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The immune system of athletes of different sports

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Abstract

Purpose: the comparative study of the immunity features of elite athletes of different sports.

Material: study involved athletes of the highest mastery level of cyclic and acyclic sports (n = 147, age 18-23 years). Athletes were divided into groups by kinds of sport. Skiers (n = 54), swimmers (n = 23), wrestlers (n = 49), boxers (n = 21).

Results: It was determined that athletes of acyclic sports (wrestlers and boxers) had a significant double increase in the level of secretory immunoglobulin IgA. In parallel, the level of immunoglobulins IgG is reduced. The highest indicators of lysosomal activity were recorded in skiers. Boxers, wrestlers, and swimmers had a decrease in the lysosomal activity level. The maximum phagocytic number is determined in wrestlers, and the minimum – in boxers.

Conclusions: Comparative study of the immunity features of elite athletes in various sports suggests that there is a strain on the immune status. This condition is especially expressed in acyclic sports athletes (wrestling, boxing). This is due to the loads in the preparation process. The data received allow to confirm the significance of immune protection indicators in monitoring the athletes functional status.

Keywords: athletes, immunity, progress, health, biochemistry, blood.

Introduction

The high level of sports mastery requires the stress of the body's adaptive capabilities. This determines the increased requirements for the health condition, stipulates the monitoring of its criteria. The reactivity and resistance are among the criteria which characterize the health and determined by the immunity condition. Currently, the level and dynamics of immunity are widely applied in sports. It is known that large training and competitive volumes of loads are associated with short-term suppression of several immune components.

Shaw et al [1] confirmed that intense sparring and hard training violate the T-cell immunity condition. This reduces the immune system ability to maintain an inflammatory response to an immune challenge, which can weaken the protection against intracellular pathogens and increase the infection risk.

The importance of the analysis of the athletes' immunological parameters is determined in the review of Dias et al [2]. Immunological markers, in combination with efficacy indicators and training monitoring, seem to be a promising tool for the clinical diagnosis of athlete's immune status and the prevention of overtraining syndrome.

Lamb et al [3] studied the relationship of immunity, psycho-emotional and hormonal features of female athletes in different periods of training. It is confirmed the immunity tension in the competitions season in parallel with the increase in anxiety and an increase in the cortisol concentration.

Heaney et al [4] investigated correlations of immune status and large volumes of physical activity in professional cyclists. It is confirmed the effectiveness of the applied indicators as a marker of physical activity and oral health criterion.

The review of Walsh and Oliver [5] is devoted to the correlations of physical activity, immunity condition and the prevalence of respiratory infections in athletes In athletes under heavy training, both innate and acquired immunity are often observed to decrease, typically 15-25%, but whether relatively modest changes in immunity increase URTI susceptibility remains a major gap in knowledge. With the exception of cell-mediated immunity that tends to be decreased, exercising in environmental extremes does not provide an additional threat to immunity and host defense. Recent evidence suggests that immune health may actually be enhanced by regular intermittent exposures to environmental stress (for example, intermittent hypoxia training).

Thus, the available literature data confirm the relevance of the chosen direction of scientific research.

The *purpose* of the research is a comparative study of the immunity features of elite athletes of different sports.

Material and methods.

Participants. The study involved athletes of the highest mastery level [n = 147; age 18-23 years; Candidates Master of Sports (CMS); Masters of Sports (MS)] of cyclic and acyclic sports. Participants were divided into groups by kinds of sport. Skiers (n = 54: n = 33 – CMS, n = 21 – MS), swimmers (n = 23: n = 12 CMS, n = 11 –

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MS), wrestlers (n = 49: n = 28 – CMS, n = 21 – MS), boxers (n = 21: n = 11 – CMS, n = 10 – MS).

Research Design. It was carried out the complex of immunological studies in accordance with generally accepted methods (Novikov D.K. [6]; Novikov D.K., Novikova V.I. [7]). The spontaneous and induced neutrophil secretory activity, the neutrophils ability to produce reactive oxygen intermediate, lysosomal activity parameters and the levels of the main types of immunoglobulins A, M, G were determined in the blood serum. The population and subpopulation spectrum of immune cells was determined by the specific gravity CD3, CD4, CD8, CD10, CD11b, CD16, CD25, CD34, CD56, and CD95.

Statistical Analysis. Statistical analysis of the results was performed applying licensed MS Excel (2010). The following descriptive statistics indicators were determined: arithmetic means, standard deviations, and errors of means. The significance of differences in groups was assessed applying a parametric indicator (Student t-test).

Results.

It is known that modulating neurohumoral effects determine the formation of a specific type of immunoreactivity in a particular athlete. This is accompanied by certain quantitative and qualitative shifts in the immune system. We have investigated the indicators of cellular and humoral links of the immune system, depending on the type of sports activity and the degree of sports mastery. In table 1 shows the indicators which characterize: 1) spontaneous and induced secretory activity of neutrophils; the ability of neutrophils to produce reactive oxygen intermediate; 2) lysosomal activity parameters and levels of the main types of immunoglobulins A, M, G.

The indicators of antibodies levels did not differ on average from the corresponding age standards in athletes of cyclic sports (swimming, skiing).

Athletes of acyclic sports (wrestlers and boxers) have a significant double increase in the level of secretory immunoglobulin IgA. In parallel, the level of immunoglobulins IgG is reduced.

The masters of sports boxers have the highest indicators: spontaneous and induced activity, the intensity of the production of reactive oxygen intermediates, lysosomal activity (tab. 1).

The similar indicators of a sNBT test (test with nitro-blue tetrazolium) and a high level of lysosomal activity were defined in the group of highly qualified skiers. These indicators did not essentially differ in all groups: a spontaneous and induced phagocytic activity of neutrophils, phagocytic number.

Tab. 2 demonstrates the functional activity of neutrophils and B-lymphocytes in candidates for the master of sports of various sports specializations.

We have identified similar patterns of secretory activity of neutrophils in correlation to the reactive

Table 1. Secretory activity characteristics of immune cells in masters of sports

Kinds of sport Groups	Skiers n = 21 1	Swimmers n =11 2	Wrestlers n = 21 3	Boxers n = 10 4	p<0,05 among groups
sNBT activity,%	50,7 ± 4,46	23,45 ±2,45	25,00 ± 6,27	45,20 ± 7,84	1-2,3, 2-4, 3-4
sNBT intensity, c.u.	0,43 ± 0,03	0,44 ± 0,06	0,32 ± 0,06	0,55 ± 0,09	3-4
iNBT activity,%	43,17 ± 2,03	35,97 ± 2,72	36,75 ± 4,61	59,80 ± 2,00	1-4; 2-4, 3-4
iNBT intensity, c.u.	0,59 ± 0,04	0,52 ± 0,05	0,65 ± 0,10	0,71 ± 0,03	1-3,4, 2-3,4
The activity of phagocytosis of neutrophil granulocytes (APN),%	41,60 ± 1,72	40,59 ± 2,20	44,25 ± 4,51	36,40 ± 5,74	
The intensity of phagocytosis of neutrophil granulocytes (IPN), c.u.	1,06 ± 0,08	1,10 ± 0,13	1,04 ± 0,16	0,96 ± 0,14	
Lysosomal activity of neutrophil granulocytes (LAN), c.u.	313,94 ± 23,98	294,94 ± 27,85	221,50 ± 9,73	357,40 ± 24,05	
Ig A – immunoglobulin A, g/l	1,34 ± 0,09	1,42 ± 0,12	2,81 ± 0,04	2,48 ± 0,17	1-3,4 2-3,4
IgM – immunoglobulin M, g/l	1,08 ± 0,06	0,95 ± 0,04	1,04 ± 0,09	0,72 ± 0,08	1-4 2-4 3-4
IgG – immunoglobulin G, g/l g/l	8,70 ± 0,38	8,45 ± 0,31	8,08 ± 0,23	7,22 ± 0,77	1-4 2-4

Notes: NBT – test with nitro-blue tetrazolium (sNBT – spontaneous; iNBT – induced); c.u. – conventional units.

Table 2. Secretory activity characteristics of immune cells in Candidates Master of Sports (M ± m)

Kinds of sport Groups	Skiers n = 33 1	Swimmers n =12 2	Wrestlers n = 28 3	Boxers n = 11 4	p<0,05 among groups
sNBT activity,%	38,41 ± 3,34	22,88 ± 1,44	24,00 ± 4,97	24,20 ± 5,88	1-2,3,4
sNBT intensity, c.u.	0,45 ± 0,03	0,33 ± 0,02	0,40 ± 0,09	0,28 ± 0,07	1-2,3,4 2-3 3-4
iNBT activity,%	41,72 ± 1,81	40,47 ± 3,37	32,00 ± 4,02	56,00 ± 8,58	1-3,4 2-3,4 3-4
iNBT intensity, c.u.	0,57 ± 0,04	0,44 ± 0,04	0,54 ± 0,07	0,78 ± 0,14	1-2,3,4 2-4 3-4
The activity of phagocytosis of neutrophil granulocytes (APN),%	42,84 ±1,79	42,83 ± 2,07	47,43 ± 3,60	44,60 ± 6,82	
The intensity of phagocytosis of neutrophil granulocytes (IPN), c.u.	1,14 ± 0,07	1,28 ± 0,11	0,95 ± 0,09	1,06 ± 0,18	
Lysosomal activity of neutrophil granulocytes (LAN), c.u.	367,49 ± 28,50	263,88 ±18,22	277,86 ±14,21	341,20 ± 30,03	1-2,3 2-4 3-4
Ig A – immunoglobulin A, g/l	1,50 ± 0,08	1,41 ± 0,08	2,27 ± 0,19	2,35 ± 0,18	1-3,4 2-3,4
IgM – immunoglobulin M, g/l	1,06 ± 0,05	0,94 ± 0,04	1,00 ± 0,05	0,77 ± 0,05	1-4 2-4 3-4
IgG – immunoglobulin G, g/l g/l	7,41 ± 0,47	8,52 ± 0,28	6,23 ± 0,27	7,34 ± 0,42	

Notes: NBT – test with nitro-blue tetrazolium (sNBT – spontaneous; iNBT – induced); c.u. – conventional units.

oxygen intermediate in athletes in comparison with the indicators of the masters of sports.

The highest indicators of lysosomal activity were defined in skiers. Boxers, wrestlers, and swimmers demonstrated a decrease in the lysosomal activity level. The maximum phagocytic number is defined in wrestlers, and the minimum – in boxers.

Wrestlers and boxers had increased levels of secretory immunoglobulin A. The amount of immunoglobulin M was the lowest in boxers. The levels of immunoglobulin A were significantly higher.

The increase in the intensity of the induced production of reactive oxygen intermediate was determined in the judo group. The maximum intensity of phagocytosis, the indicator of the lysosomal activity of neutrophils is determined in the group of boxers.

We have evaluated the immunophenotypic characteristics of cells of athletes' immune system. Table 3 demonstrates a population and subpopulation spectrum of immunocytes in a group of athletes (masters of sports of cyclic and acyclic sports).

The indicators of the immune status of candidates masters of sports are defined below.

The main populations and subpopulations of immunocytes in athletes - candidates masters of sports are presented in table 4.

There are significant changes (depending on the athletes' specialization) of the population spectrum of athletes' immune cells.

Discussion.

The results confirm the informational content and relevance of immunological indicators for assessing and predicting the athletes' condition. In this case, the complex analysis included the character of the secretory activity of immune cells, the analysis of the population and subpopulation spectrum of immune cells and the characteristic of the humoral immunity of elite athletes.

The applied research design was the analysis of the athletes' condition of the highest sports mastery level which allows to determine more clearly the influence of regular physical activities on the immune status. The comparison of the athletes' condition features of differ sports allows to determine the influence specifics on the body, to identify the factors which influence on the success.

The results of tables 1,2 confirm the significance of the control of immunoglobulins A, M, and G in the monitoring of athletes conditions. The determination of the immunoglobulin A level should be recognized

Table 3. Population and subpopulation spectrum of immunocytes in masters of sports (M ± m)

Kinds of sport Groups	Skiers n = 21 1	Swimmers n =11 2	Wrestlers n = 21 3	Boxers n = 10 4	p<0,05 among groups
CD3,%	28,94 ±2,32	34,45 ±1,90	35,50 ±2,03	33,60 ±3,84	
CD4,%	24,40 ±1,79	24,48 ±2,15	21,25 ±1,18	22,80 ±1,89	
CD8,%	29,23 ±2,59	25,76 ±2,04	25,25 ±1,63	20,80 ±1,44	1-4
CD10,%	13,17 ±1,13	12,31 ±1,13	14,75 ±1,59	6,60 ±0,62	1-4 2-4 3-4
CD11b,%	16,77 ±0,97	19,38 ±1,36	13,50 ±1,43	11,60 ±1,51	1-3,4 2-3,4
CD16,%	11,57 ±0,99	14,21 ±1,30	13,25 ±1,99	13,00 ±1,07	1-2
CD 20,%	18,97 ±1,18	17,03 ±1,53	13,50 ±1,70	14,40 ±0,86	1-3,4 2-3,4
CD25,%	13,97 ±0,95	11,45 ±1,04	14,00 ±1,41	14,80 ±0,90	
CD34,%	12,89 ±0,85	9,24 ±1,36	16,25 ±2,08	6,20 ±1,04	1-2,3,4 2-3,4 3-4
CD56,%	16,29 ±1,48	11,48 ±0,98	15,00 ±2,28	9,80 ±0,77	1-2,4 2-3 3-4
CD95,%	20,40 ±1,55	17,14 ±1,64	17,25 ±1,63	16,00 ±1,19	1-2,3,4

Note: CD3 – T-cells (in combination with TCR – transmission of a signal with antigenic recognition by T cell); CD4 – T-helper cells, monocyte subpopulations, cortical thymocyte subpopulations, EBV transformed B-cells (MNC class II co-receptor, HIV receptor); CD8 – T-cytotoxic, NK-cells subpopulations, cortical thymocyte subpopulations, (MNC class I co-receptor); CD10 – subpopulations of immature B-cells, B-cells subpopulations, cortical thymocyte subpopulations, granulocytes (CALLA, endopeptidase); CD11b – granulocytes, monocytes, NK-cells (adhesion molecule Mac-1, integrin, IC3b receptor; phagocytosis of opsonized particles); CD16 – NK-cells, granulocytes, macrophages (Fcg RIII); CD20 – subpopulations of B-cells precursors, mature B-cells; CD25 – activated T and B cells; activated macrophages (IL-2Ra chain, Tac; lymphocytic activation marker); CD34 – hematopoietic cell precursors, endothelial cells (sialomucin, ligand for L-selectin); CD56 – NK-cells, some T-cells (NK adhesion molecule of N-CAM cells); CD95 – many types of cells (Fas antigen, APO-1; central role of apoptosis).

as particularly significant. This confirms the available literature data.

Minic et al [8] studied the reactivity of the humoral immune system in professional athletes. The high informational significance of IgG, IgM, and IgA was confirmed for the analysis of the immunity features. Coad et al [9] confirmed the high significance and reliability of the determination of IgA of saliva. Teixeira et al [10] compared the immune response in triathlon athletes and runners. It was confirmed the high informational significance of IgA of salivary, its correlation with physical activity level. Coad et al [11] showed that weekly training load depending on the season of the Australian Football League can lead to a delay in the immunity recovery after the match. It is proposed to use the definition of IgA in monitoring the status of athletes, especially in the case of impaired dysimmunity. Moraes et al [12] evaluated the relationship between the intensity of training young male basketball players and the level of IgA saliva. It is confirmed that intense physical loads promote the suppression of immunity.

Analysis of the population and subpopulation spectrum of immune cells confirmed the presence of differences in athletes of cyclical and acyclic sports, especially expressed for CD10, CD20, CD34, and CD56. It allows to suggests the presence of tension in athletes immune system. There was a decrease in the proportion of these immune cells in acyclic sports in comparison with cyclic. The results received are close to the available data.

Blume et al [13] performed a longitudinal prospective study of the immune status in young athletes. The increase in training loads promoted the increase in tension.

Table 4. Characteristics of immune cells composition in candidate master of sports (M ± m)

Kinds of sport Groups	Skiers n = 33 1	Swimmers n =12 2	Wrestlers n = 28 3	Boxers n = 11 4	p<0,05 among groups
CD3,%	30,39 ±2,16	34,05 ±1,89	38,43 ±3,31	31,80 ±2,92	
CD4,%	25,18 ±1,56	25,95 ±1,44	22,57 ±1,40	19,40 ±1,29	1-4 2-4
CD8,%	29,32 ±2,73	29,39 ±1,84	18,71 ±1,27	21,00 ±2,00	1-3,4 2-3,4
CD10,%	13,39 ±1,09	8,98 ±0,68	15,14 ±2,02	5,20 ±0,49	1-2,3,4 2-3,4 3-4
CD11b,%	17,29 ±0,91	17,73 ±0,97	18,00 ±0,70	16,60 ±2,00	
CD16,%	13,16 ±0,82	15,20 ±0,63	12,57 ±1,14	11,20 ±1,47	2-3 2-4 1-4
CD 20,%	18,97 ±1,18	17,32 ±1,11	18,00 ±1,92	10,20 ±1,36	1-4 2-4 3-4
CD25,%	13,95 ±0,83	13,83 ±0,81	12,86 ±0,75	14,60 ±2,27	
CD34,%	12,68 ±0,74	8,56 ±1,22	13,43 ±1,13	5,40 ±1,29	1-2, 4 2-3,4 3-4
CD56,%	16,13 ±1,15	11,83 ±0,76	15,43 ±1,32	10,00 ±1,19	1-2,4 2-3 3-4
CD95,%	22,05 ±1,61	17,71 ±1,28	15,00 ±1,24	14,00 ±2,07	1-3,4 2-3,4

Note: CD3 – T-cells (in combination with TCR – transmission of a signal with antigenic recognition by T cell); CD4 – T-helper cells, monocyte subpopulations, cortical thymocyte subpopulations, EBV transformed B-cells (MNC class II co-receptor, HIV receptor); CD8 – T-cytotoxic, NK-cells subpopulations, cortical thymocyte subpopulations, (MNC class I co-receptor); CD10 – subpopulations of immature B-cells, B-cells subpopulations, cortical thymocyte subpopulations, granulocytes (CALLA, endopeptidase); CD11b – granulocytes, monocytes, NK-cells (adhesion molecule Mac-1, integrin, IC3b receptor; phagocytosis of opsonized particles); CD16 – NK-cells, granulocytes, macrophages (Fcg RIII); CD20 – subpopulations of B-cells precursors, mature B-cells; CD25 – activated T and B cells; activated macrophages (IL-2Ra chain, Tac; lymphocytic activation marker); CD34 – hematopoietic cell precursors, endothelial cells (sialomucin, ligand for L-selectin); CD56 – NK-cells, some T-cells (NK adhesion molecule of N-CAM cells); CD95 – many types of cells (Fas antigen, APO-1; central role of apoptosis).

Kurowski et al [14] confirmed that significant physical loads promoted dysimmunity in athletes. The significant decrease in CD14 leukocytes was observed in swimmers and skaters. Komano et al [15] confirmed the significance of CD86 as a marker of sufficient immunity. Schlabe et al [16] demonstrated the improvement in metabolic and immunological parameters in HIV-infected patients who have undergone moderate endurance training. The significant increase in absolute CD4 T cells was observed. Cury-Boaventura et al [17] studied the activation status of lymphocytes before and after the futsal match. The futsal match induced lymphocytosis and lymphocyte apoptosis, as evidenced by the externalization of phosphatidylserine, the expression of CD95 and DNA fragmentation. In addition, the competitive match caused necrotic death of lymphocytes. There were no differences in the percentage of CD4 + and CD8 + T-cells or in the profile of T-helper / suppressor between before and immediately after the match. In addition, after the futsal match, the expression levels of CD95 and CD28 decreased.

The work of Melnikov et al [18] should be recognized as the closest in the goal and tasks to be solved. The authors performed a quantitative analysis of immunoglobulins A, G, M, hemolytic activity of complement and its fragments C1-C5 in the blood serum of professional athletes-skiers, swimmers, wrestlers, boxers of the highest sports qualification. In the group of athletes belonging to acyclic sports (wrestlers and boxers), the authors found a double increase in IgA levels with a parallel decrease in immunoglobulins of the secondary immune response (IgG). In representatives of cyclic sports (swimming, skiing), the parameters of antibodies did not differ from the corresponding age norms. The linear increase in IgA and IgM products is demonstrated as a qualification and adaptation of athlete to increased physical activity. The highest level of IgG was detected in the group of high-class athletes. The authors conclude that the athletes' qualification influences significantly on the parameters of humoral immunity, forming the so-called profile of changes. At the same time, these changes can be viewed as a characteristic of the athlete's belonging to a certain specialization and sports qualification, as well as cyclic, mainly aerobic, sports such as swimming, skiing or acyclic anaerobic sports, such as boxing or wrestling. The detected changes can be mediated through desynchronosis in the dynamics of adaptive processes of different intensity at the level of the humoral immunity system in the process of improving sports scores.

Conclusions.

The comparative study of the immunity features of elite athletes in different sports allows to suggest that there is a strain on the immune status. This condition is especially expressed in athletes of acyclic sports (wrestling, boxing), which seems to be related to the loads in the training process. The data received confirms the significance of immune protection indicators in the monitoring of the functional condition of athletes.

Conflict of interests

The authors declare that there is no conflict of interests.

References

1. Shaw DM, Merien F, Braakhuis A, Dulson D. T-cells and their cytokine production: The anti-inflammatory and immunosuppressive effects of strenuous exercise. *Cytokine*. 2018;104:136-142. https://doi.org/10.1016/j.cyto.2017.10.001
2. Dias R, Baganha RJ, Cieslak F, Krinski K, Camarco NF, Verlengia R, et al. Immunological parameters and upper respiratory tract infections in team sports athletes. *Revista Brasileira De Medicina Do Esporte*. 2017;23(1):66-72. https://doi.org/10.1590/1517-869220172301149299
3. Lamb AL, Hess DE, Edenborn S, Ubinger E, Carrillo AE, Appasamy PM. Elevated salivary IgA, decreased anxiety, and an altered oral microbiota are associated with active participation on an undergraduate athletic team. *Physiology & Behavior*. 2017;169:169-177. https://doi.org/10.1016/j.physbeh.2016.12.004
4. Heaney JLJ, Killer SC, Svendsen IS, Gleeson M, Campbell JP. Intensified training increases salivary free light chains in trained cyclists: Indication that training volume increases oral inflammation. *Physiology & Behavior*. 2018;188:181-187. https://doi.org/10.1016/j.physbeh.2018.02.013
5. Walsh NP, Oliver SJ. Exercise, immune function and respiratory infection: An update on the influence of training and environmental stress. *Immunology and Cell Biology*. 2016;94(2):132-139. https://doi.org/10.1038/icb.2015.99
6. Novikov DK. *Handbook of Clinical Immunology and Allergology*. Minsk, 1987. (in Russian)
7. Novikov DK, Novikova VI. *Cellular Immunodiagnostic Methods*. Minsk, 1979. (in Russian)
8. Minic R, Papic Z, Dordevic B, Michalickova D, Llic V, Mathiesen G, et al. Profiling of microorganism-binding serum antibody specificities in professional athletes. *Plos One*. 2018;13(9). https://doi.org/10.1371/journal.pone.0203665
9. Coad S, Mclellan C, Whitehouse T, Gray B. Validity and Reliability of a Novel Salivary Immunoassay for Individual Profiling in Applied Sports Science. *Research in Sports Medicine,* 2015;23(2):140–50. https://doi.org/10.1080/15438627.2015.1005300
10. Teixeira RN, Leite GD, Gorjao R, Palmeira P, Santos CMM, Zambonatto R, et al. Immune and Inflammatory Response in Atopic Elite Endurance Athletes. *International Journal of Sports Medicine*. 2018;39(9):720-725. https://doi.org/10.1055/a-0633-9001
11. Coad S, Gray B, McLellan C. Seasonal Analysis of Mucosal Immunological Function and Physical Demands in Professional Australian Rules Footballers. *International Journal of Sports Physiology and Performance,* 2016;11(5):574–80. https://doi.org/10.1123/ijspp.2015-0242
12. Moraes H, Aoki MS, Freitas CG, Arruda AFS, Drago G, Moreira A. SIgA response and incidence of upper respiratory tract infections during intensified training in youth basketball players. *Biology of Sport*. 2017;34(1):49-55. https://doi.org/10.5114/biolsport.2017.63733
13. Blume K, Körber N, Hoffmann D, Wolfarth B. Training Load, Immune Status, and Clinical Outcomes in Young Athletes: A Controlled, Prospective, Longitudinal Study. *Frontiers in Physiology* [Internet]. 2018 Mar 23 [cited 2018 Oct 31];9. Available from: https://doi.org/10.3389/fphys.2018.00120
14. Kurowski MM, Jurczyk J, Pawelczyk M, Szulc A, Krysztofiak H, Kowalski ML. Treadmill exercise decreases expression of innate immunity molecules in peripheral blood leukocytes in competitive athletes, asthmatics and healthy subjects. *European Respiratory Journal*. 2016;48. https://doi.org/10.1183/13993003.congress-2016.PA571
15. Komano Y, Shimada K, Naito H, Fukao K, Ishihara Y, Fujii T, et al. Efficacy of heat-killed Lactococcus lactis JCM 5805 on immunity and fatigue during consecutive high intensity exercise in male athletes: a randomized, placebo-controlled, double-blinded trial. *Journal of the International Society of Sports Nutrition*. 2018;15. https://doi.org/10.1186/s12970-018-0244-9
16. Schlabe S, Vogel M, Boesecke C, Schwarze-Zander C, Rockstroh JK, Korner C, et al. Moderate endurance training (marathon-training) - effects on immunologic and metabolic parameters in HIV-infected patients: the 42 KM cologne project. *BMC Infectious Diseases*. 2017;17. https://doi.org/10.1186/s12879-017-2651-y
17. Cury-Boaventura MF, Gorjao R, de Moura NR, Santos VC, Bortolon JR, Murata GM, et al. The Effect of a Competitive Futsal Matchon T Lymphocyte Surface Receptor Signaling and Functions. *Frontiers in Physiology*. 2018;9. https://doi.org/10.3389/fphys.2018.00202
18. Melnikov IY, Zhurilo OV, Komarova IA, Sashenkov SL. Humoral factors of immunity depending on the skill levels of athletes. *Gazzetta Medica Italiana Archivio Per Le Scienze Mediche*. 2018;177(3):56-61. https://doi.org/10.23736/s0393-3660.18.03800-7

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