Ryan, GA, Long, GB, Bishop, SH, Herron, RL, & Katica, CP. The effects of ASEA on recovery from a single bout of resistance training and subsequent performance. J Sport Human Perf 2013;1(4):22-30
doi: 10.12922/jshp.0026.2013

JSHP
JOURNAL OF SPORT AND HUMAN PERFORMANCE

ORIGINAL RESEARCH OPEN ACCESS

THE EFFECTS OF ASEA ON RECOVERY FROM A SINGLE BOUT OF RESISTANCE TRAINING AND SUBSEQUENT PERFORMANCE

Ryan, GA[1], Long, GB[1], Bishop, SH[2], Herron, RL[3], & Katica, CP[3]

[1] *University of Montana Western*

2 Texas A&M University Commerce

3 University of Alabama

ABSTRACT

Delayed-onset muscle soreness (DOMS) is the feeling of discomfort within the skeletal muscle occurring after a bout of unaccustomed work. In an attempt to recover quicker from the effects of DOMS, many individuals turn to supplements and recovery beverages. The purpose of this study was to determine if the dietary supplement/recovery beverage ASEA could alleviate the pain and discomfort commonly associated with DOMS as well as enhance participants' recovery performance during three sets of total body weight lifting to failure. A counterbalanced, double blind, placebo controlled, repeated measures protocol was performed with 7 healthy, college aged, male volunteers. The protocol consisted of two trials of six lifts (seated up-right bench press, supine hip extension, seated elbow flexion, seated knee extension, seated back row, and prone knee flexion) separated by 24 hrs under one condition. Six days later, participants repeated the protocol under the other condition. Effectiveness of ASEA was measured against placebo using: 1) paired samples t-tests (alpha = 0.05), for total number of combined lifts completed; 2) difference of number of lifts from Day 1 to Day 2; 3) subjective ratings of exertion; 4) muscular soreness; 5) and perceived recovery. ASEA was ineffective in improving performance or recovery compared to the placebo in any of the parameters tested: total repetitions on Day 2 (A: 189 ± 31 reps; P: 180 ± 29 reps; p = 0.37); difference in two day number of lifts (A: 16 ± 21 reps; P: 21 ± 9 reps; p = 0.57); session RPE (Day 1: p = 0.77; Day 2: p = 0.69); difference in muscle soreness (Day 1: A: 31 ± 20; P: 34 ± 27; p = 0.73; Day 2: A: 12 ± 11; P: 18 ± 11; p = 0.64); perceived recovery (A: 6 ± 2; P: 5 ± 2; p = 0.26). The results of this study suggest that ASEA does not alleviate DOMS symptoms or enhance recovery in the manner and population tested in this study.

Keywords: DOMS; Resistance Training

INTRODUCTION

Delayed-onset muscle soreness (DOMS) is the feeling of discomfort within the skeletal muscle occurring after a bout of unaccustomed or intense work or exercise (1). DOMS is classified as a Type I muscle strain, and is usually characterized as microtrauma of myofilaments and cytoskeletal elements as well as an inflammatory response by the muscle fibers which push on nerve endings as

a result of the injury (2). This inflammatory response, in turn, is responsible for the soreness that is associated with DOMS (2). It is well accepted that DOMS impairs muscular performance. As early as 1902 researchers investigated the effect of DOMS on muscular performance, finding that DOMS affected the voluntary effort of the muscles due to the soreness experienced by the participant as well as lowering the ability of the muscle to create force (3). Recovery from DOMS has been evaluated by many researchers, most agreeing that by 72 hrs most individuals are completely recovered (1). However, some investigations noted only 1 of the 20 subjects was recovered by 48 hrs (4).

It appears as though no single method for recovery is accepted as most successful following a bout of exercise that produces DOMS (5). However, the most common form of treatment for DOMS is the ingestion of analgesics, such as nonsteroidal anti-inflammatory drugs (NSAIDs), which attack the inflammation response associated with muscle damage (1). However, recent research has suggested that the long term use of NSAIDs may actually be detrimental to recovery, due to impairment of satellite cell activity (6). Other research has focused on various modalities including: topical lotions and creams (7), ingestion of milk-based carbohydrate-protein (8), stretching (9, 10), thermal therapy (11), massage therapy (12), and cryotherapy (13). These studies have shown various levels of success in counteracting the effects of DOMS.

In an effort to recover quicker from the effects of DOMS, many individuals turn to supplements and recovery beverages. Many of these supplements contain potentially dangerous levels of caffeine (14). Other recovery beverages, including the one studied in this research ASEA (ASEA, Salt Lake City, UT), offer claims of improved performance and recovery times through the use of Coupled Reduction-Oxidation (Redox) Signaling molecules (hydrogensuperoxide (HO2), hydrogen peroxide (H2O2), hypochlorous acid (HOCl), and nitric oxide (NO) (15). It has been established that Redox changes can be sensed and relayed through the body by a number of cellular transducers (16). It is theorized that these changes can have an impact on recovery in the human body. ASEA delivers these Redox Signaling molecules in a mixture of odorless, clear, distilled water and sodium chloride, without the potential hazards of high levels of caffeine or other ingredients often found in other dietary supplements and recovery beverages (15). ASEA claims that while chronic use of the supplement produces the best results, that an acute consumption of 8 oz of the supplement, 10-15 min before exercise, will allow an individual to withstand more vigorous training periods, be less fatigued, recover faster, and experience less muscular soreness (15). Therefore, the purpose of this investigation was to determine if ASEA could alleviate the symptoms of DOMS and enhance 24-hr recovery performance after completeing four separate bouts of three sets of total body weight lifting to failure.

METHODS

Participants

Following approval by the University Institutional Review Board, 7 healthy, male, resistance trained individuals (age 22 ± 2 yrs; ht 181.4 ± 9.4 cm; wt 87.2 ± 10.5 kg; BMI 26.5 ± 3.0) were recruited for the study. Only individuals with strength training experience, defined as, training for at least 12 weeks (minimum of 2 training sessions per muscle group per week) prior to the study were included in the study. Participants provided written informed consent prior to participation, and re-consented prior to each trial. Participants were asked to refrain from any other forms of exercise other than the exercises performed during the testing

protocol for the duration of the study. Participants were also asked to maintain their normal dietary habits as close to possible to those utilized before the start of their participation in the study. However, participants were asked to ensure adequate hydration by consuming approximately 500 to 600 mL (17 to 20 fl oz) of water 2 to 3 hrs before exercise and 200 to 300 mL (7 to 10 fl oz) of water 10 to 20 minutes before arriving for testing (17).

Pre-Testing

A pre-test questionnaire was administered verbally to the participants regarding previous and present exercise experience ensuring participants meet the inclusion criterion without requiring the participants to be advanced lifters. All demographics, including semi nude body weight and height, were recorded prior to completion of the first exercise bout. Participants were introduced to the OMNI Session RPE (18), Perceived Recovery Scale (PRS) (19), and a 100 mm visual analog scale to determine muscle soreness (0 anchored with no muscle soreness and 100 anchored with extreme muscle soreness).

Additionally, the participants were informed about the order, proper technique, and muscle groups targeted for the six exercises: (1) seated up-right bench press – pectoralis major (2) supine hip extension (leg press) – gluteus maximus and quadriceps (3) seated back row (tríceps press) - latissimus dorsi (4) seated knee extension (leg extension) – quadriceps (5) seated elbow flexion (bicep curl) – bíceps brachii (6) prone knee flexion (leg curl) – hamstrings. Exercises 1, 4, and 6 were performed using LifeFitness machines (LifeFitness, Schiller Park, IL). Exercise 3 was performed with a Cybex machine (Lumax, Ronkonkoma, NY). Exercise 2 was performed with a BFS machine (Bigger, Stronger, Faster, Salt Lake City, UT). Exercise 5 was performed using a curl bar and seated bench, due to lack of seated elbow flexion machine at the testing facility.

Determination of 10-RM

Participants reported to the weight room facility to establish a ten repetition maximum (10-RM) for each of the six lifts. The 10-RM protocol has been previously determined to be valid and reliable (4). A light load (easily allowing 15 repetitions) for a warm-up prior to the 10-RM testing was used to help estimate the starting load for the 10-RM testing. Participants were then asked to estimate how much they thought they could lift for 10 repetitions while reaching volitional fatigue on the final repetition. Participants were allowed 4 min rest in between sets to ensure adequate recovery time and the process repeated, raising or lowering the weight by 2.3 to 5.6 kg, until the participant reached volitional fatigue on their 10th repetition. All 10-RM tests were supervised by the same experienced technician to ensure proper technique and that the 10-RM was determined within 3 trials. The 10-RM weight for each exercise was recorded and used for all subsequent testing sessions.

Testing Sessions

Ninety-six hrs after the determination of 10-RM, participants reported back to the facility for testing. Prior to each of the four testing session, participants were asked to determine their perceived muscle recovery using the PRS scale, a 0–10, scalar representation of varying levels of an individual's level of perceived recovery (19). Muscle soreness was also measured using a 100-mm visual analog scale. Prior to the testing sets, 1, 10 repetition warm-up set was performed using approximately (depending on the plates and weights available for the

machines) 60% of the participants previously recorded 10-RM weight load for that lift. All exercises were performed in a pattern of 3 sets, 10 repetitions, with 4 minutes of rest in between each set. Participants were instructed to continue the exercise until volitional fatigue was reached, and not just stop at the 10th repetition. Following the completion of each set, the researcher recorded the number of repetitions for that set. This procedure was repeated for each set and each of the six exercises for all testing sessions.

Upon completion of the entire exercise protocol, participants were asked to rate the overall workout difficulty using the OMNI Session RPE and completed the post exercise 100 mm visual analog scale to measure muscle soreness following a 15 minute rest period. Participants then drank 8 oz of a beverage (either treatment [ASEA] or placebo [water]) and told that this beverage may or may not aid in the muscle recovery process. Participants were sent home and instructed to return 24 hrs after the first trial to complete the second exercise session.

When participants returned for testing 24 hrs later, they were asked to estimate their muscle recovery using the PRS scale. After this was recorded, participants consumed 8 oz of the same beverage they drank after completion of the first lifting trial and waited 10 min prior to beginning the second exercise session. This trial used the same testing protocol from the first trial. The protocol used to determine drinking pattern and amount was taken from the ASEA company (15). Following the completion of the second exercise session, participants were instructed to return 144 hrs (6 days, to ensure time for recovery) later to complete the second round of exercise sessions with the same methods consuming the alternate beverage.

Statistical Analysis

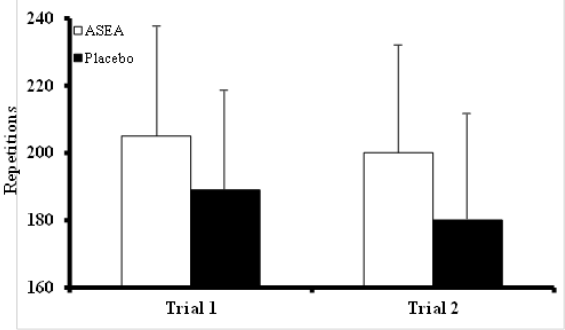
Data were analyzed using SPSS v. 19.0 (SPSS, Inc., Chicago, IL), and alpha was set at 0.05 for all comparisons. Data are presented as means ± SD. The numbers of repetitions from each set for each of the six lifts were added to create total repetitions, which were used for all analyses. Data were analyzed based on treatment type and trial days. Paired samples t-tests were conducted for all tested parameters: total number of combined lifts completed, difference of number of lifts from Trial 1 to Trial 2, subjective ratings of exertion, muscle soreness, and perceived recovery.

RESULTS

Total Repetitions

Total repetitions were calculated by combining the repetitions from the three sets of each of the six exercises tested. The results of the total repetitions between the two conditions are displayed in Figure 1.

Figure 1. Combined number of repetitions from the 6 exercises tested of 7 participants during Trial 1 and Trial 2 under both conditions (ASEA, placebo). Data are presented as means ± SD. There was no significant difference between treatments at either trial (p = 0.37).

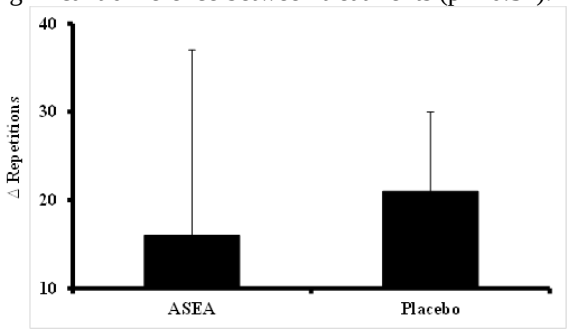


No significant difference (p = 0.56) existed on the first trial between total reps for ASEA (205 ± 33 reps) and placebo (200 ± 25 reps), or during the second trial (A: 189 ± 31 reps; P: 180 ± 29 reps).

Difference in Number of Repetitions

The change in total numbers of repetitions between Trial 1 and 2 was analyzed as Δ Rep. The results of Δ Repetitions under the two conditions are displayed in Figure 2.

Figure 2. Average difference in number of repetitions (Trial 1 – Trial 2) from the 6 exercises tested of 7 participants under both conditions (ASEA, placebo). Data are presented as means ± SD. There was no significant difference between treatments (p = 0.57).



ASEA did not affect Δ Rep evidenced by a lack of significant effect of condition (A: 16 ± 21 reps; P: 21 ± 9 reps).

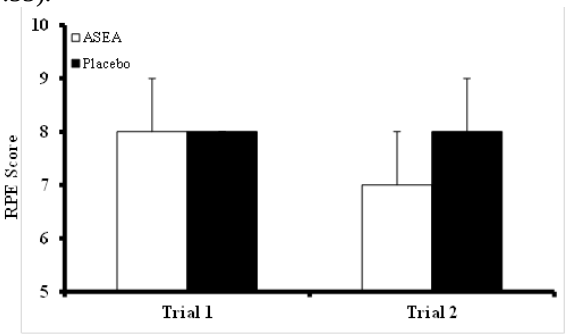
OMNI Session RPE

Following completion of each trial, participants were asked to record the perceived difficulty of the session using the OMNI RPE Scale for Resistance Exercise. The results of the OMNI Session RPE between the two conditions are displayed in Figure 3.

Muscle Soreness

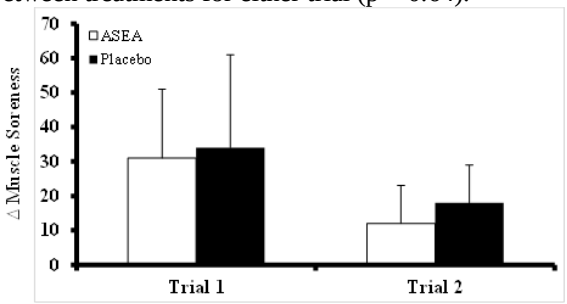
Scores for muscle soreness were tabulated prior to and immediately following completion of each trial session. As expected, muscle soreness significantly increased in both conditions following the completion of both trials (ASEA Trial 1: p = 0.01; Placebo Trial 1: p = 0.02; ASEA Trial 2: p = 0.03; Placebo Trial 2: p < 0.01). A significant difference in muscle soreness was also observed between Trial 1 and 2 under both conditions (A: Trial 1: 16 ± 14; Trial 2: 43 ± 22; p = 0.05; P: Trial 1:12 ± 9; Trial 2: 38 ± 21; p = 0.01). ASEA was unsuccessful in attenuating muscle soreness as noted by the significant difference in soreness between Trial 1 and 2. The results of the difference in muscle soreness between the two trials are displayed in Figure 4.

Figure 3. OMNI Session RPE of 7 participants during Trial 1 and Trial 2 under both conditions (ASEA, placebo). Data are presented as means ± SD. There was no significant difference between treatments (p = 0.55).



Participants did not view one condition significantly harder than the other during either Trial 1 (p = 0.77) or Trial 2 (p = 0.69). No significant difference existed between the OMNI Session RPE during either trial in the ASEA (Trial 1: 8 ± 1; Trial 2: 7 ± 1; p = 0.20) or Placebo (Trial 1: 8 ± 0; Trial 2: 8 ± 1) conditions.

Figure 4. Average difference in muscle soreness (Post trial – Pre trial) from the 7 participants under both conditions (ASEA, placebo). Data are presented as means ± SD. There was no significant difference between treatments for either trial (p = 0.64).

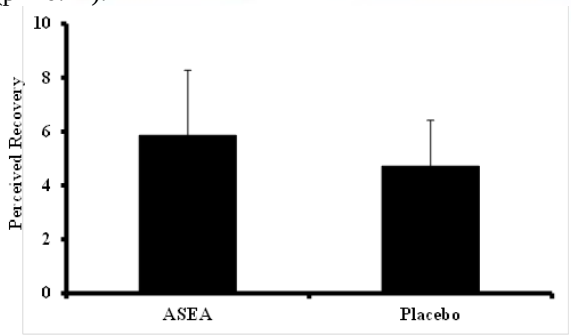


No significant difference existed between the change in muscle soreness under either condition during Trial 1 (A: 31 ± 20; P: 34 ± 27; p = 0.73) or Trial 2 (A: 12 ± 11; P: 18 ± 11).

Perceived Recovery

The results of the PRS scale between the two conditions are displayed in Figure 5.

Figure 5. Average perceived recovery of the 7 participants following 24 hrs under both conditions (ASEA, placebo). Data are presented as means ± SD. There was no significant difference between treatments (p = 0.27).



The average perceived recovery under both conditions represented that participants felt "Adequately" to "Moderately" recovered prior to completion of Trial 2. No significant difference existed between the ASEA and Placebo trials (A: 6 ± 2; P: 5 ± 2).

DISCUSSION

The purpose of this study was to determine the effectiveness of an acute supplementation of ASEA on the symptoms of DOMS and 24 hr recovery performance during four separate bouts of three sets of total body weight lifting to failure in college aged resistance trained individuals. The study mean data suggests that ASEA was not effective in alleviating the symptoms of DOMS in the manner tested. Additionally, ASEA was not able to improve the 24 hr recovery performance of the participants, as noted by a lack of significance for all variables tested. This result is similar to previous research that determined 24 hrs was insufficient for proper recovery following muscular work (3). This result disputed the ASEA claim that an acute consumption of 8 oz of the supplement would allow individuals to recover faster and experience less muscular soreness (15).

Participants were unable to perform a significantly greater number of total lifts on either day with ASEA (Trial 1: 205 ± 33 reps; Trial 2: 189 ± 31 reps) compared to the placebo (Trial 1: 200 ± 25 reps; Trial 2: 180 ± 29 reps). ASEA was unable to attenuate muscle soreness immediately following, and 24 hrs after DOMS inducing exercise. ASEA also did not influence perceived muscle soreness, as measured by PRS, or training session intensity, as measured by RPE, when compared to the placebo.

The ingredients in ASEA are distilled water, 123 mg of sodium, and 190 mg of chloride per 4 fluid ounces (15). Previous research has noted that serial and acute ingestion of sodium bicarbonate (NaHCO3) significantly improves athletic performance (20, 21). However, the company suggests this solution serves only as a vessel to deliver the "trillions of stable, perfectly balanced redox signaling molecules" in the bottle (15). Nitric oxide (NO), one of the redox signaling molecules in ASEA, is a known vasodilator that has been increasingly used as a supplement (22). However, concern has been raised that NO and other nitrites may endanger the health of the user, particularly in an athletic venue (22). As previously stated, it is understood that reduction-oxidation changes are relayed throughout the body by cellular transducers (16). How redox signaling affects the body during and post exercise is becoming of increasing interest to researchers (23). One study suggests that the use of a thiol-based antioxidant, with redox signaling capabilities, significantly hampers exercise-induced cellular adaptations, including disrupting the inflammatory response and repair capability of the muscle cells (24). Further research should focus on the properties of each redox signaling molecule in ASEA.

This study was limited by a number of factors. While this study was conducted on experienced weight lifters, a learning curve

may still have existed on some of the exercise equipment chosen for this study. Most of the participants in this study were more experienced with free weights, and some stated that becoming comfortable on the machines was difficult. Due to the limitations of experienced lifters, all participants in this study were men. ASEA suggests that for best results, individuals should consume two ounces of ASEA twice daily, and supplement with 8 ounces 10 minutes prior to intense activity. A study focusing on the chronic effects of ASEA should be considered. Additionally, future research should examine the effects of ASEA on inexperienced lifters and those individuals more likely to experience greater levels of soreness following exercise.

REFERENCES

1. Armstrong RB. Mechanisims of exercise-induced delayed onset muscular soreness: a brief review. Med Sci Sports Exer. Med Sci Sports Exer 1984;16(6):529-538. [Google Scholar]

2. Mathur S, Sheel A, Road JD, Reid W. Delayed onset muscle soreness after inspiratory threshold loading in healthy adults. Cardiopulm Phys Ther J. 2010;21(1):5-12. [Google Scholar]

3. Hough T. Ergographic studies in muscular soreness. Am J Physiol. 1902 1902;7:76-92. [Google Scholar]

4. McLester JR, Bishop PA, Smith J, Wyers L, Dale B, Kozusko J, et al. A series of studies- a practical protocol for testing muscular endurance recovery. J Strength Cond Research 2003;17(2):259-273. Available from: http://www.scholaruniverse.com/ncbi-linkout?id=12741861 PubMed PMID: 12741861. [Google Scholar]

5. Barnett A. Using recovery modalities between training sessions in elite athletes; Does it help. Sports Med. 2006 2006;36(9):781-796. Available from: http://www.nlm.nih.gov/medlineplus/exerciseandphysicalfitness.html PubMed PMID: 16937953. [Google Scholar]

6. Schoenfeld BJ. The use of nonsteroidal anti-inflammatory drugs for exercise-induced muscle damage: implications for skeletal muscle development.. Sports Med 2012 Dec;42(12):1017-1028. Available from: http://www.nlm.nih.gov/medlineplus/exerciseandphysicalfitness.html PubMed PMID: 23013520. doi: 10.2165/11635190-000000000-00000. [Google Scholar]

7. Johar P, Grover V, Topp R, Behm DG. A comparison of topical menthol to ice on pain, evoked tetanic and voluntary force during delayed onset muscle soreness. Int J Sports Phys Ther. 2012 2012;7(3):314-22. Available from: http://europepmc.org/abstract/MED/22666646 PubMed PMID: 22666646. [Google Scholar]

8. Cockburn E, Stevenson E, Hayes PR, Robson-Ansley P, Howatson G. Effect of milk-based carbohydrate-protein supplement timing on the attenuation of exercise-induced muscle damage.. Appl Physiol Nutr Metab 2010;35(3):270-277. Available from: http://www.nlm.nih.gov/medlineplus/carb

ohydrates.html PubMed PMID: 20555370. doi: 10.1139/H10-017. [Google Scholar]

9. Henschke N, Lin CC. Stretching before or after exercise does not reduce delayed-onset muscle soreness. Br J Sports Med 2011;45(15):1249-50. doi: 10.1136/bjsports-2011-090599. [Google Scholar]

10. Herbert RD, de Noronha M, Kamper SJ. Stretching to prevent or reduce muscle soreness after exercise. Cochrane Database Syst Rev. 2011; (7). doi:10.1002/14651858.CD004577.pub3.

11. Hassan ES. Thermal therapy and delayed onset muscle soreness. J Sports Med Phys Fitness. 2011 2011;51(2):249-54. [Google Scholar]

12. Zainuddin Z, Newton M, Sacco P, Nosaka K. Effects of massage on delayed-onset muscle soreness, swelling, and recovery of muscle function. J Athl Train. 2005 2005;40(3):174-80. Available from: http://europepmc.org/abstract/MED/16284637 PubMed PMID: 16284637. [Google Scholar]

13. Howatson G, Goodall S, van Someren KA. The influence of cold water immersions on adaptation following a single bout of damaging exercise.. Eur J Appl Physiol 2008 Nov;105(4):615-621. Available from: http://www.nlm.nih.gov/medlineplus/exerciseandphysicalfitness.html PubMed PMID: 19034491. doi: 10.1007/s00421-008-0941-1. [Google Scholar]

14. Buxton C, Hagan JE. A survey of energy drinks consumption practices among student -athletes in Ghana: lessons for developing health education intervention programmes.. J Int Soc Sports Nutr 2012 Mar;9(1):9-1186. Available from: http://www.jissn.com/content/9/1/9 PubMed PMID: 22444601. doi: 10.1186/1550-2783-9-9. [Google Scholar]

15. Redoxsignalingwater.com [Internet]. Salt Lake City. c2009-2013 [cited 2013 July 7]. Available from: http://www.redoxsignalingwater.com/

16. Banerjee R, Smith W. Thematic minireview series on redox sensing and regulation.. J Biol Chem 2011 Dec;287(7):4395-4396. Available from: http://www.jbc.org/cgi/pmidlookup?view=long&pmid=22147699 PubMed PMID: 22147699. doi: 10.1074/jbc.R111.330761. [Google Scholar]

17. Casa DJ, Armstrong LE, Hillman SK, Montain SJ, Reiff RV, Rich BS, et al. National athletic trainers' association position statement: Fluid replacement for athletes. J Ath Train 2000;35(2):212-224. Available from: http://europepmc.org/abstract/MED/16558633 PubMed PMID: 16558633. [Google Scholar]

18. Robertson RL, Goss FL, Rutkowski J, Lenz B, Dixon C, Timmer J, et al. Concurrent validation of the OMNI perceived exertion scale for resistance exercise. Med Sci Sports Exerc 2003;35(2):333-41. Available from: http://www.scholaruniverse.com/ncbi-

linkout?id=12569225 PubMed PMID: 12569225. doi: 10.1249/01.MSS.0000048831.15016.2A. [Google Scholar]

19. Laurent CM, Green JM, Bishop PA, Sjökvist J, Schumacker RE, Richardson MT, et al. A practical approach to monitoring recovery: development of a perceived recovery status scale.. J Strength Cond Res 2011;25(3):620-628. Available from: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+50-21-5 PubMed PMID: 20581704. doi: 10.1519/JSC.0b013e3181c69ec6. [Google Scholar]

20. Bird SR, Wiles J, Robbins J. The effect of sodium bicarbonate ingestion on 1500-m racing time. J Sport Sci. 1995 1995;13(5):399-403. Available from: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+144-55-8 PubMed PMID: 8558626. doi: 10.1080/02640419508732255. [Google Scholar]

21. Driller MW, Gregory JR, Williams AD, Fell JW. The effects of serial and acute NaHCO3 loading in well-trained cyclists.. J Strength Cond Res 2012;26(10):2791-2797. Available from: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+144-55-8 PubMed PMID: 23001395. doi: 10.1519/JSC.0b013e318241e18a. [Google Scholar]

22. Petróczi A, Naughton DP. Potentially fatal new trend in performance enhancement: a cautionary note on nitrite.. J Int Soc Sports Nutr 2010 Jun;7(7):25-1186. Available from: http://www.jissn.com/content/7//25 PubMed PMID: 20587040. doi: 10.1186/1550-2783-7-25. [Google Scholar]

23. Nikolaidis MG, Kerksick CM, Lamprecht M, McAnulty SR. Redox biology of exercise.. Oxid Med Cell Longev 2012 Sep;2012:407978-10. Available from: http://dx.doi.org/10.1155/2012/407978 PubMed PMID: 23050039. doi: 10.1155/2012/407978. [Google Scholar]

24. Michailidis Y, Karagounis LG, Terzis G, Jamurtas AZ, Spengos K, Tsoukas D, et al. Thiol-based antioxidant supplementation alters human skeletal muscle signaling and attenuates its inflammatory response and recovery after intense eccentric exercise.. Am J Clin Nutr 2013 May;98(1):233-245. Available from: http://ClinicalTrials.gov/search/term=23719546%20%5BPUBMED-IDS%5D PubMed PMID: 23719546. doi: 10.3945/ajcn.112.049163. [Google Scholar]