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The impact of physical effort on the number of white blood cells, neutrofiles and cortisol concentration in professional cyclists

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ABSTRACT

There are not many certain information about the effects exercise on the number and characteristics of white blood cells and the immune response in people who are physically active [1]. Some data suggest that lymphocytes at rest and their activity are the same in sportsman and in inactive persons. The aim of this study was to demonstrate the relationship between volume and intensity in cyclists macrocycle and changes in white blood cells, neutrofiles and cortisol concentration. This knowledge will help in preventing the negative effects of fatigue and overtraining. This work is based on results on endurance test and analysis of training loads. Venous blood was used for biochemical markers. It was taken before exercise, after its completion, and after an hour of restitution. Cortisol concentration, the number of white blood cells and neutrophiles increased in response to exercise. The output level of neutrophiles, white blood cells and cortisol did not differ from their level in untrained persons. The number of white blood cells and neutrophiles after exercise was significantly higher than their level in subsequent studies in the introductory period. The results show a significant effect of adaptation to physical effort and the quality of post-exercise immune response and the appearance of the response to exercise an open window immune. Endurance training also caused a decrease in the output level of cortisol during the major races. It can also lead to lower baseline concentration of this hormone. This does not change character of the response effort, and after an hour of restitution during the major races [2]. The increase in cortisol may increase postprandial apoptosis of white blood cells and increase the number of neutrophils. This has an influence on the immune response and the degree of regeneration of cyclists in the macrocycle.

***Keywords*:** neutrophils; cortisol; white blood cells; immunology; overtraining; cyclists

1. INTRODUCTION

Explores the effects of exercise on the efficiency of the immune mechanisms of the players are still under discussion. Definite conclusions have not been yet finally drawn [3]. In recent years there has been increased interest in the problems of the impact of exercise on the efficiency of the immune mechanisms [4]. Research on the effects of post-exercise changes in response to innate susceptibility to viral infections are still at an early stage.

It is still not known training load size which the immune system becomes unwieldy. Regular exercise of moderate intensity has anti-inflammatory effect, but the precise mechanisms underlying this phenomenon are still the subject of study [5,6]. Information from these studies can be used for individualization of training. This will enable the development of effective training methods for the athlete and counteracts the negative effects of fatigue and overtraining [7].

There are not many certain information about the effects exercise on the number and characteristics of white blood cells and the immune response of cyclists [1]. Fatigue and reduces the overtraining is certainly the number of leukocytes, which also causes a reduced immune response [5,6]. The reason for this may be increase of cortisol and adrenaline. Important in the immune response could be physical effort and his character.

This work presents the results of research on these changes in cyclists in the macrocycle.

2. MATERIAL AND METHODS

The purpose of this study was to analyze changes in the number of white blood cells, neutrophiles and cortisol levels at various stages of the macrocycle with cyclists and in response to a single strenuous.

The study involved 9 players (men) engaged in competitive cycling with professional groups. The average age was 25.6 years. Basic parameters of body composition and average endurance of selected results are shown in Table 1 and 2.

Table 1. Anthropometric parameters tested.

	Study 1	Study 2	Study 3	Study 4
	X ±SD	X ±SD	X ±SD	X ±SD
Height c. (Cm)	181,44 ±5,64	181,44 ±5,64	181,44 ±5,64	181,48 ±5,37
Weight (Kg)	72,41 ±7,35	72,63 ±7,17	72,40 ±7,00	71,96 ±6,31
Fat (kg)	7,84 ±2,51	7,07 ±2,58	6,94 ±2,15	6,62 ±1,74
Fat (%)	10,73 ±2,78	9,58 ±3,04	9,50 ±2,53	9,17 ±2,13
BMI (kg/m^2)	21,94 ±1,49	22,02 ±1,30	21,91 ±1,29	21,79 ±1,27

Table 2. Parameters such cardiovascular cyclists in the individual periods of research.

	Study 1	Study 2	Study 3	Study 4
	X ±SD	X ±SD	X ±SD	X ±SD
OKW (W)	404,33 ±33,67	436,67 ±31,45	425,33 ±28,80	418,00 ±42,67
OKWz (W/kg)	5,56 ±0,27	6,11 ±0,33	6,26 ±0,43	5,88 ±0,44
OLTW (W)	295,56 ±27,89	320,00 ±33,17	312,78 ±36,50	347,00 ±36,00
OLTWz (W/kg)	4,10 ±0,25	5,24 ±0,76	4,51 ±0,40	4,76 ±0,26
VO_2 (L/min)	4,76 ±0,46	5,05 ±0,54	4,86 ±0,50	5,07 ±0,47
VO_2 max (ml/kg/min)	65,78 ±3,87	69,56 ±4,10	68,74 ±4,60	69,67 ±1,58
VO_2 LT (l/min)	51,68 ±2,74	57,17 ±3,56	55,80 ±4,03	60,44 ±4,60
%VO_2 max LT	78,66 ±3,68	82,28 ±3,99	81,46 ±3,39	86,82 ±6,49
VE (L/min)	163,68 ±17,81	180,33 ±24,11	174,19 ±17,96	171,26 ±20,88
HR max (ud/min)	192,56 ±6,23	192,22 ±8,58	191,22 ±6,46	188,78 ±8,80
HRLT (ud/min)	170,44 ±5, 41	173,33 ±8,92	169,00 ±6,44	175,33 ±6,02
O_2/HR max (ml)	24,93 ±2,94	26,71 ±3,48	26,00 ±2,58	27,71 ±2,60

OKW - final load in watts, OLTW - load on the anaerobic threshold in Watts, OKWz - terminator relative in watts

The competitors were informed about the purpose and progress of research and signed consent in the experiment. Program experience was approved by the Bioethics Commission appointed by AWF Katowice. Collected documentation relating to the training load and training experience. Research resting and exercise were carried out in the Laboratory of functional tests and in the Department of Biochemistry of the Academy of Physical Education in Katowice.

The research program included four stages, which were carried out in successive training periods: during the transitional period in November (OP), the preparatory February (OPG), at the start of the launch period in April (OS) and during take-major start of each competitor in June (SG). The measurements of body height (cm) weight (kg) and body mass index (BMI kg/m^2). Based on the impedance method (Tanita weight) was determined fat-free mass (FFM kg), fat content (FM%) and the total content of water (TBW).

Figures 1 and 2 show the training loads carried by the competitors during the study period, and their intensity.

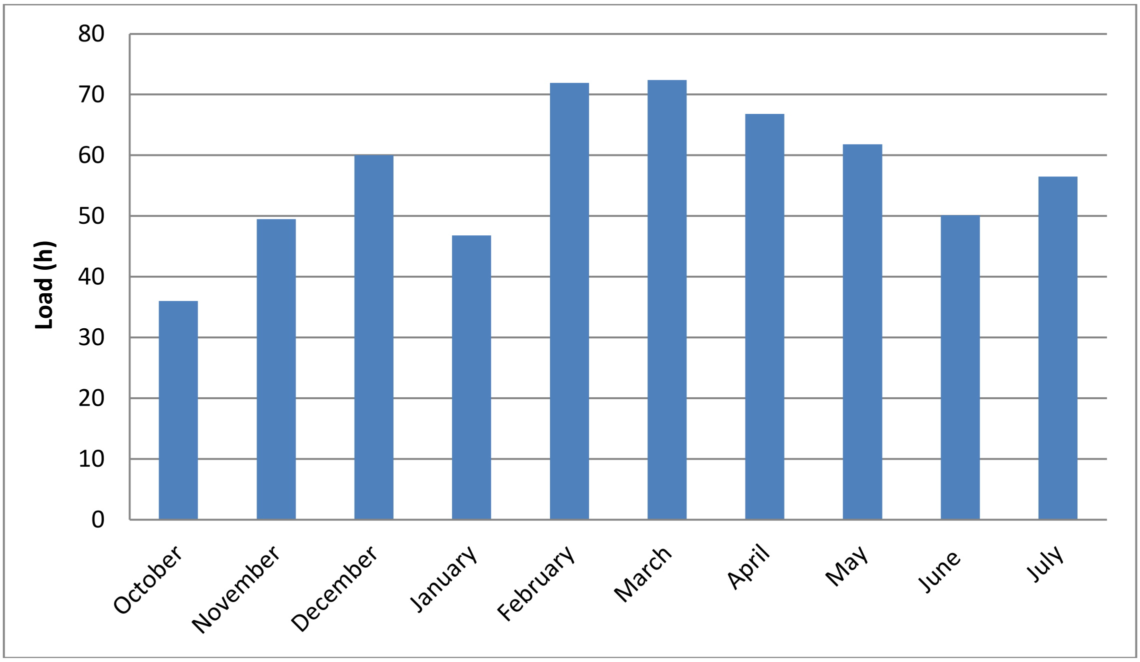

Figure 1. Training load of cyclists in the following months expressed in hours.

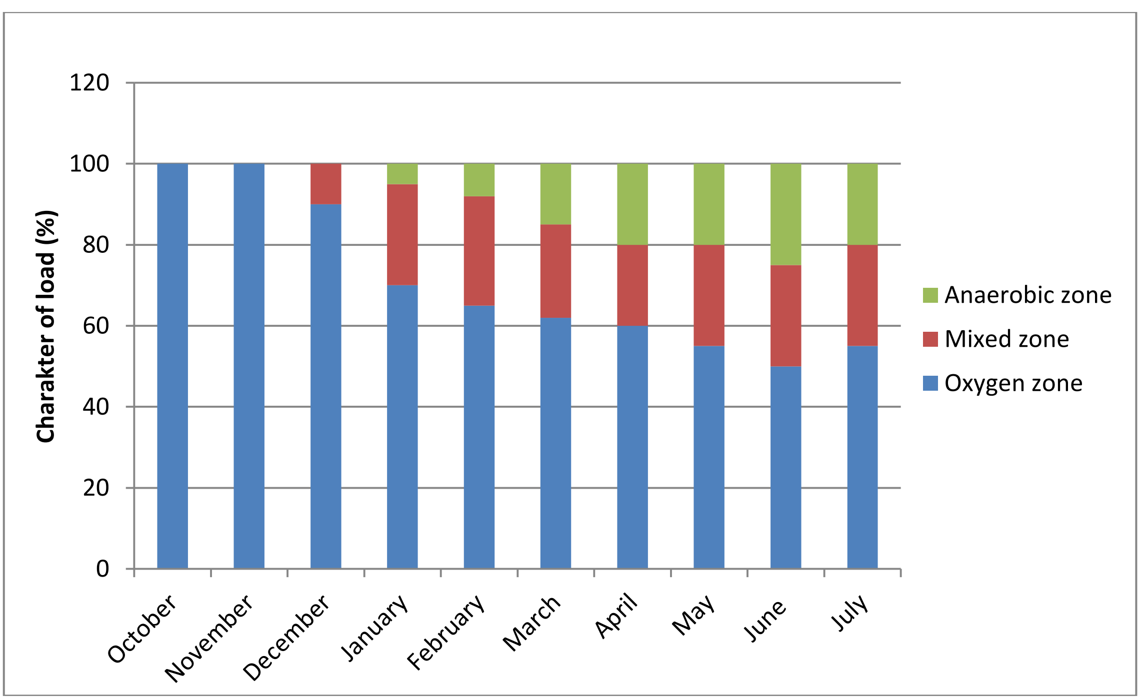

Figure 2. The nature of training loads expressed as a percentage in the coming months of year.

The venous blood was sampled for signs before starting an exercise test for determined immunological markers and endocrine diseases. At rest and during exercise test were monitored: heart rate (HR), blood pressure, pulmonary minute ventilation (VE) and the amount of oxygen uptake (VO_2). After the measurement of resting subjects started to exercise test. Shortly after its completion, and after an hour of restitution sampled venous blood for biochemical markers.

All physiological tests were carried out in the Laboratory of functional tests in AWF Katowice. Biochemical assays were performed in the laboratory: Regional Hospital in Tychy, ANCHEM Katowice Ochojec and the Department of Biochemistry AWF Katowice.

3. PERFORMANCE TEST

Endurance test was performed on a bicycle ergometer Jaeger, respectively adapted to the person. Depended on carrying out the work of gradually increasing intensity. After a five minute warm-up loading increased from 40 W every tree minutes by 40 W. The load grow to maximum exertion possibilities considered. The performance test was continued to refuse. During the test was kept cadence of 80-90 rpm.

At the end of each load were taken blood from the finger. The results obtained were used to designate the lactate threshold (AT). For the determination of blood lactate used enzymatic method using commercial tests company Boehringer Mannheim 35. To the threshold markings applied method of log-log. Registration and during the resting HR tests conducted with Sport Tester RS 800 Polar Company Inc. Finland. After the end of the effort, and after one hour of rest venous blood was sampled for biochemical determinations.

4. RESULTS

The results form tests show Table number 3 and 4.

Table 3. Number of white blood cells (WBC) and neutrophils before and after exercise after 1 hour rest in subsequent studies.

	Test/ effort	Before test	After test	1 h after test
		X ±SD	X ±SD	X ±SD
WBC ($10^3/\mu l$)	1	5,52 ±1,18	9,51 ±2,20	6,05 ±2,05
	2	5,12 ±0,78	9,15 ±1,19	4,98 ±0,68
	3	6,11 ±1,79	10,68 ±2,48	5,63 ±1,06
	4	5,80 ±0,74	9,51 ±1,74	5,65 ±0,81

Neutrofiles (10^3/µl)	1	2,80 ±0,85	3,99 ±1,15	4,07 ±2,09
	2	2,40 ±0,38	3,51 ±0,50	3,24 ±0,59
	3	3,21 ±1,40	4,48 ±1,62	3,69 ±0,83
	4	3,00 ±0,62	4,00 ±0,86	3,58 ±0,74

Table 4. The concentration of cortisol before and after exercise after 1 hour rest in subsequent studies.

Marker	Test/ effort	Before test	After test	After 1 h test
		X ±SD	X ±SD	X ±SD
Cortisol (µg/dl)	1	19,62 ±5,54	22,46 ±6,56	21,78 ±5,12
	2	19,46 ±3,55	24,32 ±5,70	23,34 ±5,09
	3	21,04 ±4,69	25,43 ±7,13	24,58 ±5,32
	4	17,49 ±3,51	22,58 ±5,54	20,15 ±4,56

The number of white blood cells after exercise and after one hour of rest was significantly higher than the initial measurement. The highest values were achieved after the effort. In the first study were came to 9,51 ±2,20, the second 9,15 ±1,19, third 10,68 ±2,48 and fourth 9,51 ±1.74. After the rest the results significantly decreased. In the first study to 6,05 ±2.05, the second 4,98 ±0,68, the third 5,63 ±1, and fourth 5,65 ±0,81. In the first study (introduction period) the third measurement (6,05 ±2.05) was significantly higher than at rest (5,52 ±1.18). In the three other tests white blood cell counts after one hour of rest lowered below the level of the output. The values before exercise and after exercise were the lowest during the preparatory period (5.12 ±0.78 and 9.15 ±1.19) and the highest during the direct preparation of starting- DPS (third test 6.11 ±1,79 and 10,68 ±2,48). After an hour of rest observed in the introducing macrocycle a smaller decrease in white blood cells (from 9.51 ±2.20 to 6.05 ±2.05) than the same interval in the DPS (down from 10.68 ±2.48 to 5.63 ±1.06). In the third study, there was the biggest difference in the response effort. The number of white blood cells increased from 6.11 ±1.79 to 10.68 ±2.48.

In response to physical effort neutrophils significantly increased in the first test 2.80 ±0.85 to 3.99 ±1.15, in the second of 2.40 ±0.38 to 3.51 ±0.50, in the third from 3.21 ±1.40 to 4.48 ±1.62 in the fourth with 3.00 ±0.62 to 4.00 ±0.86. The number in rest is the lowest and substantially increases in response to a single maximum effort. Then lowered to a value above the baseline. The exception was the first study, which showed an increase in the number of neutrophils in the measurement after one hour of rest (4.07 ±2.09) compared to the rest (2.80 ±0.85) and after exercise (3.99 ±1.15).

In preparatory mezocycles there was reduction in the number of neutrophils in the measurement of resting after exercise and after one hour of rest. The highest values of the number of neutrophils in the rest (3.21 ±1.40) and after exercise (4.48 ±1.62) was recorded during the DPS. The lowest values were recorded during the preparatory period. After an hour of restitution of the highest values recorded in the first study (4.07 ± 2.09) and the lowest in the second (3.24 ±0.59).

Concentrations of cortisol in response to a single physical exertion increases from 19.62 ±5.54 to 22.46 ±6.56 in the introductory period, from 19.46 ±3.55 to 24.32 ±5.70 during the preparatory period, from 21.04 ±4.69 to 25.43 ±7.13 in the third study, and 17.49 ±3.51 to 22.58 ±5.54 in the fourth. After rest values were slightly lower in comparison to exercise-induced concentration (21.78 ±5.12 in the first study, 23.34 ±5.09 in the second, 24.58 ±5.32 in the third and 20.15 ±4,56 in the fourth).

The lowest concentration of cortisol in response to a single intensive effort was recorded in the first study (22.46 ±6.56). In response to the physical parameters of the initial training in the mezocycle are significantly reduced with the value of 19.62 ±5.54 in the first study to 17.49 ±3.51. The nature of this response between the stages is variable. After the introductory period they decrease from 19.62 ±5.54 to 19.46 ±3.55 in preparation mezocycle.

During the DPS followed their significant and the largest increase to 21.04 ±4.69. In the main starts falling to the lowest value in the macrocycle (17.49 ±3.51). The concentration of strain characterized by a different answer. It grows gradually from the first study to a third study to 22.46 ±6.56 to 24.32 ±5.70 in the second trial and 25.43 ±7.13 in the third. After this time, there was a significant decrease in response and during the major races (fourth survey) concentration amounted to 22.58 ±5.54. Like nature of the replies were registered in the values of the hours of rest. Successively increasing concentration from 21.78 ±5.12 to 23.34 ±5.09 and 24.58 ±5.32 and in a recent study significantly reduced to 20.15 ±4.56.

5. DISCUSSION

The physical effort causes changes in circulating blood leukocytes (mainly lymphocytes and neutrophils). It was followed by concentration of neutrophils in the blood rises and is maintained for several hours after training. According to Król et al [8] lymphocyte levels during exercise increases and then decreases from two to six hours after exercise fall even below the baseline. Similar results were obtained in these studies. This could confirms the activation of the immune system in response to a single exercise.

The magnitude of these changes is determined by the intensity and duration of exercise. This effect is particularly pronounced during exercise endurance with duration longer than 1.5 hours and the intensity of 55-75% VO_2 max. Exercise tests to refuse also induce similar changes [9].

The highest concentration of cortisol and white blood cell counts were observed in the period of direct preparation of starting. The lowest values were recorded during the major races. This indicates a reduced quality of the immune response during the period starts after the main load submaximal and maximal (DPS) as well as in Meggs and contributors research in group of swimmers [10].

According to Gleeson, changes in the amount of circulating leukocytes return to the base from 3 to 24 hours after the workout [9]. However, endurance exercise may temporarily affect the immune function of the body. In this studies after one hours of rest they were below baseline levels. The results of this test also indicate that the basic immune function in athletes do not differ significantly from untrained people. The same results are presented in their study Gleeson et al. [11].

In the introductory period the number of white blood cells and neutrophils after exercise was significantly higher than the number in subsequent studies. This may indicate that a significant effect of adaptation to physical effort and the quality of post-exercise immune response. This was indicated by the survey to other athletes [12]. At the same time was observed decrease in white blood cells and slightly elevated levels of neutrophils after an hour of restitution. This is confirmed by the appearance of the response to exercise an open window, immune function and inhibition of immune (from 3 to 72 h). Intensification of exercise can lead to impaired immune response [19,20].

It is important protection the factors which may support the resistance and post-exercise recovery after exercise and after one hour of rest (supply of nutrients, proper clothing, unexposed negative environmental factors).

In response to a single maximum effort was observed increased cortisol level. This has implications for post-workout recovery. During endurance exercise, the lowest value of cortisol are recorded at an intensity of 50% VO_2 max, and the highest in the area of the lintel and the maximum [14,18]. The values measured after 1h restitution are significantly higher than registered immediately after exercise [14]. In this situation is reduced lymphocyte reaction on antigen. The physical effort and a high intensity under severe fatigue causes a weakness or the immune responses [15]. High values of cortisol in the study were registered in the current context of poorer immune response. This confirms earlier results of Jones and co-author of the athletes.

Endurance training determined a decrease of the output levels of cortisol during the major races. Intensive effort causes the biggest changes in the initial period. The difference in the output level and the post-exercise and restitution after an hour in a recent study was higher than in the first study. A single maximum effort during the major races despite lower baseline levels of the marker causes a larger change of strain. This points to a relationship between response to the intensification of a single maximum effort, reduced immune response and increased exercise capacity [13]. Endurance training can also lead to a reduction in baseline levels of the hormone [2]. This does not change the nature of the response effort, and after an hour of restitution during the major races. The nature of this response can be variable between individuals [16].

The increase in cortisol may increase both postprandial apoptosis of white blood cells and an increase in the number of neutrophiles. The nature of these changes depends both on the single maximum effort and on the training period [17]. These changes affect the immune response and the degree of regeneration of cyclists in the macrocycle [2].

6. CONCLUSIONS

In response to physical effort increases cortisol levels and the number of white blood cells and neutrophiles. The output level of these markers did not differ from their level in untrained persons. Their induces changes in physical activity and the resulting disruption of homeostasis, including inflammation.

The results show a significant effect of adaptation to exercise. Endurance training will also reduce the baseline levels of cortisol during the major races. The impact on this can be of earlier conducted intensive training loads and adapt to them. It does not change at the same time the nature of the response effort and after an hour of restitution during the major races. The increase in cortisol may increase postprandial apoptosis of white blood cells and increase the number of neutrophils. The nature of these changes depends on single maximum effort. These changes affect the immune response and the quality of post-workout recovery of cyclists in the macrocycle.

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