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The effectiveness of chocolate milk as a post-climbing recovery aid

J. POTTER, B. FULLER

University of Chichester, College Lane Chichester, West Sussex, UK

Aim. **Recovery is essential to effective performance in climbing competitions which often involve repeated bouts, and sport climbing where climbers may work a route over a number of days prior to a complete ascent.**

Methods. **This study employed a cross-over design to compare water with chocolate milk as recovery aids following an exhaustive bout of high intensity endurance climbing. Ten male climbers (age: 22±1 years; height: 178.5±7.9 cm; mass: 74.7±11.3 kg) climbed a Tredwall (Brewer Ledge M6) until volitional exhaustion. The participants consumed either water or chocolate milk 20 minutes after the climb and then again with their evening meal. The exercise protocol was repeated 24 hours after the original climb. The second condition was completed 7 days later. Workload indicators of heart rate, rate of perceived exertion (RPE), blood lactate and muscle soreness scores were recorded alongside climbing performance measures of duration and distance of the climb. A improved performance was found after the consumption of chocolate milk, with both a greater distance climbed ($F_{(1,9)=}$11.704, P=0.008) and duration ($F_{(1,9)}$ =10.922, P=0.009), there were no differences in end of climb heart rate or RPE.**

Results. **Muscle soreness scores were lower three days after exercise following chocolate milk ($t_{(8)}$=3.773, P=0.005). Chocolate milk as a recovery drink resulted in further sustained climbing, a decrease in muscle soreness, compared to water. It may be pertinent for climbers to consider its use as a recovery aid during repeated climbing bouts. Chocolate milk is a relatively unexplored recovery aid and warrants further attention.**

KEY WORDS: Sports nutritional sciences - Carbohydrates - Proteins.

Climbing as both a recreation and competitive sporting activity has gained popularity over recent years. It is a diverse sport with at least seven major disciplines and yet very little direct research exists that could be used to support performers in this very demanding sport. The need for recovery and replenishment after such a strenuous sport is essential in order to get stronger and therefore progress.[1]

Climbing is an intermittent power endurance exercise and makes use of the whole spectrum of energy systems.[2, 3] Although as with other activities this will depend upon the discipline, the technique and the participants fitness levels. Failure to recover from more explosive climbing moves in the short-term will result in fatigue and a decline in performance will occur and in the longer-term exhaustion and failure to adapt. This need to recover from the demands of climbing is amplified over two-day competitions where the climber has hours to recover from an exhaustive bout of intense climbing, such as that used in this study.

There is an abundance of research into the benefits of nutrition on sporting performance and a wealth of that related to recovery. However, there are currently no published findings on supplements that aid recovery after climbing and very little on the use of chocolate milk. Therefore this work aims to build upon the body of work that has explored the potential usefulness of chocolate milk as drink to enhance recovery and therefore sporting performance,[4] many of which who have significant improvements in endurance cycling performance with chocolate milk.[5-9]

Corresponding author: J. Potter, University of Chichester, College Lane, Chichester, West Sussex, UK. E-mail: j.potter@chi.ac.uk

Chocolate milk contains many of the elements already known to be key in effective recovery from exercise; water, electrolytes, carbohydrates and protein. It also has those other key ingredients to successful employment in sports science, good taste, easily palatable, readily available and inexpensive.

The effectiveness of sports drinks for the replenishment of water, electrolytes and carbohydrates is very well established.[10, 11] The need for the consumption of essential amino acids post-training to meet the demands of the anabolic state to repair and replenish is also know.[12] The benefits of using combined carbohydrate and protein, as in chocolate milk, are less well understood but may offer a specific advantage. Consumption of carbohydrate and protein combined has the potential to maximize recovery through the stimulus of a larger insulin response resulting in a greater uptake of both substrates into the muscle.[13] When used pre and post-exercise, a combined carbohydrate and protein supplementation may provide a more anabolic environment and promote glycogen resynthesis and tissue remodelling to a greater degree than either carbohydrate or protein supplementation alone.[14-16] Although the benefits of combining carbohydrate and protein remains controversial with studies generating inconsistent or inconclusive results,[17, 18] performance effects have been demonstrated.

Chocolate milk which contains water, electrolytes, carbohydrate and protein, may prove to be very effective for postclimbing recovery, where the replenishment of glycogen and repair of tissue is key to adaptation and improved performance. Milk consists of the desirable 4:1 carbohydrate and protein ratio.[19] Milk-based proteins promote muscle accretion to a greater extent than soy-based proteins after exercise [20] and its slower rate of gastric emptying means that it is effective at replacing sweat losses and maintaining hydration.[21] However, in 2008 Lee *et al.* did not find a difference in endurance capacity when milk, water and carbohydrate-electrolyte beverages were consumed, but different endurance results were found when chocolate flavouring was added to the milk.[22]

Karp *et al*. (2006) were the first to explore chocolate milk as a post-exercise recovery aid and found that total work done, when cycling at 70% $VO_{2max,}$ was 57% greater when chocolate milk was consumed compared to a carbohydrate replacement drink however, the two conditions were not isocaloric.[9] Later work using an isocaloric control drinks also found a significant increase in endurance performance and time to fatigue following the consumption of chocolate milk as a recovery drink in cycling,[8] football [6, 7] and endurance sports.[5] Although the exact mechanisms of some of the observed performance benefits have yet to decided Lunn, Pasiakos, Colletto *et al.* (2012) concluded that fat free chocolate milk had resulted in some unique benefits to consuming chocolate milk in reducing time to exhaustion in a 45-minute run at 65% of VO_2peak, and through muscle biopsy demonstrating positive differences in fractional synthetic rate and signalling molecules of muscle protein when compared to consumption of a non-nitrogenous isocaloric carbohydrate drink.[23]

This study focuses on short-term recovery after a period of intense climbing, in a competition setting on a sustained multi-pitch route, climbers would climb all day for consecutive two days or on a climbing trip, in which climbing occurs every day with very little time to rest, therefore rapid recovery is important in this sport. As has been seen in other sports it is likely that nutritional strategies could provide the advantage needed to succeed in this time frame by delaying the onset of factors that would otherwise cause fatigue, but currently the use of nutritional strategies in climbing is very limited and preliminary work to this study revealed that 30% of regular multipitch climbers did not even consume water after a climbing session.

The hypothesis is that chocolate milk will aid recovery, in a way that water will not, after an exhausting climbing session to enable individuals to climb harder, covering greater distances in shorter time frames and for longer on subsequent days.

Materials and methods

Participants

A criterion sample of 10 male climbers (age; 22±1 year, height; 178.5±7.9 cm, mass; 74.7±11.3 kg) with a minimum of two years regular climbing experience, agreed to participate in this study. Participants completed a health history questionnaire and gave their informed consent. University of Chichester ethics committee gave permission for this study,

and the research was undertaken in compliance with the Helsinki declaration.

Protocol

Pre-climbing procedure

Participants were asked to refrain from vigorous exercise and maintain consistency with food and beverage consumption the day before, the day of, and the day after the testing. Participants were instructed to refrain from taking protein supplements or sports drinks during the two-week testing period. Participants were given a written explanation of the testing procedure.

Warm-up

A set warm-up was completed before each test; followed by climbing specific dynamic and static stretches, followed by one minute of slow climbing on the Treadwall (Brewer Ledge M6) set at a 60° angle.

Exhausting climb

In pilot work participants got off the Treadwall prior to exhaustion through tedium therefore in order to decrease the amount of time spent on the Treadwall and to maximize muscle fatigue the exercise stage began with straight arm pull-ups until volitional exhaustion followed by shake-out and a further bout of pull-ups. This continued until they deteriorated to 75% of their initial number of pull-ups. After a two-minute rest participants climbed on the Treadwall set to vertical (90° angle) at a self-determined pace, which was used for each test. Participants drank water *ad libitum* during the exercise.

Every minute the participants were asked to step off the wall for a 30-second rest in which HR and RPE [24] were recorded. If the participants slipped or fell off for any reason other than fatigue, the minute was reset and they were asked to step back on. The participants climbed until volitional exhaustion (1 minute on, 30 seconds rest until unable to complete more than 20-seconds climbing). The distance climbed was recorded in feet and inches and converted to metric units (m), the duration of the climb was recorded by stopwatch, and the speed of the climb calculated.

Post-climbing procedure

The post-exercise blood sample was recorded immediately after the climber reached volitional exhaustion and again after 2, 4 and 6 minutes post (Lactate Pro 48107, Arkray, Japan). Immediately post-exercise participants drank either 500 mL of "For Goodness Shakes" Chocolate Milk or water, followed by 500 mL with their evening meal 2 hours after finishing the climb. Participants were instructed to maintain consistency of food and drink consumption and verbally confirmed this.

After the short recovery period of 24 hours to replicate climbing competitions, participants repeated the protocol and the same measures were taken, and given the same recovery drink as on day one. After this bout the participants then recorded muscle soreness in the flexor muscles of the forearm, muscle soreness was scored using a 5 point Likert Scale with 1 being no soreness and 5 being extreme soreness. Muscle soreness was recorded each day for a period of three days.

Seven days later the whole procedure was repeated, with participants being given the alternative recovery drink (water instead of chocolate milk and *vice versa*). The groups were randomly selected through a name draw with 5 participants in each group.

Statistical analysis

Microsoft Office SPSS version 20 was used to complete a series of repeated measures ANOVA's (condition) to explore the impact of chocolate milk consumption as compared to water on the performance measures of distance climbed, duration of climbing and speed of the climb and physiological measures of heart rate, blood lactate, and self-reported muscle soreness scores. An alpha level of 5% was chosen to indicate significance.

Results

The purpose of this work was to consider the potential of chocolate milk as a recovery aid from an exhaustive bout of climbing in experienced climbers.

Performance measures, endurance, distance and speed

The baseline values for distance climbed were different, greater distances were covered when water only was consumed (233.17±160.02 m) as the recovery drink rather than drinking chocolate milk (159.41±112.47 m), which is surprising given that this was a cross over study (Figure 1).

However, this trend was notably reversed post-recovery with a distance of 170.38±108.2 meters after water and 217.93±116.74 meters reached after chocolate milk consumption, showing an improvement on the second day of 43.59±30.48 meters (+27%) with chocolate milk and a deficit of 63.17±251.82 meters (-27%) after water as the recovery drink. Resulting in a significant interaction $F_{(1,9)=}$11.704, P=0.008.

The second performance measure of duration climbed revealed similar results with longer times were achieved when water was consumed (19.9±12.7 minutes) prior to recovery than when drinking chocolate milk (14.4±7.7 minutes) but again notably reversed the post-recovery performance with a time of 14.0±8.3 minutes with water a decrease of 30% and 17.9±8.9 minutes an improvement of 20% with chocolate milk (Figure 2).

With chocolate milk there was an increase in endurance capacity of 3.5±2.5 minutes in the post-recovery climb whereas there was a deficit of 5.9±6.8 minutes after water, resulting in a significant interaction $F_{(1,9)=}$10.922, P=0.009. Speed (m/min) was consistent for the two conditions; the post-recovery climb speed with chocolate milk averaged 15.8±11.7 m/min and 15.3±11.0 m/min with water, indicating that it is endurance rather than speed that has been impacted upon by the differing recovery drinks.

Heart rate

A significant interaction was found for average HR; $F_{(1,9)=}$5.515, p=0.043. Showing a 3.5±5.3 b.min^{-1} increase (2%) in mean heart rate during the climb after chocolate milk consumption and a decrease of 2.7±5 b.min^{-1}(1.6%) after water as the recovery drink.

There was no significant difference in maximum HR. Maximum HR in the first climb with water was 182.2±9.9bpm and in the climb after recovery 186.6±9.3bpm. With the chocolate milk the maximum HR in the initial climb was 184.3± 13.6bpm and 185.7± 13.9bpm in the post-recovery climb. Maximum heart rate values indicate that participants reached maximum exertion in all tests, which was supported by an RPE of 20 (Borg Scale) for every participant by the end of each test (Figure 3).

Blood lactate

Blood lactate changes between conditions and climbs were not found to be significantly different. In the water condition lactates went from 2.3±0.6mmol.L^{-1} to 6.7±3.6 mmol.L^{-1} at the end of the first climb, an increase of 4.4±3.0 mmol.L^{-1} (66%). In the climb after recovery with water blood lactate went from 2.7±1.2 mmol.L^{-1} to 6.0±4.1 mmol.L^{-1} an increase of 3.3.± 4.0 mmol.L^{-1} (55%). In the chocolate milk condition lactates went from

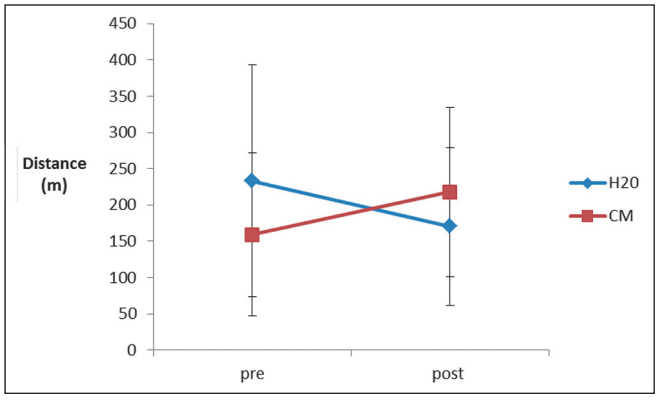

Figure 1.—Group mean±SD distance (metres) climbed for the initial and post-recoveries climb for chocolate milk and water.

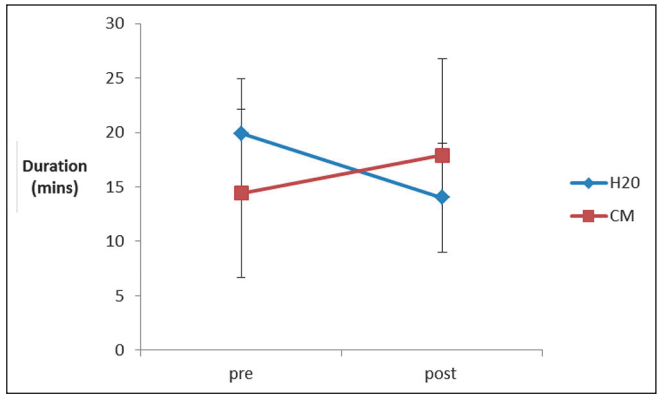

Figure 2.—Group mean±SD duration (minutes) climbed for the initial and post-recoveries climb for chocolate milk and water.

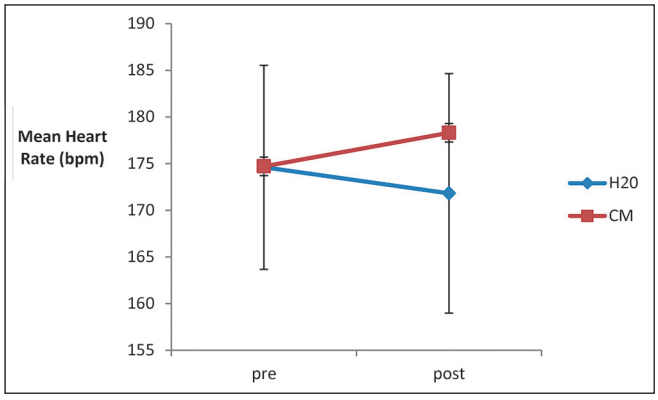

Figure 3.—Group mean±SD for mean heart rate for chocolate milk and water.

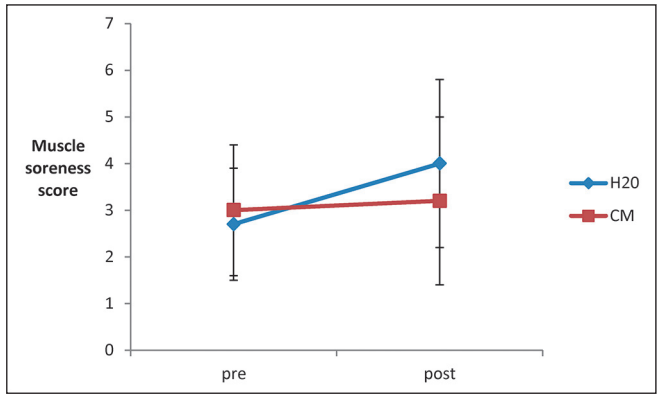

Figure 4.—Group mean±SD for self-reported muscle soreness after the recovery climb and consumption of either chocolate milk and water.

3.9±1.9mmol.L^{-1} to 8.9±4.5 mmol.L^{-1} at the end of the first climb, an increase of 4.9±4.7 mmol.L^{-1} (56%). In the climb after recovery with chocolate milk blood lactate went from 3.0 ±1.2 mmol.L^{-1} to 8.0±5.0 mmol.L^{-1} an increase of 5.1.± 5.5 mmol.L^{-1} (63%).

Muscle soreness

Postexercise muscle soreness scores were self-reported as a measure of recovery after the two bouts of exercise and the different drinks. After the second bout muscle soreness was recorded for 3 days and is shown in Figure 4.

Levels of muscle soreness were very similar, the day after, to those of the pre-test (water 2.7±1.2, chocolate milk 3.0±1.4) suggesting participants began the post-tests in similar states of muscular pain and exhaustion. After the post-recovery climb muscle soreness scores changed over time $F_{(1,9)=}12.114$, P=0.004 (Figure 3), a greater level of muscle soreness was reached after water (4±1.8) than after chocolate milk consumption (3.2±1.8) resulting in a significant interaction $F_{(1,9)=}5.557$, P=0.031.

In summary the physiological results of maximum heart rate and RPE indicate that participants did climb to volitional exhaustion in each case. However, in the post-recovery climb they were found to climb for longer and thus cover a greater distance after they had chocolate milk as opposed to water, despite the fact that mean heart rate was lower after water. The level of muscle soreness reported was less after chocolate milk.

Discussion

The purpose of this study was to examine if chocolate milk is an effective post-climbing recovery aid, allowing individuals to climb as hard and for as long the day after an exhaustive bout of climbing as the previous day, a scenario that occurs in climbing competitions. The evidence found supports the hypothesis; that chocolate milk will aid recovery, in a way that water will not, after an exhausting climbing session to enable individuals to climb harder, covering greater distances in shorter time frames and for longer on subsequent days.

The observed increase on the second climbing day in both the distance (43.6±30.5 meters) and duration (3.5±2.5 minutes) climbed following chocolate milk as a recovery drink was substantial. This is particularly notable when compared to the decrease in performance 61.3±79.9 meters and 5.9±6.8 minutes following recovery with water. A decrease in performance the day after an exhausting climb might be expected but it appears that the consumption of the chocolate milk has ameliorated this anticipated decrease and water consumption has not.

This study considers climbing endurance after recovery from an exhaustive bout of climbing and found not only a reduction in the deficit on the following climb but a 51% increase in duration climbed following chocolate milk compared to water. These findings are line with those of others who have also observed significant improvements in time to fatigue in sporting performance when compared with other recovery drinks.[5-9]

It appears as though chocolate milk will aid recovery, in a way that water will not, after an exhausting climbing session to enable individuals to climb harder, covering greater distances in shorter time frames and for longer on subsequent days. This suggests that muscular damage was minimised following chocolate milk suggesting muscle fibre repair, allowing participants to feel less muscular pain on subsequent days following exercise, this would be supported by previous indicating that there were positive changes to muscle protein turnover in response to chocolate milk as a recovery drink.[23] Previous studies [8, 9] have not found reduced muscle soreness during short-term recovery, but the 24-hour rest period allowed in this study was longer than four and 6 hours used in these studies on chocolate milk, and appears to have been sufficient to exhibit an attenuated response to the damaging exercise. Previous studies have however, found reduced creatine kinase (CK) levels, often used as a marker off muscle damage, after the consumption of chocolate milk [4, 7] and others have noted lower CK levels after consuming carbohydrates with protein after a 12- to 15-hour rest period,[14] while other works using longer training periods found that consuming carbohydrates with protein significantly decreased muscle soreness.[25, 26] A decrease in muscle soreness following a tough training session, day of climbing multiple routes on a trip, or even on a two-day competition, will undoubtedly impact on performance outcomes. Muscle soreness is likely to increase the perception of effort and potentially reduce both the intensity and duration of the performance. As high intensity climbing, like bouldering, is such a powerful sport, making use of all muscles in unusual and maximal ways, soreness can prevent technical moves being achieved and muscle soreness may affect the supple feeling of flexibility needed to complete the route.

Although this study had a crossover design it was not possible to disguise the chocolate milk and thus make the trial blind and consequently there may have been a psychological effect. The physiological data does not suggest that this was the case. Maximum heart rate, end RPE and blood lactate increases indicate that maximal exertion was achieved in all of the trials indicating that all climbs were done to maximal effort and consequently do not explain the performance outcomes.

Although lactate levels were not different between the two conditions, there was a broad range of post-exercise blood lactate found; 3 $mmol.L^{-1}$ to 16 $mmol.L^{-1}$. The least experienced climbers had the highest lactate levels and climbed shorter distances. It appeared that improved technique and fitness levels in the most experienced climbers allowed them to climb efficiently and rest effectively; giving them better performance scores, but there was no significant difference between the climber's abilities and the impact of chocolate milk as a recovery drink. This suggests that chocolate milk is an effective recovery aid for this range of ability levels and various types of climbing, involving both powerful and endurance elements to their performance.

The participants provided evidence that they were consistent with their diet from one testing week to the next. Evidence supports the fact that all participants reached fatigue, therefore it appears that "For Goodness Shakes" Chocolate Milk has had a significant impact on climbing performance over a 24-hour period, not only reducing the impact of an exhausting climb the previous day but actually improving endurance (distance) and work intensity (mean heart rate). As the type of climbing explored during this experiment involved a mixture of power and endurance, it is likely that chocolate milk could be an effective recovery aid for all climbing disciplines, including the sustained multi-pitch route used in this study but also bouldering, and although it is a more powerful and explosive form of exercise than explored in this experiment, it requires the use of resistance training and fine muscular tuning to achieve the hardest moves possible. Hartman *et al*. (2007) have suggested that milk consumption aided a twelve-week resistance programme [27] and from the evidence provided here it is probable that if climbers adopted chocolate milk as a recovery strategy when training for bouldering, their performance could be enhanced.

Recovery nutrition in the form of a drink is particularly advantageous for climbers as drinks as opposed to an appropriately constituted carbohydrate and protein meal afford the advantage of being quick, convenient and easily transported. This could be particularly important if the climbing route was a part of a longer journey or expedition where convenience was of utmost importance.

Conclusions

This study examined the influence of chocolate milk consumption on climbing performance, explor-

ing its benefits in comparison to water following an exhaustive bout of high intensity endurance climbing. It can be concluded that participants were able to climb significantly further and for a longer duration, indicating a superior climbing performance; they also indicated less muscular soreness following chocolate milk consumption as compared to water as a recovery drink following an exhaustive bout of climbing. This apparent rapid recovery from a bout of exhaustive climbing could give a good advantage in competitions, as well as general training regimes, allowing higher training levels.

The study could have been enhanced further through. More rigorous diet control to ensure no other nutritional advantages could influence the results; an in-depth exercise diary should also be kept to ensure participants expended the same amount of energy before each test and the employment of a sleep record and psychological aspects such as motivation and arousal could be useful.

Future research should consider other types of recovery drink as well as exploring more nutritional support possibilities for climbers who as a sport have very little specific sport science research support.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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