

## Diurnal Variations in Physical Performances Related to Football in Young Soccer Players

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**Received:** Jan 09, 2012

**Accepted:** Apr 13, 2012

**Key Words:** Circadian Rhythm; Soccer Players; Aerobic Exercises; Anaerobic Exercises

### Abstract

**Purpose:** This study investigated the effects of time-of-day on aerobic and anaerobic performances during the Yo-Yo, repeated sprint ability (RSA) and the Wingate tests in young soccer players.

**Methods:** In a counterbalanced and a random order, twenty junior male soccer players completed the Yo-Yo, the RSA, and the Wingate tests at two different times-of-day: 07:00 and 17:00 h. During the Yo-Yo test, the total distance (TD) covered and the estimated maximal aerobic velocity (MAV) were determined. The peak power (PP) during each sprint, the percentage of decrement of PP (PD) and total work (Wtotal) during the RSA test were, also, measured. In addition, during the Wingate test, the peak ( $P_{\text{peak}}$ ) and mean ( $P_{\text{mean}}$ ) powers were recorded.

**Results:** During the Wingate test,  $P_{\text{peak}}$  and  $P_{\text{mean}}$  were significantly higher at 17:00 than 07:00 h ( $P<0.05$ ) with diurnal gains of  $3.1\pm 3.6$  and  $2.9\pm 3.5$  % respectively. During the RSA test, PP during the first two sprints, Pdec and Wtotal were, also, higher in the evening ( $P<0.05$ ) with amplitudes of  $4.8\pm 4.6$ ,  $3.1\pm 3.0$ ,  $13.1\pm 32.1$ , and  $4.1\pm 2.5$  % respectively. Likewise, TD and MAV during the Yo-Yo test were higher at 17:00 than 07:00 h with diurnal gains of  $13.1\pm 10.7$  and  $4.2\pm 3.3$  respectively.

**Conclusions:** The present study confirms the daily variations of both aerobic and anaerobic performances during the Yo-Yo, the RSA, and the Wingate tests in trained young Tunisian soccer players.

*Asian Journal of Sports Medicine, Volume 3 (Number 3), September 2012, Pages: 139-144*

## INTRODUCTION

During short-term maximal exercises, the diurnal variation of muscle power has been well established with early morning nadirs and peak performances in the late afternoon<sup>[1-15]</sup>. Indeed, during the Wingate test, peak ( $P_{\text{peak}}$ ) and mean ( $P_{\text{mean}}$ ) power fluctuate with time-of-day, with an acrophase (peak) at  $17:24\pm 00:36$  h and  $18:00\pm 01:01$  h respectively, and an amplitude of  $7.6\pm 0.8\%$  and  $11.3\pm 1.1\%$  respectively<sup>[14]</sup>. However, during the vertical jump tests (i.e. squat jump and counter movement jump) Blonc et al<sup>[16]</sup> failed to show any time-of-day effect. They suggested that the

passive warm-up effect of the environment may blunt the diurnal rhythm of short-term maximal performance.

Moreover, during repeated sprints or cycling (RSA) tests, performances present the common characteristic to be better in the afternoon (i.e. ~17:00-18:00 h) than in the morning (i.e. ~06:00-07:00 h). Indeed, most of the studies consistently reported higher muscle power (PP) in the afternoon than the morning<sup>[17-20]</sup>; however, this diurnal variation is attenuated when sprints or cycling bouts were repeated<sup>[17-20]</sup>, suggesting a possible higher muscle fatigue at the time of the performance peaks<sup>[17,18]</sup>.

However, data examining the effect of time-of-day

on long-duration exercise performances appear to be equivocal. In most studies, such diurnal variation is attenuated or seems to dissipate when exercise is prolonged (i.e. for long duration aerobic exercise) [18,21,22]. Indeed, during laboratory testing, although some studies reported that maximal oxygen consumption ( $VO_{2\max}$ ), ventilator thresholds and/or running/cycling economy fluctuate with the time-of-day [23,24], most studies failed to observe any biorhythmic fluctuations [25-29]. However, during field testing, a recent study showed that performances during the Yo-Yo intermittent recovery test (i.e. a progressive shuttle run test) were significantly higher in the evening compared to the morning. Likewise, Souissi et al [22] showed that performance during this test was slightly higher (i.e. not-significant difference) in the evening (i.e., 20:00 h) compared to the afternoon (i.e. 14:00 h). This non-significant difference could be due to the selection of the times of testing.

Most of these studies investigated the diurnal variation of performances in sedentary or active subjects (i.e. physical education students). However, since Atkinson et al [30] showed that the amplitude of the diurnal rhythm is higher in trained compared to untrained subjects, the aim of the present study was to assess the effects of time-of-day on aerobic and anaerobic performances during field testing (i.e. the Yo-Yo, RSA and the Wingate tests) in young trained soccer players.

## METHODS AND SUBJECTS

### **Participants:**

Twenty soccer players (age:  $17.6 \pm 0.6$  yr; weight:  $71.3 \pm 4.8$  Kg; height:  $181.3 \pm 5.4$  cm; experience:  $5 \pm 1$  yr) volunteered to participate in this study. After receiving a description of the protocol each volunteer provided written informed consent. The study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the Clinical Research Ethics Committee and the Ethic Committee of the National Centre of Medicine and Science of Sports of Tunis (CNMSS).

### **Experimental Design:**

Soccer players participated in three specific tests (Yo-Yo test,  $5 \times 6$  s RSA and Wingate tests) at two times a day: 07:00 and 17:00 h in a randomized order over two days with a minimum recovery period of 36 h. These time points were chosen as they are generally reported in the literature as phases of the minimum (i.e. 07:00 h) and maximum (i.e. 17:00 h) daytime levels of physical performances [14]. All players were already familiar with the testing procedures as it was part of their usual fitness assessment program. Body mass was measured using an electronic scale (Tanita, Tokyo, Japan).

On the night preceding each test session, subjects were asked to keep their usual sleeping habits, with a minimum of 6-h sleep. Moreover, participants were requested to maintain their habitual physical activity and to avoid strenuous activity in the day before each test session. Before the morning test session, subjects were instructed to wake up at 06:00 h and they were asked to come to the laboratory at 07:00 h in a fasting state (i.e. only one glass (15 to 20 cl) of water was allowed). Before the evening test session, they had the same standard isocaloric meal at 12:00 h. After that meal, only water was allowed *ad libitum*.

During the entire experimental period, the mean ambient temperature and relative humidity of the laboratory were kept stable ( $21.1 \pm 1.1$  °C and  $44.3 \pm 7.6\%$ , respectively) in order to minimize potential effects of ambient temperature changes on the muscular system (Blonc et al. [16]).

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

The Yo-Yo intermittent recovery test consisted of 20-m shuttle runs performed at increasing velocities with 10 s of active recovery between runs until exhaustion. The velocity was adjusted according to the audio cues of the Yo-Yo test recorded on a CD (www.teknosport.com, Ancona, Italy) and broadcasted using a portable CD player (Philips, Az1030 CD player, Eindhoven, Holland). The end of the test was considered when the participant twice failed to reach the front line in time or he felt unable to complete another shuttle at the dictated speed. The total distance (TD) covered during the test and the maximal aerobic velocity (MAV) were calculated and stored for further analyses.

**Cycling tests (i.e. the repeated sprint ability (RSA), and the Wingate tests):**

The RSA and Wingate test was conducted on a friction-loaded cycle ergometer (Monark 894<sup>E</sup>, Stockholm, Sweden) interfaced with a microcomputer. As previously described by Chtourou et al.<sup>[31,32]</sup>, the test consisted of 5 × 6 s maximal sprints every 30 s (i.e. 24-s of passive recovery) against a constant resistance of 60 g • kg<sup>-1</sup> of body mass. However, the Wingate test consisted of a continuous 30-s maximal sprint against a constant resistance of 87 g • kg<sup>-1</sup> body.

Before starting each test, subjects performed a pre-test warm-up consisting of 5 min cycling at 84 W, followed by 3 min of rest and then by a 10 s maximal sprint test. The first 6 s of the 10 s sprint was used as the criterion score during the subsequent RSA cycle test. Upon completion of the 10 s test, subjects rested for 5 min before performing the RSA or the Wingate cycle test.

During the RSA test, PP during each sprint, the percentage of decrement (PD) of PP, and total work (Wtotal) over the RSA were calculated. During the Wingate test, P<sub>peak</sub> and P<sub>mean</sub> were recorded at the end of the test.

**Statistical Analyses:**

All statistical tests were processed using STATISTICA Software (StatSoft, France). Mean and SD (standard deviation) values were calculated for each variable. Once the assumption of normality with the Shapiro-Wilk W-test was confirmed, parametric tests were performed. PP during each sprint of the RSA test was analyzed using the Fisher’s one-way analysis of variance (ANOVA) with repeated measures. A paired

Student’s t-test was used to investigate differences between morning and evening for the TD and VMA during the Yo-Yo, PD and Wtotal during the RSA, and P<sub>peak</sub> and P<sub>mean</sub> during the Wingate tests. A probability level of 0.05 was selected as the criterion for statistical significance.

**RESULTS**

**Wingate test:**

P<sub>peak</sub> and P<sub>mean</sub> were significantly higher in the evening than the morning (p<0.05) (Table 1).

The diurnal gains were 3.1 ± 3.6 and 2.9 ± 3.5 % for P<sub>peak</sub> and P<sub>mean</sub> respectively.

**RSA test:**

PP were significantly higher during 17:00 than 07:00 h test sessions only during the first two sprints (Fig. 1) with diurnal gains of 4.8 ± 4.6 and 3.1 ± 3.0 % for the sprint 1 and the sprint 2 respectively. However, these daily variations were suppressed when the sprints were repeated (i.e. for sprint 3, 4, and 5).

Moreover, Pdec and Wtotal were significantly higher in the evening than the morning (P<0.05) with an amplitude of 13.1 ± 32.1 and 4.1 ± 2.5 % respectively.

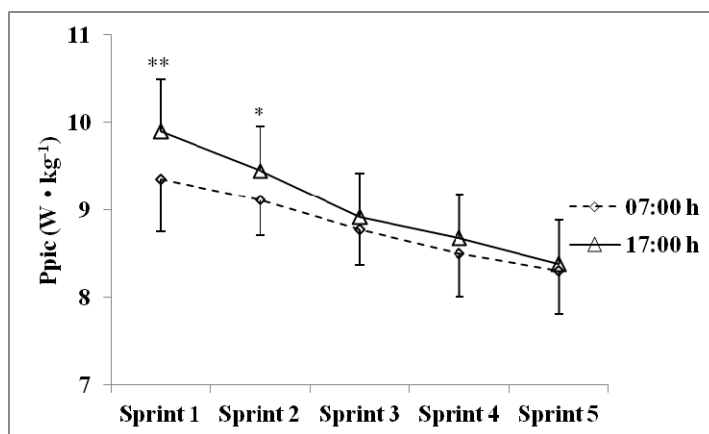
**Yo-Yo test:**

TD and MAV during the Yo-Yo intermittent recovery test were higher at 17:00 than 07:00 h. The diurnal gains were 13.1 ± 10.7 and 4.2 ± 3.3 % for TD and MAV respectively.

**Table 1:** Performances during the Wingate, RSA, and the Yo-Yo tests recorded in the morning and in the evening

Test		07:00 h Mean (SD)	17:00 h Mean (SD)	P value
Wingate	P <sub>peak</sub> (W • kg <sup>-1</sup> )	10.7 (1.2)	11.1 (0.9)	<0.01
	P <sub>mean</sub> (W • kg <sup>-1</sup> )	8.5 (0.6)	8.7 (0.4)	<0.05
RSA	Pdec (%)	6.8 (3.4)	8.5 (3.5)	<0.05
	Wtotal (W • kg <sup>-1</sup> )	43.3 (2.4)	45.1 (2.5)	<0.05
Yo-Yo	TD (m)	1764.6 (484.5)	2045.6 (534.5)	<0.05
	MAV (km • h <sup>-1</sup> )	16.3 (1.3)	17.0 (1.4)	<0.05

RSA: Repeated Sprints or Cycling; SD: Standard Deviation



**Fig. 1:** PP during the five sprints of the RSA test at 07:00 and 17:00 h  
 \*, \*\*: Significant difference in comparison with 07:00 h at the levels of  $P < 0.05$  and  $P < 0.01$

## DISCUSSION

This study was designed to assess the effects of time-of-day on aerobic and anaerobic performances during the Yo-Yo, repeated sprint ability (RSA) and the Wingate tests in young soccer players. The major finding of the present study is that aerobic and anaerobic performances of trained young soccer players fluctuate with the time-of-day. Indeed,  $P_{\text{peak}}$  and  $P_{\text{mean}}$  during the Wingate test, PP (i.e. during the first two sprints),  $P_{\text{dec}}$  and  $W_{\text{total}}$  during the RSA test; and TD and MAV during the Yo-Yo test were significantly higher at 17:00 than 07:00 h.

Concerning anaerobic performances (i.e. the Wingate test), the present study's results confirm those of previous studies in adult active subjects [1-3,5,9-15] or soccer players [4,6,17,18]. Likewise, the diurnal variation of short-term maximal performances was observed in boys [7, 8]. During the Wingate test, it has been showed that  $P_{\text{peak}}$  and  $P_{\text{mean}}$  powers fluctuate with time-of-day (i.e. circadian rhythmicity), with morning nadirs, afternoon/early evening highest values and a peak-to-trough amplitude equal to  $7.6 \pm 0.8\%$  and  $11.3 \pm 1.1\%$ , respectively [14].

For the repeated cycling exercise, the results of the present study also confirm those of the previous literature [17-20].

Consistent with this previous research, an increase of PP during the first two sprints was observed from the morning to the evening. This time-of-day effect

could be explained by the diurnal increase in central temperature during sprint cycling [19,20]. Therefore, it is possible that in the present study, the increase in muscle temperature following the first two sprints "cancelled" out the diurnal increase in central temperature on subsequent sprints. However, to confirm this hypothesis there is a need to measure the central temperature after each sprint of the repeated cycling exercise.

As mentioned above, short-term maximal single or repeated exercises' rhythms are parallel to the circadian variation in body temperature, peaking in the late afternoon. The increases in body temperature could exert a passive warm-up effect enhancing metabolic reactions, increasing the extensibility of connective tissue, reducing muscle viscosity, and increasing the conduction velocity of action potentials [2,3]. Moreover, previous studies reported that EMG activity level was not different between morning and evening testing during discontinuous [19] and continuous [5] cycling exercises. These studies suggested that the diurnal variations in maximal short-term performance are linked to peripheral, i.e. intramuscular, mechanisms rather than variation in central nervous command. Moreover, Souissi et al [12] have suggested that the daily variations of muscle power could be due to a higher aerobic contribution in energy production during the Wingate test in the evening than the morning.

Concerning aerobic exercises, the results of the present study showed a significant time-of-day effect on performances during the Yo-Yo intermittent recovery test. Although, literature's data reported equivocal findings concerning the daytime variations during long duration exercises, the present study confirms those of Hammouda et al.<sup>[18]</sup>. The authors showed that TD was significantly higher at 17:00 h than 07:00 h in young soccer players. However, as reviewed by Racinais<sup>[21]</sup>, the daily variations in maximal oxygen uptake have rarely been observed and studies that have reported significant diurnal variations showed weak amplitudes (i.e. 1-3.8%). To explain the diurnal rhythm of aerobic performances, previous studies have investigated the daily variations in physiological responses to laboratory-based exercise protocols. In this context, Reilly and Brooks<sup>[27]</sup> showed that heart rate and oxygen uptake responses to fixed sub-maximal intensities are higher in the late afternoon. "Likewise, Forsyth and Reilly<sup>[33]</sup> showed that the determination of the lactate threshold was affected by time of day in rowing, due to the lowered lactate response to set exercise at night time and in the morning<sup>[34]</sup>.

This study suffers from some limitations such as the inclusion of a control group to compare the amplitude of the rhythm between the footballers and the untrained subjects. Moreover, the present study could be completed by other investigations using more specific field testing with taking into account the environmental

conditions (i.e. as a previous study showed environmental changes affect the diurnal rhythm of sports performance<sup>[16]</sup>).

## CONCLUSION

The present study confirms the higher evening aerobic and anaerobic performances during the Yo-Yo, the RSA, and the Wingate tests in trained young Tunisian soccer players. This is an important point because it implies that all soccer players' training sessions cannot be programmed throughout the day without taking into consideration the time-of-day effect.

## ACKNOWLEDGMENTS

This study was supported by the Ministry of Higher Teaching and Scientific Research, Tunisia. We are grateful to all of the players who participated so willingly in the study. The protocol of the study was approved by the Clinical Research Ethics Committee of the National Centre of Medicine and Science of Sports of Tunis (CNMSS).

**Conflict of interests:** None

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