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The Effects of Açai (*Euterpe Oleracea Mart*) on Delayed Onset Muscle Soreness in Collegiate Male Athletes and Non-Athletes

Original Research

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Abstract

Introduction: Eccentric exercise often results in the production of markers of oxidative stress and an inflammatory response, which leads to delayed onset muscle soreness (DOMS). DOMS is associated with impaired muscular performance. Dietary interventions may reduce inflammation and improve physical performance. The aim of the study was to determine if Açai supplementation reduces muscle soreness and improves muscle function.

Methods: Twenty collegiate athletes and non-athletes were counterbalanced into an Açai group or a placebo group. Supplementation started 48 hours prior to a bout of downhill running (DR). Range of motion, muscle soreness perception, agility, and vertical jump were assessed at baseline, immediately after DR, 24, and 48 hours after DR.

Results: The Açai group (N = 10) reported significantly less muscle soreness in the quadriceps muscle (p = .011) compared to the placebo group (N = 10). Furthermore, the Açai group showed improvements in range of motion, agility, and vertical jump displacement compared to the placebo group throughout all 4-time periods.

Conclusions: Açai appears to be an effective supplement to decrease quadriceps muscle soreness after downhill running. This decrease in soreness may contribute to performance gains also noted in the Açai group.

Key Words: Dietary Supplementation, Downhill Running, Muscle Damage

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Introduction

Both individuals who engage in periodic physical activity and athletes, who engage in exercise of high intensity and/or high volume, can experience delayed onset muscle soreness (DOMS). DOMS is characterized by muscle pain and stiffness that may limit physical function for several days after exercise [1]. DOMS usually commences 12–24 hours following eccentric or intense exercise and peaks in 2–3 days, with a linear decrease in symptoms within 8–10 days[1,2]. In addition, DOMS often decreases range of motion, agility, maximum muscular power, and performance[3,4]. Furthermore, return to sport without proper recovery (i.e. absence of DOMS) has the potential to increase the risk of injury such as muscle strain[5].

There are several ways to reduce muscle soreness and enhance muscle recovery after intense exercise including whole-body vibration, cold-water immersion, massage therapy, foam roller, massage, proprioceptive neuromuscular facilitation (PNF), acupuncture, anti-inflammatory drugs (NSAID), antioxidants, and phytochemical supplementation [3]. An interesting phytochemical candidate for reduction of DOMS is Açai, which is an exotic fruit of a palm tree (Arecaceae) in the Amazon [6] with potent anti-inflammatory and antioxidant properties [7]. The extracts and juices of the fruit Açai have antiproliferative, anti-inflammatory, antioxidant, and cardio-protective properties [8-11]. For example, Jensen and colleagues showed that Açai increased range of motion and decreased pain in individuals who had mild to moderate joint pain [7]. In addition, Açai supplementation increased plasma antioxidant capacity and decreased serum lipid profile, but did not affect sprint performance in junior hurdlers [12]. However, Açai supplement did promote increased time to exhaustion, enhanced cardiorespiratory responses, decreased metabolic stress and reduced perceived exertion in pentathletes, runners and sprinters [13]. These findings suggest that Açai may be an effective phytochemical supplementation to reduce DOMS and improve performance but this has not been systematically examined.

Therefore, the aim of this research was to investigate the effects of Açai on muscle soreness and physical performance in collegiate athletes and non-athletes after a controlled bout of eccentric exercise. This study tested two hypotheses: 1. Açai supplementation will reduce muscular soreness after downhill running; 2. Açai supplementation will result in higher scores on range of motion vertical jump displacement and agility running compared to the placebo group.

Methods

Participants

Participants between 17–25 years of age, collegiate athletes, and non-athletes were recruited. All volunteers who met the above criteria were pre-screened in person. The pre-screening included the American Heart Association/American College of Sports Medicine exercise pre-participation questionnaire [14] and a health history questionnaire. Volunteers identified as low risk (presented one or less cardiovascular risk factor), and no history of muscle disorder, chronic inflammation, allergies of food from the palm trees family, and lower-extremity injury in the past 3 months qualified for the investigation. Individuals who qualified provided written informed consent as required by the Institutional Review Board.

Protocol

The investigation was conducted as a double blind, counterbalanced, and placebo-control trial. Volunteers' age, blood pressure, resting heart rate, height, weight, VO_{2max} test and 1 repetition maximum (1RM) leg press were measured. During the first visit, baseline data included a VO_{2max} test and 1 repetition maximum (1RM) leg press. The VO_{2max} standardized maximal treadmill protocol included a fixed grade at 3% and an increase in speed by 1km/h each minute until maximum sustained effort. The treadmill speed was initially set at 6km/h [1]. Expired air was sampled using the PARVO Medics TrueOne 2400 Metabolic Cart. The test was completed on a motorized treadmill (MT200 Gait Trainer Treadmill) from Spirit Medical Systems Group. The VO_{2max} test was used to counterbalance the Açai extract supplement group and placebo group. For example, the first volunteer in the fair category, according to the normative data provided by the American College of Sports Medicine [14] was placed in one group (supplement), whereas the second volunteer to score in the fair category was be placed on the opposite group (placebo). The same procedure was repeated with volunteers who scored good, excellent, or superior. Volunteers who did not fall into the fair or above categories were excluded from the study. A 1-repetition maximum (1RM) leg press test was performed during baseline. This test was performed in order to ensure that volunteers' fitness status would not be a variable, which could influence the results of this investigation. In order to determine if the 1RM between groups were statistically significant, volunteers' relative muscular strength was calculated by dividing volunteers' 1RM leg press by their body weight (relative strength = leg press 1RM / body weight).

Volunteers were instructed to maintain their usual diet and to abstain from physical activity 48 hours prior to downhill running and throughout the study. They were also asked to abstain from the use of supplements and/or sports drinks containing antioxidants and anthocyanin, a class of flavonoids, rich food such as red, purple or blue fruits, juices, and tea throughout the investigation. Volunteers reported their nutrient intake during each visit.

During the second visit, volunteers performed a 30-minute run on a calibrated motorized treadmill (MT200 Gait Trainer Treadmill, Spirit Medical Systems Group). The 30-minute run protocol consisted of a 5-minute warm-up at grade of 0% at a speed chosen by the volunteer [1]. After the 5-minute warm-up, treadmill speed was increased until 80% of predicted heart rate was achieved. The predicted heart rate of each volunteer was calculated with the use of the Karvonen Formula [15]. Volunteers' heart rate was measured with the use of a polar FT7 heart rate monitor. Once the volunteer maintained the new pace for 5 minutes, the treadmill grade was adjusted to 10% decline. After the 15-minute downhill running, volunteers also completed a 5-minute cool down at a self-selected pace and 5 minute seated passive recovery period. A previous pilot study demonstrated that 15 minutes of downhill running produced DOMS.

Intervention

After the completion of the baseline data collection, volunteers received 5 gelatin capsules, from a blinded researcher. The gelatin capsules either had the Açai supplement or the placebo (gelatin capsules filled with Domino sugar). The ConsumerLab report for the supplement, the Vitamin Shoppe Açai extract used in this study, revealed that the supplement contain Açai Berry 5:1 Extract (*Euterpe oleracea*). In addition, other ingredients include vegetable cellulose, dicalcium phosphate, magnesium stearate, and silica. No yeast, wheat, sugar, salt, soy, diary, citrus, fish, animal derivatives, preservatives, artificial colors or flavors additives were found in the Açai extract.

Volunteers took 1 gelatin capsule, 1000mg Açai extract capsule or placebo, in front of the investigator prior to leaving the laboratory. Volunteers were then instructed to take one gelatin capsule 20 minutes before dinner on day 1 and day 2, and 20 minutes before breakfast on day 2 and day 3. Volunteers initiated the supplementation 48 hours prior to the downhill running protocol and continued for 48 hours after it [1]. They returned the empty bag to the researcher during the second visit on day 3, the third visit on day 4, and the fourth visit on day 5 as a confirmation that the supplement or placebo gelatin capsules were taken.

Outcome Measures

Agility, vertical jump displacement, knee and hip flexion, and muscle soreness were measured at baseline, immediately after downhill running, 24 and 48 hours after the exercise bout. In order to complete the t-test agility test, volunteers began with both feet behind the start at point 1[16]. At their own discretion, each volunteer sprinted forward 9.14m (10 yards) to point 2. Volunteers then shuffled to the left 4.57m (5 yards) and touched the cone on point 3 with their left hand. Next, individuals shuffled to the right 9.14m and touched the cone on point 4 with their right hand and then repeated the shuffle to the left. Volunteers completed the test running backwards, passing the finish line at point 1. Volunteers performed a familiarizing trial as they walked through the course. A clock with electronic sensor was placed at point 1. The clock started when volunteers crossed point 1 and stopped when volunteers crossed the sensor plane again. The test was repeated if volunteers failed to touch the cone, crossed their feet when shuffling, and/or did not face forward at all times. Three trials were performed and the average time was used for statistical analyses.

A vertical jump trainer (VERTEC) was used to assess vertical jump displacement. The first step on this test was to measure volunteers' vertical reach. Volunteers then dropped down to a self-selected level before jumping maximally [17]. Unrestricted countermovement and free arm swing was allowed preceding the jump. The difference between vertical reach and jump height was used to represent volunteer's vertical jump performance. Volunteers had an opportunity to be familiarized with the test procedure prior to data collection. Volunteers performed three trials and the average score was used for statistical analyses.

Supine passive knee flexion and passive straight leg raise test were used to test volunteers' knee and hip range of motion (ROM) using a goniometer. Two measurements of knee flexion and hip flexion were averaged [18]. Ratings of perceived muscle soreness were assessed using a Visual Analogue Scale (VAS; [19]). Volunteers rated the soreness they experienced on the quadriceps, hamstring, and gastrocnemius muscles while stepping up (concentric muscular contraction) and down (eccentric muscular contraction) onto a 40cm box.

Statistical Analysis

All data were analyzed using Statistical Package for Social Sciences (SPSS) software (Version 20). Independent samples *t*-test was used to evaluate descriptive statistics (age, height, weight, VO_{2max}, 1RM, and resting heart rate) between the experimental and control groups. To examine the differences across four time periods (baseline, immediately after, 24 and 48 after the DOMS inducing protocol [downhill running] between the experimental group [Açai supplementation] and control [placebo] group), a mixed factor 2 groups × 4 time repeated measures ANOVA was used for each of the outcome measures. In the presence of a statistically significant F ratio, Bonferroni correction was used for post hoc analyses. Statistical significance was set at a 95% significant level (p < 0.05). Data are represented as mean ± standard deviation (SD).

Results

Twenty-eight volunteers were recruited for the study. One volunteer did not meet the VO_{2max} criteria because he scored 'poor' on the VO_{2max} test and 7 volunteers declined to participate after the study was explained. 20 volunteers qualified, provided written consent and were enrolled in the study. There were no significant differences between the placebo (n = 10) group and the Açai (n = 10) group in age, height, weight, relative strength, and VO_{2max} (Table 1).

Table 1: Descriptive Statistics of Volunteers

Variable	Açai Supplement (N=10)	Placebo (N=10)	P-Value	*t*
Age (years)	21±2	21±1.8	.656	.454
Height (cm)	181±7	175±8	.071	1.92
Relative Strength (kg)	3±0.72	2.8±0.64	.439	.762
VO_{2max} (ml/kg/min)	47±6.5	49.5±7.3	.431	.805
Weight (kg)	82±13.5	78.6±14.2	.552	.606

Data are Means ± SD

Quadriceps Muscle Soreness - There was a significant group by time interaction (F = 6.3, p = .023) in quadriceps muscle soreness (Figure 1). There was a significant main effect of group in that quadriceps muscle soreness was less in the supplement group (MSQS) compared to placebo (MSQP) (F = 8.2, p = .011). There was also a main effect of time (F = 14, p = .002). Post Hoc Bonferroni analyses (Pairwise Comparisons) revealed significant differences between before and 24 hours after (p = .002), between before and 48 hours after (p = .007), and between 24 and 48 hours after (p = .043) downhill running. However, there were no significant differences between before and after (p = .149), between after and 24 hours after (p = .445), and between after the 48 hours after (p = 1.00) downhill running. Specifically, the protocol resulted in increased quadriceps muscle soreness on both the Açai supplement group and the placebo group 24 and 48 hours after the downhill protocol. However, the soreness reported by the placebo group was significantly higher compared to the Açai supplement group.

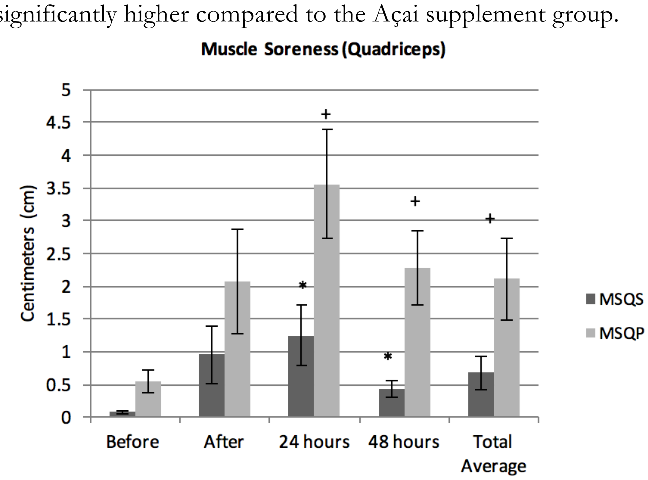

Figure 1. Quadriceps muscle soreness. Changes in muscle soreness before, after, and 24 and 48 hours after downhill running and total average muscle soreness adding all 4-time periods. Dark bars supplement

group; lighter bars placebo group. + = significantly different than before; * = significantly different than placebo, $p < 0.05$. Bars represents mean ± SE.

Range of Motion - There was no significant group by time interactions (F = .731, p = .404) in hip flexion (Figure 2). In addition, there was no main effect of group (supplement vs. placebo) (F = 3.2, p = .090). However, there was a main effect of time (F = 11.9, p = .003). Post Hoc Bonferroni analyses (Pairwise Comparisons) revealed significant difference between before and 24 hours after (p = .006) downhill running and between before and 48 hours after (p = .044) downhill running. Furthermore, there was no significant difference between before and after (p = 1.00), between after and 24 hours after (p = .088), between after the 48 hours after (p = .215), and between 24 and 48 hours after (p = 1.00) downhill running. This suggests that the protocol resulted in decreased hip flexion on both the Açai supplement group and the placebo group after, and 24 and 48 hours after the downhill protocol compared to baseline. In addition, both the Açai supplement group and the placebo group show the same effect, meaning the same ROM pattern, throughout the 4-time period.

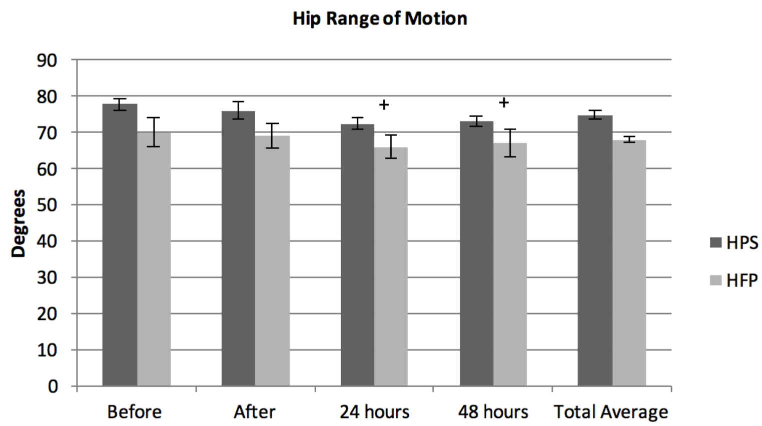

Figure 2. Hip ROM. Changes in hip range of motion before, after, and 24 and 48 hours after downhill running and total average ROM adding all 4-time periods. Dark bars supplement group; lighter bars placebo group. + = significantly different than baseline. Bars represents mean ± SE.

Agility Test - There was no significant group by time interactions (F = 1.1, p = .306) in the agility test (Figure 3). In addition, there was no significant difference between Açai supplement agility (AgilityS) and the agility placebo (AgilityP) groups (F = .413, p = .528). However, there was main significant effect of time (F = 6.6, p = .019). Post Hoc Bonferroni analyses (Pairwise Comparisons) revealed significant difference between before and 48 hours after (p = .045) downhill running. However, there was no significant difference between before and after (p = .068), between before and 24 hours after (p = .323), between after and 24 hours after (p = 1.00), between after the 48 hours after (p = 1.00), and between 24 and 48 hours after (p = 1.00) downhill running. Both the Açai supplement group and the placebo group were more agile 48 hours after the downhill protocol compared to baseline.

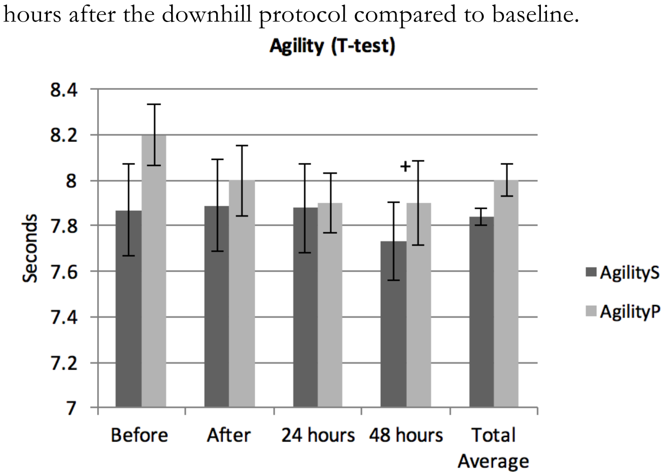

Figure 3. Agility *t*-test. Changes in agility before, after, and 24 and 48 hours after downhill running and total agility scores adding all 4-time periods. Dark bars supplement group; lighter bars placebo group. + = significantly different than baseline. Bars represents mean ± SE.

Vertical Displacement - There was no significant group by time interactions ($F = 2.4$, $p = 1.37$) in vertical displacement (Figure 4). In addition, there were no significant differences between vertical displacement supplement (VDS) and the vertical displacement placebo (VDP) groups ($F = .493$, $p = .492$) and there was no main effect of time ($F = .877$, $p = .362$).

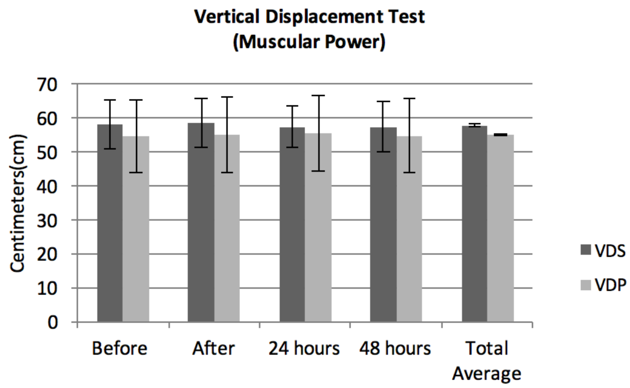

Figure 4. Vertical Displacement test. Changes in vertical displacement before, after, and 24 and 48 hours after downhill running and total vertical displacement adding all 4-time periods. Dark bars supplement group; lighter bars placebo group. Bars represents mean ± SE.

Discussion

The aim of this study was to evaluate the effects of Açai on muscle soreness and physical performance on collegiate athletes and non-athletes. Both the intervention and control groups were represented equally as there were no significant differences between groups' neither VO_{2max} nor relative strength. Açai supplementation significantly decreased perceived muscle soreness in the quadriceps muscle compared to the placebo. According to Brunett et al.[20], the quadriceps muscles face a heavy eccentric load during downhill running as they brace forward momentum on the downward grade. Muscle soreness in the quadriceps muscle was not seen in female athletes while stepping up and back down a 40cm box after 300 eccentric quadriceps contractions [21]. Drobnic and colleagues [1] saw similar results as volunteers in the curcumin group reported less pain than the volunteers in the placebo group after downhill running. Furthermore, Davis and colleagues [22] showed that curcumin can reduce inflammation and the negative side effects associated with eccentric-induced muscle damage. Curcumin and Açai have similar antioxidant and anti-inflammatory properties.

Although there was no statistical significance between the Açai and placebo groups in the agility *t*-test, there was a significant decrease in time between before and 48 hours downhill running in both groups. This difference is likely attributed to learning effect [16]. Furthermore, volunteers in the Açai group posted slightly faster times in all 4-time periods as compared to the placebo group. Similar studies reported that agility deficits did not reach statistical significance at 24 and 48 hours after the intervention [3,23]and Kargarfard and colleagues showed that agility was compromised after 72 hours by the presence of DOMS [3].

Non-significant results were also found in vertical displacement scores. However, volunteers in the Açai group scored slightly better overall scores in all 4-time periods compared to the placebo group. Previous research has shown that DOMS decreases maximal power during tasks such as vertical jump after eccentric exercise in both the experimental group and the placebo group [3,4]. Furthermore, although hip ROM showed no significant interaction between group and time, hip flexion decreased 24 and 48 hours after downhill running in both groups. This finding is similar to the finding of Thompson and colleagues [24]in which both the Vitamin C supplement group and the placebo groups showed decreased ROM in leg flexors and extensors.

Limitations and Future Directions

There are several limitations to this study including a small sample size, a short duration of supplementation, and a 48-hour maximum assessment period. Most of the other studies similar to this one had between 14-15 subjects per group while ours had only 10. However, we do not believe that a larger sample would yield different results. Our supplementation time was only 5 days in contrast to Jensen and colleagues [7] who documented decreased pain levels and increased range of motion 2–4 weeks after the beginning of Açai supplementation ($N = 14$). We originally hypothesized that 48 hrs assessment period would be sufficient to see changes in muscle soreness and performance measures. However, previous studies have shown that vertical displacement [3] and muscle soreness [25] peak at 72 hours after intervention. Future studies should examine knee ROM while the volunteers lie in a prone position, as both ends of the quadriceps muscle would be extended, which will create greater stress on the muscle as it is stretched. Although learning effect in performance tests such as the *t*-test has been confirmed by a previous study [16], it is considered reliable. In order to prevent learning effect three different types of agility test could have been used. The volunteers would be asked to perform all three agility tests during baseline; however, a different test would be used after, and 24 and 48 hours after downhill running. Lastly, future studies should add an additional assessment at 72 hours after intervention.

Media-Friendly Summary

2000mg of Açai extract starting 48 hours prior to downhill running and ending 48 hours after downhill running leads to significantly less perceived muscle soreness in the quadriceps muscle. In addition, the Açai supplementation showed a slightly difference on range of motion, agility, vertical jump displacement throughout 4-time periods (before, after, 24, and 48 hours after downhill running. In conclusion, Açai is an effective supplement to decrease quadriceps muscle soreness after downhill running. Furthermore, the consistency of results throughout the 4-time periods may suggest its potential to change performance and levels of oxidative stress and inflammation.

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Conflict of Interest

No conflict of interest

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