerobic Training Only</td>
</tr>
<tr>
<td>3</td>
<td>Electrical Stimulation</td>
<td>Sequential Compression</td>
<td>Anaerobic Training Only</td>
<td>Cupping Therapy</td>
</tr>
<tr>
<td>4</td>
<td>Sequential Compression</td>
<td>Anaerobic Training Only</td>
<td>Cupping Therapy</td>
<td>Electrical Stimulation</td>
</tr>
</tbody>
</table>

Table 1. Group assignments following randomization

**Blood Lactate Levels**

A finger prick on the non-pitching hand was used at the four measuring times to collect a capillary blood sample. The investigator collecting the sample used universal precautions, including wearing nitrile gloves, preparing the participant’s finger with an isopropyl alcohol swab, applying an adhesive bandage to the collection site, and practicing hand hygiene between sample collections. The sample was then analyzed using a capillary blood lactate analyzer (Lactate Plus, Nova Biomedical, Waltham, MA). This method of analyzing blood lactate is well described as a viable option in previous studies.11,16

**Low Volume Anaerobic Training Session**

The low volume anaerobic training session intervention for this study was the routine designed and implemented by the participants’ pitching coach. Following pitching and the second blood lactate measurement, participants would complete a recovery workout consisting of plyometric ball exercises, resistance band training for the shoulder, elbow, and wrist, jump rope, and short-distance sprints. The plyometric ball weights and resistance band tensions were based on individual participant tolerance. An example of the low volume anaerobic training routine participants completed is shown in Table 2.


<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plyometric ball tosses into external rotation standing</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Plyometric ball tosses into internal rotation standing</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Plyometric ball tosses into external rotation sidelying</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Resistance band pull aparts (Horizontal Abduction)</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Resistance band pull aparts (External Rotation)</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Jump Rope</td>
<td>2</td>
<td>30 seconds</td>
</tr>
<tr>
<td>Battle Ropes</td>
<td>2</td>
<td>30 seconds</td>
</tr>
</tbody>
</table>

**Table 2. Low volume anaerobic training routine**

**Sequential Compression**

For the sequential compression intervention, the NormaTec Pulse 2.0 Recovery System (HyperIce, Irvine, CA) was used. Participants were fitted with a compression sleeve on their pitching arm attached by a hose to the unit (Figure 1). The sleeve consisted of segmented pockets that would inflate and deflate in a pattern set by the manufacturer. The compression pressure was set at a strength level of 7 on the NormaTec device per a previous study that detailed parameters.\(^{15}\) Treatment duration was 30 minutes.

**Cupping Therapy**

For the cupping therapy intervention, plastic pneumatic cups (KhangZhu Vacuum Cupping, Beijing Kangda World Medical Appliance Center, Beijing, China) were used. Pneumatic cups were chosen to allow for a greater degree of control and consistency over the amount of suction utilized. The skin was prepared with solid coconut oil to allow for better suction. The treatment location of the cups was on the anterior and posterior deltoid (Figure 2). Two complete pumps of air were removed from each cup, and the treatment duration was 20 minutes. These treatment parameters were consistent with previous studies and clinical expert statements on cupping therapy.\(^{17-20}\)
Electrical Stimulation
A Compex Sport unit (Compex Technologies, LLC, Ecublens, Switzerland) was used for the electrical stimulation intervention. Per previous research, the low volume anaerobic training session setting was used to stimulate efferent motor neurons with a biphasic waveform, at a frequency of 9 to 1 Hz. Treatment sites for the four electrical leads were on the anterior and posterior deltoid with corresponding electrodes arrayed in a superior to inferior alignment (Figure 3). The treatment duration was 24 minutes per pre-programmed manufacturer settings.

Statistical Analysis
Prior to data analysis, identifiers were removed from the four interventions to allow for blinded analysis of the data by the responsible investigator. SPSS version 22 (IBM-SPSS Inc., Chicago, IL) was used for data management and analysis. The effectiveness of low volume anaerobic training session, electrical stimulation, cupping therapy, and sequential compression for decreasing blood lactate in collegiate pitchers after pitching was assessed using a factorial repeated measures ANOVA (with two within-subject factors: treatment and time of measurement). The assumption for sphericity was examined based on Mauchly’s test, and where the assumption was violated, ANOVA output was assessed based on Greenhouse-Geisser’s correction (For epsilon <= 0.75) or Huynh-Feldt’s correction (for epsilon>0.75). Post-hoc pairwise analyses with Bonferroni corrections were performed for statistically significant findings, with all assessments based on the 5% significance level.

RESULTS
All study participants’ mean blood lactate levels before and after pitching, after the intervention, and at follow-up are summarized in Table 3 and Figure 4. There was a statistically significant interaction between the intervention effect and time of measurement (F=2.286, p=0.02). As such, one-way repeated measures ANOVA analyses were pivoted on either within a specific time of measurement or interventions.

Before each intervention, there was no statistically significant difference in the mean blood lactate values before pitching (F= 1.592, p=0.09), after pitching but prior to the interventions (F= 2.62, p=0.06) and at follow-up 24 hours after the respective interventions (F= 0.28, p=0.83). However, there was a statistically significant difference in blood lactate levels after the various interventions (F= 6.183, p=0.01). Post-hoc analysis was indicative of a statistically significant difference in lactate values between a low volume anaerobic training session (mean = 7.62 nmol/L) and cupping therapy (mean=3.19, p=0.03) as well between a low volume anaerobic training session and sequential compression (mean =3.27, p=0.04).
This study is particularly interested in the change in blood lactate levels after pitching, pre, and post- interventions. While blood lactate levels increased with a low volume anaerobic training session (mean difference = 0.7120, p=0.57), there were statistically significant decreases immediately after the intervention for sequential (mean difference = -2.64, p=0.03) and cupping therapy (mean difference = -2.94, p<0.001). While there was decreasing in blood lactate levels following electrical stimulation, this decrease was not statistically significant (mean difference = -0.712, p=0.26).

<table>
<thead>
<tr>
<th></th>
<th>Before pitching</th>
<th>After Pitching</th>
<th>Post Intervention</th>
<th>24 hours Follow-up</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic Training</td>
<td>3.63 (2.21)</td>
<td>6.91 (5.69)</td>
<td>7.62 (6.00)</td>
<td>3.61 (3.08)</td>
<td>0.01</td>
</tr>
<tr>
<td>Sequential Compression</td>
<td>3.80 (2.03)</td>
<td>7.03 (4.52)</td>
<td>4.39 (3.46)</td>
<td>3.88 (3.78)</td>
<td>0.03</td>
</tr>
<tr>
<td>Cupping therapy</td>
<td>2.39 (1.46)</td>
<td>6.13 (3.82)</td>
<td>3.19 (1.49)</td>
<td>2.93 (1.50)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Electrical Stimulation</td>
<td>3.03 (2.26)</td>
<td>3.98 (1.84)</td>
<td>3.27 (2.17)</td>
<td>3.45 (2.85)</td>
<td>0.26</td>
</tr>
<tr>
<td>p-value**</td>
<td>0.09</td>
<td>0.06</td>
<td>0.83</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Mean (standard deviation) blood lactate level in collegiate pitchers before and after pitching, post intervention and at follow-up 24 hours after intervention (n=17) [p-value from one-way repeated measures ANOVA pivoted on each intervention (within each row); **p-value from one-way repeated measures ANOVA within each time of measurement (within each column)].

**DISCUSSION**

The purpose of this study was to determine the effectiveness of a low volume anaerobic training session, electrical stimulation, cupping therapy, and sequential compression for decreasing blood lactate in collegiate pitchers after pitching. Passive recovery was not chosen as a group, as Warren et al. previously reported that this method was ineffective for decreasing blood lactate following pitching. The results of the study showed that the sequential compression and cupping therapy interventions were the most effective in decreasing blood lactate levels in the time immediately following pitching, while a low volume anaerobic training session showed no effect. Electrical stimulation had mixed results in that there was a decrease, but not a statistically significant decrease. The result for electrical stimulation differed with results found in other studies looking at these interventions but was similar in regards to a low volume anaerobic training session. In baseball, pitchers may have situations where they pitch consecutive times in less 24 hours. This study suggests that sequential compression and/or cupping therapy may be a way to decrease lactate between those pitching sessions. Other factors that may affect the choice of method to use would include portability of equipment, initial and maintenance cost of equipment, and the availability of a qualified clinician to administer the therapy. While modalities such as electrical stimulation did not demonstrate decreases in serum lactate in this study, other research has suggested electrical stimulation may decrease blood lactate. If teams or organizations employ medical staff that are more comfortable with electrical stimulation, they may follow a protocol that is in line with other research that have shown its benefit in recovery.

This study highlights the viability of intervention-based recovery in reducing the risk of injury in baseball pitchers, particularly in the high-stress demands of competitive...
baseball. These findings suggest that cupping therapy and sequential compression may be the most effective methods for reducing blood lactate levels in collegiate pitchers immediately after pitching.

**LIMITATIONS**

One limitation of this study was the relatively low sample size. The number of participants was challenging to increase, as the sampling was a convenience sampling based on available collegiate baseball pitchers from a single university program. As such, the sample size needed to be larger to answer the research question more thoroughly. Future studies should incorporate larger sample sizes of competitive baseball pitchers, if feasible, to ensure that results can be used for a more generalized statement. This study was conducted using a convenience sample, so information on whether subjects had previously received interventions was not collected. Future studies should assess the effect of previous experience with electrical stimulation, cupping therapy, and sequential compression related to clinical outcomes.

Since all the participants took all interventions, there is potential for a carry-over effect from the previous intervention to the next. However, this was minimized via interventions taking place one week apart and the fact that each participant was randomly assigned order of intervention. Results of the analysis show no statistically significant difference in the mean blood lactate levels before pitching and after pitching before each intervention. This suggests that even if there was some carry-over effect, it was not profound.

**FUTURE RESEARCH**

There is a need for future research to compare the magnitude of the effect on blood lactate with electrical stimulation, cupping therapy, and sequential compression. Additional outcomes that could be measured in these studies include range of motion, perceived level of function, and localized blood flow. Future research should also be conducted to assess the potential physiological mechanisms behind the reported decreases in blood lactate levels that were achieved. Other areas that warrant further research include timing of intervention such as use between innings vs after the outing, and long-term effect throughout use during an entire season. Beyond baseball further research would be useful on the effect of these interventions in other sports that have quick turnarounds (ex: athletes running multiple track and field events or decathletes/heptathletes). Such research has the potential to provide information regarding how best to achieve a reduction in blood lactate via these interventions.

**CONCLUSIONS**

Blood lactate levels decreased in the period immediately following pitching with the use of cupping therapy or sequential compression. These benefits were not seen with a low volume anaerobic training session and electrical stimulation. Cupping therapy and sequential compression could be effective recovery modalities for athletes that need to be prepared quickly between competitive outings. The results of this study may help sports medicine healthcare professionals better prepare their baseball athletes for repetitive performance.

**REFERENCES**


