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The effects of weighted rope training on muscle damage of basketball players

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The present study assessed the effects of rope training and weighted rope training on muscle damage sustained by basketball players. The study group comprised 36 male basketball players, all of whom have a minimum of 4 years experience of basketball. Participants were aged between 17 and 19 years, and played in the junior league. The Rope Group (n = 12) and Weighted Rope Group (n = 12) received one week preparatory rope training, in addition to technical training. They then trained three days per week for eight weeks. A control group (n = 12) received only technical training for three days per week for eight weeks. In the first and last training sessions, venous blood samples were obtained from subjects before and after the training. The samples were tested for creatine kinase (CK), leukocyte and erythrocyte levels. Statistical analysis of the data was conducted with SPSS (Version 10.0). T-test and ANOVA were used to test for normality level and multi comparison tests, at the 0.05 and 0.01 levels. The results indicated that creatine kinase and leukocyte levels, which are the indicators of muscle damage, increased following high-intensity physical activity ; furthermore, erythrocyte level increased in line with exercise in order to transport oxygen to tissues. The findings suggest that intensive weighted rope training causes damages to muscles.

Key words: Basketball, weighted rope training, muscle damage.

INTRODUCTION AND AIM

Rope training has an important role in developing body coordination and strengthens the general athletic condition. It is used as a warm-up or coordination method in exercise (Lee 2006). Soft tissue injuries which result from impacts and torsion are common in certain sports and physical exercises. They can be rehabilitated with normal therapy methods. These injuries have two aspects. The first one is unaccustomed exercise and the second is the metabolic and chemical events resulting from tissue injuries in line with the role of muscle ischemia, although this has not been fully characterized (Simith and Miles, 2000).

Different kinds of exercises cause various muscle damages. However, eccentric muscle contractions cause more intensive muscle damage when compared with other kinds of contraction (Brown et al., 1999). The amount of isoenzyme produced by any tissue is determined genetically. It is possible to detect the tissue which is responsible for high enzyme activity with isoenzyme assessment (Murray, 1998).

The activity of creatine kinase (CK), which is an intracellular enzyme, increases in the plasma and serum following the exercise-induced muscle damage (Gillum et al., 1984; Schwane et al., 2000, 1983). Skeletal muscle is the most active zone for CK. While the activity of CK varies in line with gender, age and the type of exercise-induced muscle damage, it also varies according to ethnicity. In a polyclinic environment, high CK activity was detected in controlled subjects (Schwane et al., 2000). Long term exercises and power exercises cause significant changes in leukocyte composition and concentration (Johnson et al., 1992; Nielsen et al., 1996; Pedersen et al., 2000). During exercise, predominant lymphocyte is activated and participates in circulation (Gabriel, 1993).

The response of leukocyte is characterized in three ways in exercise-induced muscle damage. The first is the increase of concentration in circulation, the second is the filtration into damaged tissue, particularly skeletal muscle and the third is the functional transformation of leukocytes

(Simith and Miles, 2000). Neutrophils constitute a leukocyte type that is highly responsive to exercise (Pedersen and Hoffman, 2000). The main factors of increase in neutrophils are the intensity and duration of the exercise (Pyne, 1994). Stresses, such as muscle damage and heat, increase the response of the neutrophils (Gabriel et al., 1992).

According to Akgün (1992) the intensity of erythrocyte increases as a result of the liquid flow from veins to tissues before acute exercise. However, the erythrocyte level returns to normal by the reverting of liquid to veins in line with the length of the exercise (Akgün, 1992). Intensive exercises transform the blood flow from laminar to turbulent and the contraction of skeletal muscle puts pressure on veins. This situation causes damage in some erythrocytes. This is particularly the case when a sedentary person suddenly initiates intensive exercises.

For athletes, recovery can be defined as the compensation of fatigue and/or decrease in performance (that is, a tendency to stability in the internal environment of the athlete). The goal of recovery after competition for team sport athletes should be to restore the body and mind back to pre-game levels in the shortest possible time. During competition, team sport athletes can become fatigued physically, metabolically and mentally. Recovery strategies should focus on reversing or minimising these sources of fatigue (Kellmann, 2002).

Repeated isometric or concentric muscle contractions result in fatigue. However, the muscle quickly recovers without any long term loss of function. In contrast, unaccustomed eccentric muscle contraction frequently results in a greater loss of function which can take a number of days to recover (Proske and Allen, 2005).

A typical response to maximal eccentric exercise of the elbow flexors is an immediate 50 - 60% reduction in strength followed by a gradual linear recovery to baseline by 2 weeks post-exercise (Sayers and Clarkson, 2001). The latter study demonstrated that for relatively inactive muscle groups, such as the elbow flexors, the magnitude of strength loss following eccentric exercise-induced muscle damage can be dramatic and recovery can take up to 12 weeks in some cases (Eston et al., 2003). The aim of the present study is to examine the effects of rope training on muscle damage in basketball players.

MATERIALS AND METHODS

The study group was composed of 36 male basketball players within the junior league, all of whom have at least four years experience of basketball. Their ages ranged between 17 and 19 years. The Rope Group comprised 12 participants with the following characteristics: average age was 17.58 ± 0.51 year, average height was 185.67 ± 5.53 cm, average weight was 76.67 ± 9.45 kg and the average basketball experience was 5.83 ± 1.11 years. The weighted Rope Group comprised 12 participants with the following characteristics: average age was 17.50 ± 0.52 year, average height was 190.33 ± 7.77 cm, average weight was 78.75 ± 9.54 kg and the average basketball experience was 6.83 ± 1.27 years. The Control Group comprised 12 participants with the following characteristics: average age was 17.50 ± 0.52 year, average height was 187.42 ± 7.24 cm, average weight was 80.33 ± 10.61 kg and the average basketball experience was 5.50 ± 1.17 years.

The two experimental groups (rope group and weighted rope group) received one week preparatory rope training as well as technical training. They then trained three times (days) a week for eight weeks. The control group (n = 12) received only technical training three times (days) a week for eight weeks.

The Rope Group used Cable Rope with the following features: Selex (No: 0138), 270 cm rope length and 100 g rope weight. The Weighted Rope Group used Weighted Rope with the following features: Powerope (V-3067), 260 cm rope length, 600 g rope weight and 695 g total weight.

During the first and last training sessions, venous blood samples were obtained from subjects before and after the training. Samples were immediately transferred to a laboratory for examination. WBC (White Blood Cell) and RBC (Red Blood Cell) analysis was conducted with Sysmex (KX21N-Roche) hemogram equipment. Serum extracted from centrifuged blood was examined for CK activity with Integra (800 Roche) biochemistry equipment.

Training program

Preparatory rope exercises conducted one week before the training and warm-up, flexion and contraction exercises conducted for 5 minutes before each exercise.

Preparatory training program

Aim: rope adaptation, exercise method: span method, tempo: quick exercise, duration: 30 s. Break: 30 s. serial: 2.

Exercises

1. Sidewill left side will Right 2. Front windmill, 3.Overhead windmill left, 4. Overhead windmill right, 5. Figure eight Left, 6. Figure eight Right, 7. Sidewill Left Skipping 8. Sidewill right skipping 9. Front windmill Skipping.

Rope jumping program for 8 weeks

Duration of application: 8 Weeks, number of training per week: 3, Total training number: 24, method: span method, exercise tempo: with explosive tempo, of the exercises in the program, application duration : 30 - 60 s, duration of break: 30 - 60 s, number of serial: 1 - 2 set, break between serials: full break, tools and materials: jumping rope

Exercises

Basic bounce step, bell jump, skier's jump, right foot skipping, left foot skipping, alternate foot step, boxer shuffle, side straddle, scissors, bonus jump.

Statistical analysis of the data was conducted using SPSS (Version 10.0). T-test and ANOVA test were utilized to test for normality order and multi comparison tests.

RESULTS

Comparison of pre-exercise and post-exercise blood samples indicates a significant difference within the Rope

Table 1. Comparison of Blood Levels (CK, RBC and WBC) of Rope Group (RG) in pre-exercise and post-exercise period.

Variables	Measurements Pre: X_1 Post: X_2	N	Means	X_2- X_1	SD	t	P
Creatine kinase (CK) 1st week	Pre Post	12	246.17 ± 123.90 276.08 ± 135.80	+29.91	15.12	-6,854	0.000**
Creatine kinase (CK) 8th week	Pre Post	12	277.83 ± 160.59 305.42 ± 168.23	+27.59	13.26	-7.208	0.000**
Erythrocyte (RBC) 1st week	Pre Post	12	5.26 ± 0.18 5.32 ± 0.17	+0.06	7.00	-2.710	0.020*
Erythrocyte (RBC) 8th week	Pre Post	12	5.27 ± 0.27 5.40 ± 0.30	+0.13	9.00	-4.521	0.001**
Leukocyte (WBC) 1st week	Pre Post	12	7.80 ± 2.26 8.78 ± 2.20	+0.98	1.23	-2.739	0.019*
Leukocyte (WBC) 8th week	Pre Post	12	9.23 ± 2.73 9.65 ± 2.78	+ 0.42	1.55	-0.952	0.362

* $p < 0.05$; ** $p < 0.01$.

Table 2. Comparison of Blood Levels (CK, RBC and WBC) of Weighted Rope Group (WRG) in pre-exercise and post-exercise period.

Variables	Measurements Pre: X_1, Post: X_2	N	Means	X_2- X_1	SD	t	P
Creatine kinase (CK) 1st week	Pre Post	12	302.25 ± 195.41 338.58 ± 221.15	+36.33	35.10	-3.586	0.004**
Creatine kinase (CK) 8th week	Pre Post	12	290.42 ± 142.77 332.17 ± 160.69	+41.75	29.82	-4.850	0.001**
Erythrocyte (RBC) 1st week	Pre Post	12	5.12 ± 0.35 5.22 ± 0.36	+0.10	0.14	-2.554	0.027*
Erythrocyte (RBC) 8th week	Pre Post	12	5.12 ± 0.18 5.28 ± 0.31	+0.16	0.19	-2.817	0.017*
Leukocyte (WBC) 1st week	Pre Post	12	6.25 ± 1.37 7.53 ± 1.98	+1.28	0.92	-4.851	0.001**
Leukocyte(WBC) 8th week	Pre Post	12	6.78 ± 1.87 8.04 ± 2.08	+1.26	0.71	-6.061	0.000**

*$p < 0.05$; ** $p < 0.01$.

Group in terms of CK between the 1st and 8th week and RBC in the 8th week ($p = 0.01$) (Table 1). There is a significant difference in RBC and WBC levels in the 1st week ($p = 0.05$). The results indicate a significant difference in CK and WBC levels between the 1st and 8th week ($p = 0.01$) and a significant difference in RBC level ($p = 0.05$) (Table 2).

Comparison of the pre-exercise and post-exercise blood values given in Table 3 indicates a statistically significant difference within the control group in terms of

Table 3. Comparison of Blood Levels (CK, RBC and WBC) of Control Group (CG) in pre- exercise and post-exercise period.

Variables	Measurements Pre: X_1 Post: X_2	N	Means	X_2- X_1	SD	t	P
Creatine kinase (CK) 1st week	Pre Post	12	480.00 ± 156.94 615.67 ± 153.56	+135.67	42.46	-11.069	0.000**
Creatine kinase (CK) 8th week	Pre Post	12	440.58 ± 157.90 537.25 ± 173.14	+96.67	42.78	-7.828	0.000**
Erythrocyte (RBC) 1st week	Pre Post	12	5.06 ± 0.23 5.13 ± 0.24	+0.07	4.00	-5.607	0.000**
Erythrocyte (RBC) 8th week	Pre Post	12	5.23 ± 0.28 5.21 ± 0.17	+0.02	0.26	0.277	0.787
Leukocyte (WBC) 1st week	Pre Post	12	6.85 ± 1.08 8.04 ± 1.40	+1.19	0.64	-6.506	0.000**
Leukocyte (WBC) 8th week	Pre Post	12	6.98 ± 1.09 8.73 ± 0.99	+1.75	0.80	-7.494	0.000**

* $p < 0.05$ ** $p < 0.01$.

CK and WBC in the 1st and 8th week and RBC in the 1st week ($p = 0.01$). However, no significant difference was found in RBC in the 8th week ($p > 0.05$).

Pre-exercise and post-exercise blood level values presented in Table 4 indicate a significant difference between RG-CG in terms of CK levels between the 1st and 8th week in pre-exercise and post-exercise levels ($p = 0.01$).

While there was a significant difference between WRG and CG in terms of CK in the 1st post-exercise period ($p = 0.01$), there was a difference between CK level in the 1st week pre-exercise period and 8th week post-exercise period ($p = 0.05$).

The comparison of blood levels of the Rope Group in pre-training and post-training period/pre-exercise and post-exercise period indicates a significant difference in WBC level in pre-exercise period ($p = 0.05$) but no significant difference in CK and RBC level ($p > 0.05$)(Table 5).

Comparison of the blood levels of Weighted Rope Group in pre-training and post-training period/ pre-exercise and post-exercise period indicates a statistically significant difference ($p = 0.05$) (Table 6).

Comparison of blood levels of the Control Group in pre-training and post-training period / pre-exercise and post-exercise period indicates a statistically significant difference in CK level during the post-training period (Table 7). There was no significant difference in RBC and WBC levels ($p > 0.05$).

Comparison of the pre-exercise and post-exercise blood parameters of the groups indicates a significant difference between RG and CG ($p = 0.01$) in terms of CK (pre-exercise) and CK (post-exercise) in the pre-training period. In the post-training period, both post-exercise CK level ($p = 0.01$) and pre-exercise CK level ($p = 0.05$) were significant in Table 8.

There was a significant difference between WRG and CG in terms of CK level ($p = 0.01$). However, the difference between CK (pre-exercise) and CK (post-exercise) was at ($p = 0.05$) level. In the post-training period, CK (post-exercise) was significant ($p = 0.05$) (Table 8).

DISCUSSION AND CONCLUSION

According to the analysis of CK (creatine kinase) during the pre-exercise and post-exercise period, there was a significant difference in Rope Group, Weighted Rope Group and Control Group in the 1st and 8th weeks in pre-exercise and post-exercise period ($p < 0.01$). Comparison of groups in terms of CK level shows that the greatest increase was detected in CG by +135.67. There was a significant difference between CG-RG ($p < 0.01$) and CG-WRG ($p < 0.05$) in the pre-exercise period and also between CG-RG and CG-WRG ($p < 0.01$) in the post-exercise period in the 1st week. There was a significant difference between CG and RG ($p < 0.05$) in the pre-exercise period and also between CG-RG ($p < 0.01$) and CG-WRG ($p < 0.05$) in the post-exercise period in the 8th week. The most intensive muscle damage was detected in the control group and there was no significant difference between the two experimental groups. This

Table 4. Multi Comparison of Rope Group (RG), Weighted Rope Group (WRG) and Control Group (CG) in terms of Blood Levels (CK, RBC and WBC) in Pre-exercise and Post-exercise Period (Tukey, Tamhane).

Variables	Measurements	Rope group (RG) N = 12	Weighted rope Group(WRG) N = 12	Control group (CG) N = 12	F	p	Tukey, Tamhane
Creatine kinase (CK) 1th week	Pre	246.17 ± 123.90	302.25 ± 195.41	480.00 ± 156.94	6.864	0.003**; 0.029*	RG-CG; WRG-CG
	Post	276.08 ± 135.80	338.58 ± 221.15	615.67 ± 153.56	12.933	0.000**; 0.001**	RG-CG; WRG-CG
Creatine kinase (CK) 8th week	Pre	277.83 ± 160.59	290.42 ± 142.77	440.58 ± 157.90	4.151	0.037*	RG-CG
	Post	305.42 ± 168.23	332.17 ± 160.69	537.25 ± 173.14	6.886	0.005**, 0.014*	RG-CG, WRG-CG
Erythrocyte(RBC) 1th week	Pre	5.26 ± 0.18	5.12 ± 0.35	5.06 ± 0.23	1.687	0.201	
	Post	5.32 ± 0.17	5.22 ± 0.36	5.13 ± 0.24	1.397	0.262	
Erythrocyte(RBC) 8th week	Pre	5.27 ± 0.27	5.12 ± 0.18	5.23 ± 0.28	1.142	0.332	
	Post	5.40 ± 0.30	5.28 ± 0.31	5.21 ± 0.17	1.501	0.238	
Leukocyte (WBC) 1th week	Pre	7.80 ± 2.26	6.25 ± 1.37	6.85 ± 1.08	2.697	0.082	
	Post	8.78 ± 2.20	7.53 ± 1.98	8.04 ± 1.40	1.309	0.284	
Leukocyte (WBC) 8th week	Pre	9.23 ± 2.73	6.78 ± 1.87	6.98 ± 1.09	5.447	0.056	
	Post	9.65 ± 2.78	8.04 ± 2.08	8.73 ± 0.99	1.800	0.181	

* $p < 0.05$; ** $p < 0.01$.

result may be associated with the type and duration of the activity.

According to comparison of CK levels in pre-training and post-training/pre-exercise and post-exercise period during the 8 weeks, there was no statistically significant difference between RG and WRG. There was a significant decrease in CK in the control group in the post-exercise period ($p < 0.05$). The decrease may be associated with the intensity and the short duration of the technical training administered to the control group.

The increases recorded in CK in pre-exercise and post-exercise periods were as follows: Rope group 12.20% for the 1st week and 10.11% for the 8th week; weighted rope group 11.92 for the 1st week and 14.48% for the 8th week and control group 28.13% for the 1st week and 22.05% for the 8th week. The percentage increases in the rope group and control group decrease in the post-training period; however, in the weighted rope group, it shows an increase.

The difference in experimental groups may indicate that the rope group had less muscle damage in line with the training or weighted rope results in more intense muscle damage. The fact that the amount of activated leukocyte was lower in the rope group and higher in the weighted rope group supports this hypothesis.

Muscle damage increased in all groups in pre-training and post-training periods. This may be associated with the acute effect of the exercise. The greatest increase was observed in the control group. In the experimental groups, the greatest increase was in the rope group in the 1st week and in the weighted rope group in the 8th week. That is, the minor muscle damage was detected in rope group, the mediate muscle damage was detected in the weighted rope group and the major muscle damage was detected in the control group with longer and more intensive technical training. This situation may be associated with the type and duration of the activity. The degree of the exercise determines the muscle damage.

According to the literature, exercise-induced muscle damage increases the activity of CK, an intracellular enzyme in serum and plasma (Gillian et al., 1979; Schwane et al., 2000; Schwane et al., 1983). In exercise-induced muscle damage, the activity of CK varies in line with gender, age, type of the exercise and it can be synthesized in various amounts (Schwane et al., 2000).

Table 5. Comparison of blood level (ck, RBC and WBC) of rope group (RG) in pre-training and post-training period / pre-exercise and post-exercise period.

Creatine Kinase (CK)	1th week pre 8th week pre	12	246.17 ± 123.90 277.83 ± 160.59	+ 31.67	81.93	-1.339	0.208
Creatine Kinase (CK)	1 th week post 8th week post	12	276.08 ± 135.80 305.42 ± 168.23	+ 29.33	88.17	-1.152	0.274
Erythrocyte (RBC)	1 th week pre 8th week pre	12	5.26 ± 0.18 5.27 ± 0.27	+ 0.01	0.36	-0.152	0.882
Erythrocyte (RBC)	1th week post 8th week post	12	5.32 ± 0.17 5.40 ± 0.30	+ 0.08	0.38	-0.732	0.479
Leukocyte (WBC)	1th week pre 8th week pre	12	7.80 ± 2.26 9.23 ± 2.73	+ 1.43	2.09	-2.364	0.038*
Leukocyte (WBC)	1th week post 8th week post	12	8.78 ± 2.20 9.65 ± 2.78	+ 0.87	1.59	-1.902	0.084

*$p < 0.05$.

Table 6. Comparison of blood levels (CK, RBC and WBC) of weighted rope group (WRG) in pre-training and post-training period / pre-exercise and post-exercise period.

Variables	Measurements Pre: X_1 Post: X_2	N	Means	X_2- X_1	SD	t	P
Creatine kinase (CK)	1th week pre 8th week pre	12	302.25 ± 195.41 290.42 ± 142.77	-11.83	114.01	0.360	0.726
Creatine kinase (CK)	1th week post 8th week post	12	338.58 ± 221.15 332.17 ± 160.69	-6.41	144.57	0.154	0.881
Erythrocyte (RBC)	1th week pre 8th week pre	12	5.12 ± 0.35 5.12 ± 0.18	0.00	0.26	0.011	0.992
Erythrocyte (RBC)	1th week post 8th week post	12	5.22 ± 0.36 5.28 ± 0.31	+0.06	0.20	-0.925	0.375
Leukocyte (WBC)	1th week pre 8th week pre	12	6.25 ± 1.37 6.78 ± 1.87	+0.53	1.06	-1.737	0.110
Leukocyte (WBC)	1th week post 8th week post	12	7.53 ± 1.98 8.04 ± 2.07	+0.51	2.05	-0.858	0.409

*$p < 0.05$.

According to a previous study, serum CK levels were shown to increase by 21 fold in athletes after completing a race (Quindray et al., 2003). Minor and moderate exercises do not cause change in the enzyme level in 24 h, however, intensive exercise causes changes in high levels (David et al., 1983).

In a study of a sedentary group which aimed to detect the damage to skeletal and heart muscle arising from different levels of training, Hazar (2005) observed the following figures: CK level was 115.601 ± 36.012 U/L(pre-exercise) in maximums power level, 159.700 ±45.109 U/L(post-exercise) and increased by 38.15%. The moderate group was 99.38 ± 28.74 U/L (pre-exercise) and 114.125 ± 4.339 U/L (post-exercise) and increase by 45.02%. The results of the present study are in line with previous findings within the literature.

RBC levels in pre-exercise and post-exercise period show a significant difference between the Rope Group

Table 7. Comparison of blood levels (CK, RBC and WBC) of control group (CG) in pre-training and post-training period/ pre-exercise and post-exercise period.

Variables	Measurements Pre: X_1 Post: X_2	N	Means	X_2- X_1	SD	t	P
Creatine kinase (CK)	1st week pre 8th week pre	12	480.00 ± 156.94 440.58 ± 157.90	-39.42	88.47	1.543	0.151
Creatine kinase (CK)	1st week post 8th week post	12	615.67 ± 153.56 537.25 ± 173.14	-78.42	103.34	2.629	0.023*
Erythrocyte (RBC)	1st week pre 8th week pre	12	5.06 ± 0.23 5.23 ± 0.28	+0.17	0.29	-2.030	0.067
Erythrocyte (RBC)	1st week post 8th week post	12	5.13 ± 0.24 5.21 ± 0.17	+0.08	0.17	-1.501	0.162
Leukocyte (WBC)	1st week pre 8th week pre	12	6.85 ± 1.08 6.98 ± 1.09	+0.13	0.94	-0.489	0.634
Leukocyte (WBC)	1st week post 8th week post	12	8.04 ± 1.40 8.73 ± 0.99	+0.69	1.53	-1.550	0.149

*p < 0.05.

in the 8th week. However there was no significant and the Weighted Rope Group in the 1st week and between the Rope Group and the Weighted Rope Group difference in the control group in the pre-exercise and post-exercise periods. The greatest increase in RBC levels in pre-exercise and post-exercise periods was observed in Weighted Rope Group with +0.16 in the 8th week and there was no statistically significant difference between groups.

Of the two experimental groups, the Weighted Rope Group had the greater increase between the 1st and 8th weeks and RBC levels showed an increase from the 1st week to the 8th week. This increase observed in the experimental groups may be associated with the effect of acute exercise. The RBC level was affected in the Rope Group and Weighted Rope Group from rope exercises with an explosive tempo.

Erol (1995) conducted an endurance study using interval methods on 13 - 14 year old male basketball players. The results showed an erythrocyte level of 4.69 $\times 10^6/\mu L$ in the pre-exercise period and 4.96 $\times 10^6/\mu L$ in the post-exercise period. The increase by 5.68% was cited as significant ($p = 0.01$). According to Erol, erythrocyte levels can increase by 20 - 25% with proper exercise programs.

Haralambie and Senser (1980) assessed metabolic changes due to swimming. The study group comprised 16 male aged 22.3 years, who were required to swim for 90 min. Erythrocyte level was 5.09 $\times 10^6 mm^3$ in the pre-exercise period and 5.50 $\times 10^6 mm^3$ in the post-exercise period.

Stransky et al. (1979) researched the effect of swimming on physical parameters with female swimmers (age 15.8). The results showed a significant difference in the group which swam 12.806 ± 14.80 yard in a week for seven weeks in terms of erythrocyte level. The results of the study by Stransky and Mickelson are in line with the literature. Analysis of the WBC levels in pre-exercise and post-exercise periods indicated a significant difference in the Rope Group, Weighted Rope Group and Control Group. While there was no significant difference in the Rope Group in the 8th week, there was a significant difference in the Weighted Rope Group and the Control Group in the pre-exercise and post-exercise periods. When groups were compared in terms of WCB levels, the highest increase was in Control Group in 8th week by +1.75 and there was no significant difference between groups. Leukocyte level increased in all groups in line with muscle damage and the rope group showed a decrease in leukocyte level in line with the decrease in muscle damage in the 8th week.

According to the comparison of WBC level in pre and post-rope training and pre-exercise and post-exercise levels, the increase in the rope group in the pre-exercise period was significant. However, there was no significant difference in the weighted rope group and the control group in the pre-exercise and post-exercise periods. The significant difference in WBC levels may be associated with increasing muscle damage of the rope group in the1st week.

Table 8. Multi comparison of rope group (RG), weighted rope group (WRG) and control group (CG) in terms of blood levels (CK, RBC and WBC) in pre-training and post-training period / pre-exercise and post-exercise period (Tukey, Tamhane).

Variables	Measurements	Rope Group (RG) N=12	Weighted Rope Group (WRG) N=12	Control Group (CG) N=12	F	p	Tukey Tamhane
Creatine kinase (CK)	1th week pre	246.17 ± 123.90	302.25 ± 195.41	480.00 ± 156.94	6.864	0.003**; 0.029*	RG-CG; WRG-CG
	8th week pre	277.83 ± 160.59	290.42 ± 142.77	440.58 ± 157.90	4.151	0.037*	RG-CG
Creatine kinase (CK)	1th week post	276.08 ± 135.80	338.58 ± 221.15	615.67 ± 153.56	12.933	0.000**; 0.001**	RG-CG; WRG-CG
	8th week post	305.42 ± 168.23	332.17 ± 160.69	537.25 ± 173.14	6.886	0.005**; 0.014*	RG-CG; WRG-CG
Erythrocyte(RBC)	1th week pre	5.26 ± 0.18	5.12 ± 0.35	5.06 ± 0.23	1.687	0.201	
	8th week pre	5.27 ± 0.27	5.12 ± 0.18	5.23 ± 0.28	1.142	0.332	
Erythrocyte(RBC)	1th week post	5.32 ± 0.17	5.22 ± 0.36	5.13 ± 0.24	1.397	0.262	
	8th week post	5.40 ± 0.30	5.28 ± 0.31	5.21 ± 0.17	1.501	0.238	
Leukocyte(WBC)	1th week pre	7.80 ± 2.26	6.25 ± 1.37	6.85 ± 1.08	2.697	0.082	
	8th week pre	9.23 ± 2.73	6.78 ± 1.87	6.98 ± 1.09	5.447	0.056	
Leukocyte(WBC)	1th week post	8.78 ± 2.20	7.53 ± 1.98	8.04 ± 1.40	1.309	0.284	
	8th week post	9.65 ± 2.78	8.04 ± 2.08	8.73 ± 0.99	1.800	0.181	

* $p < 0.05$; ** $p < 0.01$.

The increase of WBC in pre-exercise and post-exercise periods was as follows: 12.56% in the rope group in the 1st week, and 4.55% in the 8th week 20.48% in Weighted Rope Group 1st week, and 18.58% in 8th week, 17.37% in the control group in the 1st week and 25.07% in the 8th week. While the Weighted Rope Group showed the greater increase of the two experimental groups, the greatest increase was observed in the control group in the 8th week. Although there was no significant difference between groups, the increase in all groups may be associated with the intensity and the duration of the acute exercise.

While variations by percentage show a decrease towards the end of the training in the rope group, there was a slight decrease in the weighted rope group and an increase in the control group. The difference in the experimental groups may be associated with exercise factors such as the lower number of leukocyte formations in the rope group in line with training, or more leukocyte formation because of weighted rope. Muscle damage in leukocyte activated tissues was less pronounced in the rope group and more pronounced in the weighted rope group. This finding supports the hypothesis. Previous studies have shown that long-term exercises and power exercises have significant effects on leukocyte composition and concentration (Johnson et al., 1992; Nielsen et al., 1996; Pedersen and Hoffman, 2000).

Another study has assessed that the intensity of the exercise has a significant effect on blood oxidative and that it is possible for neutrophils to be exposed to oxidation in the post-exercise period (Quindray et al., 2003). Özdengül et al. (1999) assessed that acute sub-maximal exercise causes increased levels of lymphocyte, leukocyte and granulocyte. Guyton and Hall (1996) stated that neutrophils can increase by two and three fold within the circulatory system following very intensive exercise for a period of one minute. At the end of the endurance studies conducted via extensive interval method on the male basketball players in 13 to 14 age range, Erol (1995) found pre-exercise leukocyte value as 5.81 × 10^6/µL and post-exercise as 6.06 × 10^6/µL. Thus, he revealed a significant increase of 4.30% (p = 0.01).

In a study on the blood-chemistry of 18 marathon runners, Kraemer and Brown[12] observed that the leukocyte level was 5.40 ± 1.2 × 10^6 mm^3 prior to exercise, but increased by 14.80 ± 4.5 10^6x mm^3 at the end of the race.

In the study which aimed to detect the damage of different levels of training on skeletal and heart muscle of sedentary group, Hazar[11]observed the following figures: WBC level was 7.31 ± 14.70 × 10^6 mm^3 (pre-exercise) in maximums power level and 7.82 ± 15.901 × 10^6 mm^3 (post-exercise) and increased by 6.98%. Moderate group was 7.04 ± 11.89 × 10^6 mm^3 (pre-exercise) and 8.84 ± 17.264 × 10^6 mm^3 (post-exercise) and increased by 25.57%. Literature is in line with the study by Hazar.

In conclusion, creatine kinase and leukocyte levels were shown to increase in line with acute exercise and erythrocyte levels increased in line exercises in order to carry oxygen to tissues. Therefore, experimental groups had more intense muscle damage at the end of the study period involving intensive tempo weighted rope exercises.

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