

## The Relationship between Blood Buffer Capacity and Aerobic Power with Ability to Perform High Intensity Intermittent Activities in Young Football Players

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### Abstract

**Background:** The purpose of this study was to determine the relationship between blood buffer capacity and aerobic power ( $VO_{2max}$ ) with ability to perform high intensity intermittent activities in young football players. **Methods:** 27 male football players (age  $17.66 \pm 0.49$  years) selected as subjects. Blood samples were collected before and after the yoyo intermittent test. Then, after 48 hours, the Bruce treadmill test was performed for measuring  $VO_{2max}$ . The Pearson coefficient correlation was used for analyzing data.

**Results:** A significant relationship was found between  $H^+$ ,  $HCO_3^-$ , BE and ability to perform high intensity intermittent activities ( $r=0.609$ ,  $p=0.001$ ;  $r= -0.381$ ,  $p=0.050$ ;  $r=-0.401$ ,  $p=0.038$ ), a significant relationship between  $VO_{2max}$  and ability to perform high intensity intermittent activities ( $r=0.761$ ,  $p=0.000$ ) and no significant relationship between  $Pco_2$  and ability to perform high intensity intermittent activities ( $r=-0.130$ ,  $p=0.517$ ).

**Conclusion:** Results indicate that blood buffer capacity and  $VO_{2max}$  are effective factors in the performance of intermittent activities in football players.

**Key Words:** Blood buffer capacity,

$VO_{2max}$ , high intensity intermittent activities, young football players

### Introduction

During the recent years, sport and physical education has advanced increasingly. Therefore, identification of effective factors in performance may help coaches and sport scientists to develop better training programs. A large number of team games such as football, basketball and hockey require participants to have the ability to perform high intensity intermittent activities with short- term recovery periods and maintain speed until termination of exercise. This performance ability requires desired recovery intervals during high intensity intermittent activities for fighting fatigue (Wadely & Rossignol., 1998; Bangsbo et al., 1996). Following the repeated intermittent activities such as football, the recovery should not last less than a few minutes. Such activities which cause depletion of ATP-PCr and increase in lactate and  $H^+$  accumulation require longer recovery periods (Tamlin & wenger., 2001). Increased buffer capacity and blood flow elevate Lactate removal from muscles (Holoszy & coyle., 1984). Decrease in intracellular PH reduces ability to perform high intensity intermittent exercises. Decrease in intracellular acidosis declines ability to perform intermittent sprint exercises via

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inhibition of glycolysis (Hermansen., 1981). There is no clear evidence how fatigue occur during the high intensity intermittent activities. In most studies it is known that metabolic factors (Lactate accumulation and decreased PH) (Tamlin & wenger., 2001) and depletion of muscle glycogen (Krustrup et al., 2003) play an important role in the development of muscle fatigue during high intensity intermittent activities. Base on some researches, the lactate accumulation does not make fatigue during high intensity intermittent activities. There is also no relationship between decrease in PH and decrease in performance during football race (Krustrup et al., 2006). Increase in H<sup>+</sup> buffering may improve the ability to perform high intensity intermittent activities by facilitating resynthesis of PCr or decreasing inhibition of glycolysis (Bishop & Spencer., 2004). Lactate removal from muscles resulting from increasing buffer capacity is one of effective factors in increasing performance during the intermittent activities (Holoszy & coyle., 1984). On the other hand, VO<sub>2max</sub> is a main factor during the intermittent activities and during recovery intervals of the intermittent activities (McMahon & Wenger., 1998). Thus, the buffer capacity and VO<sub>2max</sub> may be the main factors in performing intermittent activities (Bishop & Spencer., 2004). Bicarbonate (HCO<sub>3</sub><sup>-</sup>) is important extracellular buffer and phosphates, proteins and hemoglobin are intracellular buffers (Holoszy & coyle., 1984).

In general, only a few studies have been published to determine muscle metabolism and fatigue during the high intensity team games with brief recovery periods (Bishop et al., 2004). Zoladez et al (1993) reported a significant increase in blood lactate and decrease in HCO<sub>3</sub><sup>-</sup>, Pco<sub>2</sub>, PH and BE after the incremental activities (Zoladz et al., 1993). McCartney et al (1993) found a decrease in blood PH and no change in HCO<sub>3</sub><sup>-</sup>, Pco<sub>2</sub> and Po<sub>2</sub> during each stage of intermittent work (McCartney et al.,

1986). In a research Krustrup et al (2003) considered physiological response to intermittent activities in football players. The results showed no relationship between fatigue and muscle lactate and H<sup>+</sup> levels during the high intensity activities (Krustrup et al., 2003). The results of research Bishop et al (2004) indicated a significant relationship between muscle buffer capacity and aerobic power and no significant relationship between total work and buffer capacity during the repeated- sprint activities (Bishop et al., 2004). In a research of Krustrup et al (2006) muscle PH of 40 elite football player during the yo yo intermittent test reaches to 6.8 in a fatigued state. The results suggested that buffer capacity and aerobic power are main factors in performing intermittent activities (Krustrup et al., 2006). Edje et al (2006) reported decrease in pre-exercise H<sup>+</sup>, no change in post-exercise H<sup>+</sup> and improved endurance performance and lactate threshold lactate after 8- weeks consuming of NaHCO<sub>3</sub> supplement (EdJe et al., 2006). Böning et al (2007) indicated changes in intracellular buffers and no change in the rate of HCO<sub>3</sub><sup>-</sup> during and after exercise (Böning et al., 2007). Bishop et al (2008) found decrease in lactate and H<sup>+</sup> accumulation after 5-week high intensity intermittent training (Bishop et al., 2008). Based on the previous studies the factors such as PH, lactate and CP play an important role in the development of muscle fatigue during high intensity intermittent activities (Krustrup et al., 2006). It seems that the intensity of activity, the number of repetitions, duration of exercise and rest intervals in recovery periods may influence on performance during high intensity intermittent activities (Bangsbo et al., 1996). Therefore the present study designed to determine the relationship between blood buffer capacity and aerobic power with ability to perform high intensity intermittent activities in young football player and evaluate how much the

performance ability can be influenced by buffer capacity and aerobic power.

## **Methods**

### **Subjects**

Among of the members of two teams "Naft and Mehrene- reza", 36 male football players in the first class league of Tehran city (age 17.66  $\pm$ 0.49 years) volunteered as subjects. 9 of them were deleted during the test and 21 of them performed the test. Subjects participated in this study after given their written informed consent.

### **Procedures**

#### **Exercise test**

##### **The Bruce treadmill test**

The Bruce treadmill test was used as exercise test for measuring  $VO_{2max}$ . In the Bruce test, treadmill is set up with the Stage 1 speed (2.74 km / hr) and grade of slope (10%) and the athlete commences the test. At the appropriate times during the test, the speed and slope of the treadmill are adjusted. Therefore, after 3 minutes into the test the speed is adjusted to 4.02 km/hr and the slope to 12%, after 6 minutes into the test the speed is adjusted to 5.47 km/hr and the slope to 14%, and so on. The test stops when the athlete is unable to continue - this ideally should be between 9 and 15 minutes.

##### **The Yo-Yo intermittent recovery test**

The test is measured the variables  $H^+$ ,  $Pco_2$ ,  $Hco_3$  and BE. The Yo-Yo intermittent recovery test consists of repeated 2.20 -m runs back and forth between the starting, turning, and finishing line at a progressively increased speed controlled by audio bleeps from a tape recorder. Between each running bout, the subjects have a 10-s active rest period, consisting of 2.5 m of jogging. When the subjects twice have failed to reach the finishing line in time, the distance covered is recorded and represents test result. The test may be performed at two different levels with differing speed profiles (level 1

and 2). in the present study , we used the Yo-Yo intermittent recovery test, level 1 , which consist of 4 running bouts at 10-13 km.h-1 (0-160m) and another 7 runs at 13.5-14 km .h-1 (160-440m) , where after it continues with stepwise 0.5 km.h1 speed increments after every 8 running bouts (i.e., after 760 , 1080, 1400 , 1720 m. etc.) until exhaustion .the test was performed indoor on running lanes, marked by cones,, having a width of 2 m and a length of 20m. Another cone placed 5 m behind the finishing line marked the running distance during the active recovery period. Before the test, all subjects car tried out a warm – up period consisting of the first four running bouts in the test. The total duration of the test was 6-20 min. all subject were familiarized to the test by at least one pretest (Aziz et al., 2003).

The Blood samples were collected before the yoyo test. Then after warm- up, the yoyo intermittent test was performed and immediately after the test, blood samples were collected. After 48 hours, subjects arrived at Olympic national Academy in part "the evaluation center of physical capabilities" and before noon they performed the Bruce test for evaluating  $VO_{2max}$ . The Bruce test was performed using treadmill (k<sub>4</sub>b<sub>2</sub>, techno Gym, Italy). The blood samples were collected pre and post- yoyo test. 1 cm<sup>3</sup> of blood sample was collected from the radial artery in wrist using plastic syringe. After heparin of syringe, the blood sample was collected from radial artery. Then the needle was bended to prevent the air enters the saying and the lid was covered with a plastic and transformed to blood laboratory. The samples were examined using device of the measurement of blood gas and the result was printed on special sheets.

#### **Statistical analysis**

Statistical significance was assessed using Pearson coefficient correlation. The statistical package SPSS Version 16 was used for statistical analysis. Differences

were considered significant at the  $p \leq 0.05$  and results were presented as means  $\pm$ SD.

## Results

The physical characteristics, variables resulting from the yoyo intermittent test and Bruce test in male athletes ( $n=27$ ) (Table 1) were recorded.

Table 1. Physical characteristics of the athletes ( $n=27$ )

Variables	Age (yrs)	Height (cm)	Weight (kg)	Fat (%)	Distance(cm)
					$Vo_{2max}$ (ml/kg/min)
(M $\pm$ SD)	17.66 $\pm$ 0.49	173.47 $\pm$ 6.03	64.33 $\pm$ 5.31	14.28 $\pm$ 3.38	1640.74 $\pm$ 410.94
	49.76 $\pm$ 5.33				

Table 2. Descriptive statistics (M $\pm$ SD) for variables in pre and post-test in male athletes ( $n=27$ )

Variables		M $\pm$ SD	Max	Min
H+ (meq/L)	Pre-test	38.802 $\pm$ 1.4	40.65	36.131
	Post-test	55.84 $\pm$ 2.76	63.37	43.241
Hco3- (mmol/L)	Pre-test	22.53 $\pm$ 1.90	25.9	18.2
	Post-test	12.75 $\pm$ 2.76	18.8	9.2
Pco2 (mmHg)	Pre-test	36.44 $\pm$ 3.26	42.1	31.3
	Post-test	28.44 $\pm$ 4.55	33.3	26.10
BE (mmol/L)	Pre-test	-1.14 $\pm$ 1.50	1	-3.8
	Post-test	-12.65 $\pm$ 3.21	-5.1	-18.5

Descriptive statistics (M $\pm$ SD) for measured variables in pre and post-test (Table 2) and the results of Pearson coefficient correlation between variables in male athletes ( $n =27$ ) (Table 3) were recorded. Using Pearson coefficient correlation, significant relationship were found between H+ ( $r= 0.609$ ,  $p \leq 0.001$ ); Hco<sub>3</sub><sup>-</sup> ( $r= -0.381$ ,  $p \leq 0.05$ ); BE ( $r= 0.401$ ,  $p \leq 0.05$ ),  $Vo_{2max}$  ( $r= 0.761$ ,  $p \leq 0.000$ ) and performance ability of High intensity intermittent activities. Also no significant relationship was found between Pco<sub>2</sub> ( $r= 0.130$ ,  $p= 0.517$ ) and performance ability of High intensity intermittent activities.

## Discussion

There was a significant relationship between H<sup>+</sup> and ability to perform high intensity intermittent activities. This result is supported by the results of Pilegaard et al (2000), Edje et al (2003) and Bishop et al (2008) [15], but is not in agreement with the results of Edje et al (2003) and Krstrup et al (2003). This contradiction may be due to the difference in training protocol (in terms of intensity, number of repetition and recovery periods) and also type of training (intermittent vs resistance). During the high intensity exercise, H<sup>+</sup> is produced by volatile acids (e.g carbonic acid), Non-volatile acids (e.g sulfuric acid and phosphoric acid) and organic acids (e.g lactic acid and

acetoacetic acid). Our result indicate that during high intensity intermittent activities the concentration of intracellular  $H^+$  increase through production of mentioned acids and their metabolic processes (Scott & Powers., 2006). As bishop et al (2003) reported positive significant relationship between  $H^+$  concentration and the repeated sprint ability in elite female (bishop et al., 2003). In this matter, some researchers found similar results. Krstrup et al (2006) concluded that the  $H^+$  concentration of elite players increased during the yo yo intermittent test and decreased after 3-min rest (Krustrup et al., 2006).

There was a significant relationship between  $HCO_3^-$  and ability to perform high intensity intermittent activities ( $r=-0.381$ ,  $p\leq 0.05$ ). The findings of results of McCartney et al (1986) , Zoladez et al (1993) and Krstrup et al (2006) are in agreement with our result. However, the result of Böning et al (2007) is not supported our finding and indicated that intermittent activities had more effect on buffer capacity compared with the continuous activities. This may be due to type of training protocol and physical activity (Böning et al., 2007). Edje et al (2003) found the relationship between the  $HCO_3^-$  buffer and the repeated sprint ability in 3 groups (team athletes, trained and untrained endurance athletes). However, this relationship between team athletes was more than others. The results suggested that intermittent trainings improved the buffering system (Edge & Bishop., 2003).

There was no significant relationship between  $P_{CO_2}$  and ability to perform high intensity intermittent activities ( $r=-0.130$ ,  $p=0.517$ ). The previous study of Dona et al (2001) and Hermansen., (1981) are supported this result, but the result of Böning et al (2007) is not in agreement with our finding. This may be attributed to difference in the type of blood sample (venous vs. artery) and type of exercise (swimming vs. football). During high intensity activities, pulmonary ventilation

increases because of metabolic acidosis. Increased pulmonary ventilation cause more exertion of  $CO_2$  from pulmonary capillaries and decrease in  $P_{CO_2}$ .

There was a significant relationship between BE (Base excess) and ability to perform high intensity intermittent activities ( $r=0.401$ ,  $p\leq 0.05$ ). This result is supported by the results of Böning et al (2007). However, our result is not in agreement with the result of McCartney et al (1986). This may be related to difference in intensity, duration, number of repetition and recovery periods. BE or the measurable concentration of blood Base decrease after high intensity activities. Decrease in BE resulting from increasing  $H^+$  disorder Acid-Base balance. Therefore, there is relationship between BE and  $H^+$  levels after high intensity activities (Scott & Powers., 2006). Zoladez et al (1993) examined changes in acid and base in runner during an incremental intermittent test and found a significant increase in lactic acid and a significant decrease in BE in a fatigued state (Zoladez et al (1993).

There was a significant relationship between  $VO_{2max}$  and ability to perform high intensity intermittent activities ( $r=0.761$ ,  $p\leq 0.001$ ). The strong relationship between  $VO_{2max}$  and ability to perform high intensity intermittent activities show that  $VO_{2max}$  is an important factor during high intensity intermittent activities. Our result is in agreement with results of Bishop et al (2004), Edge et al (2005) and Krstrup et al (2006) and is not in agreement with the results of Bishop et al (2003). It seems that sexuality, type of exercise, protocol of training (in terms of the number of the repetition, rest intervals of recovery periods) may effect on performance during high intensity intermittent activities. However, Tamlin and venger (2001) reported a significant relationship between  $VO_{2max}$  and aerobic responses to fast recovery periods.the McMahan and Venger (1998) indicated that  $VO_{2max}$  is a main factors during high intensity intermittent activities. Bishop et

al (2004) showed a significant relationship between  $VO_{2max}$  and the ability to perform repeated sprint activities (Bishop al., 2004). Although many factors effect on the ability to perform high intensity intermittent activities, acid lactate production and increased  $H^+$  concentration in sarcoplasm of muscle cell disorder Acid-Base balance and decrease partly intracellular PH and finally cause fatigue. Studies show that increased intracellular  $H^+$  may result a disturbance in energy production and in fact,  $H^+$  can be an inhibitory factor in contractile mechanism (McCartney., 1986). Increased blood lactic acid enhances plasma lactate and  $H^+$  concentration. Also Increased  $H^+$  concentration elevate depth and frequency of breathing (Scott & Powers., 2006). The factors improving  $VO_{2max}$  can be defined as: Increased oxidative enzymes; increased number, size and rate of mitochondria and myoglobin, increased blood flow (by increased cardiac output), increased capillary Network of muscle tissue and vasodilation. In fact, increased aerobic portion during intermittent activities decrease lactate production. Also lactate removal from muscle resulting from increasing buffer capacity and blood flow improve the ability to perform high intensity intermittent activities (Holoszy & coyle., 1984).

### Conclusion

Blood buffer capacity and  $VO_{2max}$  are effective factors in the performance of intermittent activities in football players.

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