



Effects of Practicing Physical Activity During Ramadan Fasting on Health-Related Indices: An Updated Brief Review

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Abstract

Based on Moon observation, every year, adults healthy Muslims practiced Ramadan intermittent fasting (RIF) for 29 or 30 consecutive days. During RIF Muslims are allowed to food and fluid intake only during night (from sunset to sunrise). Thus, behavioral changes are observed during RIF (e.g., food and sleep habits). Despite these changes, many healthy Muslims maintain their normal habitual physical exercise practice during RIF. However, changes in blood lipids, metabolic markers, electrolytes and hematological parameters during RIF in practitioners of physical activity are yet poorly studied. Therefore, the present review article will summarize the health specific effects of RIF in subjects engaged in physical training during Ramadan.

Keywords: Fasting, Health, Hematology, Biochemical Parameters, Exercise

1. Context

During the ninth month of the lunar calendar, healthy adults Muslims are not allowed to drink and eat from dawn (*El fajr*) to sunset (*El moghreb*) during 29 or 30 days (i.e., based in the Moons observation) (1-3). Thus, food and fluid intake are allowed only during the hours of darkness (4, 5). Advancing by eleven days every year, Ramadan intermittent fasting (RIF) could occur in any seasons (6). When RIF occur during the summer months, the fasting period could exceed 15 hours in some countries and this could adversely affect physical performance (7, 8).

It has been reported that RIF affect meal frequency (9) and quantity (10) and fluid intake (11-16). Not only is the daily eating pattern, but also the food type consumed during RIF is always different from that usually eaten at pre- and post-RIF (17). In this context, increases in preference for fatty food (11, 15, 18, 19) and decreases of water intake (11, 13) has been shown during RIF. These changes can influence substrates utilization and storage and could modify body composition (11-14, 20-22). Likewise, changes in some hematological and biochemical parameters indicative of hydration status and renal function were reported (11, 13-15, 20, 21, 23-25). During RIF, adults Muslims often maintain their physical activity levels for recreation

and health purposes (26-28). In the same way, many athletes continue to train or participate to competitions during RIF (29-31). During the last years, RIF occur during the summer and thus exercise training places additional stresses on performances (32-34) and energy metabolism and fluid/electrolyte balance (13, 35). The purpose of this review article is to describe the results of published scientific research which has examined the effect of RIF on indicators of health (i.e., hematological and biochemical parameters) in physically active persons.

The literature concerning the biochemical and hematological changes during RIF was reviewed using PubMed/MEDLINE and Google Scholar database, and cross referencing the selected manuscripts with the following keywords: Ramadan fasting, Ramadan observance, hematological, biochemical, renal function, hydration status, lipid profile, physical activity, physically active and sport. The last search was completed in August 28, 2018

2. Hematological Parameters

Blood hemoglobin concentration and hematocrit are two hematological parameters utilized in body water status evaluation of athletes (36). The few studies that have investigated the effects of RIF on these two markers of hydra-

tion status in physical activity practitioners have reported conflicting results. In fact, both hemoglobin and hematocrit have been increased in physically active men (13), rugby union players (11) and rugby sevens players (14) indicating a dehydration state. Dehydration during RIF has been attributed to reductions in water intake (11, 13, 14). Decreases in hemoglobin and hematocrit were reported in footballers (37) possibly because the collection of blood samples was realized in the morning. Recently, Aloui et al. (28) showed that hemoglobin and hematocrit values of amateur footballers were superior during compared to before RIF and were higher at 05:00 P.M. compared to 07:00 A.M. during RIF. Accordingly, these data indicate that the subjects were marginally more hypo-hydrated in the afternoon than in the morning during RIF (3). Tayebi and associates (38) evaluated the effect of a hypertrophic training program (i.e., three sessions/week) during RIF on hematological parameters in weightlifters. The authors reported that hemoglobin, hematocrit, mean corpuscular hemoglobin, red blood cell count, distribution index of red blood cells and mean corpuscular volume did not change between before and during RIF (38). Likewise, it has been also demonstrated that blood platelets did not change during RIF (13, 38, 39). However, during RIF, micronutrient deficiencies (i.e., iron and vitamins) might decrease blood platelets in physically active men (40).

3. Biochemical Parameters

3.1. Plasma and Serum Electrolytes

As a hydration status indicator (36, 41), serum sodium has been observed to increase during RIF in sedentary men; but interestingly no-changes were reported in physically active subjects (40). Likewise, Maughan et al. (37) showed that serum sodium concentration did not change during RIF in footballers. It may be that physically active individuals, particularly athletes, concentrate on ensuring adequate fluid intake in the evening hours. However, during hot and humid RIF, daily fluid loss is frequent, as previously observed in rugby union (11) and sevens (23) players.

During the day of RIF, a progressive dehydration occurs (42, 43) which explains higher plasma sodium and potassium concentrations recorded at 07:00 A.M. compared to 05:00 P.M. in amateur footballers (28).

Some physically active men train at night during RIF to minimize the fluids losses that would occur if training was conducted during the day (44). This effective strategy is supported by the results of Trabelsi et al. (15) who reported that serum sodium, potassium and chloride concentrations are maintained during RIF if long-duration training was scheduled after the break of the fast; although

an increase in chloride and sodium concentrations was reported if the same training was performed before the *Iftar* meal.

However, both training at night or during the day induce increases in some serum electrolytes at the end of RIF in bodybuilders (45). These conflicting results may be explained by the fact that total water intake decreased in bodybuilders training after the break of the fast during RIF; whereas it was maintained in practitioners of long-duration exercise during the same time-of-day. It appears that resistance training athletes concentrate less on hydration than those undertaking aerobic-based training.

Regardless of training time to minimize chronic dehydration, it has been previously recommended to drink about 600 mL/h from the *Iftar* meal until the sleep and a supplementary 1 L at *Sahour* meal (46).

3.2. Renal Function Markers

Creatinine clearance, creatinine, urea and uric acid concentrations of the plasma/serum can all be used to evaluate renal function (47-49). During RIF, serum urea and creatinine increased in sedentary men that could induce kidney adaptations in physically active men and allow maintaining the concentrations of markers of renal function (40). Similarly, creatinine values did not change during RIF in elite rugby union players (50).

However, RIF of a humid and hot summer season increases creatinine, urea and uric acid concentrations (23). Additionally, increases in serum concentration of creatinine and decreases in clearance of creatinine were noticed in practitioners of long-duration exercise in a fasted (i.e., before the break of the fast) or in a fed state (i.e., after the break of the fast) during RIF (15). Furthermore, hypertrophic training program performed in a fed or in a fasted state induced an increase in creatinine values of bodybuilders who maintain their training routines during RIF (45).

3.3. Glycemia

RIF induces a reduction in blood concentration of glucose during the fasting day in healthy sedentary peoples (51, 52). Higher gluconeogenesis capacity could prevent the reduction in blood concentration of glucose in sportsmen despite the decrease in caloric intake during RIF (11, 23). Unchanged glycemia has been observed in recreational bodybuilders (24, 45), physically active men (13, 15) and footballers (53). In contrast, other studies have shown a decrease in blood glucose levels in runners (54-56) and football and basketball players (57).

Blood glucose levels will be affected by the time-of-day during which the sample was collected during RIF. Indeed,

glycemia recorded in the afternoon (04:00 P.M.) during RIF was lower than that in the morning (09:00 A.M.) in martial arts practitioners (58). Such results suggest that the ability to complete intense physical training sessions in the afternoon may be affected by a drop in blood glucose concentrations and should be avoided. However, in some cases athletes are obliged to undertake intense training session in the daylight. Although Png and colleagues (59) concluded that ingesting food with a low glycemic index at *Sahour* meal has no-beneficial effect (i.e., physiological, metabolic or performance aids) during long-duration exercise realized 12 h post-prandial during RIF, a useful strategy might be that athletes should anticipate the possibility of low afternoon blood glucose by consuming low glycemic index foods at *Sahour* meal in order to prolong the sugars release into the blood stream (60).

3.4. Lipid Profile

The combined effect of physical activity and RIF on the lipid profile present inconclusive results. Lipid profile is highly influenced, not only by diet, but also by physical activity levels, body fat and weight, and timing of blood sampling. Nevertheless, these measures are good indices of cardiovascular health and should be reported.

It has been shown that serum total cholesterol concentrations increased in judo athletes (20); but remained unchanged in footballers (21), middle-distance runners (61), rugby union players (50) and bodybuilders (24, 45). Mobilization of body fat stores during RIF may explain the observed increases in serum concentration of high density lipoprotein cholesterol (HDL-C) in judo athletes (20), footballers (21) and rugby union players (50). In support, an increase of HDL-C in practitioners of long-duration exercise before the break of the fast (15) or resistance training (bodybuilding) either in fed or fasted state (45) during RIF has been observed. Concentrations of low density lipoprotein (LDL) cholesterol has been shown to increase during RIF in judo athletes (20). This result may be explained by the increase in the consumption of saturated fatty acids due to alteration in food choices (62).

Chaouachi et al. (20) showed that serum values of triglycerides increased at sixteen days after the commencement of RIF and then return to pre-RIF values at the end of the month in judokas. In contrast, Bouhlel and colleagues (50) showed that triglycerides increased at the end of RIF in rugby players. Other reports indicate that triglycerides concentrations do not change during RIF (15, 38, 45).

The feeding behavior that occurs during RIF may increase apolipoprotein A1 levels which may protect cardiovascular system (20, 63), although apolipoprotein B concentrations have not been shown to change (20).

4. Conclusion

Practicing physical activity during RIF can cause a myriad of modifications in some hematological and biochemical parameters reflecting changes in hydration status and impairment in renal function. However, since the reported changes in hematological and biochemical parameters are all within the normal reference ranges of the laboratory, intense physical training could be practiced safely during RIF.

References

1. Aloui A, Chtourou H, Masmoudi L, Chaouachi A, Chamari K, Souissi N. Effects of Ramadan fasting on male judokas' performances in specific and non-specific judo tasks. *Biol Rhythm Res.* 2013;**44**(4):645-54. doi: [10.1080/09291016.2012.722454](https://doi.org/10.1080/09291016.2012.722454).
2. Aloui A, Chtourou H, Hammouda O, Souissi H, Chaouachi A, Chamari K, et al. Effects of Ramadan on the diurnal variations of physical performance and perceived exertion in adolescent soccer players. *Biol Rhythm Res.* 2013;**44**(6):869-75. doi: [10.1080/09291016.2013.780697](https://doi.org/10.1080/09291016.2013.780697).
3. Aloui A, Chtourou H, Hammouda O, Chaouachi A, Chamari K, Souissi N. The challenge of rapid weight loss prior to competition for Muslim combat sport athletes during Ramadan. *Biol Rhythm Res.* 2013;**44**(6):876-84. doi: [10.1080/09291016.2013.780698](https://doi.org/10.1080/09291016.2013.780698).
4. Chtourou H. *Effects of Ramadan fasting on health and athletic performance*. New York, NY: OMICS International; 2015. doi: [10.4172/978-1-63278-030-0-031](https://doi.org/10.4172/978-1-63278-030-0-031).
5. Chtourou H, Chtourou L, Trabelsi K, Tahri N, Souissi N. Possible gastrointestinal disorders for athletes during Ramadan: an overview. *Biol Rhythm Res.* 2017;**49**(1):51-60. doi: [10.1080/09291016.2017.1333196](https://doi.org/10.1080/09291016.2017.1333196).
6. Chtourou H, Briki W, Hammouda O, Aloui A, Souissi N, Chaouachi A. The effect of the time-of-day of training during Ramadan on soccer players' chronotype and mood states. *Sport Sci Health.* 2014;**10**(2):143-7. doi: [10.1007/s13322-014-0185-x](https://doi.org/10.1007/s13322-014-0185-x).
7. Chtourou H, Hammouda O, Souissi H, Chamari K, Chaouachi A, Souissi N. The effect of Ramadan fasting on physical performances, mood state and perceived exertion in young footballers. *Asian J Sports Med.* 2011;**2**(3):177-85. [PubMed: [22375237](https://pubmed.ncbi.nlm.nih.gov/22375237/)]. [PubMed Central: [PMC3289213](https://pubmed.ncbi.nlm.nih.gov/PMC3289213/)].
8. Chtourou H, Hammouda O, Chaouachi A, Chamari K, Souissi N. The effect of time-of-day and Ramadan fasting on anaerobic performances. *Int J Sports Med.* 2012;**33**(2):142-7. doi: [10.1055/s-0031-1286251](https://doi.org/10.1055/s-0031-1286251). [PubMed: [22318530](https://pubmed.ncbi.nlm.nih.gov/22318530/)].
9. BaHammam A. Assessment of sleep patterns, daytime sleepiness, and chronotype during Ramadan in fasting and nonfasting individuals. *Saudi Med J.* 2005;**26**(4):616-22. [PubMed: [15900372](https://pubmed.ncbi.nlm.nih.gov/15900372/)].
10. Husain R, Duncan MT, Cheah SH, Ch'ng SL. Effects of fasting in Ramadan on tropical Asiatic Moslems. *Br J Nutr.* 1987;**58**(1):41-8. [PubMed: [3620437](https://pubmed.ncbi.nlm.nih.gov/3620437/)].
11. Bouhlel E, Salhi Z, Bouhlel H, Mdella S, Amamou A, Zaouali M, et al. Effect of Ramadan fasting on fuel oxidation during exercise in trained male rugby players. *Diabetes Metab.* 2006;**32**(6):617-24. doi: [10.1016/S1262-3636\(07\)70317-8](https://doi.org/10.1016/S1262-3636(07)70317-8). [PubMed: [17296516](https://pubmed.ncbi.nlm.nih.gov/17296516/)].
12. Bouhlel H, Bogdanis G, Hamila A, Miled A, Chelly MS, Denguezli M, et al. Effects of Ramadan observance on repeated cycle ergometer sprinting and associated inflammatory and oxidative stress responses in trained young men. *J Fast Health.* 2016;**4**(1):39-47.
13. Trabelsi K, El Abed K, Trepanowski JF, Stannard SR, Ghlissi Z, Ghazzi H, et al. Effects of Ramadan fasting on biochemical and anthropometric parameters in physically active men. *Asian J Sports Med.* 2011;**2**(3):134-44. [PubMed: [22375232](https://pubmed.ncbi.nlm.nih.gov/22375232/)]. [PubMed Central: [PMC3289216](https://pubmed.ncbi.nlm.nih.gov/PMC3289216/)].

14. Trabelsi K, Rebai H, El-Abed K, Stannard SR, Khannous H, Masmoudi L, et al. Effect of Ramadan fasting on body water status markers after a rugby sevens match. *Asian J Sports Med.* 2011;2(3):186–94. [PubMed: 22375238]. [PubMed Central: PMC3289207].
15. Trabelsi K, el Abed K, Stannard SR, Jammoussi K, Zeghal KM, Hakim A. Effects of fed- versus fasted-state aerobic training during Ramadan on body composition and some metabolic parameters in physically active men. *Int J Sport Nutr Exerc Metab.* 2012;22(1):11–8. [PubMed: 22248495].
16. Elabed K, Trabelsi K, Ghlissi Z, Stannard SR, Leeuwenburgh C, Jammoussi K, et al. Effect of resistance training during the month of Ramadan on antioxidants and oxidative stress biomarkers in recreational bodybuilders. *Biol Rhythm Res.* 2015;46(4):459–70. doi: 10.1080/09291016.2015.1015232.
17. Leiper JB, Molla AM, Molla AM. Effects on health of fluid restriction during fasting in Ramadan. *Eur J Clin Nutr.* 2003;57 Suppl 2:S30–8. doi: 10.1038/sj.ejcn.1601899. [PubMed: 14681711].
18. Frost G, Pirani S. Meal frequency and nutritional intake during Ramadan: A pilot study. *Hum Nutr Appl Nutr.* 1987;41(1):47–50. [PubMed: 3558007].
19. el Ati J, Beji C, Danguir J. Increased fat oxidation during Ramadan fasting in healthy women: an adaptative mechanism for body-weight maintenance. *Am J Clin Nutr.* 1995;62(2):302–7. doi: 10.1093/ajcn/62.2.302. [PubMed: 7625336].
20. Chaouachi A, Chamari K, Roky R, Wong P, Mbazaa A, Bartagi Z, et al. Lipid profiles of judo athletes during Ramadan. *Int J Sports Med.* 2008;29(4):282–8. doi: 10.1055/s-2007-965338. [PubMed: 17879887].
21. Hammouda O, Chtourou H, Aloui A, Chahed H, Kallel C, Miled A, et al. Concomitant effects of Ramadan fasting and time-of-day on apolipoprotein AI, B, Lp-a and homocysteine responses during aerobic exercise in Tunisian soccer players. *PLoS One.* 2013;8(11):e79873. doi: 10.1371/journal.pone.0079873. [PubMed: 24244572]. [PubMed Central: PMC3823586].
22. Bouguerra L, Ben Abderrahman A, Chtourou H, Zouhal H, Tabka Z, Proux J. The effect of time-of-day of training during Ramadan on physiological parameters in highly trained endurance athletes. *Biol Rhythm Res.* 2017;48(4):541–55. doi: 10.1080/09291016.2016.1276271.
23. Trabelsi K, Rebai H, el Abed K, Stannard SR, Kallel C, Sahnoun Z, et al. Effect of Ramadan fasting on renal function markers and serum electrolytes after a rugby sevens match. *IOSR Journal of Pharmacy (IOSR-PHR).* 2012;2(5):42–50. doi: 10.9790/3013-25104250.
24. Trabelsi K, Stannard SR, Maughan RJ, Jammoussi K, Zeghal KM, Hakim A. Effect of resistance training during Ramadan on body composition and markers of renal function, metabolism, inflammation, and immunity in recreational bodybuilders. *Int J Sport Nutr Exerc Metabol.* 2012;22(4):267–75. doi: 10.1123/ijsnem.22.4.267.
25. Hammouda O, Chtourou H, Aloui A, Mejri MA, Chahed H, Miled A, et al. Does Ramadan fasting affect the diurnal variations in metabolic responses and total antioxidant capacity during exercise in young soccer players? *Sport Sci Health.* 2014;10(2):97–104. doi: 10.1007/s11332-014-0179-8.
26. Trabelsi K, Stannard SR, Chtourou H, Moalla W, Ghazzi H, Jamoussi K, et al. Monitoring athletes' hydration status and sleep patterns during Ramadan observance: methodological and practical considerations. *Biol Rhythm Res.* 2017;49(3):337–65. doi: 10.1080/09291016.2017.1368214.
27. Boukhris O, Hsouna H, Chtourou L, Abdessalem R, Bensalem S, Tahri N, et al. Effect of Ramadan fasting on feelings, dietary intake, rating of perceived exertion and repeated high intensity short-term maximal performance. *Chronobiol Int.* 2018;In press.
28. Aloui A, Chaouachi A, Chtourou H, Wong del P, Haddad M, Chamari K, et al. Effects of Ramadan on the diurnal variations of repeated-sprint performances. *Int J Sports Physiol Perform.* 2013;8(3):254–62. [PubMed: 22952200].
29. Souissi N, Chamari K, Chaouachi A, Monoem H, Hammouda O, Aloui A, et al. Martial arts and Ramadan fasting with special reference to Taekwondo. In: Monoem H, editor. *Performance optimization in Taekwondo: From laboratory to field.* OMICS International; 2015. 147 p.
30. Baklouti H, Aloui A, Chtourou H, Briki W, Chaouachi A, Souissi N. Does increasing active warm-up duration affect afternoon short-term maximal performance during Ramadan? *PLoS One.* 2015;10(2):e0116809. doi: 10.1371/journal.pone.0116809. [PubMed: 25646955]. [PubMed Central: PMC4315438].
31. Baklouti H, Rejeb N, Aloui A, Jaafar H, Ammar A, Chtourou H, et al. Short versus long small-sided game training during Ramadan in soccer players. *Phys Ther Sport.* 2017;24:20–5. doi: 10.1016/j.ptsp.2016.10.002. [PubMed: 28171810].
32. Aloui A, Briki W, Baklouti H, Chtourou H, Driss T, Chaouachi A, et al. Listening to music during warming-up counteracts the negative effects of Ramadan observance on short-term maximal performance. *PLoS One.* 2015;10(8):e0136400. doi: 10.1371/journal.pone.0136400. [PubMed: 26301508]. [PubMed Central: PMC4547754].
33. Aloui A, Chtourou H, Briki W, Tabben M, Chaouachi A, Souissi N, et al. Rapid weight loss in the context of Ramadan observance: Recommendations for judokas. *Biol Sport.* 2016;33(4):407–13. doi: 10.5604/20831862.1224098. [PubMed: 28090146]. [PubMed Central: PMC5143776].
34. Abdelmalek S, Denguezli M, Chtourou H, Souissi N, Tabka Z. Does Ramadan fasting affect acylated ghrelin and growth hormone concentrations during short-term maximal exercise in the afternoon? *Biol Rhythm Res.* 2015;46(5):691–701. doi: 10.1080/09291016.2015.1048949.
35. Hamouda O, Chtourou H, Farjallah MA, Davenne D, Souissi N. The effect of Ramadan fasting on the diurnal variations in aerobic and anaerobic performances in Tunisian youth soccer players. *Biol Rhythm Res.* 2012;43(2):177–90. doi: 10.1080/09291016.2011.560050.
36. Oppliger RA, Bartok C. Hydration testing of athletes. *Sports Med.* 2002;32(15):959–71. [PubMed: 12457417].
37. Maughan RJ, Leiper JB, Bartagi Z, Zrifi R, Zerguini Y, Dvorak J. Effect of Ramadan fasting on some biochemical and haematological parameters in Tunisian youth soccer players undertaking their usual training and competition schedule. *J Sports Sci.* 2008;26 Suppl 3:S39–46. doi: 10.1080/02640410802491368. [PubMed: 19085451].
38. Tayebi SM, Ghanbari Niaki A, Hanachi P, Alizadeh Ghaziani G. The effect of Ramadan fasting and weight-lifting training on plasma volume, glucose and lipids profile of male weight-lifters. *Iran J Basic Med Sci.* 2010;13(2):57–62.
39. Attarzadeh Hosseini SR, Hejazi K. The effects of Ramadan fasting and physical activity on blood hematological-biochemical parameters. *Iran J Basic Med Sci.* 2013;16(7):845–9. [PubMed: 23997915]. [PubMed Central: PMC3758056].
40. Ramadan J, Telahoun G, Al-Zaid NS, Barac-Nieto M. Responses to exercise, fluid, and energy balances during Ramadan in sedentary and active males. *Nutrition.* 1999;15(10):735–9. [PubMed: 10501284].
41. Shirreffs SM. Markers of hydration status. *J Sports Med Phys Fitness.* 2000;40(1):80–4. [PubMed: 10822913].
42. Maughan RJ, Shirreffs SM. Hydration and performance during Ramadan. *J Sports Sci.* 2012;30 Suppl 1:S33–41. doi: 10.1080/02640414.2012.688140. [PubMed: 22594964].
43. Chaouachi A, Leiper JB, Chtourou H, Aziz AR, Chamari K. The effects of Ramadan intermittent fasting on athletic performance: recommendations for the maintenance of physical fitness. *J Sports Sci.* 2012;30 Suppl 1:S53–73. doi: 10.1080/02640414.2012.698297. [PubMed: 22738880].
44. Chtourou H, Hammouda O, Aloui A, Souissi N, Chaouachi A. The optimal time of day for training during Ramadan: A review study. *J Fast Health.* 2014;2(1):46–52.
45. Trabelsi K, Stannard SR, Ghlissi Z, Maughan RJ, Kallel C, Jamoussi K, et al. Effect of fed- versus fasted state resistance training during Ramadan on body composition and selected metabolic parameters in bodybuilders. *J Int Soc Sports Nutr.* 2013;10(1):23. doi: 10.1186/1550-2783-10-23. [PubMed: 23617897]. [PubMed Central: PMC3639860].
46. Shephard RJ. The impact of Ramadan observance upon athletic

- performance. *Nutrients*. 2012;**4**(6):491-505. doi: [10.3390/nu4060491](https://doi.org/10.3390/nu4060491). [PubMed: [22822448](https://pubmed.ncbi.nlm.nih.gov/22822448/)]. [PubMed Central: [PMC3397348](https://pubmed.ncbi.nlm.nih.gov/PMC3397348/)].
47. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron*. 1976;**16**(1):31-41. doi: [10.1159/000180580](https://doi.org/10.1159/000180580). [PubMed: [1244564](https://pubmed.ncbi.nlm.nih.gov/1244564/)].
 48. Kakadiya J, Shah N. Renal function markers: A short review. *J Innov Trends Pharm Sci*. 2010;**1**:270-3.
 49. Gowda S, Desai PB, Kulkarni SS, Hull VV, Math AA, Vernekar SN. Markers of renal function tests. *N Am J Med Sci*. 2010;**2**(4):170-3. [PubMed: [22624135](https://pubmed.ncbi.nlm.nih.gov/22624135/)]. [PubMed Central: [PMC3354405](https://pubmed.ncbi.nlm.nih.gov/PMC3354405/)].
 50. Bouhlel E, Denguezli M, Zaouali M, Tabka Z, Shephard RJ. Ramadan fastings effect on plasma leptin, adiponectin concentrations, and body composition in trained young men. *Int J Sport Nutr Exerc Metab*. 2008;**18**(6):617-27. [PubMed: [19164831](https://pubmed.ncbi.nlm.nih.gov/19164831/)].
 51. Fakhrzadeh H, Larijani B, Sanjari M, Baradar-Jalili R, Amini MR. Effect of Ramadan fasting on clinical and biochemical parameters in healthy adults. *Ann Saudi Med*. 2003;**23**(3-4):223-6. [PubMed: [16985327](https://pubmed.ncbi.nlm.nih.gov/16985327/)].
 52. Larijani B, Zahedi F, Sanjari M, Amini MR, Jalili RB, Adibi H, et al. The effect of Ramadan fasting on fasting serum glucose in healthy adults. *Med J Malaysia*. 2003;**58**(5):678-80. [PubMed: [15190653](https://pubmed.ncbi.nlm.nih.gov/15190653/)].
 53. Aziz AR, Che Muhamad AM, Roslan SR, Ghulam Mohamed N, Singh R, Chia MYH. Poorer intermittent sprints performance in Ramadan-fasted muslim footballers despite controlling for pre-exercise dietary intake, sleep and training load. *Sports (Basel)*. 2017;**5**(1). doi: [10.3390/sports5010004](https://doi.org/10.3390/sports5010004). [PubMed: [29910364](https://pubmed.ncbi.nlm.nih.gov/29910364/)]. [PubMed Central: [PMC5969002](https://pubmed.ncbi.nlm.nih.gov/PMC5969002/)].
 54. 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. doi: [10.1136/bjism.2009.070425](https://doi.org/10.1136/bjism.2009.070425). [PubMed: [20519256](https://pubmed.ncbi.nlm.nih.gov/20519256/)].
 55. Aziz AR, Slater GJ, Chia MYH, Teh KC. Effects of Ramadan fasting on training induced adaptations to a seven-week high-intensity interval exercise programme. *Sci Sports*. 2012;**27**(1):31-8. doi: [10.1016/j.scispo.2011.03.004](https://doi.org/10.1016/j.scispo.2011.03.004).
 56. 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. French. [PubMed: [17632999](https://pubmed.ncbi.nlm.nih.gov/17632999/)].
 57. Aziz AR, Che Muhamed AM, Ooi CH, Singh R, Chia MYH. Effects of Ramadan fasting on the physical activity profile of trained Muslim soccer players during a 90-minute match. *Sci Med Football*. 2017;**2**(1):29-38. doi: [10.1080/24733938.2017.1393550](https://doi.org/10.1080/24733938.2017.1393550).
 58. Tian HH, Aziz AR, Png W, Wahid MF, Yeo D, Constance Png AL. Effects of fasting during Ramadan month on cognitive function in muslim athletes. *Asian J Sports Med*. 2011;**2**(3):145-53. [PubMed: [22375233](https://pubmed.ncbi.nlm.nih.gov/22375233/)]. [PubMed Central: [PMC3289210](https://pubmed.ncbi.nlm.nih.gov/PMC3289210/)].
 59. Png W, Bhaskaran K, Sinclair AJ, Aziz AR. Effects of ingesting low glycemic index carbohydrate food for the sahur meal on subjective, metabolic and physiological responses, and endurance performance in Ramadan fasted men. *Int J Food Sci Nutr*. 2014;**65**(5):629-36. doi: [10.3109/09637486.2014.886187](https://doi.org/10.3109/09637486.2014.886187). [PubMed: [24524697](https://pubmed.ncbi.nlm.nih.gov/24524697/)].
 60. Jeukendrup AE, McLaughlin J. Carbohydrate ingestion during exercise: Effects on performance, training adaptations and trainability of the gut. In: Maughan RJ, Burke LM, editors. *Sports nutrition: More than just calories - triggers for adaptation*. 69. Basel, Switzerland: Karger Publications; 2012. doi: [10.1159/000329268](https://doi.org/10.1159/000329268).
 61. 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. doi: [10.1139/H09-014](https://doi.org/10.1139/H09-014). [PubMed: [19767792](https://pubmed.ncbi.nlm.nih.gov/19767792/)].
 62. Mattson FH, Grundy SM. Comparison of effects of dietary saturated, monounsaturated, and polyunsaturated fatty acids on plasma lipids and lipoproteins in man. *J Lipid Res*. 1985;**26**(2):194-202. [PubMed: [3989378](https://pubmed.ncbi.nlm.nih.gov/3989378/)].
 63. Adlouni A, Ghalim N, Saile R, Hda N, Parra HJ, Benslimane A. Beneficial effect on serum apo AI, apo B and Lp AI levels of Ramadan fasting. *Clin Chim Acta*. 1998;**271**(2):179-89. [PubMed: [9565333](https://pubmed.ncbi.nlm.nih.gov/9565333/)].