Annals of Applied Sport Science, vol. 1, no. 4, pp. 17-26, Winter 2013

www.aassjournal.com
ISSN (Online): 2322 – 4479

Original Article

Received: 11/07/2013
Accepted: 25/11/2013

The Effect of a Single Session of Eccentric Resistance Exercise on Some Parameters of White Blood Cells

[1]Alireza Ghanbari*, [2]Seyed Morteza Tayebi

1- Teaching and Education Office, Amol, Mazandaran, Iran.
2- Faculty of Physical Education and Sport Sciences, Allameh Tabataba'i University, Tehran, Iran.

ABSTRACT

It is reported that resistance exercise causes an elevation of white blood cells (WBC) and some of its parameters such as neutrophils (NUT) and lymphocytes (LYM); but there isn't enough study about eccentric exercise (ECC). So, the purpose of this study was to investigate the effect of a single session of eccentric resistance exercise on some parameters of white blood cells. Twelve volunteer male sedentary students were selected to participate in this study. Participants were randomly divided into experimental and control groups. Experimental group performed an eccentric elbow extension (80% of one maximum repetition, 6 sets, 8-10 replicates/sets). Blood sampling implemented at 30 min before the exercise, immediately after the exercise, 2 hours after the exercise, and 24 hours after the exercise. Cell differentiation of WBC for neutrophils (NUT), lymphocytes (LYM), eosinophils (EOS), and monocytes (MON) performed using automated hematology analyzer system [Sysmex (kx-21)]. NUT:LYM ratio was also calculated. It was observed that WBC ($F = 9.611$, $p = 0.001$), NUT ($F = 9.6$, $p < 0.001$), and LYM ($F = 3.28$, $p < 0.001$) increased significantly in response to eccentric exercise, and this elevation continued by 2 hours after the test, while NUT recovered to the initial levels by 24 hours after the exercise, and WBC and LYM remained at a high level at this time. In conclusion, the elevation of WBC immediately after the test is likely due to neutrocytosis and lymphocytosis, but in the recovery period and 24 hours after the exercise is due to lymphocytosis.

Keywords: Eccentric exercise; Neutrophils; Lymphocytes.

Corresponding Author:
Alireza Ghanbari
E-mail: alireza16ghanbary@gmail.com

INTRODUCTION

One of the important and critical parts of human body, relationship of which with exercise is highly of consideration, is the immune system that its proper function can guarantee the health. If this system does not work as expected, survival would be impossible, because oursurrounding environment is full of microorganisms that can affect various parts of our body (1). Physical fatigue caused by physical work, in particular sport activities, can influence many parts and functions of the body, because severe mental and physical stresses distort the body's physiological and immunological balance (2). According to the existing studies, exercise and physical activity can have dual impacts (positive or negative) on power, efficiency of the immune system, and susceptibility to secondary diseases in athletes (1, 2). In other words, the effects of repeated intensive exercise and long-term exercise on the immune system indicate the incidence of upper respiratory tract infections and demolition of immunological factors (1, 3-5). The relationship between exercise and susceptibility to infections has been modeled as the curve J, based on which doing light exercises for pleasure throughout the life would improve the performance of the immune system in sedentary individuals. In contrast, repeated intensive exercise training would decrease the efficiency of the immune system (1). Practically speaking, it is also observed that elite athletes, especially in seasons of training and completion, are more susceptible to be affected by upper respiratory tract infections, including cold and sinusitis (6, 7). Thus, the changes induced by exercise and physical activity on the immune system vary depending on physiological fitness of individuals, type of sport, intensity of sport, and duration of sport (1, 3). The physiological mechanisms responsible for such destructive effects of intense exercise are not totally known. Hence, organized studies on the new field of sport immunology are tangibly needed (1, 8).

Resistance exercises cause transient and unstable impairments in the performance of the immune system, such as changes in the number of leukocytes, concentrations of cytokines, and performance of some cells (8). Milias *et al*. (2005) studied the status of 13 healthy men who used to do sport activities for pleasure and reported that eccentric activity (bending the elbow with a dynamometer) significantly increases the number of leukocytes, eosinophils, neutrophils, lymphocytes, and monocytes (9). Hulmi *et al*. (2010) studied the effects of 4 different resistance training protocols including 3 one-session protocols with various workloads and a 21-week protocol, with controlling the impacts of two variables of dietary supplement and age. They observed a significant increase in neutrophils and lymphocytes in all 3 one-session protocols with no difference in dietary supplement and a significant decrease in lymphocytes to below the minimum amount before the exercise in the recovery period (10).

It has been reported in the literature that peripheral total leukocyte (PTL) increases in response to moderate to intense (exhaustion level) exercise (10-16). This has been mostly attributed to neutrocytosis (10-13). Given to the phagocytosis role of neutrophils and their increase during the inflammation, such a result in not far-fetched. Moderate to intense exercise, especially unto exhaustion, would lead to destruction of muscle tissue. On the other hand, we know that muscle damage is mostly caused by sport activities, predominantly as a result of abnormal eccentric exercises. The major characteristic of such a muscle contraction is imposing extra pressure on muscle fibers and connective tissue and ultimately muscle injuries in the first time of doing them (17, 18). Eccentric contractions do not occur only during sport activities, but they also occur in daily activities such as coming down the stairs and carrying a heavy load from a high place. Although eccentric contraction demands less energy than other activities in terms of metabolism, it causes minor injuries in skeletal muscles, stronger inflammatory response, and higher oxidative stress compared with introspective activities (19). Many studies have reported the injury and muscle inflammation development caused by eccentric activities, severity of which depends on the intensity and duration of activity and also the exercise performance of muscle (19, 20). Although there are reports on resistance trainings (10, 12), no study can be found on eccentric exercises and their acute impact on the profile of white blood cells. So, the objective of the present paper is to study the effect ofa single session of eccentric resistance exercise on some parameters of white blood cells.

MATERIALS AND METHODS

The present study was a quasi-experimental research with time series plan and experimental and control treatments.

Subjects. Among the 60 student volunteers, 12 eligible students were selected and randomly divided into control and experimental groups. Inclusion and exclusion criteria included identical physical fitness; no consumption of caffeine, alcohol, cigarettes, tobacco, and antioxidant supplements; no history of diseases affecting hematological parameters and use of anti-inflammatory drugs; and no history of doing resistance activities at least during the past 2 months.

Exercise Protocol. The first phase consisted of 5 minutes of general warm up (stretching and slow exercises) and specific warm up with a barbell bar with now eight (5 kilograms) in both experimental and control groups. In the second stage, the experimental group performed 6 rounds of biceps with barbell (both arms at the same time) (only eccentric contraction) with an IRM of 80% and 8 to 10 replicates at a motion range of 60 to 140 degree. 2 minutes of rest was arranged between the rounds. In order to ensure the implementation of pure eccentric motion, the subjects took the barbell upward with the help of another person, but took it downward merely by themselves with a controlled motion with the minimum possible speed in 10 to 15 seconds. The control group did not perform the introspective motion with bearing the heavy weight; they took the barbell upward with the help of another person, then the barbell was taken completely out of their hands at the eccentric mode by that person, again it was put in their hands at introspective mode and taken upward with the help that person (shadow moving using a barbell and weights without bearing their heaviness) (20).

Blood Sampling. Blood sampling was done followed by 12 hours of overnight fasting in 4 times including 30 minutes before the test, immediately after the test, 2 hours after the test, and 24 hours after the test. WBC differential count for neutrophils (NUT), lymphocytes (LYM), eosinophils (EOS), and monocytes (MON) was done by using automatic hematology analyzer Sysmex Kx-21. LYM:NUT ratio was also calculated.

Statistical Analysis. All obtained information were analyzed using repeated measures of ANOVA by SPSS software at a significance level of 0.05.

RESULTS

For WBC variable, Mauchly's test of sphericity assumption was not approved (W=0.273, p=0.047). Hence, based on Greenhouse-Gazer modification, effect of time, intergroup effect, and interaction effect of group and time were significant (F=2.793 and p=0.001, F=6.092 and p=0.001, F=9.611

and p=0.001, respectively) (Figure 1, a). In other words, there was a significant linear increase in sample taken immediately and 2 hours after the eccentric resistance exercise, while no significant change was observed in the control group at all times.

For NUT variable, Mauchly's test of sphericity assumption was not approved (W=0.036, p<0.001). Hence, based on Greenhouse-Gazer modification, effect of time, intergroup effect, and the interaction effect of group and time were significant (F=5.41 and p<0.001, F=1.69 and p<0.001, F=9.6 and p<0.001, respectively) (Figure 1, b). In other words, there was a significant linear increase in sample taken immediately and 2 hours after the eccentric resistance exercise, while no significant change was observed in the control group at all times.

For LYM variable, the Mauchly's test of sphericity assumption was not approved (W=0.133, p=0.004). Hence, based on Greenhouse-Gazer modification, effect of time, intergroup effect, and interaction effect of group and time were significant (F=1.67 and p<0.001, F=3.09 and p<0.001, F=3.28 and p<0.001, respectively) (Figure 1, c). In other words, there was a significant linear increase in sample taken immediately and 2 hours after the eccentric resistance exercise, while no significant change was observed in the control group at all times.

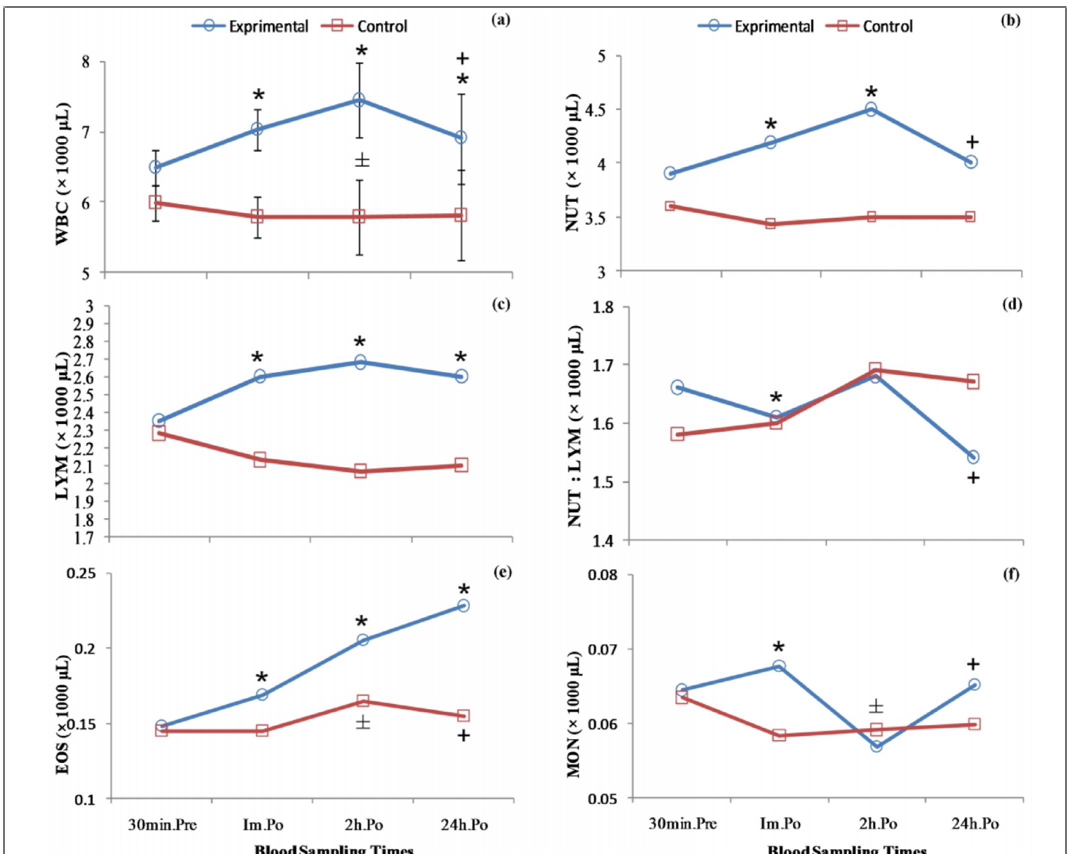

Figure 1. ***Changes of Some Hematological Variables to Single Session of Resistance Eccentric Exercise***. **a)** Total white blood cell count (WBC) changes. **b)** Neutrophil count (NUT) changes. **c)** Lymphocyte count (LYM) changes. **d)** Neutrophil to Lymphocyte count ratio (NUT: LYM) changes. **e)** Eosinophil count (EOS) changes. **f)** Monocyte count (MON) changes. **30min.Pre:** 30 minutes Pre-Test. **Im.Po:** Immediately Post Test. **2h.Po:** 2 hours Post Test. **24h.Po:** 24 hours Post Test. ***:** Significant interaction effect of time and group than to 30min.Pre at p < 0.001. **±:** Significant interaction effect of time and group than to Im.Po at p < 0.001. **+:** Significant interaction effect of time and group than to 2h.Po at p < 0.001.

For LYM:NUT ratio, the Mauchly's test of sphericity assumption was approved (W=0.48, p=0.272). Effect of time, intergroup effect, and the interaction effect of group and time were significant (F=6.42 and p<0.001, F=1.13 and p<0.001, F=8.31 and p<0.001, respectively) (Figure 1, d). In other words, there was a significant decrease in the experimental group immediately after the exercise, while no significant change was found in the control group. After 2 hours of recovery, this ratio increased to its basic levels, as this increase was significant compared with the time immediately after the exercise. A significant decrease to below the initial levels was observed after 24 hours of recovery.

For EOS variable, Mauchly's test of sphericity assumption was not approved (W=0.023, p<0.001). Hence, based on Greenhouse-Gazer modification, effect of time, intergroup effect, and the interaction effect of group and time were significant (F=5.09 and p<0.001, F=1.005 and p<0.001, F=2.39 and p<0.001, respectively) (Figure 1, e). In other words, a significant increase was observed immediately after the exercise in the experimental group which continued at 2 hours and 24 hours after the exercise, significantly different from the control group.

In terms of MON variable, Mauchly's test of sphericity assumption was not approved (W=0.037, p<0.001). Hence, based on Greenhouse-Gazer modification, effect of time, intergroup effect, and the interaction effect of group and time were significant (F=7.72 and p<0.001, F=6.95 and p<0.001, F=7.08 and p<0.001, respectively) (Figure 1, f). In other words, MON increased in response to the exercise, then significantly decreased to below the initial levels 2 hours after the exercise, and finally showed a significant increase 24 hours after the exercise.

DISCUSSION

The present paper studied the effect of a single session of eccentric resistance exercise on some parameters of white blood cells in sedentary boy students. Data analysis showed that WBC, NUT, and LYM had a significant linear increase at times immediately and 2 hours after the eccentric resistance exercise, while these variables recorded no significant change in the control group (the interaction effect of time and group). These results are consistent with the findings of Hulmi *et al*. (2010), Ghanbari-Niaki *et al*. (2005), Wu *et al*. (2004), Havil *et al*. (2003), and Aghaalinejad *et al*. (2002) (10-12). The increase in WBC was attributed to neutrocytosis, lymphocytosis or both of them in all these studied which is the same as what found in the present study. Unlike the findings of this study, Hulmi *et al*. (2004) and Havil *et al*. (2003) observed a significant decrease in LYM, after two-hour and one-hour recovery periods after the exercise, respectively (10, 13), indicating the phenomenon of "open window" implying the time that body is at risk of diseases and athletes must greatly take care of their health. In the present study, LYM still showed an increasing trend in the recovery period after the exercise. Hence, it can be generally concluded that the exercise protocols applied in this study did not lead to the suppression of the immune system and the phenomenon of "open window". 24 hours after the exercise, WBC and LYM remain data high level, despite a slight decrease, which is significantly different from 30 minutes before the exercise. On the other hand, NUT returned to its initial levels 24 after the exercise. The control group again showed no significant change at this time (the significant interaction effect of time and group). In other words, WBC changes at this time are due to lymphocytosis. The results suggest that eccentric resistance exercise could cause tissue inflammation, as it caused an increase in WBC, NUT, and LYM in order to fight this inflammation. In the previous paper published by the authors of the present study on the same protocols and examples, the findings related to lactate dehydrogenase (LDH) and creatine kinase (CK) (two enzymes that are indicative of muscle damage) were measured and their significant increase was observed at all times (20) but it did not lead to the suppression of the immune system and the phenomenon of "open window", because lymphocytes stayed at a high level until 24 hours in the recovery period and also LYM:NUT ratio [a good criteria for measurement of stress caused by sport and its afterward recovery and if the exercise is stress-bearing, this ratio stays at a high level to 24 hours after exercise (15)] showed a significant decrease immediately after the exercise in the experimental group compared with the control group. After two hours of recovery, this ratio returned to its basic levels, as it was significant compared with the time immediately after the exercise. This ration significantly decreased to below the initial levels after 24 hours of recovery.

The total peripheral white blood cells increase in response to moderate to intense (exhaustion level) exercise which is generally due to neutrocytosis. Given to the role of neutrophils and their increase during the inflammation, such a result in not far-fetched, because moderate to intense exercise, especially unto exhaustion, would lead to destruction of muscle tissue. On the other hand, the results of the recovery period after exercise showed a significant decrease in leukocytes which is mainly due to implantation in damaged tissue (10, 16). Mechanisms responsible for changes in the immune system are emerged accompanied with changes in commuting cellular neuroendocrine transmitter and changes of micro trauma in the release and secretion of cytokines. Specifically, increased levels of cytokinesis observed after eccentric activities (8, 21). In addition, in terms of redistribution of leukocytes during exercise, the role of inflammatory mediators such as releasing the compounds possessing chemotaxic properties (creatine kinase) and increasing the release of IL-1, IL-6, TNFs, and acute phase proteins can be mentioned (8, 21).

In the present study, two important indices of muscle damage and inflammation (CK and LDH) were measured (20), which significantly increased in response to merely eccentric resistance exercise (as mentioned in this study), indicating the emergence micro trauma and muscle inflammation followed by eccentric exercise. Thus, it can be said that one of the marked reasons for the increase of NUT and other immunological indicators is the influx of these cells in order to heal inflammation and tissue destruction caused by eccentric contraction at the times immediately and 2 hours after the eccentric resistance exercise. Although NUT value significantly reduced after 24 hours, it returned to its initial levels which can be due implantation in damaged tissue. In this regard, a study on comparing active and passive cooling after a session of Bruce test unto exhaustion with a two-hours recovery period, significant increase in WBC, monocytes, lymphocytes, neutrophils, and basophils and significant decrease of all these variables in both groups at 2 hours after the test were observed. Healing the inflammation and tissue destruction after exercise and implantation in damaged tissue, respectively, were mentioned as the reasons for the increase and decrease of variable (22). Another mechanism that has been proposed in some studied is the reduction in plasma volume and hemoconcentration as a result of acute resistance exercise (12), while no significant change was observed in these parameters in the present study (20). So, the results are independent of plasma volume.

Data analysis also showed that EOS in the experimental group significantly increased immediately after the exercise and this increase continued at 2 hours and 24 hours after the exercise, as it was significantly different from the control group. It was also observed that MON significantly increased immediately after the exercise, significantly decreased to below the initial levels at 2 hours after the test, and finally showed a significant increase at 24 hours after the exercise. These results are inconsistent with findings of Aghaalinejad *et al*. (2002), Havil *et al*. (2003), and Wu *et al*. (2004) (11, 13, 16).Thus, the potential mechanisms affecting the increases of white blood cells during acute exercise can be due different hormonal impacts on secretion, marginalization, and migration in WBC variables. In other words, these changes are probably associated with catecholamines, cortisol, and some chemotaxic factors (10, 15, 16).

CONCLUSION

Based on the findings of the present study, the eccentric part of resistance exercise (as performed in this study) could cause damage and inflammation in the involved muscle tissue and changes in the immune system resulting from neutrocytosis and lymphocytosis, although these changes were not enough to suppress the immune system and cause the emergence of "open window" phenomenon.

REFFRENCES

1. Gleeson M. Immune function in sport and exercise. Journal of applied physiology (Bethesda, Md : 1985). 2007;103(2):693-9. Epub 2007/02/17.
2. Baltopoulos P. Exercise induced modulation of immune system functional capacity. BIOLOGY OF EXERCISE. 2009;5(1):39-50.
3. Gleeson M, Nieman DC, Pedersen BK. Exercise, nutrition and immune function. Journal of sports sciences. 2004;22(1):115-25. Epub 2004/02/20.
4. MacKinnon LT. Special feature for the Olympics: effects of exercise on the immune system: overtraining effects on immunity and performance in athletes. Immunology and cell biology. 2000;78(5):502-9. Epub 2000/10/26.
5. Nagatomi R. The implication of alterations in leukocyte subset counts on immune function. Exercise immunology review. 2006;12:54-71. Epub 2007/01/05.
6. Campbell PT, Wener MH, Sorensen B, Wood B, Chen-Levy Z, Potter JD, et al. Effect of exercise on in vitro immune function: a 12-month randomized, controlled trial among postmenopausal women. Journal of applied physiology (Bethesda, Md : 1985). 2008;104(6):1648-55. Epub 2008/04/12.
7. Spence L, Brown WJ, Pyne DB, Nissen MD, Sloots TP, McCormack JG, et al. Incidence, etiology, and symptomatology of upper respiratory illness in elite athletes. Medicine and science in sports and exercise. 2007;39(4):577-86. Epub 2007/04/07.
8. Koch AJ. Immune Response to Resistance Exercise. American Journal of Lifestyle Medicine. 2010;4(3):244-52.
9. Milias GA, Nomikos T, Fragopoulou E, Athanasopoulos S, Antonopoulou S. Effects of eccentric exercise-induced muscle injury on blood levels of platelet activating factor (PAF) and other inflammatory markers. European journal of applied physiology. 2005;95(5-6):504-13. Epub 2005/09/10.
10. Hulmi J, Myllymäki T, Tenhumäki M, Mutanen N, Puurtinen R, Paulsen G, et al. Effects of resistance exercise and protein ingestion on blood leukocytes and platelets in young and older men. European Journal of Applied Physiology. 2010;109(2):343-53.
11. Aghaalinezhad H, Sarrafnezhad A, Gharakhanlou R, Memari A, Mirshafiei A, Nikbin B. Effect of vitamin E and C in prevention of athletes' immune system weakness. Olympic. 2002;10(3&4):73-83[Article in Farsi].
12. Ghanbari Niaki A, Tayebi SM, Ghorbanalizadeh FG, Hakimi J. Effect of a single Session of Weight-Circuit Exercise on Hematological changes of Physical education Students. Journal of Sports Sciences. 2005;1(2):77-88[Article in Farsi].
13. Havil F, Ebrahim KH, Aslankhani MA. The effect of one session of progressive aerobic exercise on innate immune system of young and adult athletes. Harakat. 2003;17:25-44[Article in Farsi].
14. Hedfors E, Holm G, Ohnell B. Variations of blood lymphocytes during work studied by cell surface markers, DNA synthesis and cytotoxicity. Clinical and experimental immunology. 1976;24(2):328-35. Epub 1976/05/01.

15. Tayebi M, Agha Alinejad H, Kiadaliri K, Ghorbanalizadeh Ghaziani F. Assessment of CBC in physical activity and sport: a brief review. Sci J Blood Transfus Organ. 2011;7(4):249-65[Article in Farsi].
16. Wu HJ, Chen KT, Shee BW, Chang HC, Huang YJ, Yang RS. Effects of 24 h ultra-marathon on biochemical and hematological parameters. World journal of gastroenterology : WJG. 2004;10(18):2711-4. Epub 2004/08/17.
17. Allen DG. Eccentric muscle damage: mechanisms of early reduction of force. Acta Physiologica Scandinavica. 2001;171(3):311-9.
18. Warren GL, Ingalls CP, Lowe DA, Armstrong RB. What mechanisms contribute to the strength loss that occurs during and in the recovery from skeletal muscle injury? The Journal of orthopaedic and sports physical therapy. 2002;32(2):58-64. Epub 2002/02/13.
19. Sumann G, Fries D, Griesmacher A, Falkensammer G, Klingler A, Koller A, et al. Blood coagulation activation and fibrinolysis during a downhill marathon run. Blood Coagulation & Fibrinolysis. 2007;18(5):435-40 10.1097/MBC.0b013e328136c19b.
20. Ghanbari AL, Tayebi SM, Delrouz H. The effect of a single session eccentric resistance exercise on some blood coagulation factors of inactive male students. Sci J Blood Transfus Organ. 2011;8(3):195-206[Article in Farsi].
21. Pedersen BK, Hoffman-Goetz L. Exercise and the Immune System: Regulation, Integration, and Adaptation. Physiological Reviews. 2000;80(3):1055-81.
22. Piraki P. Effect of Active and Passive Recovery on Athletes' White Blood Cell Count. Qom University of Medical Sciences Journal. 2008;2(2):15-20 [Article in Farsi].

مقاله اصیل
تاریخ دریافت: ۱۳۹۲/۰۴/۲۰
تاریخ پذیرش: ۱۳۹۲/۰۹/۰۴

تازه‌های علوم کاربردی ورزش
دوره اول، شماره چهارم
ص‌ص ۱۷-۲۶، زمستان ۱۳۹۲

اثر یک جلسه تمرین مقاومتی برونگرا بر برخی عوامل گلبول سفید خون

علیرضا قنبری[1]*، سید مرتضی طیبی[2]

۱- کارشناس ارشد فیزیولوژی ورزشی، آموزش و پرورش، آمل، مازندران، ایران.
۲- استادیار گروه فیزیولوژی ورزشی، دانشکده تربیت بدنی و علوم ورزشی، دانشگاه علامه طباطبایی، تهران، ایران.

چکیده

گزارش شده که ورزش مقاومتی سبب افزایش گلبول‌های سفید (WBC) و پارامترهای آن نظیر نوتروفیل‌ها (NUT) و لنفوسیت‌ها (LYM) می‌گردد؛ اما توافق کلی در خصوص تأثیر حاد جزء برونگرای فعالیت‌های بدنی وجود ندارد؛ از این رو، هدف تحقیق، بررسی اثر یک جلسه تمرین مقاومتی برونگرا بر برخی پارامترهای گلوبول سفید خون می‌باشد. بدین منظور ۱۲ دانشجوی پسر داوطلب غیرفعال از میان دانشجویان تربیت‌بدنی عمومی دانشگاه مازندران به طور تصادفی انتخاب و به دو گروه تجربی و کنترل تقسیم شدند. گروه تجربی تمرین بازگشت کنترل شده (اکستنشن) از حرکت فلکشن آرنج را با میله‌هالتر (۸۰٪ یک تکرار بیشینه، ۶ دور، هر دور با ۸ تا ۱۰ تکرار) اجرا کردند. زمان‌های خون‌گیری به منظور اندازه‌گیری عوامل انعقادی شامل ۳۰ دقیقه پیش، بلافاصله، ۲ و۲۴ ساعت پس از آزمون بود. شمارش افتراقی WBC برای NUT، LYM، ائوزینوفیل‌ها (EOS)، و مونوسیت‌ها (MON) با استفاده از دستگاه خودکار هماتولوژی آنالایزر (Sysmex kx-21) انجام شد. نسبت NUT: LYM نیز محاسبه گردید. مشاهده شد WBC ($F = ۹/۶۱۱$، $p = ۰/۰۰۱$)، NUT ($F = ۹/۶$، $p < ۰/۰۰۱$)، و LYM ($F = ۳/۲۸$، $p < ۰/۰۰۱$)، در پاسخ به ورزش برون‌گرا افزایش معناداری یافتند و تا ۲ ساعت پس از اتمام ورزش به افزایش خود ادامه دادند؛ اما ۲۴ ساعت پس از اتمام ورزش فقط NUT به سطح اولیه بازگشت، و WBC، و LYM در سطح بالایی باقی ماندند. با توجه به یافته‌ها، جزء برونگرای تمرین مقاومتی سبب افزایش WBC شد که احتمالاً ناشی از نوتروسیتوزیس و لنفوسیتوزیس بود. اما امکان دارد بالا بودن آن در دوره ریکاوری ۲۴ ساعت پس از ورزش (دوره ریکاوری) تنها ناشی از لنفوسیتوز بود.

واژگان کلیدی: ورزش برونگرا، لنفوسیت‌ها، نوتروفیل‌ها.

---

* - نوسنده مسئول:
علیرضا قنبری
پست الکترونیک: alireza16ghanbary@gmail.com

قنبری، ع.، و طیبی، س.م. (۱۳۹۲). تازه‌های علوم کاربردی ورزش، ۱(۴): ۱۷-۲۶.