Adaptive responses of myofibrillar disruption symptoms to high intensity interval aerobic training in soccer players

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Abstract: The purpose of this study was to examine the effects of high intensity aerobic interval training on muscle damage markers after exhaustive maximal exercise. Twelve soccer players performed soccer special training for 4 weeks. Before that they participated in one session exhaustive exercise in pre and post soccer special training. Blood collection was conducted in rest and exhaustion time for CPK and LDH serum level measurement. Our results showed all indicators of muscle damage changed significantly ($P<0.05$) after both bouts. Based on that, significant differences between rest times and exhaustion times were evident for CPK and LDH serum level after both exhaustive exercises. Compared to the first bout, CPK and LDH levels resulted in significantly ($P<0.05$) smaller changes after the second exercise bout in post high intensity aerobic interval training. The decline in CPK level from pre and post exhaustive exercise (rest and exhaustion time) value between bout 1 and 2 were 31% and 30%, respectively ($P<0.05$). These values for LDH level were 12% and 23%, respectively ($P<0.05$). These results suggest that 4 weeks of high intensity aerobic interval training caused significant decrease in muscle damage markers in rest and exhaustion time in soccer players.

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Introduction

During a soccer match, among various factors, physiological, technical, and tactical skills are important for optimal performance (1). Given the soccer characteristic during a soccer match (90-minute), this game has been classified as a high intensity and intermittent sport (2)and many players ordinarily run a distance between 10-12 kilometers in an intensity near to anaerobic threshold (80-90% of maximum heart rate or 70-80% of maximal oxygen consumption (VO_{2max}))(3).

When the exercise is performed in high intensity and for long time, oxygen deficiency could cause organic abnormalities or ischemia. It has proved that high intensity exercise will increase free radicals and simultaneously reduce antioxidant activities, by which inflammation and muscular damage will occur. In addition, high intensity exercises such as exhaustive exercises caused oxidative stress by which muscular damages increase free radicals. It is reported that there is a direct relationship between rate of muscular damage and high intensity exercises, that is, the higher activity, the higher muscular damages. It has been proved that plasma creatine phosphokinase (CPK) and plasma lactate dehydrogenase (LDH) levels are related to muscular and cartilage damages and inflammation (4).

CPK in plasma could be known as non-natural stress syndrome in muscles (4). Plasma CPK is a marker signifying muscle injury arising from myofibrillar disruption (14). Untrained athletes immediately after high intensity activities, have higher blood CPK level than trained athletes. Although authors reported that CPK and LDH are indirect indicators of muscular damages, they could be used to determine rate of effect of a training program(4).

Accordingly, one session of exhaustive exercise after a period, is a very suitable sample to measure effect of training on myofibrillar disruption symptoms in serum. As declared, increase of intra muscular LDH or CPK levels in the blood circulation was as a increase in fiber damage, oxygen deficiency and/or mechanical damage. It is proved that trained athletes showed less increase in the serum levels of these enzymes after exhaustive exercise (5). Therefore, the purpose of this study was to investigate the effects of high intensity aerobic interval training on muscle damage markers and myofibrillar disruption in soccer players.

Methods

Subjects

Twelve male soccer players from third Iranian divisions after being informed about the aims, experimental protocol, procedures and after

delivering writing consents participated in this study. At the time of the study, the players were in the preparation period of the season and performed 3-4 training sessions per week. Their mean (±SD) age, height, weight and percent body fat were 21.88±2.24 years, 174.22±5.33 cm, 67.77±5.7 kg, and 12.38±3.29 percent, respectively.

Experimental procedures

All subjects were recommended to get enough sleep the day before the measurement, and the objective and plan of the study were also presented. In addition, general adaptation training for the test equipment was implemented. The subject's VO_{2max} was assessed by a graded exercise test on treadmill (HP Cosmos Mercury Med 4.0) using standard Bruce protocol (Bruce et al., 1973 (6)) in the morning. The test ended when the subjects were limited by volitional exhaustion and clinical symptoms. At the exhaustion point, all subjects had to meet at least two of the following criteria: 1- a final respiratory exchange ratio (RER) > 1.0, 2- O2 consumption increased by < 2 $ml \cdot kg^{-1}$ with an increase in exercise intensity, 3- attainment of >85% of age-predicted maximal heart rate (7).

Blood collection (10 cc) was conducted from the ante brachial vein under stable conditions using a syringe. Further, blood collection was carried out four times: before and after exhaustive exercise in pre and post high intensity aerobic interval training. The collected blood was stored in blood plasma tubes treated with the anti-coagulant EDTA and centrifuged at 2500 rpm for 15 minutes. Tubes were stored at -80℃ until measurement. On the following days, players performed high intensity aerobic interval training sessions (figure1).

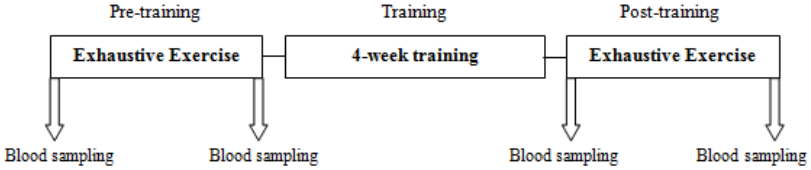

Figure1. Experimental design

Training Intervention (Hoff training)

The aerobic training intervention consisted of interval training, comprising four bouts of 4 min work periods dribbling a soccer ball around a specially designed track(8)(figure 2) on soccer field. Training cones used in the dribbling circuit were 0.3 m high and 0.15 m wide. Hurdle height was set at 0.5 m. Working intensity was at 90–95% of each player's maximum heart beat, with work periods separated by 3 min of jogging at 70% of HR max. All players wore a Polar Team System heart rate belt and monitor (Polar Electro) throughout the interval training. The interval training was performed three times a week at the end of the soccer training session, on the same days and time of day throughout the intervention period. No emphasis was placed on improving strength, sprinting, or jumping

performance throughout the intervention period. The 4-week intervention period was carried out directly after the off-season intermission period, encompassing the 4-week preseason preparation period.

Statistical Analysis

For data processing, the SPSS 18.0 program was used to calculate the average and standard deviation for each variable. One-way repeated measurement ANOVA and Paired Student's t-test applied to verify the differences in the pre-Hoff protocol and post-Hoff protocol. The post-hoc test for the groups was implemented using a least significant difference (LSD) method. Further, the significance level for verification of the hypothesis was set at $p<0.05$

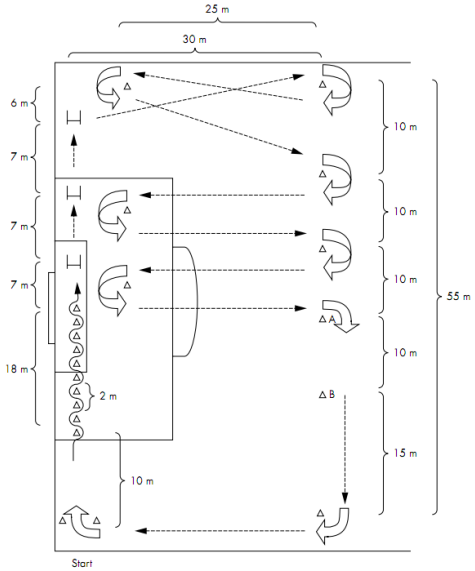

Figure2. Soccer specific dribbling track used for high intensity interval training sessions. Players dribble a soccer ball around the track, lift the soccer ball over the hurdles, and jump over the hurdles. Players dribble backwards with the soccer ball between points A and B.

Results

Changes in aerobic power

The 4 weeks aerobic training intervention manifested significant improvements in $Vo_{2max}$of 5.5% ($p<0.05$) (table 1). The mean Vo_{2max} increased from 49.14±4.65 to 51.87±5.13 $ml.kg^{-1}.min^{-1}$. Mean body mass was unchanged after the intervention period.

Table1. Changes in VO_{2max} in soccer players.

Variable	pre-Hoff training	post-Hoff training	p value
VO_{2max} ($ml.kg^{-1}.min^{-1}$)	49.14 ± 4.65	51.87 ± 5.13	0.01*

Changes in CPK

Table 2 represents the results of the ANOVA. As shown in Table2, the values of plasma CPK in soccer players increased immediately after exhaustion. The values in pre and post exhaustion time decreased after the 4-week training (figure3).

Table2. Changes in plasma CPK in soccer players.

	pre-Hoff training		post-Hoff training	
CPK (IU/l)	pre-exhaustion	post-exhaustion	pre-exhaustion	post-exhaustion
	193.66±121.57	234.33±136.44*	132.5±56.05**	163.58±62.28*,**

* Significant difference between pre and post exhaustion. ** Significant difference between pre and post Hoff training.

Changes in LDH

As shown in Table 3, the values of plasma LDH increased after exhaustion but decreased after 4-week training in players (figure4).

Table3. Changes in plasma LDH in soccer players.

	pre-Hoff training		post-Hoff training	
LDH (IU/l)	pre-exhaustion	post-exhaustion	pre-exhaustion	post-exhaustion
	164.16±27.83	220.16±52.5*	144.16±24.01**	168.33±25.39*,**

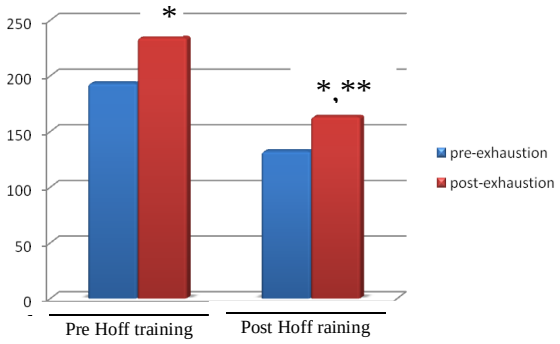

Figure3. Changes in plasma CPK before (pre) and immediately after (post) exhaustion in 12 soccer players. *P<0.05.

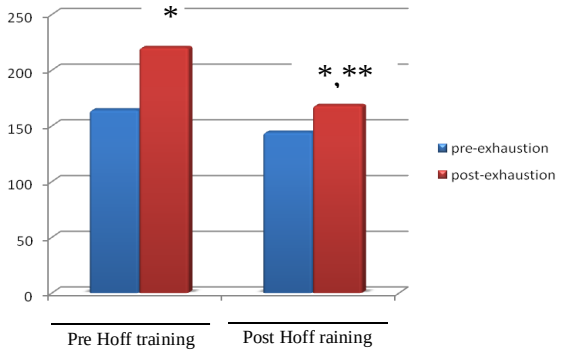

Figure4. Changes in plasma LDH before (pre) and immediately after (post) exhaustion in 12 soccer players. *P<0.05.

Discussion

Our study proved that 4 weeks of high intensity aerobic interval training with ball caused significant reduction in serum LDH level in rest (12%) and exhaustion (23%). It means serum level of LDH in the rest time in Pre-Hoff training moved down from 164.16 to 144.16 IU/l in post-Hoff training. Meanwhile in exhaustion time, serum levels of LDH

moved down from 220.16 to 168.33 IU/l. The results showed CPK significantly decrease 30 and 31% in rest and exhaustion times, respectively. This means CPK levels moved down from 193.66 IU/l (before Hoff training) to 132.5 IU/l (after Hoff training). Meanwhile in exhaustion time, serum levels of CPK moved down from 234.33 to 163.58 IU/l. Irrespective of all restrictions, Hoff training may have been able to effect on the serum levels of CPK and LDH in rest and exhaustion time. These findings of the current study are consistent with other authors who reported that high intensity training caused decrease in myofibrillar disruption indices enzymes (9,10,11,12). As it is proved in our study, one exhaustive exercise is a suitable sample to measure oxidative stress effect on the body and accordingly it was shown that after long high intensity training, trained athletes have less increase in levels of CPK and LDH (13). These findings are in line with Fowler et al (11) and Atland et al (12). They reported that after exhaustive exercise increase in muscular damage markers enzymes in untrained subjects was higher than trained subjects. In contrast to our findings, a study showed 12 weeks of high intensity training which consisted of 8 min pedaling on the cycle could not have significant effect on the level of CPK and LDH in serum. A possible explanation for this is that the duration rather than the intensity of exercise may be a more important factor in providing the cellular adaptation to exercise and in preventing the leakage of enzymes (5). In addition, it has been stated that CPK release is mainly related to exercise duration and there is a correlation 0.97 between CPK and LDH (14). Prior studies that have noted a strong relationship between muscular damages markers and exercise duration and intensity (14,15). In this respect, Hoff training had relatively long duration (4 min) and high intensity (90-95 % maximum heart rate). Also, training program included eccentric activities such as running; jumping and backward running which every one of them seems to cause increase of muscular damage markers in blood (16). Thus, one session of Hoff training as a high intensity exercise could move up LDH and CPK levels in serum. Byrnes et al found that repeating a bout of downhill running after 3 and 6 weeks resulted in significantly less perceived soreness for the second exercise bout when compared with the first exercise bout. After 9 weeks, perceived soreness ratings for the second exercise bout exceeded those for the first exercise bout (17). Given the results and specifications of Hoff training, it is expected that if these training were repeated, this training likely will reduce the increase of muscular damage markers releases in blood after a session of exhaustive activity. Thus, our results were in line with this theory that repeat of long high intensity eccentric activities could reduce the leakage of LDH and CPK in serum. On the other hand, in this study coincided with increase in VO_{2max} (5.5%) from 49.14 to 51.87 $ml.kg^{-1}.min^{-1}$, soccer players showed reduce in leakage of muscle damage markers. Our findings are in agree with those of previous studies, which also found that untrained athletes immediately after high intensity exercises and exhaustive exercises, have higher blood CPK and LDH levels than trained athletes (4,12,18).

Even though the present results provide some information about the effects of high intensity training on myofibrillar disruption symptoms, it is important to acknowledge some limitations. The most important limitation in our study was that we did not use control group and the results were reported only based on pre and post Hoff training data. However, it is evident that the results should be interpreted cautiously, but based on available data no study had measured Hoff training effect on muscular damage markers and this study can be a start point for future researches, so further research should be done to investigate the control group and different duration of training protocol.

In summary, the present study demonstrated that 4 weeks of high intensity aerobic interval training caused significant decrease in muscle damage markers leakage in rest and exhaustion time in soccer players and it was coincided with increase in their aerobic power. Finally our practical applications are these facts that high intensity training methods with specific ball training like the training program which used in our study can be used to improve Vo_{2max} and decrease delayed onset muscle soreness that both of them may help the players perform their individual functions in competitions.

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