Does Ramadan Observance Affect Cardiorespiratory Capacity of Healthy Boys?

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Abstract

Studies raising the issue of the effects of Ramadan observance (RO) on boys' 6-min walk test (6MWT) data are rare. The studies, which did not include control groups of non-fasters, presented contradictory results. This study aimed to compare the 6MWT data (6-min walk distance [6MWD; m, %predicted], heart rate [HR; bpm, % of maximal predicted HR]), oxy-hemoglobin saturation (Oxy-sat; %), systolic and diastolic blood pressures (SBP and DBP, respectively; mmHg) determined at rest ($_{Rest}$ and at the end $_{End}$ of the test) of a group of 22 healthy fasting boys (age: 12 to 15 years) with an age-matched non-fasting group ($n = 10$). The 6MWTs were performed during three experimental conditions (ECs): Pre-Ramadan, Mid-Ramadan, and Post-Ramadan. The two groups' 6MWT data for each EC were compared, and repeated factorial analysis of variance (2 groups vs. 3 ECs) was performed. Both groups had similar values of 6MWD (m, %predicted), HR_{Rest} or HR_{End} (bpm, % of maximal predicted HR), $Oxy\text{-}sat_{Rest}$, $Oxy\text{-}sat_{End}$, SBP_{Rest}, and DBP_{Rest} during the three ECs. Compared to the non-fasting group, the fasting group had significantly higher SBP_{End} (121 ± 10 vs. 130 ± 11) and DBP_{End} (72 ± 6 vs. 78 ± 7) determined during the Mid-Ramadan EC. No significant interactive effects of the groups (2) vs. ECs (3) was found for the 6MWD (%predicted; $p = .809$), HR_{Rest} (%, $p = .555$), HR_{End} (%, $p = .964$), $Oxy\text{-}sat_{Rest}$ ($p = .336$), $Oxy\text{-}sat_{End}$ ($p = .389$), SBP_{Rest} ($p = .708$), SBP_{End} ($p = .548$), DBP_{Rest} ($p = .277$), and DBP_{End} ($p = .096$). To conclude, in boys, RO does not impact the 6MWD, HR, or Oxy-sat, but it has minimal impact on the SBP_{End} and DBP_{End}.

Ramadan observance (RO; i.e., abstaining from both food and fluid ingestion from dawn to sunset) concerns every healthy Muslim starting from the age of puberty (i.e., 12 to 15 years old for boys; Aslam & Wilson, 1992). In adults, RO leads to several physiological changes (e.g., sleep, alertness, meal times and eating agenda, hypohydration, body composition, metabolic and/or ventilatory responses; Aloui et al., 2019; Ben Saad, 2018; Iraki et al., 1997; Latiri et al., 2017; Roky et al., 2012; Trabelsi, El Abed, et al., 2011; Trabelsi, Rebai, et al., 2011). Altogether, the aforementioned RO-induced changes can lead to a decrease in adults' physical activity and performance levels (Aloui et al., 2013; Aloui et al., 2018; Aziz et al., 2010; Brisswalter et al., 2011; Cherif et al., 2016; Chtourou et al., 2019; Kirkendall et al., 2008; Lessan et al., 2018; Ramadan, 2002; Ramadan et al., 1999;

Ramadan & Barac-Nieto, 2000). As children/adolescents are not miniature adults (Chang, 2010), the hypothesis that the RO physiological changes reported in adults may

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be extrapolated in children and adolescents is questionable and should be verified.

Most of the published studies examining the impacts of RO on cardiorespiratory capacity were conducted on adults (Aloui et al., 2013; Aloui et al., 2018; Aziz et al., 2010; Brisswalter et al., 2011; Chaouachi et al., 2009; Cherif et al., 2016; Chtourou et al., 2019; Kirkendall et al., 2008; Lessan et al., 2018; Ramadan, 2002; Ramadan et al., 1999; Ramadan & Barac-Nieto, 2000), and the data regarding its impacts on children's cardiorespiratory capacity are few. To the best of the authors' knowledge, only five studies have examined the impacts of RO on the physical capacities of children/adolescents (Aloui et al., 2013; Fenneni et al., 2014, 2017; Girard & Farooq, 2012; Meckel et al., 2008). The methodologies and results of the aforementioned studies were discussed by Fenneni et al. (2015). First, several different tests were performed: vertical jump test (Fenneni et al., 2014; Meckel et al., 2008), horizontal jump test (Fenneni et al., 2014), counter movement jump (Aloui et al., 2013), squat jump (Aloui et al., 2013), 20-m sprint (Fenneni et al., 2014; Girard & Farooq, 2012), 30-m sprint (Fenneni et al., 2014), 40-m sprint (Meckel et al., 2008), 4 × 10-m run (Meckel et al., 2008), sum × 40-m run (Meckel et al., 2008), 6 × 40-m performance (Meckel et al., 2008), 3,000-m run (Meckel et al., 2008), medicine ball throw (Fenneni et al., 2014), maximal oxygen uptake (Aloui et al., 2013), and 6-min walk test (6MWT; Fenneni et al., 2014, 2017). Second, in their critical analysis of the published literature about the impacts of RO on healthy children's physical capacities, Fenneni et al. (2015) concluded that "the impact of RO on the physical capacities of children appears controversial, but there is a penchant to a reduction in endurance performance, while a minor decrement or no significant impact on short-term explosive performance has been shown." Third, some important methodological limitations leading to anecdotal comparisons of physical responses between studies were noted (Fenneni et al., 2015). The main limitations concerned the lack of sample sizes calculation and the lack of information about some important data (e.g., geographical location, season, duration of fasting, test timing, previous experience with RO, children's physical activity status, average ambient temperature and relative humidity at the time of physical testing; Fenneni et al., 2015). Finally, all of the aforementioned studies did not include a parallel control group (CG) of non-fasting. The lack of a parallel CG of non-fasting explained a large part of the results' discrepancy (Fenneni et al., 2015), since this alters the internal validity of the studies' findings and therefore the variations in the data assessed cannot be exclusively related to RO. For this reason, Fenneni et al. (2015) strongly recommended that future similar studies should systematically include a CG of non-fasting in order to circumvent any threat to the internal strength of the results.

In children/adolescents, the assessment of the cardiorespiratory capacity via, for example, a field test data (e.g., 6MWT; American Thoracic Society (ATS) 2002; Ben Saad et al., 2009) provides valuable information to make management decisions leading to improve functional capacity (Connuck, 2005; Massin, 2014). The 6MWT, a self-paced test of walking capacity where subjects are asked to walk as far as possible in 6 min along a flat corridor (Holland et al., 2014), is very useful in both healthy and unhealthy children/adolescents (Andrade Lima et al., 2018; Cacau et al., 2016; den Boer et al., 2017; Himuro et al., 2017; Mylius et al., 2016). During the 6MWT, the following data are recorded/noted: 6-min walk distance (6MWD; the primary outcome of the 6MWT), systolic and diastolic blood pressures (SBP, DBP, respectively), heart rate (HR), and oxy-hemoglobin saturation (Oxy-sat; ATS, 2002; Holland et al., 2014). The strong relationships between the 6MWD and the measurements of exercise performance and physical activity support the conceptualization of the 6MWT as a test of functional exercise performance (Li et al., 2005). In children/adolescents, the 6MWD elicits a peak oxygen uptake that is similar to the one determined during a cardiopulmonary exercise test (Li et al., 2005). During exercise, the HR responses reflect the subjects' physical level (Holland et al., 2014; Singh et al., 2014). The Oxy-sat and arterial blood pressure responses during exercise are important parts of exercise data interpretation (Brenner & Allemann, 2011; Sharma et al., 2012). The only study that evaluated the impact of RO on children's/adolescents' 6MWD concluded that "RO impairs submaximal exercise capacity" (Fenneni et al., 2014). In addition, the only study dealing with the impact of RO on children's/adolescents' HR and/or Oxy-sat changes concluded that "RO influences HR data but has minimal impacts on Oxy-sat" (Fenneni et al., 2017). The Oxy-sat changes were not "clinically significant" since they were lower than 5 points (Fenneni et al., 2017). To the best of the authors' knowledge, no previous study has raised the issue of the impact of RO on children's/adolescents' arterial blood pressures determined during the 6MWT.

In real life, it is a relatively current practice for children to make their first attempt of RO while they are still prepubescent (i.e., from early adolescence; Deeb et al., 2017). It is quite questionable whether prepubescent children should be allowed to fast while religion requires such a practice only after puberty (Fenneni et al., 2015). The question that should be raised will be as follows: Does RO alter the cardiorespiratory capacity of children/adolescents? Taking into account the above considerations, the main aim of this quasi-experimental study performed on healthy boys aged 12–15 years was to compare the 6MWD, Oxy-sat, HR, SBP, and DBP of a fasting group with an age-matched non-fasting one. The null

hypothesis is that there is no difference between their 6MWD, Oxy-sat, HR, SBP, and DBP mean values.

Population and Methods

The present study is part of a project involving two parts. The first, which was recently published, aimed to evaluate the impact of RO on spirometric data (Ben Fraj et al., 2019). The authors concluded that "RO had no interaction effect with the spirometric data of healthy boys." The second part is the objective of this study.

Study Design

This quasi-experimental study was conducted in compliance with the World Medical Association (WMA) Declaration of Helsinki in a junior high school located in Kalaa-Sghira (Sousse, Tunisia). Approval for the study was obtained from the Farhat Hached Hospital Ethical Committee (approval number 1206/2015) and written consent was obtained from all the participants' parents. Boys agreed verbally to participate in this study. Participation in this study was free of pressure and participants were informed that they could withdraw from the study at any time. Participants were also informed that they can stop RO at any time.

The study was conducted during Ramadan 2015 (mean elapsed time from dawn to sunset = ~16.15 h). The means of ambient temperature and humidity during the study period (59 days) were 32.8°C and 68%, respectively. The means of ambient temperature and humidity during the Pre-Ramadan (Pre-R), Mid-Ramadan (Mid-R), and Post-Ramadan (Post-R) experimental conditions (ECs) were, 32.0, 31.6, and 34.7 °C; and 71.7, 63.8, and 73.7%, respectively.

Sample Size

The total sample size was estimated using the following formula (Maxwell et al., 2008):

$$N = \frac{(r+1)\,(Z\alpha_{/2} + Z_{1\text{-}\beta})^2\,\delta^2}{r\,d^2}$$

- *N is equal to $n_1 + n_2$ (n_1 and n_2 are the sample sizes for the two groups of fasters and non-fasters)*
- *$Z_{\alpha/2}$: normal deviate at a level of significance (= 1.96 for 5% level of significance)*
- *$Z_{1\text{-}\beta}$: normal deviate at 1-β% power with β% of type II error (= 2.33 at 99% statistical power)*
- *r (equal to n_1/n_2): ratio of the sample size required for the two groups (r = 2.5 gives the sample size distribution as 2.5:1 for the fasting and non-fasting groups). The reason for the unequal sample size was the difficulty in finding non-fasters in this age group*
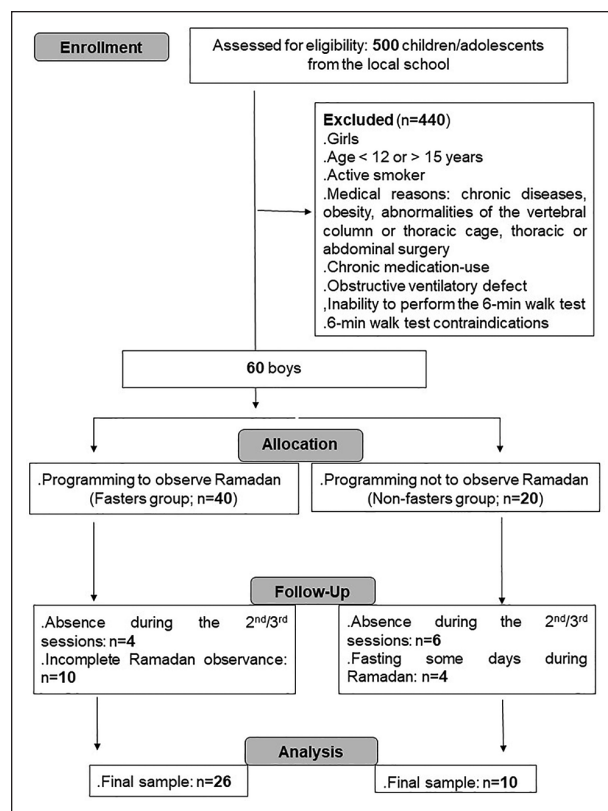

Figure 1. The study flowchart.

- δ and *d* are the pooled standard deviation (*SD*) and the difference of the 6MWD means of the two groups determined at Mid-R. These two values were obtained from a previous study having a similar hypothesis and including 18 fasting boys (mean ± *SD* of age and weight were 11.9 ± 0.8 years and 55.4 ± 18.2 kg, respectively; Fenneni et al., 2014). During the 2nd week of Ramadan, the fasters had a 6MWD of 635 ± 105 m (Fenneni et al., 2014; while the mean 6MWD predicted normal values derived from a group of healthy North African children [Ben Saad et al., 2009] was 703 ± 54 m) with a common *SD* of 78.5 m [=(105 + 54)/2]

The total sample size was 34 boys (23 fasters and 11 non-fasters). The assumption of 40% of nonattendance during the second/third testing EC gives a revised sample of 56 boys [= 34/(1 − 0.40)].

Study Population

Figure 1 describes the study consort flowchart. Only healthy volunteer participants aged 12 to 15 years were included. In this study, the term "boys" was used to include the following two terms: "children" (6 to 12 years old; http://www.ncbi.nlm.nih.gov/mesh/68002648; last

access: February 14, 2020) and "adolescents" (13 to 18 years old; http://www.ncbi.nlm.nih.gov/mesh/68000293; last access: February 14, 2020). The noninclusion criteria were smoking, chronic diseases, obesity, abnormalities of the vertebral column or thoracic cage, thoracic or abdominal surgery, chronic medication use, lack of cooperation during the spirometry test, bronchial obstruction, inability to perform the 6MWT, and 6MWT contraindications (Holland et al., 2014; $HR_{Rest} \geq 120$ bpm; high SBP_{Rest} or DBP_{Rest} [Rao, 2016]). The following exclusion criteria were applied: fasting some days during Ramadan (for the non-fasting group), incomplete RO period (for the group of fasters), and absence during the second/third testing EC.

Experimental Design

The experimental design consisted of three testing ECs: 5–7 days Pre-R (23 to 25 *Shabaan*), 3 days Mid-R (15 to 17 Ramadan), and 10–12 days Post-R (20 to 22 *Shawal*). For the group of fasters, a complete RO period was defined as including 29 days.

During the Pre-R EC, all the boys answered a medical questionnaire. Second, anthropometric data (age, height [cm], weight [kg], body mass index [BMI, kg/m^2]) were noted. After that, the boys performed a spirometry followed by a 6MWT. During the Mid-R and Post-R ECs, merely the anthropometric, spirometric, and 6MWT data were determined. The 6MWT of the three ECs was conducted at the same time of the day, around 5.5 to 3.5 h before sunset, when fasters are allowed to break their fast.

Collected Data, 6MWT Procedures, and Applied Definitions

Clinical data were gathered from a simplified medical questionnaire (Ferris, 1978). Questions were asked in Arabic and the subsequent data were collected: practice of regular sports activities, parents' professions, individual medical or surgical histories, chronic treatment use, and smoking behaviors.

During every EC, each boy performed only one 6MWT. The 6MWD (m) was noted and expressed as a percentage of the predicted local norms (Ben Saad et al., 2009): 6MWD (m) = 4.63 × height (cm) - 3.53 × weight (kg) + 10.42 × age (years) + 56.32. The following data were determined at $_{Rest}$ and at the $_{End}$ of the 6MWT: Oxy-sat (%, $Oxy\text{-}sat_{Rest}$, $Oxy\text{-}sat_{End}$), HR (bpm, % of maximal predicted HR [= 208 - 0.70 × age]; Tanaka et al., 2001; HR_{Rest}, HR_{End}, $\%HR_{Rest}$, $\%HR_{End}$), SBP (SBP_{Rest}, SBP_{End}), and DBP (DBP_{Rest}, DBP_{End}).

The 6MWT was conducted according to the standardized protocol (ATS, 2002; Holland et al., 2014). The 6MWT was performed along a seldom traveled, flat, straight corridor (40 m long; marked every 1 m with cones) with a hard surface. To minimize intraday variability, the 6MWT was conducted at the same time of day (Chtourou & Souissi, 2012). Boys were familiarized with the 6MWT to minimize the learning effect (Morales Mestre et al., 2018). They were asked to avoid strenuous activities 24 h before each testing EC and were asked to wear comfortable clothes and appropriate walking shoes. The boys sat in a chair placed near the starting position for at least 10 min before the 6MWT started. During this time, the HR, Oxy-sat (handheld pulse oximeter, M700; Zhuhai, Guangdong, China) and arterial blood pressures (electric manual blood pressure monitor with child armband, Tech Discount, France) were measured at rest. The test instructions given to the boys were those recommended by the ATS/European Respiratory Society (ATS, 2002; Holland et al., 2014). At the end of the 6MWT, the same data were remeasured.

The following data were calculated:

(i) ΔOxy-sat (=$Oxy\text{-}sat_{End}$ - $Oxy\text{-}sat_{Rest}$). For each EC, a ΔOxy-sat decrease more than 5 points was defined as a "clinically significant" desaturation (Fenneni et al., 2017; Singh et al., 2014).

(ii) Percentage changes in 6MWD, Oxy-satRest, Oxy-satEnd, HRRest, HREnd, SBPRest, SBPEnd, DBPRest, and DBPEnd at Post-R compared with Pre-R:

$$\% \,change = 100 \,x\, \frac{(Post - R\ value - Pre - R\ value)}{Pre - R\ value}$$

(iii) 6MWD change (m) = Post-R 6MWD minus Pre-R 6MWD. 6MWD higher and lower than the 90% 6MWD level minimal detectable change (e.g., an arbitrary MDC90 of 48 m) was considered as "clinically significant" decrease and increase, respectively (Klepper & Muir, 2011).

Statistical Analysis

The Kolmogorov-Smirnov test was used to analyze quantitative data distributions. The quantitative data (anthropometric [age, weight, height, BMI] and 6MWT [6MWD (m, %predict, % change), HR (bpm; % of maximal predicted HR, % change), SBP (mmHg, % change), DBP (mmHg, % change), and Oxy-sat (%, % change)] data) were expressed as mean $\pm$ *SD*. The two groups' quantitative data for each EC were compared using the Mann–Whitney *U* Test. Comparisons of the 6MWT data

Table 1. Six-Minute Walk Distance (6MWD) Values During the Three Experimental Conditions: Fasters (*n* = 26) and Non-Fasters (*n* = 10) Groups.

		Pre-R	Mid-R	Post-R	Factorial ANOVA
6MWD (m)	Fasters	680 ± 76	679 ± 98	652 ± 68	$F(2,102) = 0.196; p = .822$
	Non-fasters	635 ± 60	619 ± 69	618 ± 69	
	p	.120	.066	.120	
6MWD (%)	Fasters	89 ± 9	88 ± 11	85 ± 8	$F(2,102) = 0.213; p = .809$
	Non-fasters	86 ± 9	84 ± 10	84 ± 9	
	p	.368	.237	.537	

Note. Data were mean ± *SD*. ANOVA = analysis of variance; R = Ramadan.
Factorial ANOVA: between the three experimental conditions for the two groups.
p: Mann–Whitney *U* test between the two groups for the same experimental condition.

were made between the three ECs via a factorial analysis of variance in order to analyze the higher order interactive effects of multiple categorical independent factors (groups [2] vs. EC [3]). Qualitative data (percentages of boys with "clinically significant" desaturation or 6MWD decrease or 6MWD increase) were expressed by relative frequency. In order to differentiate between the "statistically significant" and the "clinically significant" approaches (Yaddanapudi, 2016), the percentages of boys with "clinically significant" desaturation or 6MWD decrease or 6MWD increase were compared between the two groups (two-sided chi-squared test).

Analyses were carried out using Statistica software (Statistica Kernel version 6; StatSoft, Paris, France). Significance was set at the 0.05 level.

Results

Among the initial sample of 60 boys, only 36 were retained (26 fasters and 10 non-fasters; Figure 1). The fasting and non-fasting groups had similar mean ± *SD* ages (13.3 ± 0.8 vs. 12.9 ± 0.5 years; *p* = .1974), weights (46.8 ± 9.2 vs. 41.7 ± 12.6 kg; *p* = .1288), and BMIs (18.4 ± 2. vs. 18.3 ± 4.1 kg/m^2; *p* = .5601). The fasters were significantly taller than the non-fasters (159 ± 9 vs. 150 ± 9 cm; *p* = .0273, respectively).

Impact of RO on 6MWD

There was no significant difference between the two groups' mean 6MWD data (expressed in m or as %predict) for each EC (Table 1). No significant interactive effect of the groups (2) vs. ECs (3) was found.

The fasting and non-fasting groups included similar percentages of boys with "clinically significant" 6MWD decrease (15 [57.69%] vs. 3 [30.00%], respectively; *p* = .1367) or increase (3 [11.54%] vs. 2 [20.00%], respectively; *p* = .5109).

Impact of RO on HR

There was no significant difference between the two groups' mean HR data (expressed in bpm or % of maximal predicted HR) for each EC (Table 2). No significant interactive effect of the groups (2) vs. ECs (3) was found.

Impact of RO on Arterial Blood Pressures

The two groups had similar values of SBP$_{Rest}$ and DBP$_{Rest}$ for each EC and similar values of SBP$_{End}$ and DBP$_{End}$ during the Pre-R and Post-R ECs (Table 3). However, compared to the non-fasting group, the fasting group had higher values of SBP$_{End}$ and DBP$_{End}$ during the Mid-R EC. No significant interactive effect of the groups (2) vs. ECs (3) was found.

Impact of RO on Oxy-Sat

The two groups had similar Oxy-sat values for each EC (Table 4). No significant interactive effect of the groups (2) vs. ECs (3) was found. During the three ECs, no boy presented a "clinically significant" desaturation.

6MWT Data Changes Between the Two Groups

The two groups had similar percentage changes in 6MWT data (6MWD, Oxy-sat$_{Rest}$, Oxy-sat$_{End}$, HR$_{Rest}$, HR$_{End}$, SBP$_{Rest}$, SBP$_{End}$, DBP$_{Rest}$, DBP$_{End}$) at Post-R compared with Pre-R (Table 5).

Discussion

Values of 6MWD, HR, Oxy-sat, and arterial blood pressure of the healthy 26 fasters and 10 non-fasters boys aged 12 to 15 years with similar ages, weights, and BMIs were compared during the three ECs. It appears that RO had no impact on the 6MWD, HR, Oxy-sat, and resting arterial blood pressures. However, during the Mid-R EC, the fasting group, compared to the non-fasting one, had significantly higher

Table 2. Heart Rate (HR) Values During the Three Experimental Conditions: Fasters ($n = 26$) and Non-Fasters ($n = 10$) Groups.

			Pre-R	Mid-R	Post-R	Factorial ANOVA
HR$_{Rest}$	bpm	Fasters	78 ± 7	79 ± 9	81 ± 9	$F(2,102) = 0.594$; $p = .554$
		Non-fasters	79 ± 6	80 ± 7	78 ± 9	
		p	.6589	.7372	.4065	
	%	Fasters	39 ± 3	39 ± 5	40 ± 5	$F(2,102) = 0.591$; $p = .555$
		Non-fasters	39 ± 3	40 ± 3	39 ± 5	
		p	.6589	.7911	.4065	
HR$_{End}$	bpm	Fasters	122 ± 14	120 ± 21	112 ± 13	$F(2,102) = 0.036$; $p = .964$
		Non-fasters	118 ± 13	118 ± 18	109 ± 10	
		p	.5135	.9016	.6335	
	%	Fasters	60 ± 7	59 ± 10	55 ± 6	$F(2,102) = 0.036$; $p = .964$
		Non-fasters	58 ± 6	58 ± 9	54 ± 5	
		p	.4910	.8737	.5601	

Note. Data were mean ± *SD*. ANOVA = analysis of variance; bpm = beats per minute; R = Ramadan.
%: percentage of predicted maximal HR. Factorial ANOVA: between the three experimental conditions for the two groups.
p: Mann–Whitney *U* test between the two groups for the same experimental condition.

Table 3. Arterial Blood Pressures During the Three Experimental Conditions: Fasters ($n = 26$) and Non-Fasters ($n = 10$) Groups.

			Pre-R	Mid-R	Post-R	Factorial ANOVA
SBP (mmHg)	Rest	Fasters	117 ± 11	114 ± 10	111 ± 12	$F(2,102) = 0.346$; $p = .708$
		Non-fasters	115 ± 9	110 ± 8	112 ± 10	
		p	.711	.237	.778	
	End	Fasters	131 ± 11	130 ± 11	129 ± 13	$F(2,102) = 0.605$; $p = .548$
		Non-fasters	127 ± 15	121 ± 10	126 ± 13	
		p	.427	.044	.491	
DBP (mmHg)	Rest	Fasters	68 ± 6	69 ± 6	64 ± 7	$F(2,102) = 1.301$; $p = .277$
		Non -asters	68 ± 9	66 ± 7	67 ± 5	
		p	.646	.237	.210	
	End	Fasters	78 ± 6	78 ± 7	76 ± 9	$F(2,102) = 2.400$; $p = .096$
		Non-fasters	79 ± 8	72 ± 6	76 ± 6	
		p	.672	.016	.944	

Note. Data were mean ± *SD*. ANOVA = analysis of variance; DBP = diastolic blood pressure; R = Ramadan; SBP = systolic blood pressure.
Factorial ANOVA: between the three experimental conditions for the two groups.
p: Mann–Whitney *U* test between the two groups for the same experimental condition.

SBP$_{End}$ by ~9 mmHg and DBP$_{End}$ by ~6 mmHg. The null hypothesis that there is no difference between the two groups' SBP$_{End}$ and DBP$_{End}$ mean values is rejected.

To the best of the authors' knowledge, only two studies (Fenneni et al., 2014, 2017), belonging to the same project, examined the impact of RO on the boys' 6MWT data. The methodology of the project and the two studies' main results are largely described in Table 6.

Impact of RO on 6MWD

The 6MWD was not affected by RO (Table 1). This result was inconsistent with the one previously observed by Fenneni et al. (2014) where the 6MWD was 85 m shorter during the 4th week of Ramadan compared to Pre-R (Table 6). According to Fenneni et al. (2014), the 85-m difference was higher than the arbitrary MDC90 of 48 m used to determine whether the change in the 6MWD following intervention (i.e., RO) is "clinically significant" (Klepper & Muir, 2011). The aforementioned finding is not sustained by this study since the two groups of fasters and non-fasters included similar percentages of boys with a "clinically significant" 6MWD decrease (57.69% vs. 30.00%, respectively). The present study result is not surprising since the respiratory system adapts normally during RO (Ben Fraj et al., 2019). A

Table 4. Oxy-Hemoglobin Saturation (Oxy-Sat, %) During the Three Experimental Conditions: Fasters (*n* = 26) and Non-Fasters (*n* = 10) Groups.

		Pre-R	Mid-R	Post-R	Factorial ANOVA
Oxy-sat$_{Rest}$	Fasters	95.8 ± 1.8	97.7 ± 0.8	96.9 ± 0.6	$F(2,102) = 1.101; p = .336$
	Non-fasters	96.8 ± 1.3	97.9 ± 0.9	97.1 ± 1.0	
	p	.104	.514	.387	
Oxy-sat$_{End}$	Fasters	97.0 ± 1.4	97.4 ± 0.9	97.7 ± 0.7	$F(2,102) = 0.953; p = .389$
	Non-fasters	96.7 ± 0.7	97.7 ± 0.7	97.3 ± 0.9	
	p	.323	.377	.469	

Note. Data were mean ± SD. ANOVA = analysis of variance. R = Ramadan. Factorial ANOVA: between the three experimental conditions for the two groups.
p: Mann–Whitney *U* test between the two groups for the same experimental condition.

Table 5. Six-Min Walk Test Data Changes[¥].

		Fasters (*n* = 26)	Non-fasters (*n* = 10)	*p*
6-min walk distance	m	−3.61 ± 9.66	−2.41 ± 9.23	.986
	%[a]	−3.38 ± 9.58	−1.57 ± 9.46	.876
Oxyhemoglobin saturation (%)	Rest	1.20 ± 2.07	0.33 ± 1.85	.177
	End	0.66 ± 1.61	0.61 ± 0.99	.715
Systolic blood pressure (mmHg)	Rest	−4.36 ± 10.42	−2.33 ± 7.04	.958
	End	−1.12 ± 11.66	0.02 ± 8.13	.876
Diastolic blood pressure (mmHg)	Rest	−4.83 ± 13.17	−0.57 ± 16.26	.689
	End	−1.86 ± 11.08	−2.40 ± 13.47	.639
Heart rate$_{Rest}$	bpm	3.86 ± 11.30	−1.59 ± 10.81	.542
	%[b]	3.91 ± 11.31	−1.54 ± 10.82	.542
Heart rate$_{End}$	bpm	−7.16 ± 13.80	−5.91 ± 13.63	.794
	%[b]	−7.11 ± 13.80	−5.86 ± 13.63	.794

Note. Data were mean ± SD. [¥]Change (%) = 100 × [(Post-Ramadan − Pre-Ramadan)/Pre-Ramadan]. bpm = beats per minute.
[a]Percentage of predicted 6-min walk distance. [b]Percentage of predicted maximal heart rate.
*p (Mann–Whitney *U* test) < .05: fasters versus non-fasters.

recent study concluded that "RO had no interaction effect with the spirometric data of healthy boys" (Ben Fraj et al., 2019). For example, during the Pre-R, Mid-R, and Post-R ECs, there was no significant difference between the fasters and non-fasters groups' mean forced expiratory volume in 1 s (101 ± 13 vs. 96 ± 16; 98 ± 11 vs. 97 ± 16; 101 ± 10 vs. 98 ± 16%, respectively; Ben Fraj et al., 2019). It is important to highlight that while RO impairs the adolescents'/children's performance during maximal and endurance exercises with higher intensities (e.g., increased 3,000-m running time; Fenneni et al., 2015; Meckel et al., 2008), it has no impact on the short-term explosive performance (e.g., vertical and horizontal jump tests, 20-m and 30-m sprints, and medicine ball throw; Fenneni et al., 2014).

Impact of RO on HR

RO had no significant impact on the HR (Table 2). Similar to this study finding, Fenneni et al. (2014) found similar HR$_{Rest}$ values during the four ECs of their protocol (Table 6). Contrary to this study finding, Fenneni et al. (2014) found that HR$_{End}$ values determined during the 4th week of Ramadan were lower than those of Post-R (Table 6). The findings of this study with regard to HR are in line with some results of the studies conducted on adults (Aziz et al., 2010; Brisswalter et al., 2011; Chaouachi et al., 2009), but opposite to others conducted also on adults (Husain et al., 1987; Ramadan & Barac-Nieto, 2000).

Impact of RO on Arterial Blood Pressures

RO seems to have a "statistically significant" impact on arterial blood pressures: Compared to non-fasters, fasters had higher values of SBP$_{End}$ and DBP$_{End}$ during the Mid-R EC. To the best of the authors' knowledge, this study is the first to examine the impact of RO on healthy boys' arterial blood pressures. This study results, especially with regard to DBP changes, are unclear. It seems

Table 6. Study Designs, Characteristics of Adolescents, and Main Results of the Two Studies Aiming to Evaluate the Impacts of Ramadan Observance (RO) on the Boys' 6-Min Walk Test (6MWT) Data.

Methodology of the Two Studies	
Ramadan year	2012
Timing	15:00–17:00 h
Elapsed fasting time	Dawn to sunset: ~16 h at the beginning (20th of July) and ~15 h at the end (18th of August)
Ambient temperature	~25°C
Average humidity	38%–42%
Number of experimental conditions	Four experimental conditions: 2 weeks Pre-R, R_2, R_4, and 10–12 days Post-R two tests in each period (with a recovery period of at least 36 h in between)
Number of children	18 boys observing Ramadan fasting for the first time
Control group	No
Age (years)	11.9 ± 0.8^a $[10.2–13.4]^b$ $(11.5–12.3)^c$
Height (cm)	153 ± 9^a $[149–157]^b$ $(136–168)^c$
Weight (kg)	55 ± 18^a $[46–64]^b$ $(34–91)^c$
Training status	Sedentary (practice of sport activity only at school)
6MWT familiarization	Yes
6MWT instructions	American Thoracic Society guidelines (ATS, 2002)
6MWT encouragement	Verbal encouragement

6MWT Collected Data and Main Results		
	Fenneni et al. (2014)	Fenneni et al. (2017)
Collected data	6MWD (m)	HR (%predicted maximal HR; Tanaka et al., 2001): rest, 1st, 2nd, 3rd, 4th, 5th, and 6th min Oxy-sat (%): rest, 1st, 2nd, 3rd, 4th, 5th, and 6th min 6MWD × 6th min Oxy-sat (m)
Impact of RO on 6MWD	Significant experimental condition effect 6MWD (m) was lower during R_2 (635 ± 105^a) and R_4 (601 ± 122^a) compared to Pre-R (686 ± 98^a) but returned to baseline values Post-R (687 ± 97^a)	Not reported
Impact of RO on HR (%)	Not reported	No significant experimental condition effect in resting or 3rd min values R_4 values were lower than those of Pre-R (2nd min) R_2 (1st, 2nd min) Post-R (1st, 2nd, 4th, 5th, 6th min)
Impacts of RO on Oxy-sat (%)	Not reported	No significant experimental condition effect in resting, 1st, 2nd, 4th, and 6th min values R_2 values were higher than those of Pre-R (3rd min) Post-R (5th min) Post-R values were lower than those of Pre-R and R_4 (5th min) Oxy-sat changes were not clinically significant (difference <5 points)
Impacts of RO on 6MWD × Oxy-sat (m)	Not reported	Significant experimental condition effect Pre-R value (67573 ± 7514^a) was higher than R_4 (56224 ± 12274^a) one
Main conclusion	RO reduced submaximal aerobic capacity	RO influenced HR data but had a minimal effect on Oxy-sat values

Note. 6MWD: 6-min walk distance; HR = heart rate; Oxy-sat = oxy-hemoglobin saturation; R = Ramadan; R_1 = 1st week of R; R_2 = end of the 2nd week of R; R_4 = 4th week of R.
Data were ^{a}mean $\pm$ *SD*. ^{b}Range (minimum–maximum). ^{c}95% confidence interval.

that the increases of SBP_{End} by ~9 mmHg and DBP_{End} by ~6 mmHg are not "clinically significant" in healthy boys. First, the Mid-R SBP_{End} values of the fasters and non-fasters (130 ± 11 and 121 ± 10 mmHg, respectively) were closer to those previously reported for healthy boys aged 12–13 years (126 ± 22 mmHg) or 14–15 years (129 ± 21 mmHg; Ben Saad et al., 2009). Second, the Mid-R DBP_{End} values of the fasters and non-fasters (78 ± 6 and 72 ± 6 mmHg, respectively) were also closer to those previously reported for healthy boys aged 12–13 years (70 ± 11 mmHg) or 14–15 years (68 ± 9 mmHg; Ben Saad et al., 2009). Additional future studies preferably with a continuous arterial blood pressure measurement (e.g., each min of the 6MWT) are necessary.

The arterial blood pressures increase during RO could be explained in one possible way. Fluctuations in lifestyle during Ramadan may impact the agenda of food intake (pre-fast meal before dawn, fast-breaking meal at sunset, then unlimited food intake and hydration are allowed till dawn) and the quality of foods (e.g., increase of protein intake, of vitamin A-rich fruits and other fruits, and of milk and milk products; decrease in the consumption of foods from tubers and roots, nuts and legumes, and dark green leafy vegetables; Khaled Trabelsi & Chtourou, 2019), which could impact blood pressures (Maughan et al., 2010). The validity of the above justification should be demonstrated in children/adolescents. In fact, in adults, fasting has been associated with catecholamine inhibition and a reduced venous return, causing a decrease in the sympathetic tone, thus leading to a decrease in blood pressures (Husain et al., 1987).

Impact of RO on Oxy-Sat

RO had no impact on the Oxy-sat (Table 4). Similar to this study result, Fenneni et al. (2017) found similar values of Oxy-sat$_{Rest}$ and Oxy-sat$_{End}$ during the four ECs (Table 6). Similar to our results, in which no boy presented a "clinically significant" desaturation, in Fenneni et al.'s study (2017), the Oxy-sat significant changes between the ECs were considered as "clinically insignificant" (i.e., they were <5 points; Singh et al., 2014).

Methodology Discussion

Discussion of the sample size, the study design, the 6MWT choice, and the applied procedures was previously detailed (Ben Fraj et al., 2019; Fenneni et al., 2015, 2014, 2017). The two main strongpoints of this study, compared to the five similar ones related to the impacts of RO on the healthy children's/adolescents' physical performances (Aloui et al., 2013; Fenneni et al., 2014, 2017; Girard & Farooq, 2012; Meckel et al., 2008), were the inclusion of a non-fasting CG and the quasi-experimental design. The inclusion of a CG eliminates some bias and

outside influence that could alter the results of the experiment (Fenneni et al., 2014, 2015). The CG allows researchers to focus on the phenomena (i.e., RO) they're trying to test (Azarian, 2011). The benefits of a quasi-experimental research (Harris et al., 2006; e.g., more feasible, reduce the time and resources required) were previously highlighted (Ben Fraj et al., 2019).

This study presents three limitations. The first concerns the convenience sampling, which is considered as a confounding factor. All boys were aware of the study goals, which might increase concern about religious prejudice and then might stimulate fasters to collaborate during the 6MWTs. The second limitation concerns the lack of control for diet and it was preferable to evaluate the dietary intake of included boys. Eating patterns and the quality of foods during Ramadan month are different from those during other months of the year. For example, some authors (Farooq et al., 2015) reported that protein intake of sedentary teenagers ($n = 9$, age: 13 to 15 years) increased significantly during Mid-R compared to Pre-R; perhaps because of increased protein-rich foods during the holy month. The third limitation concerns the high rate of "lost to follow-up" (40% = 24/60; Uhlig, 2018). This induces bias and reduces the study power, which affects the generalizability of the results (Uhlig, 2018).

In conclusion, RO performed by healthy boys aged 12 to 15 years does not impact the 6MWD, the HR, or the Oxy-sat. It has minimal impacts on SBP and DBP. Yet, this finding cannot be generalized to boys with chronic cardiorespiratory and/or metabolic diseases who want to observe Ramadan.

Authors' Contributions

SBF, AM, IL, and HBS: Literature search, data collection, study design, analysis of data, Manuscript preparation and review of manuscript.
All authors read and approved the final manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

Aloui, A., Baklouti, H., Souissi, N., & Chtourou, H. (2019). Effects of Ramadan fasting on body composition in athletes: A systematic review. *La Tunisie Médicale*, 97(10), 1087–1094. https://www.ncbi.nlm.nih.gov/pubmed/31691936

Aloui, A., Chaouachi, A., Chtourou, H., Wong del, P., Haddad, M., Chamari, K., & Souissi, N. (2013). Effects of Ramadan on the diurnal variations of repeated-sprint performances. *International Journal of Sports Physiology and Performance*, 8(3), 254–262. https://www.ncbi.nlm.nih.gov/pubmed/22952200

Aloui, A., Chtourou, H., Hammouda, O., Souissi, H., Chaouachi, A., Chamari, K., & Souissi, N. (2013). Effects of Ramadan on the diurnal variations of physical performance and perceived exertion in adolescent soccer players. *Biological Rhythm Research*, 44(6), 869–875. doi:10.1080/09291016.2013.780697

Aloui, A., Driss, T., Baklouti, H., Jaafar, H., Hammouda, O., Chamari, K., & Souissi, N. (2018). Repeated-sprint training in the fasted state during Ramadan: Morning or evening training? *The Journal of Sports Medicine and Physical Fitness*, 58(7–8), 990–997. https://www.ncbi.nlm.nih.gov/pubmed/28229567. doi:10.23736/S0022-4707.17.07090-6

Andrade Lima, C., Dornelas de Andrade, A., Campos, S. L., Brandao, D. C., Mourato, I. P., & Britto, M. C. A. (2018). Six-minute walk test as a determinant of the functional capacity of children and adolescents with cystic fibrosis: A systematic review. *Respiratory Medicine*, 137, 83–88. https://www.ncbi.nlm.nih.gov/pubmed/29605218. doi:10.1016/j.rmed.2018.02.016.

Aslam, M., & Wilson, J. V. (1992). Medicines, health and the fast of Ramadan. *Journal of the Royal Society of Health*, 112(3), 135–136. https://www.ncbi.nlm.nih.gov/pubmed/1629878. doi:10.1177/146642409211200308

ATS (American Thoracic Society). (2002). ATS statement: guidelines for the six-minute walk test. *American Journal of Respiratory and Critical Care Medicine*, 166(1), 111–117. https://www.ncbi.nlm.nih.gov/pubmed/12091180. doi:10.1164/ajrccm.166.1.at1102

Azarian, R. D. (2011). Potentials and limitations of comparative method in social science. *International Journal of Humanities and Social Science*, 1(4), 113–125. http://www.ijhssnet.com/journals/Vol._1_No._4;_April_2011/15.pdf

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(7), 516–521. https://www.ncbi.nlm.nih.gov/pubmed/20519256. doi:10.1136/bjsm.2009.070425

Ben Fraj, S., Miladi, A., Guezguez, F., Ben Rejeb, M., Bouguila, J., Gargouri, I., Rouatbi, S., Latin, I., & Ben Saad, H. (2019). Does Ramadan fasting affect spirometric data of healthy adolescents? *Clinical Medicine Insights Pediatrics*, 13, 1179556519862280. https://www.ncbi.nlm.nih.gov/pubmed/31384137. doi:10.1177/1179556519862280

Ben Saad, H. (2018). Pulmonary function of young Muslim males during the month of Ramadan: Some points to highlight. *American Journal of Men's Health*, 12(6), 2220–2221. https://www.ncbi.nlm.nih.gov/pubmed/27489148. doi:10.1177/1557988316662840

Ben Saad, H., Prefaut, C., Missaoui, R., Mohamed, I. H., Tabka, Z., & Hayot, M. (2009). Reference equation for 6-min walk distance in healthy North African children 6-16 years old. *Pediatric Pulmonology*, 44(4), 316–324. https://www.ncbi.nlm.nih.gov/pubmed/19330774. doi:10.1002/ppul.20942

Brenner, R., & Allemann, Y. (2011). Exercise testing and blood pressure. *Praxis*, 100(17), 1041–1049. https://www.ncbi.nlm.nih.gov/pubmed/21863574. doi:10.1024/1661-8157/a000638

Brisswalter, J., Bouhlel, E., Falola, J. M., Abbiss, C. R., Vallier, J. M., & Hausswirth, C. (2011). Effects of Ramadan intermittent fasting on middle-distance running performance in well-trained runners. *Clinical Journal of Sport Medicine*, 21(5), 422–427. https://www.ncbi.nlm.nih.gov/pubmed/21857506. doi:10.1097/JSM.0b013e3182293891

Cacau, L. A., de Santana-Filho, V. J., Maynard, L. G., Gomes, M. N., Fernandes, M., & Carvalho, V. O. (2016). Reference values for the six-minute walk test in healthy children and adolescents: A systematic review. *Brazilian Journal of Cardiovascular Surgery*, 31(5), 381–388. https://www.ncbi.nlm.nih.gov/pubmed/27982347. doi:10.5935/1678-9741.20160081

Chang, A. B. (2010). Pediatric cough: Children are not miniature adults. *Lung, 188*(Suppl 1), S33–S40. https://www.ncbi.nlm.nih.gov/pubmed/19672656. doi:10.1007/s00408-009-9166-2

Chaouachi, A., Coutts, A. J., Chamari, K., Wong del, P., Chaouachi, M., Chtara, M., Roky, R., & Amri, M. (2009). Effect of Ramadan intermittent fasting on aerobic and anaerobic performance and perception of fatigue in male elite judo athletes. *Journal of Strength and Conditioning Research*, 23(9), 2702–2709. https://www.ncbi.nlm.nih.gov/pubmed/19910805. doi:10.1519/JSC.0b013e3181bc17fc

Cherif, A., Roelands, B., Meeusen, R., & Chamari, K. (2016). Effects of intermittent fasting, caloric restriction, and ramadan intermittent fasting on cognitive performance at rest and during exercise in adults. *Sports Medicine*, 46(1), 35–47. https://www.ncbi.nlm.nih.gov/pubmed/26438184. doi:10.1007/s40279-015-0408-6

Chtourou, H., & Souissi, N. (2012). The effect of training at a specific time of day: A review. *Journal of Strength and Conditioning Research*, 26(7), 1984–2005. https://www.ncbi.nlm.nih.gov/pubmed/22531613. doi:10.1519/JSC.0b013e31825770a7

Chtourou, H., Trabelsi, K., Boukhris, O., Ammar, A., Shephard, R. J., & Bragazzi, N. L. (2019). Effects of Ramadan fasting on physical performances in soccer players: A systematic review. *La Tunisie médicale*, 97(10), 1114–1131. https://www.ncbi.nlm.nih.gov/pubmed/31691939.

Connuck, D. (2005). The role of exercise stress testing in pediatric patients with heart disease. *Progress in Pediatric Cardiology*, *20*(1), 45–52. doi:10.1016/j.ppedcard.2004.12.004

Deeb, A., Al Qahtani, N., Akle, M., Singh, H., Assadi, R., Attia, S., Suwaidi, H., Hussain, T., & Naglekerke, N. (2017). Attitude, complications, ability of fasting and glycemic control in fasting Ramadan by children and adolescents with type 1 diabetes mellitus. *Diabetes Research and Clinical Practice*, *126*, 10–15. https://www.ncbi.nlm.nih.gov/pubmed/28189949. doi:10.1016/j.diabres.2017.01.015

den Boer, S. L., Flipse, D. H., van der Meulen, M. H., Backx, A. P., du Marchie Sarvaas, G. J., Ten Harkel, A. D., van Iperen, G. G., Rammeloo, L. A., Tanke, R. B., Helbing, W. A., Takken, T., & Dalinghaus, M. (2017). Six-minute walk test as a predictor for outcome in children with dilated cardiomyopathy and chronic stable heart failure. *Pediatric Cardiology*, *38*(3), 465–471. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5355503/. doi:10.1007/s00246-016-1536-y

Farooq, A., Herrera, C. P., Almudahka, F., & Mansour, R. (2015). A prospective study of the physiological and neurobehavioral effects of Ramadan fasting in preteen and teenage boys. *Journal of the Academy of Nutrition and Dietetics*, *115*(6), 889–897. doi:10.1016/j.jand.2015.02.012

Fenneni, M. A., Latiri, I., Aloui, A., Rouatbi, S., Chamari, K., & Ben Saad, H. (2015). Critical analysis of the published literature about the effects of Ramadan intermittent fasting on healthy children's physical capacities. *The Libyan Journal of Medicine*, *10*(1), 28351. https://www.ncbi.nlm.nih.gov/pubmed/28349815. doi:10.3402/ljm.v10.28351

Fenneni, M. A., Latiri, I., Aloui, A., Rouatbi, S., Chamari, K., & Saad, H. B. (2017). Effects of Ramadan intermittent fasting on North African children's heart rate and oxy-haemoglobin saturation at rest and during sub-maximal exercise. *Cardiovascular Journal of Africa*, *28*(3), 176–181. https://www.ncbi.nlm.nih.gov/pubmed/27805239. doi:10.5830/CVJA-2016-078

Fenneni, M. A., Latiri, I., Aloui, A., Rouatbi, S., Saafi, M. A., Bougmiza, I., Chamari, K., & Saad, HB. (2014). Effects of Ramadan on physical capacities of North African boys fasting for the first time. *The Libyan Journal of Medicine*, *9*(1), 25391. https://www.ncbi.nlm.nih.gov/pubmed/28349760. doi:10.3402/ljm.v9.25391

Ferris, B. G. (1978). Epidemiology standardization project (American Thoracic Society). *The American Review of Respiratory Disease*, *118*(6 Pt 2), 1–120. https://www.ncbi.nlm.nih.gov/pubmed/742764.

Girard, O., & Farooq, A. (2012). Effects of Ramadan fasting on repeated sprint ability in young children. *Science & Sports*, *27*(4), 237–240.

Harris, A. D., McGregor, J. C., Perencevich, E. N., Furuno, J. P., Zhu, J., Peterson, D. E., & Finkelstein, J. (2006). The use and interpretation of quasi-experimental studies in medical informatics. *Journal of the American Medical Informatics Association*, *13*(1), 16–23. https://www.ncbi.nlm.nih.gov/pubmed/16221933. doi:10.1197/jamia.M1749

Himuro, N., Abe, H., Nishibu, H., Seino, T., & Mori, M. (2017). Easy-to-use clinical measures of walking ability in children and adolescents with cerebral palsy: A systematic review. *Disability and Rehabilitation*, *39*(10), 957–968. https://www.ncbi.nlm.nih.gov/pubmed/?term=10.1080%2F09638288.2016.1175036 10.1080/09638288.2016.1175036

Holland, A. E., Spruit, M. A., Troosters, T., Puhan, M. A., Pepin, V., Saey, D., McCormack, M. C., Carlin, B. W., Sciurba, F. C., Pitta, F., Wanger, J., MacIntyre, N., Kaminsky, D. A., Culver, B. H., Revill, S. M., Hernandes, N. A., Andrianopoulos, V., Camillo, C. A., Mitchell, K. E., . . . Singh, S. J. (2014). An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. *The European Respiratory Journal*, *44*(6), 1428–1446. https://www.ncbi.nlm.nih.gov/pubmed/25359355. doi:10.1183/09031936.00150314

Husain, R., Duncan, M. T., Cheah, S. H., & Ch'ng, S. L. (1987). Effects of fasting in Ramadan on tropical Asiatic Moslems. *The British Journal of Nutrition*, *58*(1), 41–48. https://www.ncbi.nlm.nih.gov/pubmed/3620437. doi:10.1079/bjn19870067

Iraki, L., Bogdan, A., Hakkou, F., Amrani, N., Abkari, A., & Touitou, Y. (1997). Ramadan diet restrictions modify the circadian time structure in humans. A study on plasma gastrin, insulin, glucose, and calcium and on gastric pH. *The Journal of Clinical Endocrinology and Metabolism*, *82*(4), 1261–1273. https://www.ncbi.nlm.nih.gov/pubmed/9100605. doi:10.1210/jcem.82.4.3860

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*(Suppl 3), S15–S27. https://www.ncbi.nlm.nih.gov/pubmed/19085449. doi:10.1080/02640410802422199

Klepper, S. E., & Muir, N. (2011). Reference values on the 6-minute walk test for children living in the United States. *Pediatric Physical Therapy*, *23*(1), 32–40. https://www.ncbi.nlm.nih.gov/pubmed/21304341. doi:10.1097/PEP.0b013e3182095e44

Latiri, I., Sandid, S., Fennani, M. A., Hadrich, M., Masmoudi, T., Maatoug, C., Zammit-Chatti, M., Chamari, K., & Ben Saad, H. (2017). The effects of Ramadan fasting on the spirometric data of healthy adult males. *American Journal of Men's Health*, *11*(4), 1214–1223. https://www.ncbi.nlm.nih.gov/pubmed/28625120. doi:10.1177/1557988316675091

Lessan, N., Saadane, I., Alkaf, B., Hambly, C., Buckley, A. J., Finer, N., Speakman, J. R., & Barakat, M. T. (2018). The effects of Ramadan fasting on activity and energy expenditure. *American Journal of Clinical Nutrition*, *107*(1), 54–61. https://www.ncbi.nlm.nih.gov/pubmed/29381798. doi:10.1093/ajcn/nqx016

Li, A. M., Yin, J., Yu, C. C., Tsang, T., So, H. K., Wong, E., Chan, D., Hon, E. K. L., & Sung, R. (2005). The six-minute walk test in healthy children: Reliability and validity. *The European Respiratory Journal*, *25*(6), 1057–1060. https://www.ncbi.nlm.nih.gov/pubmed/15929962 doi:10.1183/09031936.05.00134904

Massin, M. M. (2014). The role of exercise testing in pediatric cardiology. *Archives of Cardiovascular Diseases*, 107(5), 319–327. https://www.ncbi.nlm.nih.gov/pubmed/24841496. doi:10.1016/j.acvd.2014.04.004

Maughan, R. J., Fallah, J., & Coyle, E. F. (2010). The effects of fasting on metabolism and performance. *British Journal of Sports Medicine*, 44(7), 490–494. https://www.ncbi.nlm.nih.gov/pubmed/20484315. doi:10.1136/bjsm.2010.072181

Maxwell, S. E., Kelley, K., & Rausch, J. R. (2008). Sample size planning for statistical power and accuracy in parameter estimation. *Annual Review of Psychology*, 59, 537–563. https://www.ncbi.nlm.nih.gov/pubmed/17937603. doi:10.1146/annurev.psych.59.103006.093735

Meckel, Y., Ismaeel, A., & Eliakim, A. (2008). The effect of the Ramadan fast on physical performance and dietary habits in adolescent soccer players. *European Journal of Applied Physiology*, 102(6), 651–657. https://www.ncbi.nlm.nih.gov/pubmed/18071743. doi:10.1007/s00421-007-0633-2

Morales Mestre, N., Audag, N., Caty, G., & Reychler, G. (2018). Learning and encouragement effects on six-minute walking test in children. *The Journal of Pediatrics*, 198, 98–103. https://www.ncbi.nlm.nih.gov/pubmed/29703575. doi:10.1016/j.jpeds.2018.02.073

Mylius, C. F., Paap, D., & Takken, T. (2016). Reference value for the 6-minute walk test in children and adolescents: A systematic review. *Expert Review of Respiratory Medicine*, 10(12), 1335–1352. https://www.ncbi.nlm.nih.gov/pubmed/?term=10.1080%2F17476348.2016.1258305. doi:10.1080/17476348.2016.1258305

Ramadan, J. (2002). Does fasting during Ramadan alter body composition, blood constituents and physical performance? *Medical Principles and Practice*, 11(Suppl 2), 41–46. https://www.ncbi.nlm.nih.gov/pubmed/12444309. doi:10.1159/000066413

Ramadan, J., & Barac-Nieto, M. (2000). Cardio-respiratory responses to moderately heavy aerobic exercise during the Ramadan fasts. *Saudi Medical Journal*, 21(3), 238–244. https://www.ncbi.nlm.nih.gov/pubmed/11533791

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(10), 735–739. https://www.ncbi.nlm.nih.gov/pubmed/10501284. doi:10.1016/s0899-9007(99)00145-8

Rao, G. (2016). Diagnosis, epidemiology, and management of hypertension in children. *Pediatrics*, 138(2), e20153616. https://www.ncbi.nlm.nih.gov/pubmed/?term=10.1542%2Fpeds.2015-3616. doi:10.1542/peds.2015-3616

Roky, R., Herrera, C. P., & Ahmed, Q. (2012). Sleep in athletes and the effects of Ramadan. *Journal of Sports Sciences,* 30(Suppl 1), S75–S84. https://www.ncbi.nlm.nih.gov/pubmed/22694752. doi:10.1080/02640414.2012.693622

Sharma, K., Kohli, P., & Gulati, M. (2012). An update on exercise stress testing. *Current Problems in Cardiology*, 37(5), 177–202. https://www.ncbi.nlm.nih.gov/pubmed/22469057. doi:10.1016/j.cpcardiol.2011.11.004

Singh, S. J., Puhan, M. A., Andrianopoulos, V., Hernandes, N. A., Mitchell, K. E., Hill, C. J., Lee, A. L., Camillo, C. A., Troosters, T., Spruit, M. A., Carlin, B. W., Wanger, J., Pepin, V., Saey, D., Pitta, F., Kaminsky, D. A., McCormack, M. C., MacIntyre, N., Culver, B.H., . . . Holland, A. E. (2014). An official systematic review of the European Respiratory Society/American Thoracic Society: Measurement properties of field walking tests in chronic respiratory disease. *The European Respiratory Journal*, 44(6), 1447–1478. https://www.ncbi.nlm.nih.gov/pubmed/25359356. doi:10.1183/09031936.00150414

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology*, 37(1), 153–156. from https://www.ncbi.nlm.nih.gov/pubmed/11153730. doi:10.1016/s0735-1097(00)01054-8

Trabelsi, K., & Chtourou, H. (2019). Teaching physical education during ramadan observance: Practical recommendations. *International Journal of Sport Studies for Health*, 2(1), e88013. http://intjssh.com/en/articles/88013.html. doi:10.5812/intjssh.88013

Trabelsi, K., El Abed, K., Trepanowski, J. F., Stannard, S. R., Ghlissi, Z., Ghozzi, H., Masmoudi, L., Jammoussi, K., & Hakim, A. (2011). Effects of ramadan fasting on biochemical and anthropometric parameters in physically active men. *Asian Journal of Sports Medicine*, 2(3), 134–144. https://www.ncbi.nlm.nih.gov/pubmed/22375232.

Trabelsi, K., Rebai, H., El-Abed, K., Stannard, S. R., Khannous, H., Masmoudi, L., Sahnoun, Z., Hakim, A., Fellman, N., & Tabka, Z. (2011). Effect of ramadan fasting on body water status markers after a rugby sevens match. *Asian Journal of Sports Medicine*, 2(3), 186–194. https://www.ncbi.nlm.nih.gov/pubmed/22375238.

Uhlig, A. (2018). Strategies to reduce patient loss during the follow-up period of randomized trials. *Der Urologe Ausg A*, 57(5), 601–604. https://www.ncbi.nlm.nih.gov/pubmed/?term=10.1007%2Fs00120-018-0639-x. doi:10.1007/s00120-018-0639-x

WMA. World Medical Association Declaration of Helsinki. Available December 26, 2019, from: http://www.wma.net/en/30publications/30ethicsmanual/pdf/ethics_manual_arabic.pdf

Yaddanapudi, L. N. (2016). The American statistical association statement on p-values explained. *Journal of Anaesthesiology & Clinical Pharmacology*, 32(4), 421–423. doi:10.4103/0970-9185.194772