

Physical activity during Ramadan fasting: Effects on body composition, hematological and biochemical parameters.

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Abstract—Ramadan is the holiest month in the Islamic calendar. The uniqueness of Ramadan is that food and fluid intake is concentrated into the hours between sunset and the following sunrise. Many participants of Ramadan maintain physical activity during Ramadan. However, the effect of practicing physical activity during Ramadan on body composition, hematological and biochemical parameters is not well known. This review summarizes the health specific effects of Ramadan fasting in practitioners of physical activity and provides some practical recommendations supported by the evidence-based scientific literature.

Keywords—Ramadan fasting, dietary intake, physical activity, body composition, renal function, electrolytes, dehydration, immune system, inflammatory markers.

I. INTRODUCTION

Ramadan fasting, one of the five pillars of Islam, occurs during the 9th lunar month of the Islamic calendar (Aloui et al. 2012a,b). Throughout the world, millions of Muslims fast during Ramadan to fulfill this religious obligation (Chtourou et al. 2011, 2012). Ramadan month occurs eleven days earlier every year and thus over time may occur in any of the four seasons (Hamouda et al. 2012). Thus, the length of the daily fast during Ramadan varies from 11–18 hours in tropical countries (Chaouachi et al. 2012). During this holy month, Muslims are allowed to eat and drink only between sunset (*el moghreb*) and dawn (*el fajr*). Not only is the eating pattern greatly altered during the Ramadan period, but the amount and type of food eaten during the night may also be significantly different to that usually consumed during the rest of the year (Leiper et al. 2003). These dietary changes can influence substrate availability and utilization (Bouhleb et al. 2006, Chaouachi et al. 2008, Trabelsi et al. 2011a, Trabelsi et al. 2011b, Trabelsi et al. 2012a, Trabelsi et al. 2012b) and induce changes in hematological and biochemical parameters (Bouhleb et al. 2006, Trabelsi et al. 2011a, Trabelsi et al. 2011b, Trabelsi et al. 2012b).

Participants of Ramadan often maintain physical activity during the holy month for recreation and health purposes. However, sportsmen continue to practice physical activity during Ramadan to improve their performance in order to participate in national and international competitions. The sporting calendar is not modified for religious observances and that sporting events are programmed throughout the annual calendar (Kirkendall et al. 2008). For example, London 2012 Olympic Games will run from 27 of July to 12 of August, while Ramadan will start on July 21 and last until August 20. However, if the Ramadan falls in summer, practicing physical activity places additional stresses on electrolyte balance and also metabolism. This review will examine and summarize the current knowledge of the effects of practicing physical activity during Ramadan fasting on body composition, hematological and biochemical parameters. In addition, we formulate some practical recommendations for Muslim athletes, physically active men and coaches supported by the evidence-based scientific literature. The literature on the impact of Ramadan fasting on body composition, hematological and biochemical parameters was reviewed by using MEDLINE and SPORTDiscus database searches, and cross referencing these articles using the search terms of hydration, dehydration, fluid consumption, dietary intake, sport, hematological, biochemical, body composition and Ramadan fasting.

II. DIETARY INTAKE

Energy intake

Typically, two meals are consumed during Ramadan, one before sunrise and the other after sunset rather than three meals in the normal daily life. Consequently to this alteration in the time and number of meals, energy intake decreased during Ramadan in physically active men (Trabelsi et al. 2011a, Abdelmalek et al. 2011), female taekwondo players (Memari et al. 2011), rugby union (Bouhleb et al. 2006) and sevens players (Trabelsi

et al. 2011b). However, other investigations demonstrated an opposite results showing the energy intake of sportsmen did not change during Ramadan (Maughan et al. 2008, Karli et al. 2007, Chaouachi et al. 2008, Aziz et al. 2011, Brisswalter et al. 2011). A summary of available findings related to daily energy intake is presented in Table 1.

Macronutrient intake

The majority of findings related to macronutrient intake of sportsmen during Ramadan fasting are mixed. Carbohydrates intake of rugby union (Bouhleb et al. 2006) and sevens players (Trabelsi et al. 2011b) decreased during Ramadan and was about 4 g. Kg⁻¹.d⁻¹. The latter value is under 5 – 6 g.Kg⁻¹.d⁻¹ recommended for rugby players (Broad and Cox. 2008). However, carbohydrate intake of football players (about 7 – 8 g. Kg⁻¹.d⁻¹) did not change during Ramadan (Maughan et al. 2008) and is consistent with the recommendation that players should eat 5 – 7 g. Kg⁻¹.d⁻¹ during periods of light training and 7 – 12 g. Kg⁻¹.d⁻¹ during periods of heavy training (Burke et al. 2006, Hawley et al. 2006).

Dietary protein intakes decreased during Ramadan in rugby union (Bouhleb et al. 2006) and it remained unchanged in rugby sevens players (Trabelsi et al. 2011b). However, the value of about 1 g. Kg⁻¹.d⁻¹ recorded in the previous studies was under the recommended range (about 1.2 – 1.7 g. Kg⁻¹.d⁻¹) regardless the type of exercise (Tipton and Wolfe. 2004). Contrary to these observations, protein intake of football players did not change during Ramadan (Maughan et al. 2008) and was at the upper end of the recommended range for football players (Hawley et al. 2006).

Fat intake did not change during Ramadan in Judokas (Chaouachi et al. 2008), football players (Maughan et al. 2008), rugby union (Bouhleb et al. 2006) and sevens players (Trabelsi et al. 2011b). Expressed as percentage of energy intake, fat intake did not change during Ramadan compared to before Ramadan (Chaouachi et al. 2008, Maughan et al. 2008, Trabelsi et al. 2011b). However, levels of fat intake are higher than the recommendation for athletes which is around 20 – 25 % of total energy intake (Burke et al. 2006). These discrepant findings concerning energy and macronutrient intakes are believed to be due to the differences in eating habits between countries practicing Ramadan (Maughan et al. 2008). In addition, the limitation of the choice of food eaten such the special meals provided to football players (Maughan et al. 2008) can be a factor influencing findings concerning energy and macronutrient intakes.

Micronutrient intake

Regarding micronutrient intake, it was noticed a decrease in the consumption of saturated fatty acids and an increase in the consumption of monounsaturated fatty acids during Ramadan in rugby union players (Bouhleb et al. 2006). In contrast, polyunsaturated fatty acids intakes did not change during Ramadan (Bouhleb et al. 2006).

Sodium intakes decreased during Ramadan in football players (Maughan et al. 2008) suggesting lower salt content of the food eaten at this time (Maughan et al. 2008). Similarly, dietary iron intakes decreased during Ramadan; and were relatively high compared with the recommended intakes (Panel on micronutrient. 2001). Vitamin E and vitamin C consumption decreased during Ramadan in students of sports and physical education (Abdelmalek et al. 2011).

During Ramadan, athletes should try to adopt a general pattern of intake which is similar to that of the non fasting period; with the difference being the timing or schedule of the meal sitting. For examples, matching the Ramadan's sahur meal with the normal routine lunch meal; Ramadan's breaking fast meal with the dinner meal; and Ramadan's night snack with the breakfast meal (Aziz and Weileen. 2008).

Water intake

Total water intakes decreased in physically active men practicing aerobic exercise in fasted state during Ramadan (Trabelsi 2011a, Trabelsi et al. 2012a). The same finding was reported in rugby union (Bouhleb et al. 2006), sevens players (Trabelsi et al. 2011b) and recreational bodybuilders (Trabelsi et al. 2012b). In contrast, total water intakes did not change in physically active men practicing aerobic exercise in fed state during Ramadan (Trabelsi et al. 2012), football players (Maughan et al. 2008), football and basketball players (Aziz et al. 2011), well trained runners (Brisswalter et al. 2011) and Judokas (Chaouachi et al. 2008). During a single training session occurring in warm environmental condition, a loss of more than 3 liters of sweat can be noticed (Shirreffs et al. 2006). Notwithstanding the importance of adequate hydration on the health status of athletes and physical performance, a survey of the water intake during Ramadan month should be done to avoid dehydration. This can be done easily by weighing the athlete before and after training to determine the fluid loss that needs to be replaced. In fact, to ensure euhydration, athlete needs to consume 1.5 times of this amount (Coyle. 2004). In addition, drinking oral rehydration solutions that contain salt can aid rehydration (Maughan. 1998).

Body mass and body composition

Heterogeneous findings exist regarding the effect of Ramadan fasting on body mass and body composition of physical activity practitioners. Several studies indicated that physically active men can lose weight via aerobic training during Ramadan month (Trabelsi et al. 2012a, Ramadan et al. 1999, Haghdoost and PoorRanjbar et al. 2009, Aziz et al. 2011). Similarly, a decrease in body mass was noticed in football players

(Maughan et al. 2008), elite athletes from different sports (Kordi et al. 2011), Judokas (Chaouachi et al. 2008), rugby union (Bouhleb et al. 2006) and sevens players (Trabelsi et al. 2011b). In contrast, other studies indicated the absence of change in body weight during Ramadan in football players (Meckel et al. 2008, Güvenc. 2011), middle distance runners (Chennaoui et al. 2009, Brisswalter et al. 2011) and elite power athletes (Karli et al. 2007). See Table 2 for a presentation of available findings. The decrease in body mass was explained by several factors such as dehydration (Bouhleb et al. 2006, Trabelsi et al. 2011a, Trabelsi et al. 2011b, Trabelsi et al. 2012a), the decrease in caloric intake while maintaining the training schedule (Trabelsi et al. 2011b) and the increase of the utilization of stored body fat as energy substrate (Bouhleb et al. 2006, Trabelsi et al. 2011a, Trabelsi et al. 2011b, Trabelsi et al. 2012a).

Results concerning the effect of Ramadan fasting on body fat percentage are mixed. Physically active men practicing aerobic exercise in fasted state can lose body fat percentage during Ramadan (Trabelsi et al. 2012). The same finding has been reported in Judokas (Chaouachi et al. 2008), rugby union (Bouhleb et al. 2006) and sevens players (Trabelsi et al. 2011b). The decrease of body fat percentage can be explained by the increase of its utilization as energy substrate at rest and during exercise (Stannard. 2011). In contrast, the absence of change in body fat percentage has been reported in physically active men (Stannard and Thompson. 2008), recreational bodybuilders (Trabelsi et al. 2012b) middle distance runners (Chennaoui et al. 2009, Brisswalter et al. 2011), elite power athletes (Karli et al. 2007) and football players (Maughan et al. 2008). A summary of available findings pertaining to body fat percentage is presented in Table 3. These discrepant findings can be explained by factors such as different dietary intakes and exercise regimen. In addition, the different methods employed to measure the body fatness such as Skinfold thickness method (Trabelsi et al. 2011a, Trabelsi et al. 2011b, Trabelsi et al. 2012a, Trabelsi et al. 2012b, Bouhleb et al. 2006, Brisswalter et al. 2011), bioelectric impedance (Karli et al. 2007, Givenc. 2011) and underwater weighing (Stannard and Thompson. 2008) can explain the diverging findings. Clearly, including a non invasive reference method to measure body fatness (eg., DEXA) in future studies is warranted.

Hematological parameters

The few investigations that have examined the effects of Ramadan fasting on hematological parameters in physical activity practitioners have reported heterogeneous findings. In fact, an increase in hematocrit and a decrease in hemoglobin were noticed in Judokas (Chaouachi et al. 2008). However, football players experienced a decrease in hematocrit and hemoglobin during Ramadan (Maughan et al. 2008). In the other hand, hematocrit and hemoglobin have both been reported to increase in rugby union (Bouhleb et al. 2006) and sevens players (Trabelsi et al. 2011b) indicating a state of dehydration. The latter was attributed to the decrease in water intake during Ramadan (Trabelsi et al. 2001a, Trabelsi et al. 2011b, Bouhleb et al. 2006). Although, values of hematological parameters have been reported to be within the normal reference range for the laboratory (Trabelsi et al. 2011b). Tayebi et al (2010a) investigated the effect of weight-lifting training program during Ramadan on some hematological parameters. The authors reported no change in hematocrit, hemoglobin, red blood cell count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration and red cell distribution width. Similarly, blood platelets did not change during Ramadan (Trabelsi et al. 2011a, Tayebi et al. 2010a). This finding opposes the results of Ramadan et al. (1999) who attributed the decrease in blood platelets during Ramadan to a deficiency in specific micronutrients (iron and vitamins).

Biochemical parameters

Renal function markers

Results concerning the effect of Ramadan fasting on renal function markers of sportsmen are equivocal. Physically active men practicing moderate aerobic exercise before or after the break of fast experienced an increase in the creatinine clearance and indicating impairment in the renal function during Ramadan (Trabelsi et al. 2012). In addition, an increase in urea, creatinine and uric acid has been reported in subjects training before the break of fast (Trabelsi et al. 2012a). However, Ramadan et al (1999) reported an absence of change during Ramadan in the values of creatinine, urea and uric acid concentrations in physically active men. Football players experienced an increase in creatinine values, a decrease in the urea values and no change in uric acid values during Ramadan (Maughan et al. 2008). These discrepant findings are believed to be due to the hydration status of subjects.

Serum electrolytes

Serum sodium concentration, one indicator of the hydration status of athletes (Oppliger and Bartok. 2002), did not change during Ramadan in football players (Maughan et al. 2008) and physically active men (Ramadan et al. 1999).

Serum sodium and chloride concentrations increased during Ramadan in physically active men practicing moderate aerobic exercise in a fasted state (Trabelsi et al. 2012a). In contrast, those changes were absent when an equivalent amount of aerobic exercise was practiced in fed state (Trabelsi et al. 2012a). Thus, dehydration can be avoided by practicing aerobic exercise after the break of fast.

Inflammatory markers

Heterogeneous findings exist regarding the effect of training during Ramadan fasting on inflammatory markers. In fact, C-reactive protein increased in judokas (Chaouachi et al. 2009), decreased in football players (Maughan et al. 2008) and did not change in middle distance runners (Chennaoui et al. 2009) and recreational bodybuilders (Trabelsi et al. 2012b). While serum transferrin increased in football players (Maughan et al. 2008), it did not change in judokas during Ramadan (Chaouachi et al. 2009). Prealbumin, Albumin, Haptoglobin and homocysteine remained unchanged during Ramadan in Judokas (Chaouachi et al. 2009). Similarly, ferritin did not change during Ramadan in football players (Maughan et al. 2008).

Immune markers

The immune system can be affected by one month of energy restriction due to altered hydration status, hormonal status and serum iron level (Meckel et al. 2008). However, the opposite was also reported namely acute energy restriction can enhance antioxidant capacity and therefore improve immune system (Rankin et al. 2006). Therefore, this comes as no surprise if the results concerning the effect of training during Ramadan fasting on immune markers are equivocal. In fact, leucocytes decreased in football players training in the afternoon during Ramadan (Maughan et al. 2008) while it remained unchanged during Ramadan in Judokas (Chaouachi et al. 2009) and recreational bodybuilders (Trabelsi et al. 2012b). Neutrophils, lymphocytes and monocytes did not change in judokas (Chaouachi et al. 2009) and recreational bodybuilders (Trabelsi et al. 2012b). In contrast, immunoglobulin A and immunoglobulin G increased during Ramadan in judokas (Chaouachi et al. 2009).

Antioxidants markers

One study to date has examined the effect of Ramadan fasting on the antioxidant status of athletes. Judokas experienced an increase in blood levels of vitamin A and a decrease in blood levels of vitamin E during Ramadan (Chaouachi et al. 2009). Clearly, further researches including markers of oxidative stress are needed.

Lipid profile

The effect of the combination of Ramadan fasting and physical activity on the parameters of the lipid profile is controversial. Total cholesterol, high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) have each been shown to increase in Judokas (Chaouachi et al. 2008). However, only free fatty acid levels have been shown to increase in middle-distance runners (Chennaoui et al. 2009). In the other hand, Ramadan fasting coupled with resistance training did not affect any parameters of the lipid profile (Tayebi et al. 2010b).

Physically active men practicing aerobic exercise in a fasted state during Ramadan experienced an increase in blood levels of HDL-C (Trabelsi et al. 2012a). Increases in HDL-C have been shown to reduce the likelihood of developing atherosclerosis and cardiovascular artery disease (Gordon and Rifkind. 1989). Values of LDL-C did not change in physically active men practicing aerobic exercise during Ramadan (Trabelsi et al. 2012). The authors suggested an absence of change in the dietary saturated fat intake to explain this finding (Matisson and Grundy. 1985). Thus, meals containing high amount of dietary saturated fat must be avoided during Ramadan.

III, CONCLUSION

Practicing aerobic exercise during Ramadan can be used as a non-pharmaceutical strategy to reduce body fat as well as improving the lipid profile. However, the state of dehydration can be avoided by adequate fluid intakes during the nighttime and by minimizing the body water loss.

Elites and professional sportsmen can continue training during Ramadan with no adverse effect on the renal function and immune and inflammatory systems. Thus, continuance of training during Ramadan can be performed safely.

REFERENCES

- [1]. Abdelmalek, S., Souissi, N., Takayuki, A., Hadouk, S., & Tabka, Z. (2011). Effect of acute maximal exercise on circulating levels of interleukin-12 during Ramadan fasting. *Asian Journal of Sports Medicine*, 3, 154-160.
- [2]. Aloui, A., Chaouachi, A., Chtourou, H., Wong, D.P., Haddad, M., Chamari, K., & Souissi, N. (2012a). Effects of Ramadan on the Diurnal Variations of Repeated Sprints Performances. *International Journal of Sports Physiology and Performance* (In press).
- [3]. Aloui, A., Chtourou, H., Masmoudi, L., Chaouachi, A., Chamari, K., & Souissi, N. (2012b). Effects of Ramadan fasting on male judokas' performances in specific and non-specific judo tasks. *Biological Rhythm Research* (In press).
- [4]. Aziz, A.R., Slater, G.J., Hwa Chia, M.Y., & The K.C. (2011). Effects of Ramadan fasting on training induced adaptations to a seven-week high-intensity interval exercise programme. *Science & Sport*, 27, 31-38.
- [5]. Aziz, A.R., Wahid, M.F., Png, W., & Jesuvadian, C.V. (2010). Effects of Ramadan fasting on 60 min of endurance running performance in moderately trained men. *British Journal of Sports Medicine*, 44,516-521.

- [6]. Aziz, A.R., & Weilleen. (2008). Practical tips to exercise training during fasting month. *ISN Bulletin*, 1, 13-19.
- [7]. Bouhlel, E., Denguezli, M., Zaouali, M., Tabka, Z., & Shephard, R.J. (2008). Ramadan fastings effect on plasma leptin, adiponectin concentrations, and body composition in trained young men. *International Journal of Sport Nutrition and Exercise Metabolism*, 18, 617-627.
- [8]. Bouhlel, E., Salhi, Z., Bouhlel, H., Mdella, S., Amamou, A., Zaouali, M., . . . Shephard, R.J. (2006). Effect of Ramadan fasting on fuel oxidation during exercise in trained male rugby players. *Diabetes & Metabolism: Clinical and Experimental*, 32, 617-624.
- [9]. Brisswalter, J., Bouhlel, E., Falola, J.M., Abbiss, C.R., Vallier, J.M., & Hauswirth, C. (2011). Effects of Ramadan intermittent fasting on middle-distance running performance in well-trained runners. *Clinical Journal of Sport Medicine*, 21, 422-427.
- [10]. Broad, E.M; & Cox, G.R. (2008). What is the optimal composition of an athlete's diet?. *European Journal of Sport Science*, 8, 57-65.
- [11]. Burke, L. M., Loucks, A. B., & Broad, N. (2006). Energy and carbohydrate for training and recovery. *Journal of Sports Sciences*, 24, 675-685.
- [12]. Chaouachi, A., Chamari, K., Roky, R., Wong, P., Mbazaa, A., & Bartagi, Z. (2008). Lipid profiles of judo athletes during Ramadan. *International Journal of Sports Medicine*, 29, 282-288.
- [13]. Chaouachi, A., Coutts, A.J., Wong, D.P., Roky, R., Mbazaa, A., Amri, A., & Chamari, K. (2009b). Haematological, inflammatory, and immunological responses in elite judo athletes maintaining high training loads during Ramadan. *Applied Physiology Nutrition and Metabolism*, 34, 907-915.
- [14]. Chaouachi, A., Leiper, J.B., Chtourou, H., Aziz, A.R., & Chamari, K. (2012). The effects of Ramadan intermittent fasting on athletic performance: Recommendations for the maintenance of physical fitness. *Journal of Sports Science* 30, 53-73.
- [15]. Chennaoui, M., Desgorges, F., Drogou, C., Boudjemaa, B., Tomaszewski, A., Depiesse, F., . . Gomez-Merino, D. (2009). Effects of Ramadan fasting on physical performance and metabolic, hormonal, and inflammatory parameters in middle-distance runners. *Applied Physiology, Nutrition, and Metabolism*, 34, 587-594.
- [16]. Chtourou, H., Hammouda, O., Chaouachi, A., Chamari, K., & Souissi, N. (2012). The effect of time-of-day and Ramadan fasting on anaerobic performances. *International Journal of Sports Medicine* 33, 142-147.
- [17]. Chtourou, H., Hammouda, O., Souissi, H., Chamari, K., Chaouachi, A., & Souissi, N. (2011). The effect of Ramadan fasting on physical performances, mood state and perceived exertion in young footballers. *Asian Journal of Sports Medicine* 2, 177-185.
- [18]. Coyle, E.F. (2004). Fluid and fuel intake during exercise. *Journal of Sport Sciences*, 22, 39-55.
- [19]. Fall, A., Sarr, M., Mandengue, S.H., Badji, L., Samb, A., Gueye, L., & Cissé, F. (2007). Effects of prolonged water and food restriction (ramadan) on performance and cardiovascular responses during incremental exercise in tropical climate. *Science & Sports*, 22, 50-53.
- [20]. Gordon, D.J., & Rifkind, B.M. (1989). High-density lipoprotein--the clinical implications
- [21]. of recent studies. *The New England journal of medicine*, 321, 1311-1316
- [22]. Güvenç, A. (2011). Effects of Ramadan fasting on body composition, aerobic performance and lactate, heart rate and perceptual responses in young soccer players. *Journal of Human Kinetics*, 29, 79-91.
- [23]. Haghdoost, A.A., & PoorRanjbar, M. (2009). The interaction between physical activity and fasting on the serum lipid profile during Ramadan. *Singapore Medical Journal*, 50, 897-901.
- [24]. Hamouda, O., Chtourou, H., Farjallah, M.A., Davenne, D., & Souissi, N. (2012). The effect of Ramadan fasting on the diurnal variations in aerobic and anaerobic performances in Tunisian youth soccer players. *Biological Rhythm Research* 43, 177-190.
- [25]. Hawley, J. A., Tipton, K. D., & Millard-Stafford, M. L. (2006). Promoting training adaptations through nutritional interventions. *Journal of Sports Sciences*, 24, 709-721.
- [26]. Karli, U., Güvenç, A., Aslan, A., Hazir, T., & Acikada, C. (2007). Influence of Ramadan fasting on anaerobic performance and recovery following short time high intensity exercise. *Journal of Sports Science and Medicine*, 6, 490-497.
- [27]. Kirkendall, D. T., Leiper, J. B., Bartagi, Z., Dvorak, J., & Zerguini, Y. (2008). The influence of Ramadan on physical performance measures in young Muslim footballers. *Journal of Sports Sciences*, 26, 15-27.
- [28]. Kordi, R., Abdollahi, M., Memari, A.H., Najafabadi, M.G. (2011). Investigating two different training time frames during Ramadan fasting. *Asian Journal of Sports Medicine*, 2, 205-210.
- [29]. Leiper, J.B., Molla, A.M., & Molla, A.M. (2003). Effects on health of fluid restriction during fasting in Ramadan. *European Journal of Clinical Nutrition*. 57, 30-38.
- [30]. Mattison, F.H., & Grundy, S.M. (1985). Comparison of the effects of dietary saturated, monounsaturated and polyunsaturated fatty acids on plasma lipids and lipoproteins in man. *Journal of Lipid Research*, 26, 194-202.
- [31]. Maughan, R.J. (1998). The sports drink as a functional food: formulations for successful performance. *Proceedings of the Nutrition Society*, 57, 15-23
- [32]. Maughan, R.J., Bartagi, Z., Dvorak, J., & Leiper, J.B. (2008a). Dietary intake and body composition of football players during the holy month of Ramadan. *Journal of Sports Sciences*, 26, 29-38.
- [33]. Maughan, R.J., Leiper, J.B., Bartagi, Z., Zrifi, R., Zerguini, Y., & Dvorak, J. (2008b). Effect of Ramadan fasting on some biochemical and haematological parameters in Tunisian youth soccer players undertaking their usual training and competition schedule. *Journal of Sports Sciences*, 26, 39-46.
- [34]. Meckel, Y., Ismaeel, A., & Eliakim, A. (2008). The effects of the Ramadan fast on physical performance and dietary habits in adolescent soccer players. *European Journal of Applied Physiology*, 102, 651-657.

- [35]. Memari, A.H., Kordi, R., Panahi, N., Nikookar, L.R., Abdollahi, M., & Akbarnejad, A. (2011). Effect of ramadan fasting on body composition and physical performance in female athletes. *Asian Journal of Sports Medicine*, 3, 161-166.
- [36]. Opliger, R.A., & Bartok, C. (2002). Hydration Testing of Athletes. *Sports Medicine*, 32, 959-971.
- [37]. Panel on Micronutrients (2001). Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Subcommittees on Upper Reference Intakes of Nutrients and of Interpretation and the Uses of Dietary Reference Intakes, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. Washington, DC: National Academies Press (accessed at: <http://www.nap.edu>).
- [38]. Ramadan, J., Telahoun, G., Al-Zaid, N.S., & Barac-Nieto, M. (1999). Responses to exercise, fluid, and energy balances during Ramadan in sedentary and active males. *Nutrition*, 15, 735-739.
- [39]. Rankin, J.W., Shute, M., Heffron, S.P., & Saker, K.E. (2006). Energy restriction but not protein source affects antioxidant capacity in athletes. *Free Radical Biology and Medicine*, 41, 1001-1009.
- [40]. Shirreffs, S.M & Maughan, R.J. (2008) Water and salt balance in young male football players in training during the holy month of Ramadan. *Journal of Sports Sciences*, 26, 47-54.
- [41]. Souissi, N., Souissi, H., Sahli, S., Tabka, Z., Dogui, M., Ati, J., Davenne, D. (2007). Effect of Ramadan on the diurnal variation in short-term high power output. *Chronobiology International*, 24, 991-1007.
- [42]. Shirreffs, S.M., Aragon-Vargas, L.F., Chamorro, M., Maughan, R.J., Serratosa, L., & Zachwieja, J.J. (2005). The sweating response of elite professional soccer players to training in the heat. *International Journal of Sports Medicine*, 26, 90-95.
- [43]. Stannard, S.R. (2011). Ramadan and its effect on fuel selection during exercise and following exercise training. *Asian Journal of Sports Medicine*, 2, 127-133.
- [44]. Stannard, S.R., & Thompson, M.W. (2008). The effect of participation in Ramadan on substrate selection during submaximal cycling exercise. *Journal of Science and Medicine in Sport*, 11, 510-517.
- [45]. Tayebi, S.M., Hanachi, P., Niaki, A.G., Ali, P.N., & Ghaziani, F.G. (2010a). Ramadan fasting and weight-lifting training on vascular volumes and hematological profiles in young male weight-lifters. *Global Journal of health Science*, 2, 160-166.
- [46]. Tayebi, S.M., Niaki, A.G., Hanachi, P., & Ghaziani, F.G. (2010b). The effect of Ramadan fasting and weight-lifting training on plasma volume, glucose and lipids profile of male weight-lifters. *Iranian Journal of Basic Medical Science*, 13, 57-62.
- [47]. Tian, H.H., Aziz, A.R., Weileen, P., Wahid, M.F., Yeo, D., & Png, A.L.C. (2011). Effects of Fasting During Ramadan Month on Cognitive Function in Muslim Athletes. *Asian Journal of Sports Medicine*, 2, 145-153.
- [48]. Tipton, K. D., & Wolfe, R. R. (2004). Protein and amino acids for athletes. *Journal of Sports Sciences*, 22, 65-79.
- [49]. Trabelsi, K., El Abed, K., Stannard, S.R., Jammoussi, K., Zeghal, K.M., & Hakim, A. (2012a). Effects of fed-versus fasted-state aerobic training during Ramadan on body composition and some metabolic parameters in physically active men. *International Journal of Sport Nutrition and Exercise Metabolism*, 22, 11-18.
- [50]. Khaled Trabelsi, Stephen R. Stannard, Ronald J. Maughan, Kamel Jamoussi, Khaled M. Zeghal, Ahmed Hakim. (2012b). Effect of resistance training during Ramadan on body composition, and markers of renal function, metabolism, inflammation and immunity in Tunisian recreational bodybuilders *International Journal of Sport Nutrition and Exercise Metabolism*. 22, 267 - 275.
- [51]. Trabelsi, K., El Abed, K., Trepanowski, J.F., Stannard, S.R., Ghilissi, Z., Ghozzi, H.,...Hakim, A. (2011a). Effects of Ramadan fasting on biochemical and anthropometric parameters in physically active men. *Asian Journal of Sports Medicine*, 2, 134-144.
- [52]. Trabelsi, K., Rebai, H., El-Abed, K., Stannard, S.R., Khannous, H., Masmoudi, L.,... Tabka, Z. (2011b). Effect of Ramadan fasting on body water status markers after a rugby sevens match. *Asian Journal of Sports Medicine*, 2, 186-194.

Table1. Effects of Ramadan fasting on energy intake

Reference	Subjects	Training program	effect
Trabelsi et al. 2011b	12 male recreational rugby sevens players	120 min/day for 4 times/week	↓
Trabelsi et al. 2012b	9 recreational bodybuilders	Hypertrophic training program for 3 times/week	↔
Memari et al. 2011	12 professional female taekwondo players	60 min/day for 4-5 times/week	↓
Abdelmalek et al. 2011	9 sports and physical education students	-	↓
Meckel et al. 2008	10 young male soccer players	90 min/day for 3 times/week and one competition/week	↔
Trabelsi et al. 2012a	10 physically active men	40-60 min/day aerobic training in fasted state for at least 3 times/week	↔
Trabelsi et al. 2012a	9 physically active men	40-60 min/day aerobic training in fed state for at least 3 times/week	↔
Karli et al. 2007	10 male elite power athletes	120 min/day for 6 times/week	↔
Bouhleb et al. 2006	9 elite male rugby players	120 min/day for 5 times/week	↓
Chaouachi et al. 2008	15 elite male Judo athletes	120 min/day for 6 times/week	↔
Aziz et al. 2011	10 young male soccer or basketball players	interval training for 3 times /week	↔
Chennaoui et al. 2009	8 middle - distance runners	6 to 10 times/week = 8 hours/week	↔
Güvenç. 2011	16 young male soccer players	120 min/day for 3 times/week	↔
Maughan et al. 2008	59 young male soccer players	60 min/session for 6 to 8 session /week	↔
Brisswalter et al. 2011	9 well trained runners	specific training program for 3 times/week	↔

Table 2. Effects of Ramadan fasting on body mass

Reference	Subjects	Training program	effect
Trabelsi et al. 2012b	9 recreational bodybuilders	Hypertrophic training program for 3 times/week	↔
Trabelsi et al. 2011b	12 male recreational rugby sevens players	120 min/day for 4 times/week	↓
Memari et al. 2011	12 professional female taekwondo players	60 min/day for 4-5 times/week	↓
Abdelmalek et al. 2011	9 sports and physical education students	-	↓
Meckel et al. 2008	10 young male soccer players	90 min/day for 3 times/week and one competition/week	↔
Trabelsi et al. 2012a	10 physically active men	40-60 min/day aerobic training in fasted state for at least 3 times/week	↓
Trabelsi et al. 2012a	9 physically active men	40-60 min/day aerobic training in fed state for at least 3 times/week	↓
Karli et al. 2007	10 male elite power athletes	120 min/day for 6 times/week	↔
Bouhleb et al. 2006	9 elite male rugby players	120 min/day for 5 times/week	↓
Chaouachi et al. 2008	15 elite male Judo athletes	120 min/day for 6 times/week	↓
Aziz et al. 2011	10 young male soccer or basketball players	interval training for 3 times /week	↔
Chennaoui et al. 2009	8 middle - distance runners	6 to 10 times/week = 8 hours/week	↔
Güvenç. 2011	16 young male soccer players	120 min/day for 3 times/week	↔
Maughan et al. 2008	59 young male soccer players	60 min/session for 6 to 8 session /week	↓
Brisswalter et al. 2011	9 well trained runners	specific training program for 3 times/week	↔
Ramadan et al. 1999	6 physically active men	jogging or brisk walking exercise with a duration of 30-60 min/day (after dusk) for 3 to 5 times/week	↓
Fall et al. 2007	12 sports and physical education students	-	↔
Stannard and Thompson. 2007	8 physically active men	2 to 5 times /week in the weight training gymnasium	↓
Kordi et al. 2011	14 elite male from different sports	specific training 1 hours before the break of fast	↓
Kordi et al. 2011	20 elite male from different sports	specific training 3 hours after the break of fast	↓
Haghdost and PoorRanjbar 2009	42 physically active men	45-60 min/day for 3 times/week	↓
Souissi et al. 2007	12 sports and physical education students	-	↔
Aziz et al. 2010	10 moderately trained male runners	2 to 5 times/week for between 15 to 25 km /week	↓
Tayebi et al. 2010	10 young weight lifters	90 min/day for 3 times/week	↓

Table 3. Effects of Ramadan fasting on body fat percentage

Reference	Subjects	Training program	effect
Trabelsi et al. 2012b	9 recreational bodybuilders	Hypertrophic training program for 3 times/week	↔
Trabelsi et al. 2011b	12 male recreational rugby sevens players	120 min/day for 4 times/week	↓
Meckel et al. 2008	10 young male soccer players	90 min/day for 3 times/week and one competition/week	↑
Trabelsi et al. 2012a	10 physically active men	40-60 min/day aerobic training in fasted state for at least 3 times/week	↓
Trabelsi et al. 2012a	9 physically active men	40-60 min/day aerobic training in fed state for at least 3 times/week	↔
Karli et al. 2007	10 male elite power athletes	120 min/day for 6 times/week	↔
Bouhleb et al. 2006	9 elite male rugby players	120 min/day for 5 times/week	↓
Chaouachi et al. 2008	15 elite male Judo athletes	120 min/day for 6 times/week	↓
Chennaoui et al. 2009	8 middle - distance runners	6 to 10 times/week = 8 hours/week	↔
Maughan et al. 2008	59 young male soccer players	60 min/session for 6 to 8 session /week	↔
Brisswalter et al. 2011	9 well trained runners	specific training program for 3 times/week	↔
Ramadan et al. 1999	6 physically active men	jogging or brisk walking exercise with a duration of 30-60 min/day (after dusk) for 3 to 5 times/week	↔
Stannard and Thompson. 2008	8 physically active men	2 to 5 times /week in the weight training gymnasium	↔