INTRODUCTION:

Sport climbing, bouldering, and recreational rock-climbing all, in part, rely on forearm and finger flexion strength, as well as endurance. Methods to recover and/or increase climbing performance include hand shaking, finger stretching (Balas; Fryer; Green) and even selected supplements thought to increase muscle oxidation and performance (Fryer; Sas-Nowosielski). Climbing typically involves extended periods of time where finger flexors are in static contractions eventually resulting in muscular fatigue and discomfort (Fryer). To alleviate the fatigue and in an attempt to speed recovery hand shaking is often used during the climb to try to re-oxygenate (Balas) and maximize blood flow to the forearm muscles (Green). Stretching the fingers is also very commonly utilized between climbing pitches to help with recovery.

At any resting point or a time in which both hands are free, climbers often stretch their fingers and wrists in order to recover more quickly. Stretching may alleviate pain, lack of mobility, and reduce risk of injury (Safran). Not only does stretching help prevent these issues but stretching can also help increase physical performance (Young). It has even been shown that stretching can significantly improve the blood flow to the affected muscle (Esposito), which is likely a major cause for the acute improvement of muscular function following a bout of stretching.

With respect to blood flow, researchers have concluded that strong muscle contractions tend to occlude arterial inflow due to intramuscular pressure (See References of citation Humphreys PW. Lind AR. J Physiol. 1963. 166(1), 120-135). Results of a recent study regarding rock climbers and the relationship between forearm oxygenation and blood flow during submaximal sustained contractions suggests that oxidative capacity may be of more

importance than the blood flow occlusion in performance (Fryer). With respect to oxygenation, following maximal and submaximal finger contractions Macleod and associates (see references) concluded that muscle re-oxygenation during rest phases was a predictor of endurance performance. Therefore, re-oxygenation of the finger flexors is essential to continue climbing.

In order to improve effectiveness on grip strength recovery, one study (Heyman) compared four methods: passive recovery, cycle ergometry, elecromyostimulation, and cold-water immersion of the forearms and found that active recovery and cold-water immersion was superior in preserving performance. The researchers concluded that these positive effects were accompanied by a greater lactate removal and a decrease in subcutaneous tissue temperatures.

Studies seeking to determine if "shaking out" provides a means for forearm and finger flexor recovery have met with mixed results. For instance, Baláš and associates (see references) compared shaking and non-shaking and determined that hand shaking during a short rest period resulted in significantly ($p<0.05$) greater and quicker re-oxygenation of the forearm muscles over the non-shaking group. Conversely, Green and Stannard (see references) compared passive rest, "shaking out", and handgrip vibration on forearm recovery after handgrip contractions and found no significant ($p>0.05$) on recovery among the three protocols. The purpose of this study was to compare passive rest, shaking and stretching protocols on grip strength and time to grip exhaustion.

Methods:

A total of 44 healthy participants (15 male, 29 female) were recruited from a kinesiology course at Oklahoma State University. Participants self-reported their age, body weight, and gender. Mean demographics are represented by table 1. The only exclusions from this study were

participants with ailments that would prevent them from providing reliable data (such as upper body injuries).

Table 1. Participant demographics

Gender	Mean Age	Mean Weight (in kg)
Male (*n*=15)	21.1	84.4
Female (*n*=29)	20.3	65.1

Prior to beginning their role in the study, participants were briefed on the protocol of the study and asked to sign a university approved IRB consent form. Each of the 44 participants were randomly put into one of three groups (A = passive rest, B = shaking, or C = stretching) prior to testing. Grip strength was measured using a hand dynamometer (Jamar Technologies Hydraulic Hand Dynamometer, Sammons Preston Inc., Bolingbrook, Ill 60440), prior to performing a timed max hang test. Following the timed max hang test each participant engaged in one of the three protocols for 30 seconds and subsequently were tested on hand grip and maximal hang time.

For the handgrip protocol the participants were asked to flex 90° at the elbow and to squeeze the hand grip dynamometer with maximum force. Three trials were recorded. Following the hand grip assessment, participants were told to hang as long as possible from a round 1" by 1" bar using only their middle and distal phalanges, without the use of the thumb. Following the timed hang, participants in group A (n=15) passively rested with the arms to their side for 30 seconds, group B (n=15) "shook out" the forearms with the arms to their side for 30 seconds, and group C (n=14) passively stretched both fingers and wrists simultaneously for 30 seconds.

Shaking and stretching methods were demonstrated prior to testing. After the completion of the recovery protocols each participant's grip strength was measured followed by a second timed max hang test. The time until failure was recorded for each trial. Group results were compared using repeated measures ANOVA (SPSS, Statistics 28.1) with an alpha level set at $p<0.05$

RESULTS

Overall grip pre- to post strength diminished by an average 10.7% by the three protocols. The reduction in pre- to post grip strength by resting protocol was 7.9% (0.77 kg), by the shanking protocol 13.1% (1.22 kg), and by the stretching group 11.0% (0.95 kg). While no significant ($p>0.05$) differences among the protocols were found, the resting protocol was slightly superior in grip strength recovery (Table 2), with shaking reflecting the largest loss of recovery. The average reduction in pre- to post timed maximal hang time was 18.4 seconds. The passive rest protocol reduction in maximal hang time for the resting group was 32.3% (13.3 sec), the shaking group 27.45% (10.1 sec) and the stretch group 27.7% (6.6 sec) (Table 3). Again, no significant ($p>0.05$) pre-to post hang time differences were found among any of the protocols. However, the resting protocol exhibited the greatest recovery of the three protocols.

Figure 2. Pre- to post grip strength change.

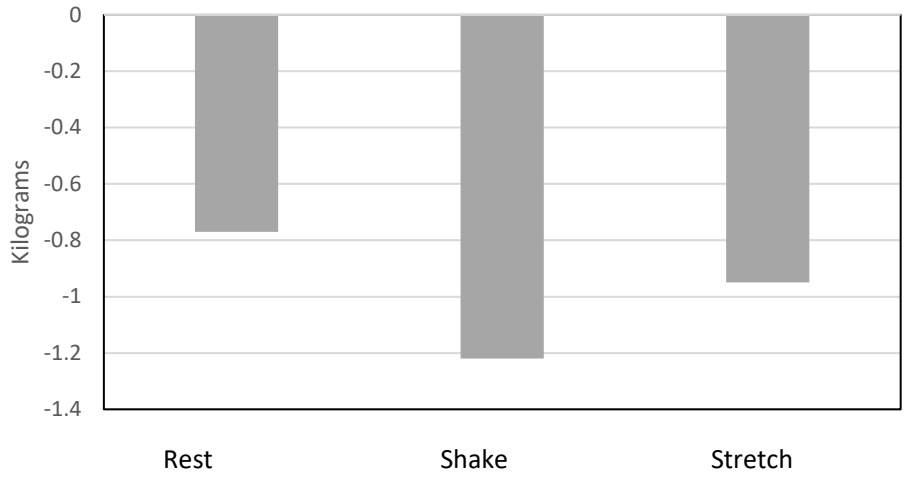
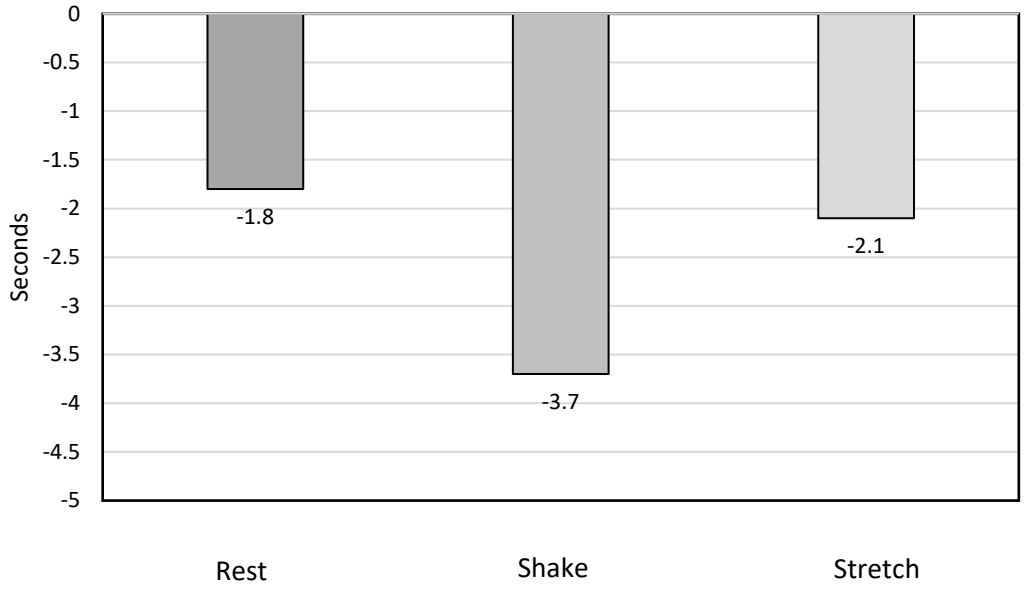


Figure 3. Pre- to post timed hang time change



DISCUSSION

Previous studies have used intermittent contraction and relaxation protocols (Green 4; Philippe), however; the ratio between the two has not been determined (Balas). It has been suggested that shaking the hands close to the body likely increases micro- and macro-vascular blood flow thereby enhancing the delivery of oxyhemoglobin to the muscle (Balas). Few studies have sought to compare acute recovery methods. The present study did not attempt to ascertain the ratio of contraction and relaxation time on muscle recovery, rather we chose to measure time to fatigue following the three protocols. While not practical during a climbing bout, Heyman and associates (in refs) sought to compare four recovery methods on rock climbing performance. The methods compared were a) passive recovery, b) active recovery [cycle ergometer], c) electrostimulation of the forearm muscles, and d) cold water immersion. Results indicated that active recovery and cold water immersion preserved performance due to greater lactate removal. Another study (Valenzuela in refs) compared "easy climbing" and walking as means of climbing recovery and found that climbers were able to ascent further in a set time after easy climbing. More specific to the current study, Balas and associates (in refs) found that during intermittent tests, shaking the hand with the fingers pointing down resulted in significantly quicker re-oxygenation which contradicts the results found by Green and Stannard (see references) who concluded that neither "shaking out" or low-frequency vibration were unlikely to affect climbing performance. Based on the present study, passive resting with the arms to the side appeared to be slightly, but not significantly superior to shaking or stretching.

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