Journal of Fasting and Health
http://jfh.mums.ac.ir
JFH

Effect of Ramadan Fasting and Triangular Exercise Progressive on the Vigilance, Mood and Blood Glucose in Trained Athletes

Said Lotfi[1]*, Ilham Zerdani[2], Ahmed Aggour[1], Ahmed Fethddine[1], Abdelouaheb Tazi[3], Mohammed Talbi[4]

1. Research and Assessment Unit in Physical Activity and Sport (CREAPS), Superior Normal School (ENS), Hassan II University, Casablanca, Morocco
2. Department of Biology. Laboratory of Ecology and Environment (LEE). Faculty of Sciences, Hassan II University, Casablanca, Morocco
3. The Hassan II Foundation for Scientific and Medical Research on Ramadan (FRSMR), Faculty of Medicine and Pharmacy, Hassan II University, Casablanca, Morocco
4. Analytical chemistry laboratory and physical chemistry of materials, Hassan II University, Casablanca, Morocco

ARTICLE INFO

Article type:
Original article

Article History:
Received: 3 Oct 2015
Revised: 28 Oct 2015
Accepted: 29 Oct 2015
Published: 3 Nov 2015

Keywords:
Blood glucose
Mood
Ramadan fasting
Triangular exercise
Vigilance

ABSTRACT

Introduction: This study has for objective the assessment of the vigilance, mood states variations and the blood glucose levels, during a triangular effort progressive in trained athletes during Ramadan fasting (RF).
Methods: Ten trained male athletes aged 21.8 ± 1.1 years are evaluated before (B.RF), during (1st, 2nd and 3th week) and after Ramadan fasting, in the blood-glucose, vigilance, and mood states at rest and after (A. Ex.) a triangular exercise test (TUB II).
Results: Comparing to the reference period (B.RF), the RF induces a decrease in the maximal aerobic power (TUB II) approximately 2- 5% and a hypoglycaemia. The objective vigilance is doubly influenced by the RF ($F=14.58$, $P<0.002$) and the exercise ($F=13.04$, $P<0.02$), and decreasing significantly during the 1st and 2nd week of RF. However the subjective vigilance and moods states are not varied neither by the RF nor by the exercise.
Conclusion: The results should guide the work of physical education teachers and coaches to a programming by integrating more of periods of complete recovery, and avoiding risky tasks requiring sustained attention.

► *Please cite this paper as*:
Lotfi S, Zerdani I, Aggour A, Fethddine A. Tazi A, Talbi M. Effect of Ramadan Fasting and Triangular Exercise Progressive on the Vigilance, Mood and Blood Glucose in Trained Athletes. J Fasting Health. 2015; 3(3): 103-110.

Introduction

It is established in the literature under the usual conditions that the advent of a state of hypoglycaemia led to disturbances of vigilance, of vision, a fall of the sustained attention and a state of asthenia regardless of the nature of activity of the subject. Other studies have shown decreased alertness and a increase of the somnolence observed 30 min after a session training with a great energy expenditure. (1-3).

However, few studies have observed a slight hypoglycemia (lower of 100 mg/dl) at rest and after exercise in the conditions of food abstinence among the trained athletes at rest and after exercise during the Ramadan fasting (4,5).

The hypoglycemia, dehydration and disorders of sleep–wake cycle and eating schedule relatively impair some cognitive (6) and psychomotor functions, such as the daytime vigilance (7,8), level of the concentration (9,10), memory (6), recognition and total reaction time (11,12), perceived exertion of the training and sport performance (9,13-15).

It has been reported that fasting affects some psychological characteristics of athletes: an increase of sensation of tiredness, depression, confusion, anger, and some psychophysiological needs, and disorders mood (9, 15-18). From their responses, it can be concluded that the great majority of parameters were substantially impaired during and after physical exercise. An increase of the state and competitive anxiety, psychosomatic component scores, physiological needs and somatic reaction, psychological states, have also been found in competition periods during the Ramadan fasting (15). The comparison between fasting people and non-fasting people in some studies showed that the sportsmen in fasting suffer from discomfort

* *Corresponding author:* Lotfi Said, Research and Assessment Unit in Physical Activity and Sport (CREAPS), Superior Normal School (ENS), Hassan II University, Casablanca, Morocco. E-mail: lotfisaid@gmail.com

during Ramadan (9,13,19,20). These states have also observed in the students after the workout sessions of physical education. Few of studies which have investigated the blood glucose and psychological parameters during the resistance exercise and fasting in athletes (6,10,15,21). The objective of this study is the assessment of changes in glycemia, vigilance and moods states during a triangular effort progressive in trained athletes during Ramadan fasting.

Material and methods

Participants

Ten trained male athletes aged 21.8 ± 1.1 participated in this study, and were accepted for the investigation with their informed consent. All subjects engaged in at least two-hour training sessions, five times each week for 3 years, in a program in physical education and sports at university and continued their regular training program during Ramadan. All the subjects are musulmans, healthy, non smokers, and regularly faste Ramadan entirely, and all resident in university city. They are selectionned from 1500 m run test (presented a higher correlation with the TUB II).

Tests

Body Weight. It was measured to the nearest 0.1 kg using an electronic body weight scale ((Seca Instruments Ltd., Germany). The subjects are evaluated an hour before the beginning of the tests. The taken measures is performed feet nude and with a slight held of sport.

Test of the University of Bordeaux II (TUB II) developed by Cazorla and Léger (1993) (22). It is a progressive triangle test with stages of 3 min of race interspersed by periods of rest during one min. The test lasts approximately 40 minutes and evaluates the speed maximum aerobic with the incomplete recoveries. The test consists of running on a track, with markers every 25 m, for a succession of stages each of 3 minutes duration, beginning at 14 km h-1 and increasing by 2 $km.h^{-1}$ up to 18 $km.h^{-1}$, then by 1 $km.h^{-1}$ to the superior speeds. These stages are separated by one minute of recovery (to allow a sample of blood to be taken). At each stage, the athletes should follow the speed imposed by a broadcasting device of sound signals (which replaces the usual cassette). The test is stopped when the athletes are not capable any more of following the rhythm imposed by the signals and are unable to make the mark by the signal. The last stage announced is the performance of the subject corresponding to the sum of the time (in seconds) made in each bearing.

The validation of the TUB II was carried out from the reference tests: Leger and Boucher Test (1980) and the VAM-Eval Test, estimating the Maximal Aerobic Speed level (MAS) developed by Cazorla and Léger (1993) (22) and Hourcade et al., (1997) (23). This corresponds to a test of 1500 m race ($r = 0.83$, $p<0.05$). The TUB II performances are significantly correlated with those of 800 m, and the values of K4 (portable gas analyzer) on the VO2 max, and the MAS.

Blood Glucose Levels. The evaluation of the level of glucose in the blood (mg/dl) was carried out in complete rest 15 minutes before the test of the TUB II and just after the last bearing carried out by the subject using a System Bionime Rightest TM GM 300 to test strip which the principle of measurement is based on the reaction with glucose oxidase.

Digital Substitution Chiffre-Symbole Test (DSST). The DSST is one the tests of the Wechsler Adult Intelligence Scale developed by Wechsler (WIAS, 2003) (24), through a coding-decoding of system of figures in symbols in 90 seconds. The performance of the subject is the number of boxes filled properly. The DSST is one subscale of WAIS, and has a good standardization sample and it is also considered to be reliable and valid in a large standardization sample. The validity of test (WAIS) as a measure of global intelligence. It is correlated highly with other IQ tests. The reliability coefficients (internal consistency) are .93 for the Performance IQ averaged across all age groups and .97 for the Verbal IQ, with an r of .97 for the full scale. DSST scores have been shown to be significantly correlated with tests of fine motor speed and motor dexterity. The reliability coefficients are very strong (split half reliability coefficient is .95+; test-retest is 0.83).

The subjects have already undergone a training to this test to limit the effects of learning. This test is administered 15 minutes after the exercise.

Visual Analogue Scale (VAS.) The Visual Analog Scale is a self-assessment. It is widely used due to its simplicity and adaptability to a broad range of populations in several parameters. Its usefulness has been validated in by several works, and is

known as a methodologically sound instrument for quantitative assessment of neuropsychological parameters and detection the clinical changes. This scale is sensitive, reproducible, reliable and validated and has a good acceptability. For construct validity, the VAS scores are correlated with the interval scales, the psychological scales, and the clinical interviews, and is highly correlated with a 5-point verbal descriptive scale ("nil," "mild," "moderate," "severe," and "very severe") and with wide Numeric Rating Scales. The reliability (test–retest reliability) is very high (r: .94+).

In our study, VAS assesses seven states of mood on a visual scale horizontal to 10 cm (25). Three variables include the general vigilance (energetic, drowsiness and tiredness) and four other variables include the general mood (happy, in form, anxiety and clumsiness), calculated through the formulas proposed by Monk (1989) (26).

Subjective Alertness (SA): SA= [energetic + 200 - (drowsiness + tiredness)] / 4.

General Mood (GM): GM = [happy + In + form 200 - (anxious + clumsiness)] /4.

Research Design

The study was conducted in the Laboratory of Research and Assessment in Physical Activity and Sport (CREAPS), Hassan II University, Casablanca (Morocco) All evaluations are carried out in the afternoon (15- 16h: 30 mn), after 9-10 h of fasting, one week before (B.RF), three times during Ramadan fasting: the first (1st W), second (2nd W) and the third week (3th W) and once after two weeks of the end of Ramadan month (A.RF). The ambient temperature is 20-25 degree Celsius. Five minutes of heating in the form of stretch have been carried out prior to the beginning of the tests. No physical effort was provided by the athletes the morning. The blood glucose level, DSST and VAS are administered at rest (30 min before) and 15 min after the TUB II (A.Ex).

Data Analysis

The results were analyzed using the test of analysis of variance (ANOVA) to a factor with repeated measures for the body weight and the TUB II. Friedman's ANOVA by rank test was used if the normality test failed. The ANOVA two factors is carried out for the Blood glucose level, DSST and VAS values. The post-hoc analyzes have been carried out by the non-parametric Wilcoxon test for paired samples for each variable, with B.R taken as the reference period compared to other periods of evaluation; and the threshold of significance is 0.05 . The data have been processed with SPSS (SPSS Inc. Chicago, IL, version 22).

Results

The means and standard deviations of physical performance, body weight, blood glucose and mood states and vigilance recorded during and outside of Ramadan fasting are presented in Table 1.

Table 1. Variation of body weight, TUB II performance (sec), blood glucose (mg/l), vigilance and moods states before, during and after Ramadan fasting. The reported values are expressed as mean ± sd.

Parameters		B.RF	1st W	2nd W	A.RF	ANOVA	
						F	*p*
Body Wight (kg)		74.3±8.78	74.3 ±8.92	74.1±9.15	75.05±8.96	-	Ns
TUB II (sec)		751.7±159.03	768.4*±156.40	796.0*±189.13	777*±191.50	2.98	0.04[a]
Blood glucose (mg/l)	Rest	84.5±15.7	74.4±8.27 *	75.7 ±8.88 *	78.4 ±11.16	3.72	0.03[a]
	A.Ex	109.5±24.15	80 ±14.65 [a *]	83.7 ±18.8	97.3 ±23.13	-	NS
DSST	Rest	59.37 ±11.85	44.4 ±11.25 *	51±10.67 *	58.66 ±10.65	14.58	0.002[a]
	A.Ex	61.87±10.31	47.1 ±11.74 * †	53.5 ±12.38*†	59.44 ±12.62*	13.04	0.02[b]
Subjective Alertness	Rest	48.65±0.827	48.67±0.755	48.77±1.07	48.41 ±1225	-	NS
	A.Ex	48.31±1.05	48.12±1.06	48.31±1.34	48.36±1.26	-	NS
General Mood	Rest	51,225±1.293	50.3±1.343	50.60±1.248	50.52±1.12	-	NS
	A.Ex	50.75±0.92	50.77±1.261	50.60±1.237	50.41±1.42	-	NS

a: effect of Ramadan fasting; b: effect of the exercise

*significant at p < 0.05; **: significant at p< 0.01. Comparison to B.RF compared by the Wilcoxon test

†: Comparison between the scores obtained at rest and A.Ex (after exercise) by the Wilcoxon test (p<0.05)

Physical performance values obtained by the TUB II are influenced significantly by the Ramadan fasting (F= 2.98, p< 0.04). The average performance gradually decreases during the 1st W, 2nd W and 3nd W and A.RF respectively of 2.22 %, 5.89%, 5.10% and 3.37 %. The values of the body weight do not undergo any significant variation compared to the initial values.

The ANOVA II shows the significant effect of fasting (F = 3.7, p<0.03) on the values of the blood glucose levels and no effect of the exercise and its interaction with the fasting. The post hoc comparisons show that the average at the rest decrease during the 1stW (84.5 ± 74.4 vs 15.7 ±8.27, p<0.002), 2nd W (84.5 ± 75.7 vs 15.7 ±8.88, p<0.04), and 3nd W (84.5 ±15.7 vs 77.66 ±8.88, p<0.05) compared to the B.RF values respectively -11.95 %, -10.52 % and - 8.31 %. The blood glucose levels after 15 min of the exercise show a slight tendency to increase compared to the rest values in the 1stW (84.5 ±15.7 ±14.65 vs 80, p<0.05). However, the average the blood glucose levels at rest and after exercise remain below 1g/l.

The results of the objective vigilance show a significant effect of Ramadan (p<0.002) and of the physical exercise (p<0.02) on the scores of DSST. In effect, the average of the DSST, compared to the reference period, decreases significantly during the 1st W (at rest of -25.21 %, A.Ex. of -23.87, p<0.05), the W2 (at rest of -14.10 %, A.Ex to -13.53 %, p<0.05), and the 3st W (at rest of -6.86 %, A.Ex. of -8.84 %, p<0.05). No significant variation is observed nor between B.RF and A.RF and neither between 3st W and A.RF, even if it shows a slight increase.

The posthoc comparison, shows that the DSST scores recorded A.Ex. compared to rest period increase significantly (p<0.05) during Ramadan (1st W of +6.08 %; 2ndW of +4.90 %). In outside of Ramadan, the comparisons of scores pre and post TUB II are not significant.

However, the scores recorded on the subjective alertness, general mood evaluated by the VAS are modified neither by fasting nor by physical exercise.

Discussion

This study was designed to assess variations in the vigilance, mood states and glycemia during a triangular effort progressive in trained athletes during Ramadan fasting. The data obtained showed that fasting has influenced the performance of the TUB II, this a triangular exercise progressive mobilized the maximum aerobic power (MAP), and the metabolic intermediate power by high speeds gradually of the stages of 3 min interspersed by intervals of recovery of 1 min. This last is of more and more incomplete when the imposed running speed gradually increases. During the first levels (12-4 km/h), it requests the metabolism aerobic. In effect the rest minute is relatively sufficient for the cardiovascular recovery (27). But, the latest levels achieved by the subjects, mobilize more and more the anaerobic metabolism, with a large production of lactate (28). The contribution in respiratory oxygen during the recovery of a minute becomes incomplete to oxidize completely the lactic acid product reaching 8 to 16 mmol/l to the stage 16 km/h. Consequently, the subjects are forced to stop by the speed imposed by the test. The main results of this study revealed a significant decrease in physical performance values obtained by the TUB II, reaching 2-5% during the Ramadan fasting comparing to the reference period (B.RF). According to our results, it has found in literature a reductions in the maximum aerobic power (MAP), and the VO_2max in the sedentary subjects (29), and trained athletes (16,19,30,31) in the similar tests (23). However, the variations in these finding are very broad ranging from 2.7 to 22 %, they depend probably of the sports training styles.

The last review of literature has concluded that when the water level in the body is reduced to more than 2 %, a alteration of the performance in endurance is highly likely (2). Moreover, when the dehydration is combined with the reducing of hepatic glycogen level (hypoglycemia threshold) and without energy intake, the physical performance is compromised automatically (32). The flow of blood in muscle and the muscle glycogen use are reduced consequently (33) led to the reduction of the exercise intensity (34).

The variations of the values of the body weight observed in our work are not significant during Ramadan, despite the disruption of the food system. This finding is in concordance with the results identified in footballers (9,13,35), runners (16,36) and the power athletes (17). Although the training sessions are 3 to 5 times

per week. The constancy of this parameter is often interpreted as the resultant of the balance between the intake and energy expenditure.

The results obtained through this study on the blood glucose levels show a significant effect of fasting, and an absence of triangular exercise progressive effect (TUB II) with average values always to below 100 mg/dl during and outside of the Ramadan. This decline may be linked to several physiological factors. In fact, previous studies have shown that, during Ramadan fasting, the athletes are subject to a severe hypoglycaemia after the exercise (4,5,37) due to water loss, electrolytic no restored and an increase of the osmolarity (38). Consequently, it induces thermoregulation disorders (3,39), and an hypovigilance (7,38,40), and a decrease in physical performance and rate of sports training (41,42).

However, we have observed in our results, that hypoglycaemia is reduced more and more during Ramadan fasting (-11.95 %; -10.52 %; -8.31 %) demonstrating the process of the body's adaptation to fasting. In addition, the stability of the blood glucose levels after the exercise in relation to the period B.RF and its slight tendency to increase in relation to the rest, found in our work, is also observed by other studies in sedentary and athletes (37,43), and is the result of Cori cycle activation and the effect of insulin on blood glucose levels during the recovery period.

Through our results, the levels of vigilance objective (DSST) are doubly influenced by the effect of fasting and the effect of the exercise. The decrease of the vigilance at rest during Ramadan fasting compared to the reference period, can be explained by the circadian rhythm disturbance (7,44,45), the sleep disorders (9), the hypohydratation, and the blood glucose decreasing. This hypoglycemia often reduces the functions cognitive (46). These results were consistent with some studies which showed deterioration (less 20 %) of the concentration and subjective vigilance during Ramadan in sedentary subjects and athletes (7,10,9). However, Lotfi et al, (2010) (6) showed in their results that the intermittent fasting imply differently effects on cognitive functions (work memory, visual perception, errors performances) and physiological parameters.

However, the increase in scores of the vigilance objective post-exercise found in our study, is the result of three factors: the effect of the increase in blood glucose levels after the exercise compared to the rest values, the effect of heat delayed after the exercise (47) and the neurostimulant effect of exercise on the cerebral cortex (production of dopamine, norepinephrine, and serotonin) acting as activating factor on the cognitive performance (48).

However, these effects only last about twenty minutes following the activity load and the moment of training. In fact, ours observations were only measured just 15 min after the end of the exercise and some residual implicit exercise effect on the cognitive vigilance activation may still occur during this period and consequently the physical exercise has a counterbalancing effect.

However the subjective alertness and general mood evaluated in our results show that they are not affected by neither the fasting and nor by the exercise. When the subjects are called to express their psychological states by the VAS, they tend to demonstrate the constancy of their psychological states, and to underestimate the exercise and fasting effect: so they declared that they are as usual less sleepy, less tired, less clumsy, less anxious, more energetic, happy, and in a good physical fit. This result is confirmed by some studies, which observed no variation of the subjective perception of the tiredness and the training load in trained athletes during Ramadan fasting (8,9). This result is confirmed by some studies, which observed no variation of the subjective perception of the tiredness and the training load in trained athletes during Ramadan fasting (9,10,36). However, these findings remain opposed to some descriptive and experimental studies which confirmed the deterioration of mood states and the increase of malaise in the sedentary subjects and trained athletes such as anxiety, drowsiness, irritability, tiredness, nervousness, hunger, thirst, headache, dizziness, digestive disorders, and psychosomatic reactions (8-10,15-17,49). Several studies are required to identify the fasting and exercise conditions on vigilance levels, on the university students' achievement and on shift workers performance during Ramadan, weighted as a function of sex, age, and the level of the physical condition.

Conclusion

The Ramadan fasting induces a decrease in the maximal aerobic power and a hypoglycemia in the athletes trained. The disruption of the circadian rhythm and the lack of energy intake are the main causes. These factors have led to an alteration of the objective vigilance at rest. However, the physical exercise counterbalances slightly the fasting effect just after. In addition the states of mood and the subjective alertness are not modified by fasting effects and physical exercise. But, if the triangular exercise progressive is prolonged and carried out in a hot climate, the alterations of energy processes and cognitive will be more important,

The results obtained by our study should guide the work of teachers and coaches to a reprogramming integrating more of periods of complete recovery, and avoiding risky tasks requiring sustained attention.

Acknowledgment

This study was supported by Hassan II Foundation for Scientific and Medical Research on Ramadan. We are grateful to the subjects who volunteered for this study. We also thank Badaoui Rachid for his assistance in the preparation of the manuscript.

References

1. Krifi M, Ben Salem M, Ben Rayana MC, Alsuemi C, Ben Farhat N, Triki S, et al. Ramadan, activité physique et variations biologiques. J Med Nutr. 1989; 25(4):223-9.
2. Judelson DA, Maresh CM, Anderson JM, Armstrong LE, Casa DJ, Kraemer WJ, et al. Hydration and muscular performance: does fluid balance affect strength, power and high-intensity endurance? Sports Med. 2007; 37(10):907–21.
3. Sawka MN, Noakes TD. Does dehydration impair exercise performance? Med Sci Sports Exerc. 2007; 39(8):1209–17.
4. Faye J, Fall A, Badji L, Cisse F, Stephan H, Tine P. Effects of Ramadan fast on weight, performance, and glycemia during training for resistance. Dakar Med. 2005; 50(3):146–51.
5. Haghdoost AA, Poorranjbar M. The interaction between physical activity and fasting on the serum lipid profile during Ramadan. Singapore Med J. 2009; 50(9):897-901.
6. Lotfi S, Madani M, Tazi A. Boumahmaza M, Talbi M. Variation of cognitive functions and glycemia during physical exercise in Ramadan fasting. Rev Neurol (Paris). 2010; 166(8-9):721–6.
7. Lotfi S, Madani M, Tazi A, Zerdani I, Boumahmaza M, Talbi M. Variations de la vigilance, de la fréquence cardiaque, et de la température corporelle au cours des exercices physiques pendant le jeune de ramadan. Ann Afr Med. 2013; 6(2):1113-23
8. Aziz AR, Chia M, Wahid MF, Png W, Wong JT, Teh KC. Effects of Ramadan fasting on maximal bench press strength performance in trained athletes. Proceedings of the III International Conference of Physical Education and Sports Science. Singapore; 2010.
9. Leiper JB, Junge A, Maughan RJ, Zerguini Y, Dvorak J. Alteration of subjective feelings in football players undertaking their usual training and match schedule during the Ramadan fast. J Sports Sci. 2008; 26(Suppl 3):S55–69.
10. Aziz AR, Wahid MF, Png W, Jesuvadian CV. Effects of Ramadan fasting on 60 min of endurance running performance in moderately trained men. Br J Sports Med. 2010; 44(7):516-21.
11. Lotfi S, Madani M, Tazi A, Boumahmaza M, Talbi M. CNS Activation, reaction time, blood pressure and heart rate variation during ramadan intermittent fasting and exercise. World J Sports Sci. 2010; 3(1):37-43.
12. Ali MR, Amir T. Effects of fasting on visual flicker fusion. Percept Mot Skills. 1989; 69(2):627-31.
13. Zerguini Y, Kirkendall D, Junge A, Dvorak J. Impact Of Ramadan on physical performance in professional soccer players. Br J Sports Med. 2007; 41(6):398-400.
14. Waterhouse J. Effects of Ramadan on physical performance: chronobiological considerations. Br J Sports Med. 2010; 44(7):509–15.
15. Lotfi S, Rahmoun S, Saydi S, Madani M, Tazi A, Talbi M. Changes in states of anxiety and psychosomatic reactions in competition periods during the ramadan fasting. Int J Adv Psychol. 2013; 2(2):112-7.
16. Chennaoui M, Desgorces F, Drogou C, Boudjemaa B, Tomaszewski A, Depiesse F, et al. Effects of Ramadan fasting on physical performance and metabolic, hormonal, and inflammatory parameters in middle-distance runners. Appl Physiol Nutr Metab. 2009; 34(4):587–94.
17. Karli U, Guvenc A, Aslan A, Hazir T, Acikada C. Influence of Ramadan fasting on anaerobic performance and recovery following short time high intensity exercise. J Sports Sci Med. 2007; 6(4):490–7.
18. Chaouachi A, Coutts AJ, Chamari K, Wong del P, Chaouachi M, Chtara M, et al. Effect of Ramadan intermittent fasting on aerobic and anaerobic performance and perception of fatigue in male elite judo athletes. J Strength Cond Res. 2009; 23(9):2702-9.

19. Kinugasa T, Nair G, Aziz AR. Effects of Ramadan fasting on physical performance and psychological characteristics in youth soccer players. Proceedings of the III International Conference of Physical Education and Sports Science. Singapore; 2010.
20. Khalfallah T, Chaari N, Henchi MA, Merchaoui I, Bchir N, Akrout M, et al. Evaluation de l'impact du jeune du mois de Ramadan sur la charge physique de travail. Arch Des Maladies Profession Env. 2003; 65(7):564-70.
21. Boussif M, Bigard AX, Chalabi H, Guezennec CY. Effets du jeûne de Ramadan sur les performances physiques et la consommation maximale d'oxygène (VO2 max) chez les coureurs de demi-fond et les footballeurs. Revue Sci Staps. 2010; 17(7):27-37.
22. Cazorla G, Léger L. Comment évaluer et développer vos capacités aérobies: epreuves de course navette et épreuve VAMEVAL. AREAPS.1993; 2:123.
23. Hourcade JC. Etude comparative de deux tests de terrain: le test de l'Université Victor Segalen Bordeaux 2 (TUB 2) et le VAMEVAL. Mémoire pour le diplôme de Maîtrise en STAPS. Bordeaux, France: Faculte des Sciences du Sports et de I'Education Physique de Bordeaux; 1997.
24. Wechsler D. Adult Intelligence Scale (WAIS III). Paris: Centre de Psychologie Appliquée; 2003.
25. Hindmarch I. Psychomotor function and psychoactive drugs. 1980. Br J Clin Pharmacol. 2004; 58(7):S720-40.
26. Monk TH. A Visual Analogue Scale technique to measure global vigor and affect. Psychiatry Res. 1989; 27(1):89-99.
27. Cazorla G, Hourcade JC. Etude comparative de deux tests de terrain: le test de l'Université Victor Segalen Bordeaux 2 (TUB II) et le VAMEVAL. Mémoire pour le diplôme de Maîtrise en STAPS. Bordeaux, France: Faculté des Sciences du Sport et de l'Education Physique de Bordeaux; 1997.
28. Cazorla G, Boussaidi L, Godemet M. Evaluation du rugbyman sur le terrain. Actes du Congrès médical de la Fédération Française de Rugby: Pathologies du rugbyman, épaule, genoux, rachis, physiologie. Deed of Medical Congress of French Federation of Rugby, Lyon, France; 2004. P. 435-56.
29. Khedder A, Achour N, Asou Messad N, Souzayen A, Nacef T. Etude comparative de l'adaptation de l'organisme à l'effort sur ergocycle pendant et après Ramadan. Méd du sport. 1983; 4:16-7.
30. Fall A, Sarr M, Mandengue SH, Badji L, Samb A, Gueye L, et al. Effets d'une restriction hydrique et alimentaire prolongée (ramadan) sur la performance et les réponses cardiovasculaires au cours d'un exercice incrémental en milieu tropical chaud. Sci Sports. 2007; 22(1):50–3.
31. Brikci A, Faynot R, Davenne D. Ramadan et pratique physique. Dans: Bulletin de liaison des professeurs d'éducation physique de l'académie de Reims nº 23-24. Académie de Reims. 2000; 3:3-9.
32. Below PR, Mora-Rodriguez R, Gonzalez-Alonso J, Coyle EF. Fluid and carbohydrate ingestion independently improve performance during 1 h of intense exercise. Med Sci Sports Exerc. 1995; 27(2):200–10.
33. González-Alonso J, Calbet JA, Nielsen B. Metabolic and thermodynamic responses to dehydration-induced reductions in muscle blood flow in exercising humans. J Physiol. 1999; 520(Pt 2):577–89.
34. Rauch HG, St Clair Gibson A, Lambert EV, Noakes TD. A signalling role for muscle glycogen in the regulation of pace during prolonged exercise. Br J Sports Med. 2005; 39(1):34–8.
35. Meckel Y, Ismaeel A, Eliakim A. The effect of the Ramadan fast on physical performance and dietary habits in adolescent soccer players. Eur J Appl Physiol. 2008; 102(6):651–7.
36. Wahid MF, Aziz AR, Png W, Lai G, Jesuvadian C. Reproductibility of submaximal responses excise performance during endurance running in the Ramadan fasting month in moderately trained men. Singapore: Youth In Physical Education And Sport; 2010. P. 351-7.
37. Ba S, Seck D, Kane MO, Seck MB, Sarr FB, Ciss M, et al. Étude comparative de l'effet du jeûne pendant le Ramadan sur la glycémie au repos chez les sportifs et les sédentaires. Dakar Med. 2005; 50(1):22-51.
38. Ramadan JM, Barac-Nieto M. Cardio-respiratory responses to moderately heavy aerobic exercise during the Ramadan fasts. Saudi Med J. 2000; 21(3):238-44.
39. Zurovski Y, Eckstein L, Horowitz M. Heat stress and thermal dehydration: lactacidemia and plasma volume regulation. J Appl Physiol. 1991; 71(6):2434–9.
40. Naghii MR. The significance of water in sport and weight control. Nutr Health. 2000; 14(2):127–32.
41. Gisolfi CV, Copping JR. Thermal effect of prolonged treadmill exercise in the heat. 1974. Med Sci Sports Exerc. 1993; 25(3):310–5.
42. Greenleaf JE, Castle BL. Exercise temperature regulation in man during hypohydration and hyperhydration. J Appl Physiol. 1971; 30(6):847–53.
43. Sadraoui M, Tabka Z, Sfar H, Zebidi A. Evolution de certains paramètres métaboliques et hormonaux au cours du jeûne de Ramadan. Actes du 1er congrès international sur Ramadan et santé, Casablanca, Janvier; 1994.
44. Souissi N, Souissi M, Souissi H, Chamari K, Tabka Z, Dogui M, et al. Effect of time of day and partial

sleep deprivation on short-term, high-power output. Chronobiol Int. 2008; 25(6):1062–76.
45. Souissi N, Souissi H, Sahli S, Tabka Z, Dogui M, Ati J, et al. Effect of Ramadan on the diurnal variation in short-term high power output. Chronobiol Int. 2007; 24(5):991-1007.
46. Warren RE, Frier BM. Hypoglycaemia and cognitive function. Diabetes Obes Metab. 2005; 7(5):493–503.
47. Monk TH, Leng VC, Folkard S, Weitzman ED. Circadian rhythms in subjective alertness and core body temperature. Chronobiologia. 1983; 10(1):49-55.
48. Brisswalter J, Legros P. Interactions between energetical and cognitive process: theorical and methodological approaches. Sci Sports. 1996; 11(2):71-80
49. Chaouachi A, Coutts AJ, Wong del P, Roky R, Mbazaa A, Amri M, et al. Haematological, inflammatory, and immunological responses in elite judo athletes maintaining high training loads during Ramadan. Appl Physiol Nutr Metab. 2009; 34(5):907-15.