The influence of competitive activity on selected biochemical and haematological parameters of amateur soccer athletes

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Abstract:

This study aimed to explore the changes caused by competitive activity to C-Reactive Protein (CRP), Myocardial Creatine Kinase (CK-MB), Lipoprotein- α Lp(α), Leucocytes (WBC) and Platelets (PLTs) counts in amateur soccer athletes. The sample consisted of 40 subjects, 20 of which were soccer players assigned to the experimental group while the remaining 20 consisted the control group. Blood samples were taken before and after a football match. The experimental design used for data analysis was 2 (Groups) X 2 (Measures) for independent samples with repeated measures on the last factor for all dependent variables. The Bonferroni method was used to investigate further significant interactions (post hoc). Statistical significance was set at $p < 0.05$ for all statistical analyses. The findings of the study showed that after the football match, players had significantly higher values of CRP, CK-MB, and Lp(α) than before the game and also compared with the control group ($p < 0.05$). Moreover, a significant increase of leucocytes (WBC) and platelets (PLT) was noted in footballers after the match ($p < 0.05$). The results demonstrate that football is a dynamic and demanding sport and it can result in significant changes in selected biochemical and haematological parameters of the athletes.

Key words: Soccer, CRP, CK-MB, Lp(α), WBC, PLT, biochemical markers, haematological markers.

Introduction

Soccer is a very dynamic and demanding sport, which requires high level aerobic capacity and considerable energy reserves (Bangsbo, 1994; Reilly & Borrie, 1992). During competitive activity, athletes receive great strains with an impact on physical health and body function, significantly affecting their performance (Souglis et al., 2013). Moreover, during a match, soccer players experience large fluctuation in activity level, with high intensity periods, such as fast running, jumps, tackling and fast changes of direction, alternating with periods of low and medium intensity movement (Ekblom, 1996). The soccer players intense anaerobic efforts combined with 1vs.1-type competitive situations (duels), during which opponents come into physical contact to gain control of the ball, play a significant role for footballers' haematological and biochemical status (Souglis, 2014). One such haematological and biochemical profile demonstrating damage to muscular tissue has been reported in haematological and biochemical studies on athletes participating in heavy physical activities, especially middle and long distance runners (Bangsbo et al., 1991; Dufaux et al., 1981; Deitrik, 1991).

One of the main inflammation parameters studied in relation to cardiovascular disease is C-Reactive Protein (CRP), an acute phase protein, already identified in 2004 as an independent risk factor for coronary disease by the American Heart Association (Pearson et al., 2004). Although it is well known that medium to high intensity exercise causes a transient increase in the plasma pre-inflammatory cytokine levels, as well as in acute phase proteins such as CRP, long-term, systematic exercise is linked to lower values of both pre-inflammatory cytokines and acute phase proteins in the blood of such exercising people (Moldoveanu et al., 2001). Colbert et al. (2004) have shown that daily exercising 70 to 79-year-old senior people, irrespective of gender, had lower CRP levels as compared to their peers who performed no physical activities. Albert et al. (2004) have concluded the same after studying a similar age group, with the correlation being significantly lower, mainly concerning the study male sample.

Another important biochemical marker is Myocardial Creatine Kinase (CK-MB), a myocardial isoenzyme (myocardial lesion marker). The effect of exercise is very important. König et al. (2003) investigating myocardial stress after a competitive bicycle race through measuring changes in biochemical markers, such as CK-MB, in combination with attentive heart examinations, found that CK-MB was considerably increased after the race, although none of the bikers showed pathological findings. The results have shown that a high percentage of professional footballers subjected to unusually intense exercise demonstrated an increase of plasma CK-MB. Moreover, a study by Jaffe et al. (1984) found CK-MB increase after intense exercise during a football match in 7 out of 9 people measured; however, there were no clinical results of myocardial injury. Lippi

et al. (2008) investigated the impact of a 21-kilometre run on Caucasian athletes, over parameters demonstrating muscular and cardiac lesion, such as CK-MB, found considerable increase in parameter concentrations post-race as compared to pre-race. CK-MB values were 1.2 times higher than pre-exercise status, which shows the heavy impact of submaximum aerobic exercise on the CK-MB biochemical marker.

Lipoprotein- α Lp(α) often increases in patients with diabetes, hypothyroidism, chronic renal failure who demonstrate microalbuminuria, and it decreases in patients with hepatic failure and hypothyroidism. Lp(α) plasma levels are affected by gender, age, diet and physical exercise. Specifically, in a study by Randall et al. (2004) on obese African Americans, a 20% increase of Lp(α) was noted after a three-month exercise and diet programme. Intervention studies show that 9 to 12 months of heavy exercise may increase Lp(α) serum levels; however, these changes are generally small (10 to 15%) and, for most people, Lp(α) serum levels remain low.

The main function of Leucocytes (WBC) is fighting infections, i.e. body defence through phagocytosis of invading micro-organisms and the production, or only transport and distribution, of antibodies during immunisation. As concerns exercise impact on WBC, Teleford et al. (1991) noted that soccer practice at an intensity of 75% of HR_{max} caused an increase in leucocytes. Avlonitou et al. (2007) explored the impact of training on the WBC number in 10 athletes of the women's national soccer team. Measurements were taken pre- and post-training and 4 hours after the training session. The results demonstrated that the WBC number increased significantly after training and remained high for up to 4 hours after the session. Fatouros et al. (2009), in a study on 20 male soccer players, found an increase in leucocytes up to 24 hours after competitive activity. An increase in WBC was noted by Andersson et al. (2009) in 10 elite female athletes after a football match. Sureda et al. (2007) found that the intensity of a football match significantly affects the WBC increase, noting that the team playing with higher intensity demonstrated higher increase in WBC.

Blood Platelets (PLT) contribute to the healing of injuries and breaks in the wall of blood vessels, and play a primary role in haemostasis, releasing a phospholipid which accelerates blood coagulation; at the same time, they are involved in the internal and external blood clotting mechanism along with the several agents they include. Concerning exercise impact on platelet levels, Nemet et al. (2009), in research of blood samples collected before and after exercise sessions, found that an intense exercise period may increase considerably the number of platelets in exercising female adolescents. Labriola et al. (2009) also noted a considerable platelet increase after a marathon run. Ahmadizad et al. (2006) investigated the impact of resistance training on platelet activation in twenty healthy male subjects, who completed three rounds of six exercises of five to seven repeats, at an intensity matching 80% of a maximum repeat (1RM), followed by a 30-minute rest. They found an increase in the number of platelets after completion of the exercises.

This study aimed to explore possible changes in biochemical and haematological markers (CRP, CK-MB, Lp(a), WBC and PLT) occurring during a soccer match to establish the level of strain the latter causes.

Material & Methods

Forty subjects participated in the study. Twenty of them were soccer athletes (aged 24.3 $\pm$ 5.2 years) and 20 (aged 23.2 $\pm$ 4.0 years) were assigned to the control group. Athletes were studied during the 2007-2008 competition period in official matches and high level effort, to the best controllable extent (e.g. importance of matches) and under approximately the same weather and field conditions.

The soccer players training age was 12 $\pm$ 3.4 years, while the control group subjects demonstrated a regular level of daily physical activity (public servants, private company employees, students, etc.). In addition to match participation, the athletes also underwent daily training (5-7 times per week). Training included variable intensity exercises lasting 75-90 min. Both athletes and control group subjects were selected through random sampling among several volunteers. All subjects, both athletes and controls, were very light to non-smokers and consumed little to no alcohol.

They were all instructed to follow specific, calorie-balanced diet during the week of the blood sampling (daily intake of 55-60% carbohydrates, 25-30% fat and 10-15% protein). All athletes and controls were subjected to routine medical examination (cardiogram, blood pressure measurement, chest X-ray) which showed no pathological conditions. All subjects were informed in detail about the study purpose, process and design and delivered an informed consent form for the participation in the research.

Measurements

Anthropometric data

The following anthropometric measurements were taken: height, body weight, body fat percentage (Table 1). Height was measured with a stadiometer in centimetres (cm). Body weight was measured in kilograms (kg) using a standard beam balance, while for body fat percentage, the Meyhew method (1981) was used, which relies on measuring the thickness of two skinfolds, mid-femoral and supra-iliac, with a Harpenden skinfold caliper (John Bull, British Indicators, Ltd., West Sussex, United Kingdom).

Table 1. Anthropometric data for experimental and control groups

	Age (years)	Weight (Kg)	Height (cm)	Fat (%)
Experimental	23.3 $\pm$ 5.2	74.9 $\pm$ 7.0	179.0 $\pm$ 3.7	12.3 $\pm$ 1.8
Control	24.2 $\pm$ 4.0	79.2 $\pm$ 6.8	180 $\pm$ 7.6	21.4 $\pm$ 4.2

Blood sampling

For both the soccer players and the controls, two blood samples were taken. The first blood sample was performed in the morning of the match day, after 12-hour overnight fasting, with no competitive activity occurring in the previous two days. The second blood sample was taken 8 hours after the first one and immediately after the competitive activity (5.5-6 hours after lunch). During sampling, subjects were at a sitting position. Samples were collected from the basilic and median basilic vein, 5 ml were taken at each blood sampling and placed in glass tubes with no anti-coagulant to collect the serum. Also, blood was placed in special full-blood-count-type tubes with EDTA to specify the number of leucocytes and platelets. Sample centrifugation (10 min at 2,500 rpm) was performed within one hour from sampling. Then serum was stored at -70 °C until the assay day.

Parameter assay

CRP was assayed with immunonephelometry on a Dade Behring analyser using appropriate reagents. Lp(a) was assayed in the same way. CK-MB was assayed on an Abbott Architect-type biochemical analyser, also using appropriate reagents. Finally, leucocyte and platelet numbers were found using a special full blood count computer, CDS series cap M, which provided immediate, reliable results.

Statistical Analysis

The experimental design used for data analysis was 2 (Groups) X 2 (Measures) for independent samples with repeated measures on the Measures factor for all dependent variables. Bonferroni post hoc analyses were conducted to identify statistically significant differences. The level of significance was set at $p < 0.05$ for all statistical analyses (Gamst, Meyers, & Guarino, 2008).

Results

C-Reactive Protein (CRP). The results of the Groups by Measures ANOVA for CRP showed statistically significant differences for Measures main effect ($F_{1,38} = 18.55, p < .001, \eta_p^2 = .328$) and Groups by Measures interaction ($F_{1,38} = 15.59, p < .001, \eta_p^2 = .291$); however, there was no statistically significant difference for Groups main effect ($F_{1,38} = 3.34, p = .075, \eta_p^2 = .081$). Bonferroni post hoc analyses for the significant interaction has shown that statistical significance was due to the higher value of the protest of the experimental group ($M = 4.55 \pm 1.47$) as compared to the pretest of the same group ($M = 3.40 \pm 1.00$), as well as both measures of the control group ($M_{pre} = 3.40 \pm .82, M_{post} = 3.45 \pm .76$) (see Figure 1).

Figure 1. Means and standard deviations of CRP (mg/dl) for the Experimental and Control Groups, in pretest and posttest Measures (* significantly different from all other measures, $p < .05$).

Myocardial Creatine Kinase (CK-MB). Groups by Measures ANOVA for the CK-MB marker showed statistically significant differences for Measures main effect ($F_{1,38} = 79.83, p < .0001, \eta_p^2 = .677$) and Groups by Measures interaction ($F_{1,38} = 74.82, p < .0001, \eta_p^2 = .663$); however, there was no statistically significant difference for Groups main effect ($F_{1,38} = 1.62, p = .212, \eta_p^2 = .041$) factor. Bonferroni post hoc analysis of the significant interaction has shown that statistical significance was due to the higher value of CK-MB at the posttest of the experimental group ($M = 3.48 \pm 1.15$) as compared to the pretest of the same group ($M = 2.24 \pm .93$), as well as the pretest ($M = 2.47 \pm .89$) and posttest ($M = 2.49 \pm .92$) of the control group (see Figure 2).

Figure 2. Means and standard deviations of CK-MB (IU/L) for the Experimental and Control Groups, in pretest and posttest Measures (* significantly different from all other measures, $p < .05$).

Lipoprotein (Lp(a)). The results of the Groups by Measures ANOVA for the Lp(α) marker showed statistically significant differences for Groups ($F_{1,38} = 4.89, p = .033, \eta_p^2 = .114$) and Measures main effects ($F_{1,38} = 10.83, p = .002, \eta_p^2 = .222$) as well as for Groups by Measures interaction ($F_{1,38} = 4.25, p = .046, \eta_p^2 = .101$). Bonferroni post hoc analysis of the significant interaction has shown that statistical significance was due to the statistically higher values of Lp(α) at the posttest of the experimental group ($M = 6.47 \pm 2.15$) as compared to the pretest of the same group ($M = 6.10 \pm 2.17$), as well as the pretest ($M = 5.07 \pm 1.01$) and posttest measures ($M = 5.15 \pm 1.09$) of the control group (see Figure 3).

Figure 3. Means and standard deviations of Lp(α) (mg/dl) for the Experimental and Control Groups, in pretest and posttest Measures (* significantly different from all other measures, $p < .05$).

Leucocytes (WBC). Groups by Measures ANOVA for the Leucocytes (WBC) showed statistically significant differences for Groups ($F_{1,38} = 8.90, p = .005, \eta_p^2 = .190$) and Measures main effects ($F_{1,38} = 76.93, p < .0001, \eta_p^2 = .669$) as well as the Groups by Measures interaction ($F_{1,38} = 76.93, p < .0001, \eta_p^2 = .669$). The statistically significant difference of Groups main effect was due to the higher concentration of WBC in the experimental group ($M = 7.77 \pm 1.34$) as compared to the concentration in the control group ($M = 6.63 \pm 1.08$). Bonferroni post hoc analysis of the significant interaction has shown that statistical significance was due to the higher value of the posttest of the experimental group ($M = 8.62 \pm 1.38$) as compared to the pre-test of the same group ($M = 6.93 \pm 1.43$), as well as both measures of the control group ($M_{pre} = 6.63 \pm 1.07, M_{post} = 6.63 \pm 1.09$) (see Figure 4).

Figure 4. Means and standard deviations of Leucocytes (WBC) ($\times 10^3/\text{ul}$) for the Experimental and Control Groups, in pretest and posttest Measures (* significantly different from all other measures, $p < .05$).

Platelets (PLT). Groups by Measures ANOVA for the Platelets (PLT) showed statistically significant differences for Measures main effect ($F_{1,38} = 38.10, p < .001, \eta_p^2 = .501$) and Groups by Measures interaction ($F_{1,38} = 34.11, p < .001, \eta_p^2 = .473$); however, there was no statistically significant difference for Groups main effect ($F_{1,38} = .42, p = .521, \eta_p^2 = .011$). Bonferroni post hoc analysis of the significant interaction has shown that statistical significance was due to the higher value of the post-test of the experimental group ($M = 292.95 \pm 58.11$) as compared to the pre-test of the same group ($M = 245.90 \pm 43.10$), as well as both measures of the control group ($M_{pre} = 259.85 \pm 39.56, M_{post} = 261.15 \pm 37.66$) (see Figure 5).

Figure 5. Means and standard deviations of Platelets PLT ($\times 10^3/\text{ul}$) for the Experimental and Control Groups, in pretest and posttest Measures (* significantly different from all other measures, $p < .05$).

Discussions and conclusions

Heavy training and matches may impact significantly biochemical and haematological parameters which, if not evaluated in a timely and appropriate manner, may result in performance deterioration or even injuries. Therefore, it is of special importance to evaluate as well as properly interpret biochemical and haematological parameters.

C-Reactive Protein is the best known and most prevalent molecule of the body's acute phase response. It is mainly produced in the liver, as a response to a variety of stimulators, and it heightens inflammatory response to all those factors initiating the acute phase response. Exercise seems to be bearing many of such changes in the body of the person exercising, which may be attributed to the acute response initiated after heavy and exhausting exercise (Souglis, 2014). This study has shown a significant increase in CRP at measurements immediately after a match, as compared to values before a match. These findings are in accordance with literature data. Specifically, Moldoveanu et al. (2001) have studied the response of agents to exercise and have demonstrated the transient increase of the agent. Moreover, the same change pattern was shown in a study by Ispirlidis et al. (2008), who found increased CRP levels after competitive activity. A significant CRP increase was also found in a study by Souglis et al. (2009), highlighting an increase in the agent mainly in the 24 hours after competitive activity for female soccer players. Changes are a result of mechanisms, such as inflammatory response to injuries or agents that might be linked to heightened inflammation in the athlete (e.g. an autoimmune disease or a transient infection by some micro-organism). Also, this increase could be justified as a result of the proportionate increase caused by heavy exercise to the levels of IL-6 (Hellsten et al., 1997; Bruunsgaard et al., 1997), i.e. the main stimulator of CRP secretion. Although CRP increase may not be comprehensible at all times, the relation is clear, and it seems to be founded on the acute inflammation caused by acute exercise.

CK-MB is a myocardial isoenzyme which is not normally detectable in plasma, it increases mainly during myocardial infarction, as well as polymyositis, muscular dystrophy, injuries, surgical operations, hyperthermia and hypothermia, chronic renal failure and serious myoglobulinuria. 10-20% of total CK in the myocardium is CK-MB, while it is 2% in the skeletal muscles (Protopapas, 1993). Research has shown that sports activity may cause a considerable increase of CK-MB. Specifically, Lippi et al. (2008), in a study of 10 athletes, have found that submaximum aerobic exercise (21-klm run) affected muscular damage markers; CK-MB was measured before and after the race denoting a considerable increase lasting more than 24 hours. In the present study, CK-MB increased significantly immediately after the match. This increase of the concentration fraction of CK-MB may not have myocardial origin but it may be the result of the efflux of this isoenzyme from skeletal muscular fibres which over-function or get injured (Rogers et al., 1985; Lijnen et al., 1988). The present findings are in accordance with Jaffe et al. (1984) who found heavy CK-MB activity in blood plasma in young professional athletes after heavy exercise in football matches. Also, Shave et al. (1985), in a two-day women marathon run, noted high CK-MB concentrations after the end of the race, which remained high even after the first day.

Lipoprotein Lp(α) is considered an acute phase protein and an independent risk factor for cardiovascular disease (Danesh, Collins, & Peto, 2000). Serum Lp(α) levels are greatly defined by genetic factors and do not seem to be affected by environmental factors which may modify lipoproteins, such as LDL or HDL cholesterol, to a greater extent (Mackinnon et al. 1997). This study showed increase of Lp(α) concentration after a match as compared to the pre-match value. Literature data are few in relation to the effect of individual exercise on Lp(α) levels. On the other hand, study of the effect of long-term, intensive exercise on the agent levels demonstrates complex and, many times, inconsistent results (Ouellette, 2004). Specifically, Mackinnon et al. (1997) noted a positive effect of exercise whereas another study (Mackinnon & Hubinger, 1999) has noted no significant differences after long exercise. Ruiz et al. (2004) have recorded increased Lp(α) levels, finding that football and volleyball players showed increased levels of Lp(α) after individual exercise, while swimming athletes presented a relatively lower increase of the Lp(α) levels in comparison to the aforementioned athlete groups. Moreover, Byrne et al. (2002) have not shown any statistically significant difference in Lp(α) levels after a closing programme of exhaustive exercise, lasting 2 days, for athletes of the Royal Army. On the contrary, Harry et al. (1999) showed statistically significant reduction in the Lp(α) levels in triathlon athletes after related competitive activity. Finally, Griffin et al. (1988) and Dufaux et al. (1986) have not demonstrated any significant difference in Lp(α) levels before and after competitive activity.

As concerns WBC, in the present study, their number increased considerably right after a match in comparison to pre-match values. These results are in accordance with those of other researchers showing an increase in the number of leucocytes. Specifically, Rebelo et al. (1988) found an increase of leucocytes, especially neutrophils, in professional footballers, as well as third league footballers, at the end of the competitive period as compared to the number at the beginning of the competitive period. Also, according to Deitrik (1991), an increase of WBC was noted in experienced marathon runners after the start of the race. The same results were found by Hack et al. (1992) in highly trained long distance runners and triathlon athletes after an average training period. Other researchers noted a decrease in WBC. Fallon et al. (2001), examining female soccer players, have found considerable reductions in the number of leucocytes and neutrophils, after a week of moderate training. Bury et al. (1998) also noted a drop in neutrophil function, with increased neutrophil numbers and decreased lymphocyte numbers, which tends to normalize after the competitive period. There also other

studies stating that no changes have been noted in the number of leucocytes in professional soccer players during the competitive period and after its completion (Bury et al., 1998; Filaire et al., 2003).

In the present study, platelets (PLT) increased considerably immediately after competitive activity in comparison to the values before. The results are in accordance with findings by other researchers studying the impact of heavy exercising on platelets in triathlon athletes (Mockel et al., 2001) and middle and long distance runners (Banfi et al., 1995). Karakoc et al. (2005) noted an increase in platelets after competitive activity in 10 soccer players of the Turkish league. Also, Hanke et al. (2010), in a study on marathon and triathlon athletes, have found that, although coagulation is activated during physical exercise irrespective of type, significant platelet activation was only observed during the marathon run and, to a lesser extent, during the triathlon. This may be due to the fact that extended platelet function may increase due to mechanical changes. In general, physical activity provides adequate stimuli for responses in the number of platelets, which is probably due to the recruitment of groups of mature platelets from catecholamines (Mockel et al., 2001; Banfi et al., 1995). Although training of endurance athletes has not shown abnormal morphological changes in platelets (Banfi et al., 1995), the effect of physical exercise and condition on the function of platelets is not yet fully clarified (Gonzales et al., 1996). Indeed, the changes in the haemostatic system caused by exercise occur in conjunction with increased platelet reactivity, coagulation and fibrinolysis, which may account for the rate of thromboembolic episodes (Rocker et al., 2000). However, in some people, especially those with a predisposition for thrombosis or other thrombogenic risk factors, they may disturb the balance between coagulation and fibrinolysis during heavy exercise (Labriola et al., 2009).

The results of the present study have shown that a football match results in significant changes in the levels of various biochemical and haematological markers, with soccer players being subjected to intense strain which may bear significant changes in blood morphological components. Also, the results suggest the occurrence of the haemolysis effect as well as biochemical dysfunction, which soccer players suffer. It should be noted, however, that the changes of those markers have not exceeded the normal range to a dangerous extent. The results show that on the day after the competitive activity, it is essential players to follow rehabilitation training using relaxation training techniques for faster return to normal values.

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