

## Does Islamic fasting affect cognitive functions in adolescents? A systematic review

Ata Pourabbasi,<sup>1</sup> Mahbubeh Sadat Ebrahimnegad Shirvani,<sup>2</sup> Amir Hossein Shams<sup>3</sup>

### Abstract

A considerable population of the Muslim community is made up of youngsters who observe fast during the month of Ramadan. There are other activities in Ramadan that the adolescents might be involved in, such as education in which one's proper cognitive activity is necessary. The current systematic review was planned to evaluate the relationship between Islamic fasting and cognitive activities. A number of studies have paid attention to the brain structure and scope of cognitive changes during fasting. Islamic fasting may affect cognitive activities such as spatial memory, visual memory and attention that play an important role in effective education. It is suggested to conduct a study with a larger sample size, using similar evaluation tools, targeting different cognitive tasks.

**Keywords:** Islamic fasting, Adolescents, Cognition.

### Introduction

Islamic world spans more than 57 countries. Based on different statistics, there are about 1.5 to 2.02 billion Muslims living in these countries.<sup>1,2</sup> Fasting, is one of the five Islamic pillars that is wajib (must be done), and all adult Muslim fulfilling the capability criteria shall observe fast in the month of Ramadan. The fasting Muslims in Ramadan, from dawn until dusk, abstain from eating, drinking, smoking and sexual intercourse. However, these limitations are lifted after sunset. Overall, there are about 1 billion Muslims fasting in Ramadan.<sup>3</sup> Depending on the geographical location of countries, the fasting time between dawn and dusk varies from 12 to 20 hours in a day.<sup>4</sup> This avoidance from eating and drinking may have different effects on the activities of the body. Among different activities that seem to be affected by the limited intake of calories and liquids are cognitive activities. Many studies have shown negative effects of limited intake of calorie and water on memory, attention and

concentration. A considerable population of Muslim community is made up of youngsters who should observe fast during Ramadan. Worthy of note is the fact that there are other activities in Ramadan that the young people might be involved in, such as education in which one's proper cognitive activity is necessary. There are contradictory reports, however, on the effects of Islamic fasting on cognitive activities. The current systematic review of literature was planned to evaluate the relationship between Islamic fasting and cognitive activities. Surely, knowing this relationship will help the Muslim community and others to schedule better for different activities, especially an effective education, during Ramadan.

### Method and Strategy

The review comprised studies that were part of English databases till April 2016. The international scientific databases searched included Scopus and PubMed. Related articles were found using key English words or collocations, including brain function, brain, learning, cognitive, cognition, adolescence, and schooling. In addition, a reference list was prepared in which published studies were examined to add more sensitivity and to choose more articles that wouldn't be probably found online.

### Selecting Articles

First, a list was compiled which included the title and abstract of all articles found on the named online databases. Then, each of them was examined separately. As the next step, repetitive titles, name of author(s), year of publication, and issue and journal names were removed. Accordingly, all those articles exploring Islamic fasting and its relationship with cognitive activity were made part of the current review. Papers were excluded if they were unrelated to the purpose of the study.

### Quality Control

After reviewing the titles, an abstract of the selected articles was constructed by using the standard strengthening the reporting of observational studies in epidemiology (STROBE) checklist which contains 43 different parts, and targets different aspects of a methodology such as sampling, measuring variables,

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<sup>1</sup>Diabetes Research Center, Endocrinology And Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran, <sup>2</sup>Foundation for Education, Research And Services On Educational Medicine And School Health, Tehran, Iran, <sup>3</sup>Faculty of Science, Biopharmaceutical Sciences, University of Ottawa, Canada.

**Correspondence:** Ata Pourabbasi. Email: atapoura@gmail.com

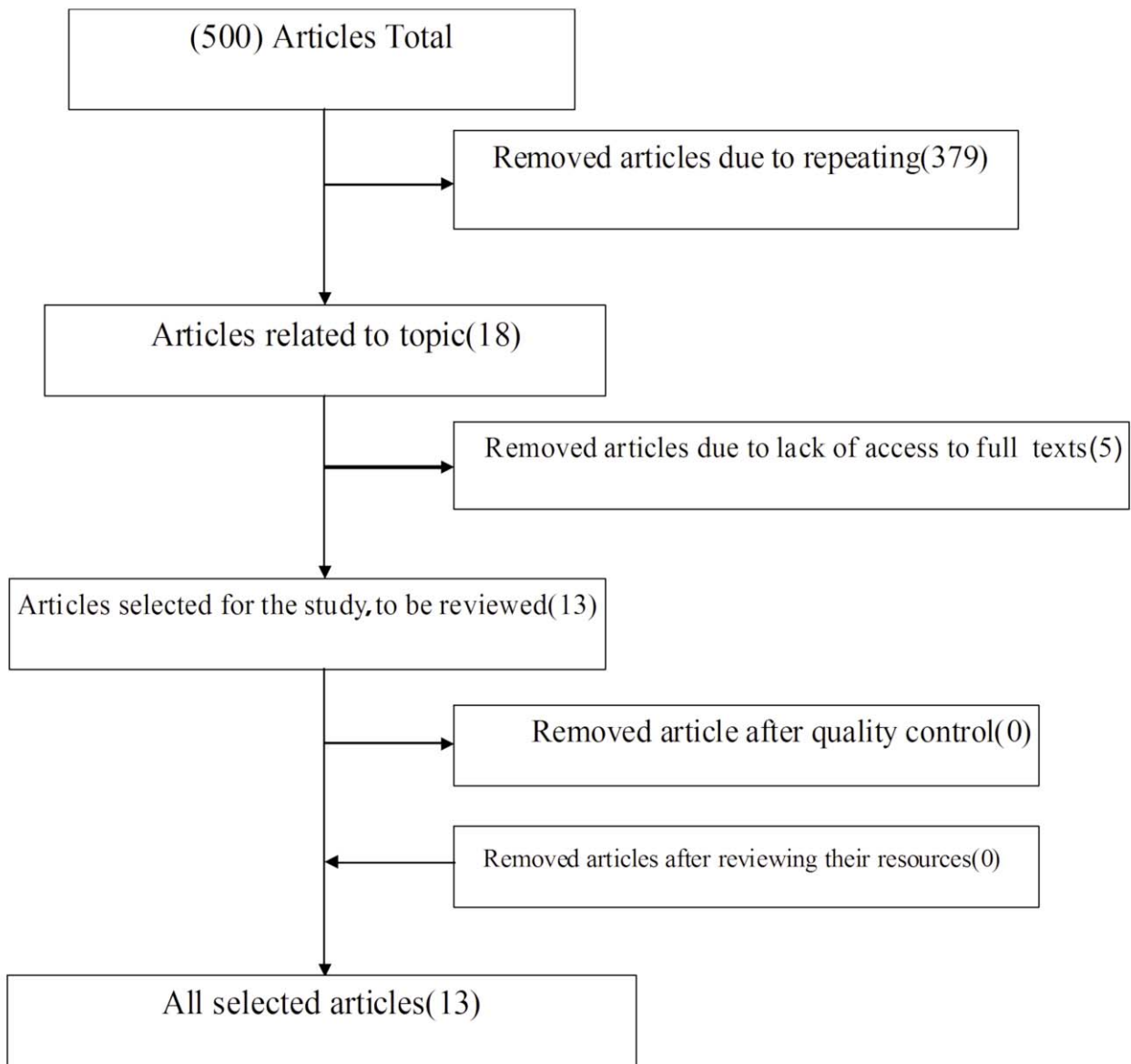
analysis, and goals. Finally, articles with at least 40 points evaluated through STROBE were included. Data in each article was then extracted for further use.

Information regarding the title, first author(s), year of study, type of study, age group, sex, sample size, data related to physical state, and its relation with anthropometric parameters (if existed) were all investigated.

**Results**

Using related keywords and search filters with high

sensitivity, 500 articles were found until the end of April 2016. Eventually, after excluding repetitive articles, 121(24%) articles were shortlisted. After studying the titles and abstracts, 103(85%) articles were found to be unrelated to the subject matter, and were excluded. Afterwards, emails were sent to the authors of the remaining 18(15%) studies requesting access to full text. After leaving out 5(28%) studies that had to be omitted due to response later than 2 weeks or restrained access to full texts, 13(72%) studies went through final examination. Four (31% (Figure).



**Figure:** Flowchart of search strategy and the evaluation of papers.

## Examining Islamic Fasting and Brain Structure Changes

A number of studies have paid attention to the brain structure and scope of cognitive changes during fasting. Through brain imaging studies, Bakan et al.<sup>5</sup> applied diffusion tensor imaging technique on 50 persons in age group of  $30.2 \pm 8.5$  years. After examining microstructure changes of brain after 3 weeks of fasting, they found that the apparent diffusion coefficient (ADC) values in hypothalamus and, to a lower degree, in insula were lower in the first phase of study (4th week of Ramadan), compared to second phase (2 months after Ramadan) and that reported in controls.

Restricted diet while fasting in Ramadan may lead to the disturbance of receiving hunger signals in body by affecting the functions of hypothalamus and insula, It is worthy of note that fractional anisotropy values associated with amygdala, middle temporal cortex, thalamus and, to a lower degree, medial prefrontal cortex were found to be lower in the first phase of the study compared to the second phase and that of the control group. These important sections of brain perform a primary role in the processing of emotions, memory, stress, coping, especially adjusting thirst and hunger. No significant differences were observed in terms of ADC and fractional anisotropy (FA) values in different sections of the participants' brain during the 2nd phase of the study compared with that of controls. As a result, Bakan et al came up with the conclusion that Islamic fasting for 3 weeks in Ramadan can lead to minor changes in the neuron structures.<sup>5</sup>

In another study, Boujraf et al.<sup>6</sup> used functional magnetic resonance imaging (fMRI) to examine the motor cortex areas of the brain. They proposed that that the size and intensity of motor cortex (areas 25) increased significantly even after 28 days post-Ramadan compared with 5-10 days before Ramadan. This expansion in size and intensity may well elucidate the behavioural changes, especially in one's diet.

## Investigating the Relationship between Fasting and Cognitive Activities

In a review study, Cheriff et al. examined the effects of fasting and limited calorie intake on the cognitive activities of adult athletes in different situations, such as resting as well as while doing physical activities. It also indicated that mental wellness such as coping and decision-making strategies may be adversely affected during daylight fasting.<sup>7</sup> On the other hand, Meo et al.<sup>4</sup> studying physiological changes in body during Ramadan found that Islamic fasting had no negative effect on the

brain and cognitive activities. Najaf Abadi et al.<sup>8</sup> examined the short-term memory and the cognition/inhibition flexibility of 17 female athletes based on digit span test (DST) parameters and Stroop colour test. Islamic fasting did not contribute to any significant changes in DST parameters. However, Stroop experiments<sup>2,3</sup> showed a considerable recovery in Ramadan. The data suggest that fasting in Ramadan does not result in any significant changes in short-term memory and/or cognition/inhibition flexibility. After all, no significant changes, except in their interference index have been reported after Ramadan.<sup>8</sup>

Another study conducted by Farooq et al.<sup>9</sup> examined the cognitive activity based on spatial cognition, attention, planning, working memory tasks and working memory capacity in a population of 18 boys aged  $12.6 \pm 1.5$  years. The results showed that during the 4th week of Ramadan, spatial cognition, planning, working memory tasks and working memory capacity increased significantly, but attention fell in subjects aged 9-12.<sup>9</sup> Furthermore, Bouhlel et al.<sup>10</sup> conducted a study on 10 karatekas aged  $18.5 \pm 0.5$  years who were fasting. The participants were examined based on simple reaction time (SRT) and choice reaction time (CRT). Results showed that CRT was not affected by fasting, but SRT was negatively influenced. Researchers believed that such changes had their roots in the nature of cognition tasks.<sup>10</sup> Yasin et al.<sup>11</sup> evaluated mathematical problem-solving and memory testing in their study as indicators of cognitive functioning. No effects on students' cognitive activity were observed. It is worth mentioning that a significant increase in students' sleeping periods during the day and decrease at night was reported.<sup>11</sup> In addition, Bahammam et al.<sup>12</sup> examined 8 subjects aged  $25.3 \pm 2.9$  years using John drowsiness scale (JDS), blink total duration, and mean reaction time to compare the cognitive and dizziness states in Ramadan. They found that rapid eye movement sleep (REMS) period decreased significantly during Ramadan, but JDS did not show any significant changes.<sup>12</sup> Roky et al.<sup>13</sup> studied disparity in athletes' sleeping cycles during Ramadan in which the lack of harmony in athletes' cognitive activity was observed due to changes in sleeping habits and lack of sufficient sleeping. However, the findings of Margolis et al.<sup>14</sup> study proved otherwise. In that study, comprising a group of medical school students, it was found that despite the significant decrease in night sleep and increase in day sleep, the group's sleepiness scale had not changed significantly before and after Ramadan.<sup>14</sup> As it seems, there is not a unified conclusion amongst the scientists. Furthermore, Doniger et al.<sup>15</sup> drew the conclusion that Islamic fasting decreases fasting-related information significantly. Also,

**Table:** Summary of selected studies including Authors and related information.

No.	First author	Type of study	Population under study	Evaluated cognitive domains	Tools/evaluation parameters	Main findings
No. 1	First author GhayourNajafabadi <sup>8</sup>	Type of study Case control study	18 female athletes 13-24 years age	Short term memory Inhibition/cognitive flexibility	Digit Span test (DST) Stroop Color Test (SCT)	Two groups had no significant difference in short memory and inhibition. After Ramadan interference index showed a significant decline.
2	Farooq, A <sup>9</sup>	Case control study	18 boys age 12.6 (1.5) years age boys	Spatial planning Working memory	CANTAB	At week 4, performance on the spatial planning and working memory task and working memory capacity test increased significantly while match-to-sample test performance declined in preteens only
3	Bakan, A. A <sup>5</sup>		50 persons (30 men, 20 women) 30.2 (8.5) years age	Microstructural changes in brain	Diffusion tensor imaging	A 3 week period of fasting may lead to changes at microstructure level in the brain structures which will be visible through diffusion tensor imaging.
4	Doniger, G. M <sup>15</sup>	Cohort study	46 persons 24 (±2.1) years age	Attention Executive function Memory Motor skills Information processing Verbal function Visual spatial	Mindstreams global assessment battery	Fasting-related deficits were found in all cognitive tasks tested and were often associated with tasks requiring perception of spatial relations.
5	Bahammam, A. S <sup>12</sup>	Cohort study	8 persons 25.3 (2.9) years age	Drowsiness	Johns Drowsiness Scale (JDS) Blink Total Duration Mean Reaction Time CogState Software	REM sleeping period was significantly less during Ramadan. No significant difference monitored in MRT and JDS values before and after Ramadan.
6	Tian, H. H <sup>18</sup>	Before & after study	18 persons, 20.9 (±3.3) yrs age	Processing speed Visual attention Visual learning Visual memory Working memory Verbal learning Verbal memory		Processing speed and visual attention were better at 9 am
7	Lotfi, S <sup>25</sup>	Before & after study	11 men, age 20.45 (±1.65) years	Working memory Visual perception		In afternoon significant decline in psychomotor
8	Azizi, F <sup>16</sup>	Historical cohort	191 kids 3 to 14 years age	Intellectual development	Wechsler Intelligence Scale for Children-Revised (WISC-R)	No significant difference noticed between kids with moms fasting and the ones of not fasting
9	Yasin, W. M <sup>11</sup>	Before & after study	30 studnets	Mathematical problem solving Memory testing	Questionnaire	No difference noticed in evaluation tasks before and after Ramadan
10	Maughan, R. J <sup>17</sup>	Review article			R	Daily naps were increased and night sleeps were decreased significantly
11	Roky, R <sup>19</sup>	Review article			R	Sleeping cycle disorder, change and decrease of sleep. May be effective on athletes cognitive activities.
12	Cherif, R <sup>7</sup>	Review article			R	This article has emphasized on a tight schedule that keeps the sleeping cycles in a routine Daylight fasting may have negative effects on some domains such as Coping and decision making
13	Meo, S. A <sup>4</sup>	Review article			R	No specific effects on brain and cognitive activities were monitored

tasks requiring perception of spatial relation is under negative effect based on their study.<sup>15</sup> Amongst 191 children aged 4-13 years, Azizi et al.<sup>16</sup> investigated the relationship between pregnant mothers and their

newborns' intelligence quotient (IQ). They could find no significant difference between children's IQ of fasting mothers and non-fasting ones.<sup>16</sup> Maughan et al.<sup>17</sup> studied hydration in athletes in Ramadan, and learnt that loss of 1-

2% of body's water may harm physical and cognitive abilities. They indicated that in-rest people in a day without water and food lose only 1% body mass index (BMI) water. Yet, this amount can never damage cognitive activity in an individual, unless increased water loss occurs due to extreme heat or activity.<sup>17</sup>

In two other studies, cognitive changes were tested in different hours of a day in Ramadan. Tian et al.<sup>18</sup> conducted a study on 18 Muslim athletes, and examined verbal processing, verbal learning, working memory, visual memory, visual learning, visual attention, and memory speed before and after Ramadan at 9 am and 4 pm. At 9 am, processing speed and visual attention were significantly better. Though verbal learning, verbal memory and psychomotor fell significantly at 4 pm. This research concluded that cognitive activities needing sustained rapid response had a better performance in the morning, but decreased in the afternoon, and non-speed-dependant accuracy measures of cognitive tasks were more resistant to daytime fluctuations.<sup>18</sup> Another research by Roky et al.<sup>19</sup> evaluated cognitive functioning of 10 youths on 7 days before Ramadan and on 6th, 15th, 28th days of Ramadan as well as 18 days after Ramadan. They examined the volunteers at 9am, 11am, 1pm, 4pm, 8pm and 11pm through different parameters such as movement reaction time (MRT), critical flicker fusion (CFF), and eyes' alertness. They concluded that objective alertness at 9am and 4pm decreased, and at 11pm it increased significantly. MRT was shown to have the highest increase on the 6th day, but CFF was not shown to have any significant changes during the study period.<sup>19</sup>

## Discussion

The present review article examined the relationship between Islamic fasting, cognitive activities and brain changes among adolescents fasting during Ramadan. Of the papers reviewed in this study, the majority of cases are related to athletes, and cognitive activities were only one of the variables examined. In addition, all the reviewed papers used a sample size less than 50 subjects, except the historical cohort study of Azizi et al. conducted on 191 children. Considering the contradictory results rampantly seen in different studies, age group differences were amongst the challenges faced by the researchers. One must also consider different geographical locations of Islamic countries and their different fasting times, which might have a direct effect on the outcomes of the studies.<sup>20</sup> Various evaluation tools hold account for raising various outcomes as well. These studies only looked at general cognitive activities such as, memory, attention, concentration, executive functions and psychomotor that were mainly related to physical

activities, leaving other cognitive tasks out of examination. An effective education must also include reasoning, comprehension, judgment, abstract thinking<sup>21-24</sup> but such things were not considered in the studies reviewed. The study by Lotfi, S et al.<sup>25</sup> is also worthy of note (Table). However, learning from these studies, Islamic fasting may affect cognitive activities such as spatial memory, visual memory, and attention, which play important roles in an effective education.<sup>9,15,18</sup> Of course, these are not long-term studies, and the results might be influenced by the duration of studies.<sup>19</sup>

All in all, those youths who are planning to fast during Ramadan, while continuing their education, should have a very flexible agenda for specific days and hours so that scholastic activities that deal with concentration, spatial and visual memory should be fulfilled in the early hours of the day, and other academic activities like learning new lessons, general exams (entrance or final exams first) should be scheduled for the first half of Ramadan.

## Conclusion

Despite having temporary effects on cognitive tasks, Islamic fasting does not undermine scholastic activities and students' functions at school or university. To understand a more precise relationship between Islamic fasting and cognitive activities, it is recommended to conduct a study with a larger sample size, using similar evaluation tools, targeting different cognitive tasks.

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