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Original Article

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Acute and Short-Term Effects of Oral Feeding of Jujube Solution on Blood Platelets and its Morphological Indices in Response to a Circuit Resistance Exercise

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ABSTRACT
The present study investigated the acute and short-term effects of oral feeding of jujube solution on blood platelets and its morphological indices in response to circuit resistance exercise. Fourteen young male volunteer students were randomly divided into the placebo and jujube solution groups. All participants performed one circuit resistance exercise [9 stations/nonstop, 30 seconds for each station (10-14 repetitions), 3 sets with a 3-minute active rest between sets, and an intensity of 75% with one repeat maximum]. In an acute supplementation protocol, participants received either a placebo or a jujube solution (0.5 g/kgbody weight in 2.5cc of distilled water) an hour before testing. Blood samples were collected 60 minutes before feeding, immediately after, and 2 hours after the exercise. In the short-term supplementation protocol, participants received either placebos or jujube solutions (0.5 g/kgbody weight in 2.5cc of distilled water) for as long as 7 days at certain times and in a double-blind manner. Blood samples were collected 30 minutes before, immediately after, and 2 hours after the exercise. Platelet counts (PLT), platelet distribution width (PDW), mean platelet volume (MPV), and platelet large cell rate (PLC-R) were measured with a hematology auto analyzer. The acute supplementation protocol showed that PLT increased in the placebo group in response to exercise and decreased during the recovery period; in the jujube solution group the alterations were insignificant ($p=0.031$). PDW, MPV, and PLC-R were not affected by supplementation type and did not change in response to exercise, but they decreased during the 2-hour recovery period ($p<0.05$). The short-term supplementation protocol showed that PLT, PDW, MPV and PLC-R were not affected by supplementation type and did not change in response to exercise ($p>0.05$), but all values except PLT (increased in response to exercise and during recovery [$p<0.05$]) decreased in the 2-hour recovery period ($p<0.05$). In conclusion, acute jujube solution supplementation could inhibit PLT in response to circuit resistance exercise; so, it can probably inhibit the negative effects of intensive circuit resistance exercise on platelet aggregation and activation.
Key Words: Platelets, Circuit Exercise, Resistance Exercise, Jujube, Supplementation.

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INTRODUCTION

Today, the instance of many diseases like cardiovascular diseases and cancers has increased with industrialization and changes in people's lifestyles (1). One main reason for cardiac events is the alteration and imbalance of the homeostasis system which results in thrombosis and ultimately cardiac arrest (1, 2). Fibrinolysis and coagulation are two parts of the homeostasis process (1, 3). When a vessel is ruptured, stimulus substances of the coagulation system are activated from the injured tissue and cause blood clots to form by overcoming anti-clotting agents (4, 5). Various clinical and pathological studies have shown that a disturbance in blood homeostasis, excessive accumulation and dysfunction of platelets associated with the development and progression of cardiovascular disease, and platelets have key roles in blood homeostasis both in healthy bodies and diseased ones (6, 7). The effect of having inefficient platelets in the progression of atherogenesis and other clinical complications such as atherosclerosis has been clearly defined in recent years (2). Based on previous studies, thrombogenesis factors related to platelets play a key role in the initiation and progression of atherogenesis and plaque formation (8, 9). It has been documented that arterial occlusion is ascribable to thrombosis caused by increased platelet aggregation and altered platelet behavior in patients with cardiac ischemia (10).

Physical activity has a direct relationship with the decreased presence of cardiovascular disease and plays a main role in auto-control of the cardiovascular system (2, 7). The acute and chronic effects of endurance activities on homeostasis have recently been considered. The circulation of platelets in humans can increase rapidly with dynamic physical activity (11, 12), such that thrombocyte parameters have been found to increase in response to exercise through hormonal changes, increased circulation, and release from the spleen, bone marrow, and lungs (13).

Conversely, intense and long-term activities may cause acute myocardial disorders and sudden death in susceptible individuals (14). Previous studies have shown that acute and intense activity causes increased platelet adhesion and aggregation and may be a reason for infarction and sudden death during acute and intense activity (15, 16). In other words, if a physical activity is intensive and long-term, it may increase the speed of platelet adhesion and the formation of platelet plaque. This feedback loop can lead to an occlusive platelet thrombosis within a few minutes (14).

The discussion of the effects of exercise on thrombocyte parameters continues as there are controversial reports. Rezaeimanesh, Ahmadizad, and Ebrahim (2015) reported increased platelet count (PLT) and mean platelet volume (MPV) after a simulated session of football. PLT decreased significantly during a 30-m recovery period, but MPV remained at a high level. Platelet distribution width (PDW) had no significant changes (10). Ghanbari-Niaki and Tayebi (2013) showed insignificant changes in PLT, MPV, PDW, and platelet large cell-rate (PLC-R) after a single session of low intensity (35% 1RM) circuit resistance exercise (10 stations, 20 s for each station, 3 circuits) (17). Ghanbari, Tayebi, and Delrouz (2011) reported unchanged PLT, MPV, PDW, PLC-R values after a session of eccentric resistance exercise (only biceps curl) at high intensity (85% 1RM, 6 sets) (18). Ghanbari-Niaki *et al.* (2005) showed that a session of circuit resistance exercise with moderate intensity (10 exercises, nonstop, 60% 1RM, 20 s for each exercise, 3 sets, 180 s active rest in between sets) increased PLT and MPV;

however, PDW and PLC-R remained unchanged (19).

There is little data about the effects of supplementation along with exercise on thrombocyte parameters. Hulmi *et al.* (2010) reported that, after 4 protocols of resistance exercise and training (3 protocols of single session with different workloads, and one protocol with 21 weeks) with the control of two independent variables [nutritional supplementation (whey protein, milk, placebo) and age (young and older)], PLT increased in all 3 single session protocols; no differences were seen between nutritional supplementations, but older subjects had a lower increase compared with younger ones (20).

Herbal medicines or medicinal plants are widely used to treat disease and in weight control (21, 22). Ziziphus/Jujube/Red Date/Annab is a plant from the Rhamnaceous family that contains various proteins, CHOs, and amino acids such as alanine, aspartic acid, and glutamic acid (23). It can also participate in the formation of glutamine. Furthermore, its antioxidant effects in exercise and training (24) and its high level of antioxidant compounds have been confirmed. Jujube contains fatty acids, β-carotene, α-tocopherol, and phenolic compounds (24). It is believed that the dried jujube fruit can be an anodyne, anticancerous, a refrigerant, sedative, stomachic, styptic, tonic, and immune response enhancer (25-27). It is considered a hematopoietic medicinal herb in traditional medicine (28). Noori-Ahmadabadi *et al.* (2013) investigated the effects of 100, 200, and 400 mg jujube extracts (taken twice daily for 14 days) on peripheral blood cells and found that it had no significant effect on PLT (29). Conversely, Seo *et al.* (2013) reported that the extract from Zizyphus jujube seeds inhibited collagen-, thrombin-, and AA-induced platelet aggregation in vitro, considering the protective effect of this medicinal herb against cardiovascular diseases related to platelet over-aggregation (30).

There are some studies about the beneficial effects of jujube on immunological function (25-27, 31, 32), inflammation (33, 34), antioxidant status (35, 36), apoptosis induction in tumor cells (37, 38), and its protective effect against cardiovascular diseases related to platelet over-aggregation (30). There are also reports of the protective effects of exercise along with the consumption of jujube extract on the status of overweight and on cardiovascular disease (39), cardiac muscle apoptosis in response to acute exercise (40), and neutrophil apoptosis in response to a session of circuit resistance exercise (41); however, there is no data about the effect of a session of circuit resistance exercise in conjunction with consuming jujube solution on blood thrombocyte factors. Thus, the aim of this study was to investigate the acute and short-term effects of oral feeding of jujube solution on blood platelets and its morphological indices in response to a circuit resistance exercise.

MATERIALS AND METHODS

Participants. The present study was approved by the Research Ethics Committee of the Iranian Sport Sciences Research Institute and was conducted in accordance with the policy statement of the Declaration of Iranian Ministry of Health. Written informed consent was obtained from 14 young healthy male students. All subjects were asked to complete a medical examination and fill a medical questionnaire to ensure that during the past month they had not taken any regular medication, smoked, consumed alcohol or taken any regular exercise in the past 2 months, and were free of cardiovascular or metabolic diseases or recent symptoms of upper respiratory tract infection in the month prior to the start of these tests. The volunteers were randomly assigned to 2 groups (n=7) including a

Circuit Resistance Exercise group with placebo (age: 24.5±2.5 years, height: 171.17±1.7 cm, weight: 67.51±4.92 kg) and Circuit Resistance Exercise group (n=7) with jujube solution (age: 25.25±1.31 years, height: 179.75±3.63 cm, weight: 74.04±5.78 kg).

Exercise Protocol and Blood Collection. Participants were taken to the weight room and weighed three times before the main trial. A strength test was performed at first and second visits to determine one repetition maximum (1-RM) of all participants for each of the 9-resistance exercises employed in the study. 1-RM value was determined by trial, by adding or removing weights after each attempt, as required. Subjects were allowed to take as much time as they felt necessary to recover from each attempt. Subjects completed a practice session to ensure that each participant was able to complete the entire exercise session on the third visit and to confirm that weight lifting was inducing fatigue by the end of the session. This was confirmed by visual and verbal feedback from participants (30). Records of 1-RM are presented in Table 1.

Table 1. Exercise's 1-RM Records of participants

	Variables (kg)	groups	Mean ± SE
1	crunch	placebo	127.12 ± 8.66
		Jujube solution	129.49 ± 10.21
2	back extension	placebo	199.76 ± 24.46
		Jujube solution	270.77 ± 82.12
3	biceps curl	placebo	54.01 ± 5.38
		Jujube solution	62.55 ± 4.49
4	triceps press	placebo	57.39 ± 4.29
		Jujube solution	60.97 ± 4.67
5	knee extension	placebo	156.15 ± 13.07
		Jujube solution	173.69 ± 11.27
6	knee curl	placebo	100.43 ± 9.67
		Jujube solution	110.35 ± 18.12
7	standing calf raise	placebo	152.63 ± 15.20
		Jujube solution	166.08 ± 10.25
8	chest press	placebo	73.29 ± 3.38
		Jujube solution	77.56 ± 9.83
9	seated row	placebo	126.46 ± 7.73
		Jujube solution	149.15 ± 11.45

Jujube Preparation. The semi-dried fruits of Ziziphus Jujube were washed, and seeds were separated and the soft red parts were removed. The samples were dried at 50°C and ground to a powder using a mortar (38).

Combination Assessment of jujube extraction by Gas Chromatography-Mass Spectrometry (GC-MS). Compounds of jujube extraction were detected by GC-MS by semi-quantitative method. The contents of jujube extraction compounds were quantified using an internal standard (3-octanol, 99%, Sigma-Aldrich). Wine volatile compounds were analyzed using an Agilent 5975 Mass Spectrometer coupled to an Agilent 7890A Gas Chromatograph (Agilent, Santa Clara, USA). A DB-WAX column (60 m×0.25 mm ID and 0.25 µm film thickness) was used for separation. The working parameters were as follows: injector temperature of 210°C, EI source of 230°C, MS

Quad of 150°C and transfer line of 210°C. The initial temperature was 30°C for 8 min, which was increased to 150°C at a rate of 3°C/min. Injector port temperature was 290 oC and helium used as carrier gas at a flow rate 1.5 ml/min . A total of 15 compounds were positively or tentatively identified by GC-MS that contain 92.27% the area under the peak totally (Table 2).

Table 2. Combination Assessment of jujube extraction by Gas Chromatography-Mass Spectrometry (GC-MS).

Combination	The area under the Peak (%)	Retention time (min)
furfural	51.33	20.21
4-Pyrone	9.51	17.07
Oleic acid	6.31	39.00
palmic acid	4.15	35.70
Imidazole	3.03	23.59
Cyclononasiloxane	2.03	42.05
Cyclodecasiloxane	1.75	35.63
Oxantin	1.61	10.65
Guanine	1.58	27.20
gamma.-Sitosterol	1.17	44.56
Niphimycin	1.16	26.89
Iron	1.10	45.65
Butanediol	1.07	27.00
Phthalic acid	1.02	45.48
Pentasiloxane	1.01	48.34
Dodecanoic acid	0.97	27.616
octadecamethyl	0.95	32.604
Methyl 2-furoate	0.92	14.28
1,4-dicarbonic acid	0.86	51.997
Tetradecanoic acid	0.74	31.840
Total	92.27	

Exercise Protocol. Recent studies have shown that appetite hormones such as ghrelin, increase during starvation and before feeding (breakfast, lunch and dinner) and this serves to increase absorption levels (42). Accordingly, participants in both groups of supplementation protocol were taken to the test location after a 12 h overnight fast. All participants performed a session of circuit resistance exercise in two cycles, simultaneously. Each cycle contained 9 exercises (crunch, back extension, biceps curl, triceps press, knee extension, knee curl, standing calf raise, chest press, seated row, machines were used in all exercises). The test included three non-stop circuits with a 3-minute active rest period between circuits. Each exercise was performed for 30 s (about 10-14 repeats) with one repeat maximum (1RM) of 75%. The exercise protocol is shown in figure 1.

First Supplement Protocol. Subjects arrived at the test location at 08:00 where they rested for about 30 minutes. Then subjects received placebo (2.5cc/kg of body weight in distilled water sweetened with sugar without calories and colored by food dye) and jujube solution (0.5 gr/kg body weight in 2.5^{cc} distilled water) at 08:30 in double-blind manner and rested for about 60 min, at 09:30 all subjects performed the circuit resistance exercises in two cycles, simultaneously. The first peripheral venous blood samples were drawn at 08:30 before supplements of placebo and jujube solution, second blood samples were taken

immediately after exercise at 10:00, then subjects remained seated for 120 min, and the third set of blood samples were taken at 12:00. The research design and blood collection of the first supplementation protocol is shown in figure 2.

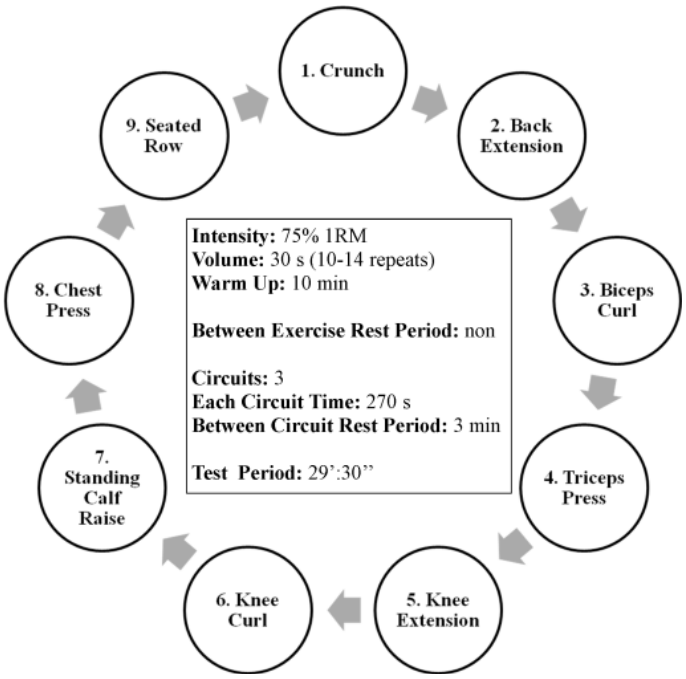


Figure 1. Exercise protocol

Second Supplement Protocol. The groups received oral jujube solution (0.5 g/kg body weight in 2.5cc distilled water) and placebo (2.5cc/kg of body weight in distilled water sweetened by sugar with no calories, and colored by food dye); this supplement was taken daily for one week in a double blind manner without any physical training during this period. Subjects in both groups arrived at the test location at 08:00 and rested for about 30 minutes. All subjects performed circuit resistance exercise in two cycles at 08:30, simultaneously. The first peripheral venous blood samples were taken on the 8th day and after 12 hours of overnight fasting at 08:30. The second set of blood samples was taken immediately after exercise at 09:00; then subjects remained seated for 120 minutes. The third set of blood samples was taken at 11:00. The research design and blood collection of the second supplementation protocol is shown in figure 3.

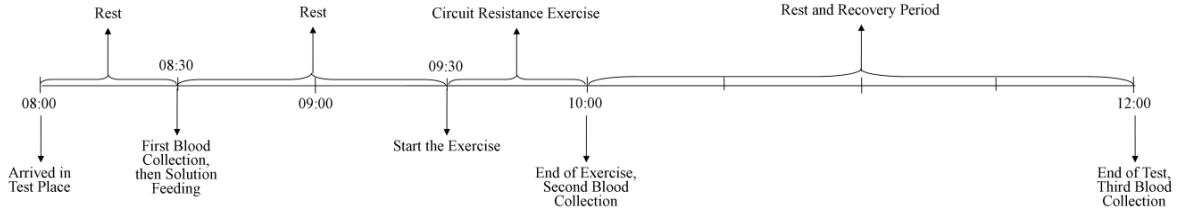


Figure 2. Research Design and Blood Collection of First Supplement Protocol

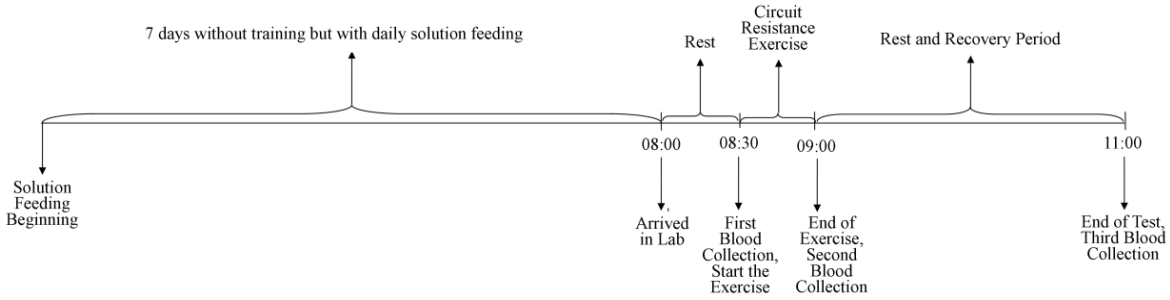


Figure 3. Research Design and Blood Collection of Second Supplemen Protocol

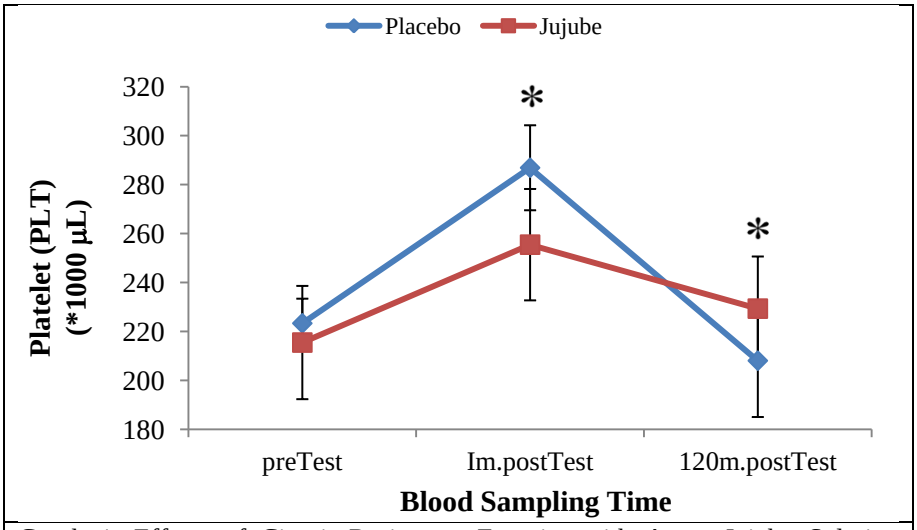
Leukocyte parameters PLT, PDW, MPV and PLC-R were assessed by automated hematology analyzer (SYSMEX-kx-21).

Statistical Analysis. Repeated measure (two-way) ANOVA was used to determine the effects of TIME and SOLUTION by SPSS software at significance level of p = 0.05. All data were presented as means with standard error of mean.

RESULTS

First Supplementation Protocol

PLT; Mauchly's test of sphericity for PLT count was met (W = 0.948, p = 0.744). The main effect of TIME and also interaction of TIME and SOLUTION with the assumption of sphericity was determined significant [(F = 20.93, p = 0.001) and (F = 4.02, p = 0.031) , respectively] and this effect was quadratic [(F = 39.7, p = 0.001) and (F = 5.32, p = 0.04) , respectively]. But the main effect of SOLUTION was determined as not significant (F = 0.052, p = 0.824) (Table 2). In other words, when the PLT was unchanged over time in jujube supplementation group, it was significantly elevated during the exercise and decreased to under baseline during the 2 h recovery period in placebo group (Graph 1).



Graph 1. Effects of Circuit Resistance Exercise with Acute Jujube Solution Feeding on PLT. Significant interaction of TIME×Group at p=0.031.

PDW; Mauchly's test of sphericity for PDW was met (W = 0.981, p = 0.899). The main effect of TIME with the assumption of sphericity was determined significant (F = 4.01, p = 0.031) and this effect was linear (F = 4.7, p = 0.05). But the main effect of

SOLUTION and interaction of TIME and SOLUTION was determined as not significant [(F = 4.646, p = 0.08) and (F = 1.98, p = 0.16), respectively] (Table 3). In other words, PDW decreased in response to circuit resistance exercise without any effect from supplementation, and this decline was determined significant during a 2 h recovery period in comparison to immediately after exercise (p=0.049) and but was determined as not significant in comparison to baseline (p=0.151), and also in immediately after exercise in comparison to baseline (p=1.00) (Table 4).

MPV; Mauchly's test of sphericity for MPV was met (W = 0.743, p = 0.196). The main effect of TIME with the assumption of sphericity was determined significant (F = 6.03, p = 0.008) and this effect was both linear (F = 5.8, p = 0.033) and quadratic (F = 6.6 p = 0.024). But the main effect of SOLUTION and interaction of TIME and SOLUTION was determined as not significant [(F = 2.541, p = 0.137) and (F = 0.047, p = 0.954), respectively] (Table 3). In other words, MPV decreased in response to circuit resistance exercise without any effect from supplementation, so that was determined as not significant during exercise (p=1.00) and but was determined significant during 2 h recovery period (p=0.005), and it was determined as not significant in 2 h after exercise in comparison to baseline (p=0.099) (Table 4).

PLC-R; Mauchly's test of sphericity for PLC-R was met (W = 0.86, p = 0.436). The main effect of TIME with the assumption of sphericity was determined significant (F = 6.01, p = 0.008) and this effect was both linear (F = 6.83 p = 0.027) and quadratic (F = 5.3 p = 0.039). But the main effect of SOLUTION and interaction of TIME and SOLUTION was determined as not significant [(F = 2.706, p = 0.126) and (F = 0.469, p = 0.63), respectively] (Table 3). In other words, PLC-R decreased in response to circuit resistance exercise without any effect from supplementation, so that was determined as not significant during exercise (p=1.00) and but was determined significant during 2 h recovery period (p=0.016), and it was determined as not significant in 2 h after exercise in comparison to baseline (p=0.082) (Table 4).

Second Supplementation Protocol

PLT; Mauchly's test of sphericity for PLT was met (W = 0.804, p = 0.301). The main effect of TIME with the assumption of sphericity was determined significant (F = 32.2, p = 0.001) and this effect was quadratic (F = 46.7 p = 0.001). But the main effect of SOLUTION and interaction of TIME and SOLUTION was determined as not significant [(F = 0.065, p = 0.803) and (F = 0.755, p = 0.481), respectively] (Table 5). In other words, PLT changed in response to circuit resistance exercise without any effect from supplementation, so that there were significant elevation and decline in post-test and after recovery period to baseline (both p = 0.001); but it was determined as not significant during 2 h recovery period (p=0.321) (Table 6).

PDW; Mauchly's test of sphericity for PDW was met (W = 0.903, p = 0.57). The main effect of TIME with the assumption of sphericity was determined significant (F = 16.2, p = 0.001) and this effect was both linear (F = 35.1, p = 0.001) and quadratic (F = 6.21, p = 0.028). But the main effect of SOLUTION and interaction of TIME and SOLUTION was determined as not significant [(F = 0.807, p = 0.387) and (F = 0.452, p = 0.642), respectively] (Table 5). In other words, PDW decreased in response to circuit resistance exercise without any effect from supplementation, and this decline was determined significant during a 2 h recovery period in comparison to both baseline (p=0.001) and immediately after exercise (p=0.001), but was determined as not

significant in immediately after exercise in comparison to baseline (p=1.00) (Table 6).

MPV; Mauchly's test of sphericity for MPV was met (W = 0.645, p = 0.09). The main effect of TIME with the assumption of sphericity was determined significant (F = 17.96, p = 0.001) and this effect was both linear (F = 26.9, p = 0.001) and quadratic (F = 10.85, p = 0.006). But the main effect of SOLUTION and interaction of TIME and SOLUTION was determined as not significant [(F = 0.376, p = 0.551) and (F = 0.141, p = 0.869), respectively] (Table 5). In other words, MPV changed in response to circuit resistance exercise without any effect from supplementation, so that it was unchanged during circuit resistance exercise (p=0.452) and it was decreased during a 2 h recovery period in comparison to both baseline (p=0.001) and immediately after exercise (p=0.001) (Table 6).

PLC-R; Mauchly's test of sphericity for PLC-R counts was not met (W = 0.56, p = 0.041). Taking account of Greenhouse-Geisser adjustment in df, the main effect of TIME was significant (F = 21.27, p = 0.001) and this effect was both linear (F = 32.2, p = 0.001) and quadratic (F = 11.56, p = 0.005). But, the main effect of SOLUTION and interaction of TIME and SOLUTION was determined not significant [(F = 0.534, p = 0.479) and (F = 0.143, p = 0.79)] (Table 5). In the other words, PLC-R counts decreased in response to circuit resistance exercise without effect of supplementation, and this decline in recovery period to both baseline and post-test was determined significant [both (p = 0.001)] and unchanged in post-test to baseline (p = 0.689) (Table 6).

Table 3. Effects of Circuit Resistance Exercise with Acute Jujube Solution Feeding on Platelet count and it's Morphological Characteristics.

Variables	Group	Sample	Mean±SE	Tests of Within-Subjects Effects		
				Effects	F	p
PLT ($\times10^3$ μL)	Placebo	preTest	223.28±10.06	TIME	20.934	0.001**
		Immediately postTest	286.85±17.37			
		120min postTest	208.00±23.01	GROUP	0.052	0.824
	Jujube	preTest	215.42±23.14			
		Immediately postTest	255.42±22.76	TIME×GROUP	4.026	0.031*
		120min postTest	229.28±21.30			
PDW (fL)	Placebo	preTest	13.88±0.78	TIME	4.01	0.031*
		Immediately postTest	13.54±0.66			
		120min postTest	12.97±0.72	GROUP	3.65	0.08
	Jujube	preTest	11.95±0.22			
		Immediately postTest	12.41±0.29	TIME×GROUP	1.98	0.160
		120min postTest	11.81±0.33			
MPV (fL)	Placebo	preTest	10.25±0.43	TIME	6.04	0.008**
		Immediately postTest	10.27±0.36			
		120min postTest	10.00±0.33	GROUP	2.54	0.137
	Jujube	preTest	9.60±0.10			
		Immediately postTest	9.61±0.19	TIME×GROUP	0.047	0.954
		120min postTest	9.38±0.16			
PLCR (%)	Placebo	preTest	28.17±3.07	TIME	6.014	0.008**
		Immediately postTest	27.84±2.62			
		120min postTest	25.87±2.50	GROUP	2.71	0.126
	Jujube	preTest	22.74±0.75			
		Immediately postTest	23.20±1.34	TIME×GROUP	0.47	0.63
		120min postTest	21.55±1.35			

PLT: Platelet. PDW: Platelet Distribution Width. MPV: Mean Platelet Volume. PLCR: Platelet Large Cell Rate*: Significant Level at p<0.05. **: Significant Level at p<0.01.

Table 4. Effects of Acute Circuit Resistance Exercise on Platelet count and it's Morphological Characteristics without Effect of Acute Solution Feeding.

Variables	Sample	Mean±SE	preTest	Immediately postTest	120min postTest
PDW (fL)	preTest	12.92±0.41		1.00	0.151
	Immediately postTest	12.98±0.36			0.049*
	120min postTest	12.39±0.39			
MPV (fL)	preTest	9.29±0.22		1.00	0.099
	Immediately postTest	9.94±0.20			0.005**
	120min postTest	9.69±0.18			
PLCR (%)	preTest	25.45±1.58		1.00	0.082
	Immediately postTest	25.52±1.47			0.016*
	120min postTest	23.71±1.42			

PDW: Platelet Distribution Width. MPV: Mean Platelet Volume. PLCR: Platelet Large Cell Rate. *: Significant Level at $p<0.05$. **: Significant Level at $p<0.01$.

Table 5. Effects of Circuit Resistance Exercise with Short-Term Jujube Solution Feeding on Platelet count and it's Morphological Characteristics.

Variables	Group	Sample	Mean±SE	Tests of Within-Subjects Effects		
				Effects	F	p
PLT ($\times10^3$ μL)	Placebo	preTest	215.14±9.09	TIME	32.235	0.001**
		Immediately postTest	165.28±15.27			
		120min postTest	226.42±9.62	GROUP	0.065	0.803
	Jujube	preTest	227.85±16.20			
		Immediately postTest	265.28±9.10	TIME×GROUP	0.755	0.481
		120min postTest	226.42±14.75			
PDW (fL)	Placebo	preTest	13.44±0.58	TIME	16.241	0.001**
		Immediately postTest	13.55±0.67			
		120min postTest	12.18±0.64	GROUP	0.807	0.387
	Jujube	preTest	12.84±0.28			
		Immediately postTest	12.72±0.47	TIME×GROUP	0.45	0.642
		120min postTest	11.80±0.22			
MPV (fL)	Placebo	preTest	10.10±0.32	TIME	17.96	0.001**
		Immediately postTest	10.15±0.37			
		120min postTest	9.64±0.34	GROUP	0. 376	0.551
	Jujube	preTest	9.84±0.17			
		Immediately postTest	9.88±0.17	TIME×GROUP	0.141	0.869
		120min postTest	9.45±0.16			
PLCR (%)	Placebo	preTest	27.17±2.47	TIME	21.278	0.001**
		Immediately postTest	27.48±2.78			
		120min postTest	23.41±2.63	GROUP	0.534	0.479
	Jujube	preTest	25.02±1.37			
		Immediately postTest	25.07±1.45	TIME×GROUP	0.143	0.79
		120min postTest	21.68±1.21			

PLT: Platelet. PDW: Platelet Distribution Width. MPV: Mean Platelet Volume. PLCR: Platelet Large Cell Rate. **: Significant Level at $p<0.01$.

Table 6. Effects of Acute Circuit Resistance Exercise on Platelet count and it's Morphological Characteristics without Effect of Short-Term Solution Feeding.

Variables	Sample	Mean±SE	preTest	Immediately postTest	120min postTest
PLT ($\times 10^3$ μL)	preTest	221.50±9.29		0.001**	0.321
	Immediately postTest	265.28±8.89			0.001**
	120min postTest	226.42±8.81			
PDW (fL)	preTest	13.14±0.32		1.00	0.001**
	Immediately postTest	13.14±0.41			0.001**
	120min postTest	11.99±0.34			
MPV (fL)	preTest	9.97±0.18		0.452	0.001**
	Immediately postTest	10.02±0.20			0.001**
	120min postTest	9.55±0.20			
PLCR (%)	preTest	26.10±1.41		0.689	0.001**
	Immediately postTest	26.27±1.57			0.001**
	120min postTest	22.55±1.45			

PLT: Platelet. PDW: Platelet Distribution Width. MPV: Mean Platelet Volume. PLCR: Platelet Large Cell Rate. **: Significant Level at $p<0.01$.

DISCUSSION

The results of this study showed that consuming jujube solution daily before a session of acute resistance exercise for one week (short-term effect) had no effect on PLT in response to that exercise. However, PLT in both the supplementation and placebo groups increased in response to exercise and decreased under the baseline during the 2-h recovery period. Noori-Ahmadabadi *et al.* (2013) investigated the effects of different dosages of jujube extraction on CBC. Their results showed that supplementation 2 times per day for 14 days had no significant effect on PLT (29). Hulmi *et al.* (2010) reported an elevation in PLT levels in all three protocols of acute resistance exercise and a reduction in PLT during the 2-h recovery, without the effect of nutritional supplementation of whey protein, milk and placebo (20). Ahmadizad, El-Sayed, and Maclaren (2006) also reported increased PLT after acute circuit resistance training; however, it was transient and decreased during the 30-m recovery period (43).

The mechanism of elevation in PLT may be (independent from plasma volume) due to blood returned from the vascular bed of the spleen, bone marrow, and the accumulation of blood flow within the pulmonary artery to the involved muscles (44). It has been reported that epinephrine injections cause strong contractions in the spleen, which holds a reserve of about one-third of the body's platelets. This mechanism probably explains the increased platelet circulation during exercise (9). It has also been said that much of increased platelets is due to the release of it from the spleen, bone marrow, and lungs, and the less of it is related to haemoconcentration (10, 17, 19, 20, 45).

In the current study, an acute effect of jujube solution supplementation increased PLT in the placebo group in response to acute resistance exercise, but it decreased to below the baseline during the 2-h recovery period. In the supplementation group, no significant change was seen at any time; in other words, acute feeding of jujube solution can inhibit the acute alteration of relatively intensive circuit resistance exercise. Seo *et al.* (2013) reported that the extract of Zizyphus jujube seeds inhibited collagen-, thrombin-, and AA-induced platelet aggregation (30). Ahmadizad and El-Sayed (2003) showed that platelet aggregation was significantly elevated with a high

concentration of ADP after a single session of resistance exercise with three intensities of 40%, 60%, and 80% of 1RM; PLT and MPV also had significant elevations, and these parallel alterations suggested in vivo platelet activation (2). The current study found that in both protocols, MPV, PDW, and PLC-R (three indices of platelet activation) did not change in response to circuit resistance exercise, but, like PLT, decreased significantly during the 2-h recovery period. A decrease in PDW suggests a uniformity in the size of platelets; a decrease in MPV indicates a decrease in platelet size (46); and when PLC-R decreases, a decreased ratio of big platelets to total platelet counts is seen (47), suggesting the presence of older platelets in the blood (older platelets are smaller than younger ones) and a situation decreasing platelet production from bone marrow (46). In the current study, there were no differences between the jujube solution supplementation and placebo groups, but, based on the effect of acute jujube solution feeding on PLT inhibition and the lack of alteration in PDW, MPV, and PLC-R, it can be concluded that jujube solution supplementation probably inhibits the negative effects of acute intensive circuit resistance exercise. It has been reported in the literature that jujube promotes blood circulation (48) and prevents cardiovascular diseases related to platelet over-aggregation (30).

CONCLUSION

The investigation of the effects of a relatively intensive circuit resistance exercise following acute and short-term jujube solution feedings showed that only in acute supplementation with jujube solution, PLT was increased in the placebo group in response to exercise and was decreased during the recovery period; in the jujube solution group, the alterations were insignificant and, thus, inhibited. Therefore, acute jujube solution feeding probably inhibits the negative effects of acute intensive circuit resistance exercise on platelet aggregation and activation. It is noteworthy; however, that PLT is a variable that is affected by acute jujube solution supplementation, not from the short-term loading of it.

APPLICABLE REMARKS

- It is suggested to the people engaged in resistance training that oral feeding of jujube solution (0.5 g/kg of body weight dissolved in 2.5 ml of water) at least one hour before exercise can possibly prevent from increased platelet aggregation and activation and its negative effects (caused by relatively intense acute exercise) by inhibiting it.

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تازه‌های علوم کاربردی ورزش
دوره سوم، شماره سوم
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اثر مصرف حاد و کوتاه‌مدت محلول خوراکی عناب بر پلاکت‌های خون و برخی شاخص‌های مورفولوژیک آن در پاسخ به یک جلسه تمرین مقاومتی دایره‌ای

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چکیده

مطالعه حاضر به بررسی اثرات حاد و کوتاه‌مدت محلول خوراکی عناب بر پلاکت‌های خون و شاخص‌های ریخت‌شناسی آن در پاسخ به یک جلسه تمرین مقاومتی دایره‌ای پرداخت. ۱۴ دانشجوی پسر جوان داوطلب بطور تصادفی در دو گروه دارونما و محلول عناب تقسیم شدند. همه شرکت‌کنندگان یک وهله تمرین مقاومتی دایره‌ای [۹ ایستگاه بدون توقف، ۳۰ ثانیه برای هر ایستگاه (۱۴- ۱۰ تکرار)، ۳ دور، ۳ دقیقه استراحت فعال بین هر دور، با شدت ۷۵٪ یک تکرار بیشینه] را اجرا کردند. در پروتکل مکمل‌گیری حاد، شرکت‌کنندگان یک وعده دارونما و محلول عناب (۰/۵ گرم به ازای هر کیلوگرم وزن بدن در ۲/۵ سی‌سی آب مقطر) را یک ساعت قبل از تمرین مصرف کردند؛ و نمونه‌های خونی ۶۰ دقیقه قبل از مصرف، بلافاصله و ۲ ساعت پس از تمرین جمع‌آوری شد. در پروتکل مکمل‌گیری کوتاه‌مدت، دارونما و محلول عناب (۰/۵ گرم به ازای هر کیلوگرم وزن بدن در ۲/۵ سی‌سی آب مقطر) را روزانه در ساعت مشخصی به مدت هفت روز قبل از تمرین و بطور دوسوکور مصرف کردند؛ و نمونه‌های خونی ۳۰ دقیقه قبل، بلافاصله و ۲ ساعت پس از تمرین جمع‌آوری شد. تعداد پلاکت (PLT)، ضخامت توزیع پلاکت (PDW)، میانگین حجم پلاکت (MPV)، نرخ پلاکت‌های بزرگ (PLC-R) توسط دستگاه هماتولوژی آنالایزر خودکار اندازه‌گیری شد. در پروتکل مکمل‌گیری حاد، PLT گروه دارونما در پاسخ به ورزش افزایش و در دوره ریکاوری کاهش یافت، در حالی که در گروه عناب تغییر معناداری نکرد ($p=۰/۰۳۱$). از طرفی PDW، MPV و PLC-R بدون تأثیر نوع مکمل‌گیری، طی تمرین تغییری نکرد؛ ولیکن طی ریکاوری کاهش یافت ($p<۰/۰۵$). در پروتکل مکمل‌گیری کوتاه‌مدت، PLT، PDW، MPV و PLC-R بدون تأثیر نوع مکمل‌گیری، طی تمرین تغییری نکرد؛ اما همه متغیرها بجز PLT (در پاسخ به ورزش و طی ریکاوری افزایش یافت)، طی ریکاوری کاهش یافت ($p<۰/۰۵$). در نهایت مکمل‌گیری حاد عناب موجب مهار PLT در پاسخ به یک جلسه تمرین مقاومتی عناب شد؛ در نتیجه احتمالاً بتواند اثرات منفی تمرین مقاومتی دایره‌ای نسبتاً شدید حاد بر تجمع و فعال‌شدن پلاکت را بازداری کند.

واژگان کلیدی: پلاکت، تمرین مقاومتی، تمرین دایره‌ای، عناب، مکمل‌گیری.

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