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Changes in biochemical and functional parameters for men during exercise

Abstract: Benefits of physical activity are undeniable. The aim of the present research was to determine the effects of physical activity and age on cholesterol and glucose levels in the blood, as well as changes in the functional parameters of the cardiovascular system, during stepwise increases in physical load for men employed in the same place, but with different levels of physical activity. The subjects were 95 military officers who were divided into groups according to the level of physical activity of their occupation, with veloergometry used as physical load. Cholesterol and glucose levels in the blood were taken as biochemical indices. The results showed that occupational physical activity had a positive effect on biochemical and cardiovascular functional parameters before, during, and after the physical load. Only the cardiovascular rate (systolic blood pressure) in older subjects was significantly higher than that of the younger persons; for all other parameters, age had no effect at all.

Keywords: Cardiovascular system, physical activity, biochemical tests, heart rate, heart rate recovery, arterial blood pressure

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Key points:

1. Professional activities may influence personal physical activity.
- Higher levels of physical activity, rather than younger age, positively affected cholesterol and blood glucose levels.
- Professional activity requiring more physical effort resulted in lower variability of the cardiovascular functional indices during stepwise increases in physical load.

1 Introduction

Benefits of physical activity in old age are undeniable. However, it is equally important to maintain recommended levels of physical activity during the working years. Occupation has a huge impact on physical activity. Technical development requires increasingly less physically demanding work. Therefore, people become physically passive, resulting in an overall decline in physical activity. This decline is already causing deterioration of biochemical and cardiovascular functional indices in men. Men aged 45-55 years suffer from cardiovascular diseases more often than women of the same age [1].

To assess the cardiovascular response to exercise, common functional indicators are maximal oxygen consumption, heart rate, cardiac output and stroke volume, and arterial blood pressure [2]. With physical loads, heart rates of athletes do not increase suddenly [3]. With slower contractions, diastole (cardiac relaxation) is longer, resulting in an improved resting heart rate [4]. After a physical load, heart rates of athletes return to baseline faster [3].

During physical loads, arterial blood pressure insignificantly differs between athletes and non-athletes; it may be only slightly lower for endurance athletes. During exercise, systolic blood pressure rises to 200-240 mm Hg, and diastolic blood pressure falls. The changes depend on the amount of physical load and personal athletic fitness. Arterial blood pressure in athletes increases more slowly [3]. Blood pressure returns to normal after low physical loads within 3-5 min.; after high and long-lasting loads, it recovers more slowly. Human capacity for physical labor is determined according to cardiovascular response to physical load [4]. Blood pressure in athletes recovers faster after a physical load [3].

The research aim was to determine the effects of physical activity and age on cholesterol and glucose levels in the blood, as well as changes in the functional parameters of the cardiovascular system, during stepwise increases in physical load for men employed in the same place, but with different levels of physical activity.

2 Materials and methods

2.1 Subjects

The study enrolled 95 military officers. Their mean age (standard deviation) was 36.9 (6.8) years (the youngest was 22.0 years old and the oldest – 51.0 years old); the median of age (years) – 37.0). On the basis of the age distribution median, we distinguished two sample groups: (1) <37 years – 48.4 per cent (n = 46), and (2) ≥ 37 years – 51.6 per cent (n = 49).

According to their physical activity, the subjects were divided into the following groups:

Group 1 – exercising less than 30 minutes per day and not exercising at work;

Group 2 – exercising more than 30 minutes daily, engaging in sports at work 2-3 times / week and meeting? physical standards 1-2 times / year;

Group 3 – exercising more than 30 minutes daily, engaging in sports at work 2-3 times / week, meeting physical standards 1-2 times / year and engaging in sports after work.

All research participants were non-smokers. Two hours before the study, they were asked not to eat and not to engage in vigorous physical activity.

2.2 Baseline testing

To establish the health status of the subjects, biochemical blood tests were carried out, the blood glucose and cholesterol levels were established, an electrocardiogram (ECG) was recorded and evaluated, the heart rate was calculated and the resting blood pressure was measured.

Before testing, the subjects had not eaten for at least several hours, they had not consumed alcohol or any medication, and they had rested well. The subjects performed a veloergometry test; they were given accurately dosed standardized physical loads to determine their physical fitness and evaluate the functioning of their cardiovascular system. The subjects performed the veloergometry test with a physical load that increased stepwise every 2 min., i.e., they started exercising with a 50 W load at the frequency of 60 rpm, and the workload increased at each step by 50 W. The load was increased up to sub-maximal heart rate or the appearance of clinical signs. During the entire study, the subjects' health condition was monitored, their heart rate was observed and cardiac activity was followed on the monitor; at the end of each stage, arterial blood pressure was measured, and an ECG was recorded. After the physical load, the subjects rested. During their rest (6-10 min) and during their use of a veloergometer, changes in the cardiovascular functional parameters were recorded every 2 minutes (blood pressure and heart rate were measured), and the general condition of the subjects was observed (Figure 1).

2.3 Statistical analysis

Research data were processed with SPSS 17.0 statistics software. In all cases, the arithmetic means and standard deviations were calculated. Significant difference between the compared values was considered at $p < 0.05$. Chi-square ($\chi 2$) test was used to verify statistical hypotheses.

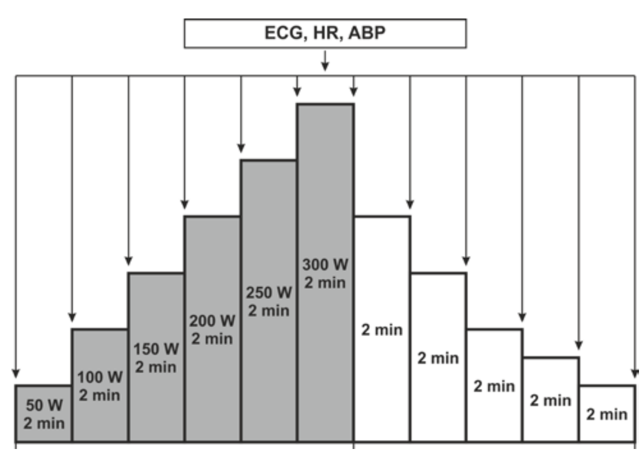

Figure 1: Protocol scheme of recording cardiovascular functional indices

Note: ECG – electrocardiogram, HR – heart rate, ABP–arterial blood pressure

The relationships between the variables were evaluated to determine the correlation coefficients (r). For comparison of group means, we applied Student's *t* test, and for more than two groups, ANOVA analysis of variance (Fisher's exact test) and Fisher's LSD multiple comparison (post-hoc) test were used.

Informed consent: Informed consent has been obtained from all individuals included in this study.

Ethical approval: The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance with the tenets of the Helsinki Declaration.

3 Results

Effect of subjects' physical activity on their cholesterol and blood glucose levels. We found that significantly more (p <0.05) subjects in group 1 had increased cholesterol and blood glucose levels (Table 1) compared to subjects in groups 2 and 3.

Effect of subjects' age on their cholesterol and blood glucose levels. Spearman's correlation analysis did not reveal significant links between age and cholesterol level (r = 0.2, p = 0.1) or blood glucose level (r = -0.01, p = 0.9). The same tendency was confirmed by Pearson's correlation analysis for quantitative expressions of these variables. Insignificant correlations between the age and cholesterol (r = -0.2, p = 0.1) and the age and glucose level (r = 0.09, p = 0.4) were found in the total test sample and between all groups of subjects.

Effect of subjects' physical activity on the changes in their functional parameters of the cardiovascular system. Heart rate arithmetic mean (standard deviation) of subjects during the load (Table 2) was 82.5 (13.6) times / min before the study. During the load, the first measurement (50 W) showed 101.4 (13.9) times / min, and the fifth measurement (250 W) for the remaining 12 subjects–151.3 (12.5) times / min.

The research data (Table 2) showed that 150 W physical load (6 min) was completed by 93.7 per cent of subjects; the percentage prevalence of persons in group 1 was significantly lower than that of persons in groups 2 and 3. Physical load of 200 W (8 min) was completed by 55.8 per cent of subjects; only 8 per cent were in group 1, and that was significantly less than in groups 2 and 3. The load of 250 W (10 min) was not completed by all subjects in group 1; significantly more subjects in group 3 completed this load compared to group 2. Only subjects in group 3 completed the 300 W physical load (12 min).

Research results showed that the heart rate of persons in group 1 changed faster than that of persons in groups 2 and 3 and reached the submaximal rate faster.

Averages of systolic blood pressure significantly differed in groups only after the fourth measurement (8 min) during the recovery: systolic blood pressure of persons in group 1 was significantly higher than that of subjects in groups 2 and 3 (Table 3).

Blood pressure of persons in group 1 significantly differed before the study, during the load (measurement 2) and during the recovery (measurement 4), compared to the values in other groups (Table 4).

Analyses of age effect on the changes in cardiovascular functional parameters during physical load. Comparison of the mean differences in measurement of individual heart rate, systolic blood pressure and diastolic blood pressure during exercise (between measurements 2-1, 3-2, 4-3, i.e., the observed changes from one measurement to another) according to age groups are reported

Table 1: Comparison of subjects' cholesterol and blood glucose levels according to their physical activity

Parameter		Physical activity groups Group 1 (n=25)	Group 2 (n=54)	Group 3 (n=16)	
Cholesterol levels in blood, mmol / l	>5.2	80.0*	64.8	50.0*	*p=0.049
Glucose levels in blood, mmol / l	>5.5	68.0*	57.4	31.3*	*p=0.03

Note: * χ^2- chi-square test of independence.

Table 2: Heart rate of subjects before the study and its changes during the physical load and recovery taking into account physical activity groups

Heart rate	Physical activity groups Total (n=95)	Group 1 (n=25)	Group 2 (n=54)	Group 3 (n=16)	
	Mean (SD)/n/per cent (times /min)				
Before the study					
Measurement	82.5(13.6)/95	91.8(13.5)/25*,**	80.5(10.6)/54*	74.9(15.9)/16**	F=10.5; df=2; p<0.001;
	100	**100**	**100**	**100**	*,**p<0.001
During the load					
Measurement 1	101.4(13.9)/95	101.4(13.4)/25*,**	98.5(11.1)/54*	93.6(14.9)/16**	F=12.6; df=2; p<0.001;
(50W)	**100**	**100**	**100**	**100**	*,**p<0.001
Measurement 2	120.2(14.4)/95	132.8(12.5)/25*,**	117.6(10.9)/54*,***	109.3(14.5)/16**,***	F=21,5; df=2;
(100W)	**100**	**100**	**100**	**100**	p<0.001; *,**p<0.001; ***p=0.02
Measurement 3	138.3(12.6)/89	147.0(7.3)/19*,**	137.7(11.6)/54*,***	130.1(15.0)/16**,***	F=9.5; df=2;
(150W)	**93.7**	**76**	**100**	**100**	p<0.001; *,**p<0.01; ***p=0,02
Measurement 4	148.2(10.4)/53	152.2(0.7)/2	149.8(8.6)/38	142.5(14.0)/13	F=2.7; df=2; p=0.07
(200W)	**55.8**	**8**	**70.4**	**81.3**	
Measurement 5	151.3(12.5)/12		155.5(5.1)/6	147.2(16.7)/6	p=0.3
(250W)	**12.6**		**11.1**	**37.5**	
Measurement 6	164/1			164/1	
(300W)	**1.1**			**6.3**	
During recovery					
Measurement 3	87.6(8.5)/24	90.8(7.9)/4	90.1(6.2)/15*	77.8(9.2)/5*	F=6.0; df=2; p<0.01;
(6 min)	**25.3**	**16**	**27.8**	**31.3**	*p=0.03
Measurement 4	90.4(12.2)/48	96.8(10.5)/13	89.1(11.3)/28	84.0(14.7)/7	F=3.2; df =2; p=0.05;
(8 min)	**50.5**	**52**	**51.9**	**43.8**	
Measurement 5	99.0(13.8)/23	110.1(8.0)/8*,**	92.6(9.8)/11*	94.5(20.5)/4**	F=5.7; df =2; p=0.01;
(10 min)	**24.2**	**32**	**20.4**	**25**	*,**p<0.04

Note: The p value was established on the basis of parametric ANOVA analysis. In order to determine which averages differed statistically significantly from each other, we used Fisher's LSD Multiple Comparison post-hoc test.

in Table 5. Between measurements 2 and 1 as well as 4 and 3, the change in systolic blood pressure was significantly higher in the group of older subjects. There were no significant differences in the mean heart rate and diastolic blood pressure values between the individual measurements. The mean differences of systolic blood pressure during measurements 3 and 2 (r = 0.2, p = 0.04) and 4 and 3 during the load (r = 0.3, p = 0.03), as well as diastolic blood pressure during measurements 4 and 3 (r

Table 3: Systolic blood pressure in subjects before the study and its changes during physical load and recovery time taking into account physical activity groups

Systolic blood pressure	Physical activity groups				
	Total (n=95)	Group 1 (n=25)	Group 2 (n=54)	Group 3 (n=16)	
	Mean (SD)/n/per cent (mmHg)				
Before the study					
Measurement	134.5(11.1)/95	137.0(8.7)/25	133.4(11.6)/54	134.0(12.9)/16	F=0.9; df =2; p=0.4
	100	**100**	**100**	**100**	
During the load					
Measurement 1	146.2(13.2)/95	149.2(11.0|)/25	144.9(13.1)/54	145.9(16.6)/16	F=0.9; df =2; p=0.9
(50W)	**100**	**100**	**100**	**100**	
Measurement 2	163.8(15.5)/95	168.6(13.1)/25	161.6(14.5)	163.8(20.7)	F=1.8; df =2; p=0.2
(100W)	**100**	**100**	**100**	**100**	
Measurement 3	184.5(18.7)/89	191.7(14.4)/19	181.5(17.5)/54	186.3(24.8)/16	F=2.2; df =2; p=0.1
(150W)	**93.7**	**76**	**100**	**100**	
Measurement 4	198.2(19.4)/54	211.0(32.5)/2	196.3(16.6)/39	201.9(23.4)/13	F=0.9 df =2; p=0.4
(200W)	**55.8**	**8**	**70.4**	**81.3**	
Measurement 5	206.4(17.3)/12		209.5(11.6)/6	203.0(22.4)/6	p=0.5
(250W)	**12.6**		**11.1**	**37.5**	
Measurement 6	239/1			239/1	
(300W)	**1.1**			**6.3**	
During recovery					
Measurement 3	125.3(7.7)/24	124.0(8.2)/4	124.8(5.6)/15	128.0(12.9)/5	F=0.4; df =2; p=0.7
(6 min)	**25.3**	**16**	**27.8**	**31.3**	
Measurement 4	131.4(6.7)/48	135.8(5.0)/13*,**	130.2(6.8)/28*	128.4(5.9)/7**	F=4.5; df =2; p=0.02;
(8 min)	**50.5**	**52**	**51.9**	**43.8**	*,**p<0.02
Measurement 5	137.2(8.3)/23	135.4(5.3)/8	140.0(10.1)/11	133.3(6.7)/4	F=1.3; df =2; p=0.3
(10 min)	**24.2**	**32**	**20.4**	**25**	

Note: The p value was established on the basis of parametric ANOVA analysis. In order to determine which averages differed significantly from each other, we used Fisher's LSD Multiple Comparison post-hoc test.

= 0.3, p = 0.04), significantly correlated with the subjects' age (Figure 2).

4 Discussion

Our study involved three groups of subjects: the level of physical activity in the first group was low, medium in the second, and high in the third. In the cohort study by E. Clays et al., [5] the authors found that recreational physical activity should be coordinated within the framework of professional activity. Still other researchers have found that men with highly physically demanding jobs who also engaged in physical activity (PA) during leisure time had a four times increased incidence of coronary events [5].

Our results showed that among patients with low PA, the number of subjects with increased cholesterol and blood glucose levels was significantly higher compared to those in the high PA group. It is known that aerobic exercise reduces the risk of cardiovascular diseases by increasing the levels of high-density lipids (HDL) in the blood [6]; hence, it improves the lipid

Table 4: Diastolic blood pressure in subjects before the study and its changes during physical load and recovery time taking into account physical activity groups

Diastolic blood pressure	Physical activity groups Total (n=95)	 Group 1 (n=25)	 Group 2 (n=54)	 Group 3 (n=16)	
	Mean (SD)/n/per cent (mmHg)				
Before the study					
Measurement	84.3(10.3)/95	89.2(10.9)/25*,**	82.9(8.2)/54*	81.2(13.1)/16**	F=4.3 df=2; p=0.02
	100	**100**	**100**	**100**	*,**p<0.02
During the load					
Measurement 1	89.3(10.8)/95	92.9(11.1)/25	88.2(9.6)/54	87.6(13.3)/16	F=2.0; df =2; p=0.1
(50W)	**100**	**100**	**100**	**100**	
Measurement 2	93.6(10.6)/95	97.8(10.6)/25*,**	92.3(9.8)/54*	90.9(11.9)/16**	F=2.9; df =2; p=0.055
(100W)	**100**	**100**	**100**	**100**	*,**p<0.05
Measurement 3	97.5(11.2)/89	103.2(12.5)/19	95.6(9.8)/54	97.6(12.2)/16	F=2.2; df =2; p=0.1
(150W)	**93.7**	**76**	**100**	**100**	
Measurement 4	99.3(10.3)/54	110.0(0)/2	98.1(9.1)/39	101.2(13.2)/13	F=1.9 df =2; p=0.2
(200W)	**55.8**	**8**	**70.4**	**81.3**	
Measurement 5	96.4(11.1)/12		98.3(5.7)/6	94.5(15.1)/6	p=0.6
(250W)	**12.6**		**11.1**	**37.5**	
Measurement 6	95/1			95/1	
(300W)	**1.1**			**6.3**	
During recovery					
Measurement 3	75.3(8.3)/24	72.0(9.5)/4	76.9(5.7)/15	73.20(13.7)/5	F=0.4; df =2; p=0.7
(6 min)	**25.3**	**16**	**27.8**	**31.3**	
Measurement 4	82.7(7.9)/48	86.9(6.9)/13*,**	81.7(6.9)/28*	78.7(11.0)/7**	F=3.2; df =2; p=0.05
(8 min)	**50.5**	**52**	**51.9**	**43.8**	*,**p<0,02
Measurement 5	88.7(10.8)/23	94.4(9.8)/8*	87.8(10.2)/11	79.8(9.3)/4*	F=3.0; df =2; p=0.07
(10 min)	**24.2**	**32**	**20.4**	**25**	*p<0.03

Note: The p value was established on the basis of parametric ANOVA analysis. In order to determine which averages differed significantly from each other, we used Fisher's LSD Multiple Comparison post-hoc test.

profile [7]. Multifold moderate-intensity running exercise regulates triacylglycerol metabolism. A number of studies have shown that passive lifestyle and low physical fitness levels are associated with high cholesterol levels, obesity and type II diabetes [8]. Physical activity improves glucose tolerance and insulin sensitivity [8]. Unfortunately, statistical analysis showed no differences in biochemical indices of subjects with low and moderate physical activity levels, but in the second group of subjects both cholesterol and mean blood glucose levels were lower than those of physically inactive persons. These findings may be explained by the fact that blood glucose levels begin to rise gradually after 30 years of age. For men, the total amount of cholesterol increases, and in the 6th decade it stabilizes [9]. Our analysis of the age, cholesterol and blood glucose

Table 5: Distribution of differences of the subjects' heart rate, systolic and diastolic blood pressure during physical load according to age groups

Difference between the measurements	Age, years <37	≥37	p value
Heart rate, mean (SD)/n, times/min			
2-1	19.5(7.4)/46	18.8(8.1)/49	0.7
3-2	19.7(6.0)/41	20.1(6.2)/48	0.7
4-3	16.3(4.7)/25	15.6(7.2)/28	0.7
Systolic blood pressure, mean (SD), mmHg			
2-1	15.8(6.2)/46	19.2(9.3)/49	0.04
3-2	20.2(7.6)/41	21.7(8.5)/48	0.4
4-3	13.7(5.1)/26	18.8(9.4)/28	0.02
Diastolic blood pressure, mean (SD), mmHg			
2-1	4.1(5.3)/46	4.3(6.6)/49	0.9
3-2	3.7(7.6)/41	4.6(5.0)/48	0.5
4-3	1.0(4.0)/26	2.5(4.1)/28	0.2

Note: The p value was established according to Student's *t* test.

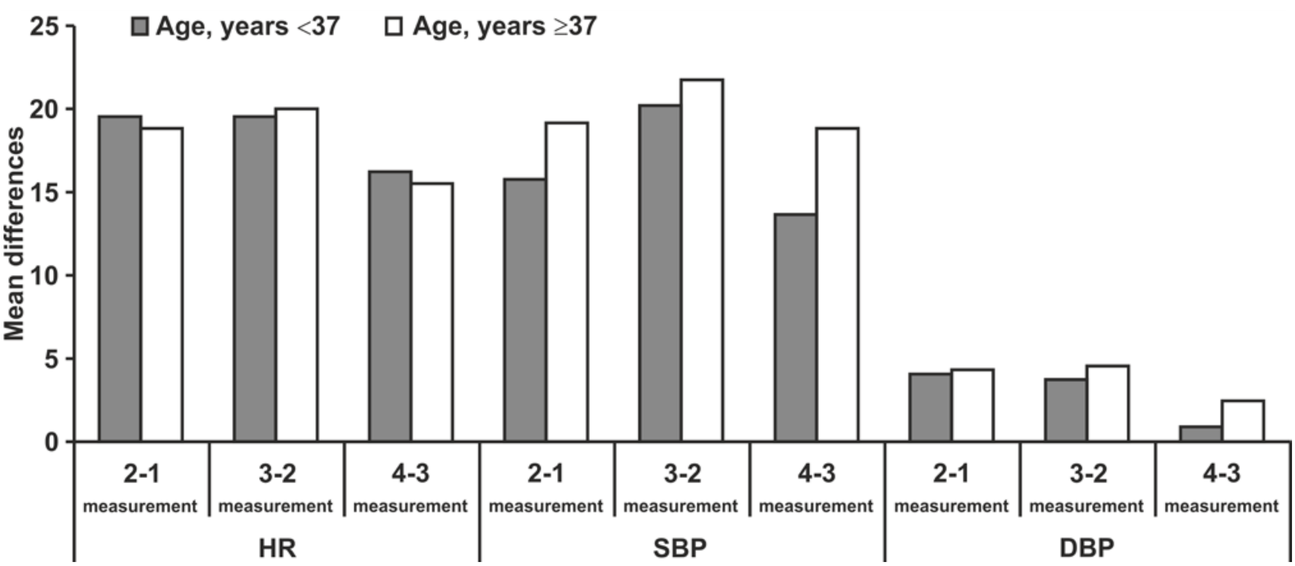

Figure 2: Distribution of mean differences of the subjects' heart rate, systolic and diastolic blood pressure during physical load according to age groups (times/min; mmHg)

levels did not yield any significant links. However, our results suggest that physical activity helps to maintain lower cholesterol and glucose levels in the blood, which reduces the chances of cardiovascular diseases in later life.

Our survey results show that during the stepwise graded exercise test, people with improved functional capacity demonstrated less variation in cardiovascular functional parameters in the exercise and recovery sequence. For subjects with low PA, heart rate and blood pressure prior to and during the load were significantly higher; these values increased much more quickly, and subjects reached the submaximal heart rate earlier. The experimental findings suggest that regular moderate physical activity effectively reduces blood pressure in individuals with normal and increased blood pressure [10, 11]. Endurance exercise improves both autonomic heart rate control under the condition of rest and autonomous heart rate response [3]. Due to the effect of endurance on physical loads, adaptation of the cardiovascular system depends not only on exercise intensity, frequency and duration [12], but also on the individual's age, gender, and genetics, as well as type of exercise performed [13]. The normal human aging process is associated with the variability of the parameters and the spectrum of power decrease [14]. This study shows that systolic blood pressure change was significantly higher in the older group, but there were no significant differences in the mean heart rate and diastolic blood pressure during the individual measurements. Thus, high levels of physical activity at work as regular endurance exercise [3] increase cardiovascular capacity, regardless of age.

5 Conclusions

in summary, we suggest that physical activity, more than age, resulted in the positive biochemical test results, but these changes were effected only by a high level of physical activity at work. The differences in physical activity levels in professional activities did not have a statistically significant effect on the subjects' cholesterol and blood glucose levels. However, professional activity that requires more physical effort resulted in lower variability of the cardiovascular functional indices during stepwise increases in physical load. It is, therefore, very important, when an occupation is sedentary. to maintain the physical activity levels beneficial for health in other areas (leisure, mobility, housework).

The results show that the changes in the cardiovascular functional indices before, during and after exercise can be uninformative, if the subjects are not grouped according to external and internal factors.

Conflict of interest: The authors state that they have no conflicts of interest.

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