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Effects of Walking Football During Ramadan Fasting on Heart Rate Variability and Physical Fitness in Healthy Middle-Aged Males

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Abstract

This study aimed to investigate the effect of a walking football (WF) program during Ramadan fasting (RF) on heart rate variability (HRV) indices, body composition, and physical fitness in middle-aged males. Thirty-one healthy sedentary men were randomized to WF ($n = 18$) and control ($n = 13$) groups. Both groups participated in RF. The WF group were involved in a training program (small-sided games) of three sessions a week during RF. The time and frequency domains of HRV, body composition, handgrip, lumbar strength, Modified Agility Test (MAT), and 6-minute walk test (6MWT) were measured before Ramadan (BR), during Ramadan (DR), and after Ramadan (AR). We reported that RF has significantly altered some parameters of HRV DR; the mean HR decreased while the mean RR, LF, and HF increased. WF had a significant effect on HRV and mean HR DR compared with BR and AR decreased while mean RR, HF and LF increased. DR, body mass decreased in both groups, while body mass index (BMI) decreased and lean mass increased only in WF group. Lower body mass and BMI levels were reported AR only in WF group. Physical capacity improved AR, compared with BR, only in the WF group with longer distance in 6MWT, shorter time(s) in MAT, and higher lumbar strength levels. We conclude that RF increases parasympathetic system activity. WF practice during RF is safe and might improve body composition, physical fitness, autonomic cardiac function, and physical fitness in middle-aged males.

Keywords

autonomic heart function, walking football, Ramadan, health, fitness

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Introduction

Holy Ramadan is the nineth lunar month (29–30 days long). Fasting is one of the five pillars of Islam (Adawi et al., 2017). Healthy Muslims fast from dawn to dusk (12–20 hr/day, depending on the season and the geographical region). Observers refrain from eating food, drinking liquids, and other physical needs such as smoking and sexual intercourse (Ghram et al., 2021; Jahromi et al., 2014). Ramadan fasting (RF) as intermittent fasting is mandatory for all healthy adult Muslims (Akbari et al., 2022; Lessan & Ali, 2019). Several studies have been conducted over the last decade to investigate the impact of RF on physiological performance (Maughan et al., 2010; Zerguini et al., 2007). Because of its potential positive effects on health and aging, intermittent fasting is linked to enhanced longevity (Persynaki et al., 2017). Importantly, fasting has been associated with some heart benefits (Nematy et al., 2012) including decreased cardiac events (Temizhan et al., 1999).

Heart rate variability (HRV) can reflect the adjustment of heart rate (HR) by providing a picture of the dynamic balance between sympathetic and parasympathetic branches of the autonomic nervous system (ANS) (Aubert et al., 2003; White & Raven, 2014). HRV serves, therefore, as an important index of pathological changes and is widely used to diagnose cardiovascular risk (Ammar et al., 2021; Kubota et al., 2017). Decreased HRV is

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associated with advancing age, increased risk of cardiac events in clinically disease-free patients (Tsuji et al., 1996), and higher mortality rates (Kleiger et al., 1987; Odemuyiwa et al., 1991). Increased HRV is associated with lower mortality rates (Sandrone et al., 1994; Yusuf et al., 1985). HRV is reduced during periods of stress and can be increased with exercise (Prinsloo et al., 2014). Indeed, it was previously reported that athletes have a higher HRV than sedentary individuals (Goldsmith et al., 1992).

Although widely credited as an effective marker for cardiovascular health and as a noninvasive tool to estimate autonomic activity, limited number of studies investigated the effects of fasting on HRV, with no clear consensus. While Mazurak et al. (2013), reported that an acute (48 h) total fast induced a decrease in total HRV under baseline conditions, Rodrigues et al. (2019), reported no significant alteration in HRV following an acute fasting of 12 hr in healthy adults. To the best of the authors' knowledge, only one study has examined the chronic effect of chronic intermittent fasting and reported higher HRV in the fasting group compared with the nonfasting group after Ramadan (Cansel et al., 2014). Thus, further studies are needed to confirm whether RF is a sufficient stimulus to improve HRV in healthy adults.

Football practice is beneficial to cardiorespiratory, musculoskeletal, and metabolic systems (Krustrup et al., 2010). Recreational football might help restore the fitness and cardiac function of aging sedentary adults (Andersen et al., 2014; Schmidt et al., 2014) and maintain an active lifestyle (Luo et al., 2018). Walking football (WF) has been recently recognized as a variant of football and credited as an optimal, motivating, and enjoyable activity for older adults (Cholerton et al., 2021; Madsen et al., 2021; Reddy et al., 2017; Zainudin et al., 2021). Twelve weeks of WF reduce heart disease and stroke risks and improve blood pressure (BP) of people aged 50 to 65 years (Reddy et al., 2017). It was demonstrated that HRV remained unchanged after low-to-moderate aerobic exercise in fasting and nonfasting healthy individuals (Rodrigues et al., 2019) and after moderate-intensity exercise with low and moderate carbohydrates intake (Lima-Silva et al., 2010).

Fasting and exercise training are used as nonpharmacological interventions to investigate the regulation of intermediary metabolism (Maughan et al., 2010). Fasted-state training may decrease body weight, fat-free mass, and fat mass (Zouhal et al., 2020). Recent studies recommend WF for fasting Muslims. (Zainudin et al., 2021). Further studies are needed to determine the concomitant effects of RF and exercise on factors affecting both the ANS and physical capacity. There is also little information about the impact of RF only on HRV parameters. This study aimed to investigate the effect of a WF program during RF on HRV indices, body composition, and physical fitness in middle-aged males. We hypothesized that WF would improve HRV, body composition, and fitness parameters in middle-aged adults.

Materials and Methods

Ethical Approval

The study was approved by the local research ethics committee (***information anonymized for peer review***) and the protocol was conducted according to the Declaration of Helsinki. Participants received a detailed description of the study protocol, including the possible risks and benefits associated with the investigation; and submitted written informed consent before participation.

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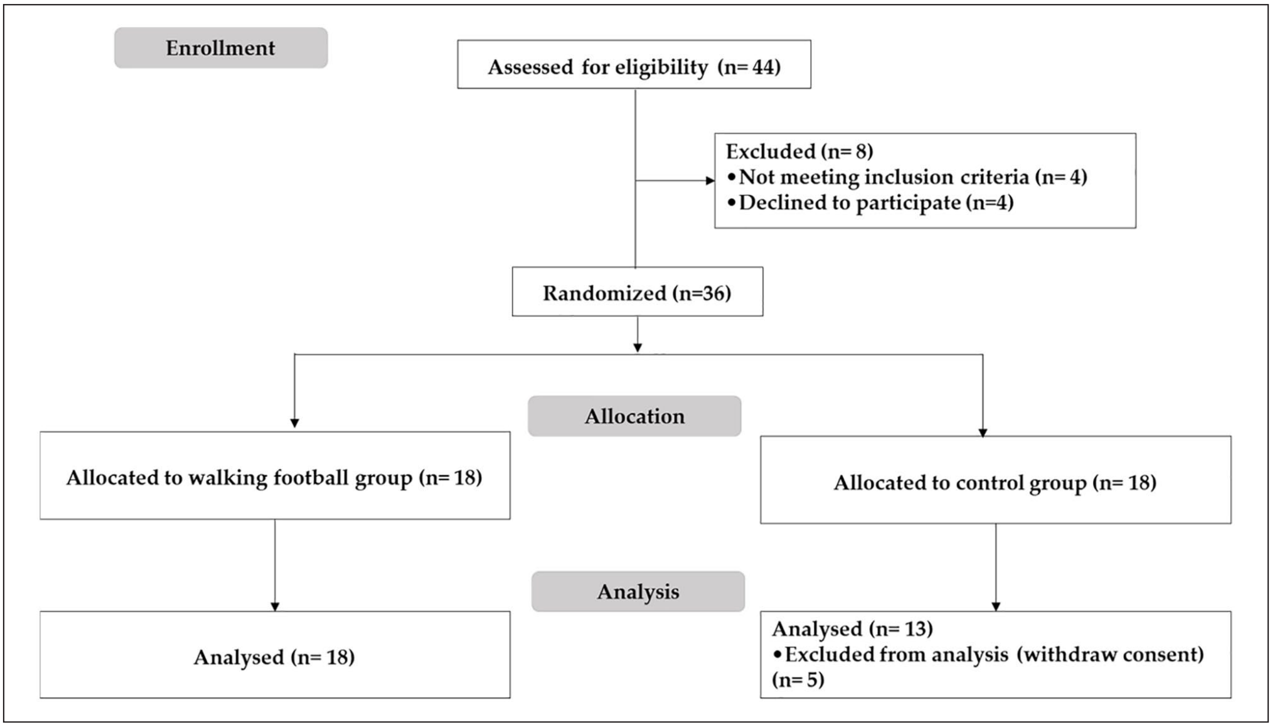

Figure 1. The Consort Flow Diagram.

Participants

A total of 44 participants were initially enrolled in this study between May and June 2019. The inclusion criteria were age 45 years or older, healthy, willing to fast throughout Ramadan, and the ability to provide informed consent. All participants were nonsmokers. Participants with orthopedic, cardiovascular, pulmonary, neurologic or metabolic issues were excluded.

According to the International Physical Activity Questionnaire classification, healthy inactive, irregularly active, and active people were included (Craig et al., 2003). Participants classified as "very active" were considered not representative of the general population (outliers) and were excluded. Of the 44 participants, four declined to participate in the study, and four did not meet the inclusion criteria. Finally, 36 participants (body mass index [BMI] < 30) were included in the study and were randomly assigned to the WF group ($n = 18$) who participated in RF and WF training or the control group (CON, $n = 18$) who participated only in RF and were not receive any physical activity interventions (Figure 1).

In WF, we retained the data of subjects who participated in at least 90% of the training schedule.

Randomization and Blinding

The randomization sequence (ratio 1:1) was generated using a computerized block randomization generator (randomizer.org, accessed on April 20, 2019). An independent study coordinator conducted the allocation sequence, who was not involved in the assessment and data analysis processes, enrolling participants in sequentially numbered, opaque, sealed envelopes.

Experimental Design

The study was conducted in Sfax, Tunisia, in 2019. Ramadan lasted from May 6 to June 5. The length of each daytime fast was approximately 15 to 16 hr. During the fasting period, participants abstained from food, drink, smoking, and sexual activity between dawn and sunset. The participants were familiarized with testing procedures and measurements before the start of the study.

To reduce the impacts of circadian rhythms, all testing sessions were held in the morning at the same time of day and in the same order. Fitness assessment included anthropometric measurements and assessment of cardiorespiratory capacity, muscular strength and flexibility through field tests. HRV data were collected in a silent room, with controlled temperature and relative humidity. Tests were performed in three separate sessions. The first session was performed one week prior to Ramadan (BR) and the second and the third sessions at the end of the second week (DR) and 7–10 days after Ramadan (AR), respectively (Figure 2).

During Ramadan, WF participated in a 4-week training program with three sessions per week interspersed by

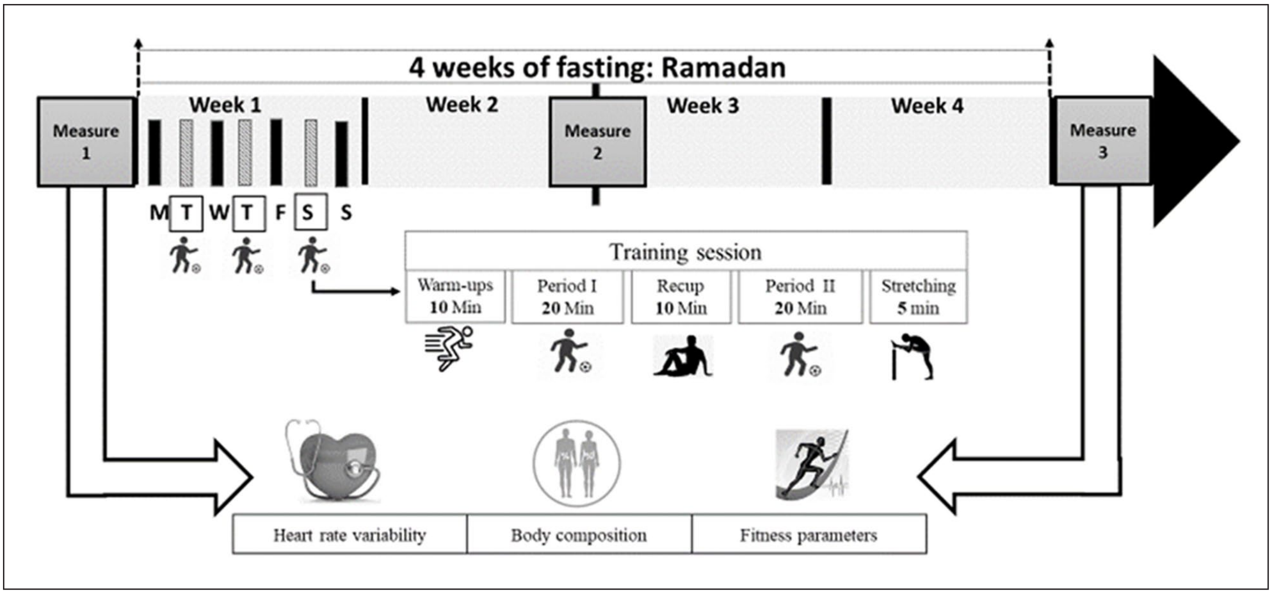

Figure 2. Experimental Design.

at least 48 hr of recovery. Training sessions were scheduled from 4:00 pm to 6:00 pm. Each session lasted ~65 min: 10 min warm-up, two 20-min periods of play with a half time of 10 min, 5 min of stretching. During the 20-min period of play, WF played small-sided games 4 versus 4 or 5 versus 5 on a football pitch of 30 to 45 m × 45 to 60 m, respectively. Meanwhile, CON remained inactive, as they were instructed to maintain their current lifestyle until the end of the study and simply underwent the assessment tests.

HRV Analysis

HRV indices were recorded using Polar technology (Polar V800, Polar Electro Oy, Kempele, Finland). This device has been considered a reliable and valid method of capturing and analyzing interbeat variability (Giles et al., 2016). Data were collected between 10 am and 11 am to avoid a possible circadian influence on the autonomic function. Before the test, participants rested comfortably in a supine position for at least 10 min in a quiet dimly lit room with constant temperature. During the test, the participants were asked to lie still, close their eyes, abstain from talking, and maintain normal breathing frequency. Tidal volume was maintained during the testing at a constant breathing rate of 0.25 Hz by listening to recorded breathing sounds at this rate to neutralize the effect of respiratory sinus arrhythmia on HRV. The test duration gives a good definition of frequency-domain measures and an acceptable resolution of time-domain measures ("Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology," 1996; Shaffer et al., 2020). Before signal analysis, all ectopic beats were filtered and corrected. To analyze the HRV, we calculated the following parameters in the time domain: the mean of the RR intervals, the standard deviation of the normal RR interval (SDNN), the root mean square of the successive differences of the R-R intervals (RMSSD), and the percentage of successive interval differences larger than 50 ms (PNN50). The frequency-domain parameters were obtained based on the fast Fourier transformation to quantify the low-frequency bands (LF) (0.04–0.15 Hz), high frequency (HF) (0.15–0.40 Hz), and the ratio LF/HF expressed in units (n.u) were measured. In the nonlinear domain, we used SD1 as an index of the instantaneous variability of beat-to-beat data. Data analysis was performed by the same researcher using the standard Kubios HRV software (v. 3.1.1.).

Body Composition

Body mass was measured to the nearest 0.1 kg on a digital scale (Tanita TBF 401, Tanita Corp., Japan), and height was measured to the nearest 0.1 cm on a stadiometer (Holtain, Crymych, Dyfed, UK). BMI was computed by dividing body mass in kilograms by height in square meter (kg/m^2). A foot-to-foot bioelectric impedance analyzer was used to determine body fat percentage (BF%), fat-free mass (FFM), and total body water (TBW) content (Tanita TBF 401, Tanita Corp., Japan). This method has been validated against the reference methods (Bosy-Westphal et al., 2008). The bioelectrical

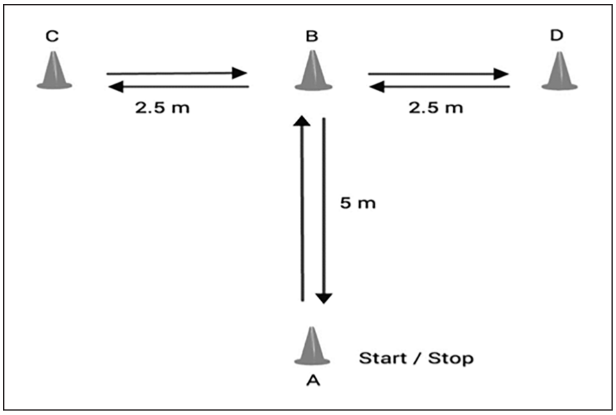

Figure 3. Modified Agility T-Test (MAT).

impedance measurements were carried out following the manufacturer's recommendations. For the measurement, subjects were requested to remove all clothing (excluding shorts), shoes, jewelry, and other accessories. Gender, height, and level of physical activity were manually entered into the keypad interface. Subjects were measured while standing erect with their bare feet on the footpads of the analyzer.

6-Min Walk Test

The 6-min walk test (6MWT) was performed outdoors along a flat, straight, 30-m walking course and measured using the better of two tests separated by ≥30 min as per ATS guidelines (Crapo et al., 2002). HR was recorded before and after the 6MWT. Participants were encouraged every minute during the test. They were allowed to stop and rest during the test but were instructed to resume walking as soon as they felt able to do so. We used a stopwatch to measure test time and a HR monitor (Polar V800, Polar Electro Oy, Kempele, Finland) to assess HR. At the end of the test, the 6-min walking distance (6MWD) was recorded.

Modified Agility T*-Test*

The Modified Agility *T*-Test (MAT) was used to assess the speed of participants while measuring their agility by using photoelectric cells (Figure 3). The participants performed the MAT by completing multidirectional sprinting, shuffling, and backpedaling (Hickey et al., 2009; Sassi et al., 2009; Scanlan et al., 2019). Each participant was required to perform three trials separated by 5 min of rest for recovery. The participants started at cone A, made a forward linear sprint of 5 m to cone B, a leftward shuffle of 2.5 m to cone C, a rightward shuffle of 5 m to cone D, a leftward shuffle of 2.5 m back to cone B, and finally a linear backpedal of 5 m to cone A.

Hand Grip Strength

The maximum strength of the forearm and hand muscles assessment was conducted using a hydraulic dynamometer (Model SH5001, Saehan Corporation, Korea) following the American Society of Hand Therapists recommendations (MacDermid et al., 2015). Subjects were seated with the arms parallel to the body, flexed at the elbow to 90°, and the forearm in a neutral position. Wrist flexion or extension was not allowed. Each participant repeated the test three times and only the highest value was considered. The dominant side was defined according to the self-reported preferred hand while performing daily activities (Günther et al., 2008). The subjects were instructed to perform their maximum isometric effort for 5 s during the test with a 1-min rest interval between the tests. The standardized instructions "When I say go, grip as hard as you can until I say stop" and "Harder. . . harder . . . harder . . . relax" were given prior and throughout the test, respectively (Innes, 1999; MacDermid et al., 2015). No other body movements were allowed.

Lumbar Strength

A calibrated lumbar strength dynamometer (BASELINE, New York, USA) was used to measure the static strength of back muscles. The dial ranges from 0 to 300 kg. Participants stand on the platform with their legs shoulder-width apart, knees extended, arms outstretched, chest bent toward the hips and palms facing down. They had to bow down enough to reach the dynamometer chain, which should be perpendicular to the platform. The experimenter faced the participant, offset to the side, and held the participant's hips to prevent any movement. After the demonstration and a familiarization trial, three trials were performed. Then, participants pulled the chain until their back was perfectly straight with rest periods of 2 min between trials. Maximal strength for the three trials was used for further analysis.

Statistical Analysis

Data analyses were performed using SPSS version 25 for Windows (SPSS Inc, Chicago, Il, USA). Values are presented as means ± standard deviation (*SD*). The Shapiro–Wilk test was performed to check the normality of data. Two-way ANOVA with repeated measures was used to determine the differences between groups (2-Condition Group: WF or CON × 3 Times of Measurement: BR, DR, AR. When a difference was identified, a Bonferroni post hoc test was used. An a priori power analysis was conducted using G*Power3 (Faul et al., 2007) to test the difference between two independent group means using a two-tailed test, a medium effect size ($d = .50$), and an alpha of .05. Results reported that a total sample of 44 participants was required to achieve a power of .95. Effect sizes were calculated as partial eta-squared (η^2p) for the ANOVA to estimate the meaningfulness of significant findings. η^2p values of 0.01, 0.06, and 0.13 represent small, moderate, and large effect sizes, respectively. Statistical significance was assigned at $p < .05$ for all analyses.

Table 1. Baseline Anthropometric Data Characteristics.

	WF (n = 18)	CON (n = 13)
Age (year)	53.70 ± 7.3	52.75 ± 4.2
Body mass (kg)	89.1 ± 9.7	84.6 ± 9.7
Height (cm)	177.75 ± 5.1	175.46 ± 5.8
BMI (kg/m^2)	28.2 ± 3	27.9 ± 2.3
Fat mass (%)	23.7 ± 5.3	23.4 ± 5.6
Lean mass (%)	54.2 ± 4	55.2 ± 3.6

Values are presented as mean ± *SD*.
WF = walking football group; CON = control group; BMI = body mass index.

Results

Population Characteristics

Of the 36 study participants, 5 participants in the CON opted out of the study: personal reasons (n = 1), back pain (n = 1), unexpected work (n = 2), moving to other country (n = 1). Therefore, 31 participants completed the study (18 in the WF and 13 in the CON) (Figure 1). Baseline characteristics of participants are reported in Table 1. There were no significant differences in baseline characteristics WF and CON, indicating the homogeneity of the two groups.

HRV

HRV is reported in Table 2. Two-way ANOVA with repeated measurements of mean HR and mean RR data showed a significant interaction (Ramadan × Group). The statistical analysis reported a significant main effect of Ramadan on Mean HR, mean RR, HF, and LF. Mean HR was significantly lower in DR compared with BR (p = .000) and in AR (p = .002) in WF. Mean HR was significantly lower AR in WF compared with CON (p = .010).

Mean RR was significantly higher in DR compared with BR(p = .000) and in AR compared with DR AR (p = .000*)* in WF. Mean RR was significantly lower AR compared with DR in CON (p = .018) and was significantly higher in WF compared with the CON (p = .001). In addition, HF and LF were significantly higher DR compared with BR (p = .022 for HF and LF) and in AR compared with DR (p = .026 for HF; and p = .017 for LF) in WF. A significant main effect of the group was detected only in LF/HF (p = .022). No significant changes were detected for SDNN, RMSSD, PNN%, SD1, and LF/HF.

Body Composition

Body composition is reported in Table 3. The statistical analysis reported a significant main effect of Ramadan on body mass, BMI, fat mass (%), lean mass (%), and TBW (kg). Body mass was significantly lower DR (p = .000) and AR (p = .000) compared with BR in WF and DR compared with BR in CON (p = .004). BMI was significantly lower DR (p = .000) and AR (p = .005) compared with BR in WF. Lean mass increased only in the WF group DR compared with BR (p = .005) while AR it increased for both groups (p = .001 for WF; and p = .004 for CON). Fat mass (%) was significantly lower AR compared with BR in CON (p = .016). However, there is no significant effect on TBW in both groups.

6MWT and MAT

The results of 6MWT, MAT, and strength performance are reported in Table 4. The two-way ANOVA with repeated measurements of 6MWD and MAT reported a significant interaction (Ramadan × Group; p = .000; and p = .018, respectively). The statistical analysis reported a significant main effect of Ramadan on 6MWD, HRmax, mean HR, and MAT (p = .000) and the main effect of group on 6MWD (p = .006). 6MWD was significantly lower DR and AR in CON compared with WF (p = .000). 6MWD was significantly higher DR (p = .036) and AR (p = .000) compared with BR in the WF. HRmax was significantly higher AR compared with DR only in WF (p = .023) Also, HRmax was significantly higher DR in WF compared with CON (p = .008). MAT performance was significantly lower AR compared with BR (p = .000) and DR (p = .000) in WF. MAT was significantly lower DR (p = .000) and AR (p = .013) in WF compared with CON.

Handgrip and Lumbar Strength

Handgrip and lumbar strength are reported in Table 4. Statistical analysis reported significant interaction (Ramadan × Group) only on lumbar strength (p = .027) and a nonsignificant main effect of Ramadan and main effect of group on Gripping force and Lumbar strength. Lumbar strength was significantly higher after R compared with before *R* (p = .019) in WF group.

Table 2. Variation of HRV Averages (Time Domain, Frequency Domain, and Geometric Parameter) Before, During, and After Ramadan for Both Groups.

					Group effect			Ramadan effect			Group × Ramadan		
Parameters		BR	DR	AR	$F_{(1,29)}$	p value	η^2p	$F_{(2, 58)}$	p value	η^2p	$F_{(2,58)}$	p value	η^2p
Mean HR (beats/min)	CON	66.59 ± 10.25	64.5 ± 15.55	71.44 ± 7.09	0.382	0.542	0.013	11.326	0.000	0.281	3.746	0.029	0.114
	WF	70.59 ± 11.92	58.12 ± 7.61[a]	68.3 ± 7.59[b]									
Mean RR (ms)	CON	921 ± 142.1	965.7 ± 164.3	847.5 ± 84.2[b]	0.418	0.523	0.014	20.568	0.000	0.415	4.247	0.019	0.128
	WF	873 ± 146.3	1,048.3 ± 129.1[a]	888.3 ± 94.7[b]									
SDNN (ms)	CON	33.32 ± 14.96	34.86 ± 21.79	33.89 ± 15.35	1.620	0.213	0.053	1.568	0.217	0.051	0.972	0.384	0.032
	WF	34.18 ± 10.74	46.41 ± 21.49	36.73 ± 15.32									
RMSSD (ms)	CON	34.63 ± 20.42	35.38 ± 24.25	31.95 ± 17.18	1.181	0.286	0.039	0.191	0.827	0.007	0.115	0.891	0.004
	WF	36.88 ± 15.03	40.89 ± 19.17	38.74 ± 21.94									
PNN50 (%)	CON	9.16 ± 8.97	7.81 ± 11.35	3.53 ± 3.18	2.851	0.102	0.090	1.289	0.283	0.043	0.789	0.459	0.026
	WF	10.62 ± 14.5	14.48 ± 13.4	10.78 ± 11.99									
SD1 (ms)	CON	24.51 ± 14.45	25.04 ± 17.16	22.61 ± 12.16	1.181	0.286	0.039	0.192	0.826	0.007	0.115	0.891	0.004
	WF	26.1 ± 10.64	28.94 ± 13.57	27.41 ± 15.53									
HF (ms^2)	CON	381.8 ± 343.9	474.6 ± 944.7	298.9 ± 306.1	4.075	0.053	0.123	4.207	0.020	0.127	2.139	0.127	0.069
	WF	496.6 ± 562.9	1,291.2 ± 1,227.9[a]	510.1 ± 716.7[b]									
LF (ms^2)	CON	535.7 ± 565.2	614.2 ± 917.8	368.6 ± 378.8	0.571	0.456	0.019	4.814	0.012	0.142	2.080	0.134	0.067
	WF	382.9 ± 288.9	1,143.8 ± 1,260.4[a]	365.3 ± 222.2[b]									
LF/HF (ratio)	CON	2.299 ± 2.329	1.79 ± 1	2.128 ± 2.262	5.850	0.022	0.168	0.505	0.606	0.017	0.189	0.829	0.006
	WF	1.271 ± 0.837	1.157 ± 0.708	1.285 ± 0.763									

Values are means ± *SD*; HR = heart rate; RR = duration between two adjacent R-wave peaks; SDNN = standard deviation of normal to normal R-R intervals; SDNN = standard deviation of normal to normal R–R intervals; RMSSD = root mean square difference of successive R–R intervals; PNN50 = measure of the number of adjacent NN intervals which differ by more than 50 ms; SD1 = standard deviation of the distance of each point; VLF = very low frequency; LF = low frequency; HF = high frequency. [a]significantly different from BR at $p < .05$; [b]significantly different from DR at $p < .05$.

Table 3. Body Composition, Before, During, and After Ramadan for Both Groups.

Parameters		BR	DR	AR	Group effect			Ramadan effect			Group × Ramadan		
					$F_{(1, 29)}$	p value	η^2p	$F_{(2, 58)}$	p value	η^2p	$F_{(2, 58)}$	p value	η^2p
Body mass (kg)	CON	84.6 ± 9.7	82.8 ± 9.5[aa]	83.4 ± 9.7	1.019	0.321	0.034	39.452	0.000	0.576	4.497	0.015	0.134
	WF	89.1 ± 9.7	85.8 ± 9.[4aaa]	86.4 ± 9.3[aaa]									
BMI (kg/m²)	CON	27.9 ± 2.3	27.4 ± 2.3	27.5 ± 2.5	0.002	0.965	0.000	17.453	0.000	0.376	2.599	0.083	0.082
	WF	28.2 ± 3	27.1 ± 2.8[aaa]	27.5 ± 2.8[aa]									
Fat mass (%)	CON	23.4 ± 5.6	21.9 ± 3.1	20.7 ± 3.6[a]	0.048	0.828	0.002	11.018	0.000	0.275	0.500	0.609	0.017
	WF	23.7 ± 5.3	21.8 ± 5.3	21.6 ± 5.1									
Lean mass (%)	CON	55.2 ± 3.6	56 ± 2.3	57 ± 2.7[aa]	0.391	0.537	0.013	16.309	0.000	0.360	1.050	0.357	0.035
	WF	54.2 ± 4	55.8 ± 4.1[aa]	55.9 ± 3.8[aa]									
TBW (kg)	CON	62.2 ± 8.5	62.1 ± 7	63.4 ± 6.9	0.651	0.426	0.022	3.399	0.040	0.105	0.118	0.889	0.004
	WF	64.3 ± 6.6	64.1 ± 5.4	65 ± 6.4									

Values are means ± *SD*; BMI = body mass index; TBW = total body water; BR = before Ramadan; DR = during Ramadan; AR = after Ramadan; WF group = walking football group.
[a]Significantly different from BR at $p < .05$; [aa]Significantly different from BR at $p < .01$; [aaa]Significantly different from BR at $p < .001$.

Table 4. Effect of Ramadan Fasting on 6MWT, Agility and Strength Test Performance Before, During, and After Ramadan for Both Groups.

					Group effect			Ramadan effect			Group × Ramadan		
Parameters		BR	DR	AR	$F(1,29)$	p value	η^2p	$F(2,58)$	p value	η^2p	$F(2, 58)$	p value	η^2p
6MWT													
Distance (m)	CON	660 ± 56.3	662.4 ± 52.6	689.3 ± 47.7	8.786	0.006	0.233	28.579	0.000	0.496	9.502	0.000	0.247
	WF	675.8 ± 58.8	715.7 ± 65.9[a]	789.8 ± 73.1[*ab]									
Mean HR (beats/min)	CON	109 ± 16	113 ± 17	130 ± 11	0.857	0.362	0.029	9.054	0.000	0.238	0.133	0.876	0.005
	WF	114 ± 17	118 ± 27	131 ± 16									
Max HR (beats/min)	CON	133 ± 19	129 ± 21	148 ± 14	1.590	0.217	0.052	10.645	0.000	0.269	0.061	0.941	0.002
	WF	138 ± 19	137 ± 25[*]	155 ± 20[b]									
Agility and strength test													
MAT, time (s)	CON	7.89 ± 0.75	8.33 ± 0.7	8.03 ±0.94	1.68	0.206	0.055	8.22	0.000	0.221	4.31	0.018	0.13
	WF	7.94 ± 0.55	8.04 ± 0.75[*]	7.38 ± 0.7 [*ab]									
Lumbar strength (kg)	CON	134.3 ± 33.1	129.6 ± 31.3	132.5 ± 30.2	0.060	0.809	0.002	2.405	0.099	0.077	3.858	0.027	0.117
	WF	125.9 ± 17.3	129.5 ± 19.5	134.7 ± 18.1[a]									
Hand grip (kg)	CON	49.3 ± 6.6	48.3 ± 7.1	49 ± 6	1.544	0.224	0.051	1.637	0.203	0.053	1.632	0.204	0.053
	WF	45.3 ± 6.5	45.9 ± 5.5	47.7 ± 5.1									

Values are mean ± *SD*; HR: heart rate, 6MWD: 6-min walking test, MAT: modified *T*-test; BR = before Ramadan; DR = during Ramadan; AR = after Ramadan; WF group = walking football group; CON = control group.
*Significantly different from control group at $p < .05$; [a]Significantly different from BR at $p < .05$; [b]Significantly different from DR at $p < .05$.

Discussion

The objective of this study was to investigate the effects of Ramadan intermittent fasting on HRV and, the effects of WF training and RF on HRV indices, body composition, and physical fitness in middle-aged adults. This study found a significant effect of practicing WF while fasting on mean RR (p = .029) and HR (p = .019) associated with an improvement in body mass (p = .015), 6MWT (p = .000), MAT (p = .018) and lumbar strength (p = .027) performance. In addition, RF had a significant effect on four parameters of HRV DR; the mean HR decreased (p = .000) while the mean RR (p = .000), LF (p = .020) and HF (p = .012) increased. In addition, RF had a significant effect on body composition; body mass (p = .000), lean mass (p = .000), BMI (p = .000), fat mass (p = .000), and TBW (Kg) (p = .040). Finally, a significant group effect was founded only on LF/HF ratio (p = .022) and on the performance 6MWT (p = .006).

The effect of exercise training and RF on HRV, a reflection of the cardiac ANS and a promising method for monitoring cardiovascular health, has received little attention. Our results demonstrated that RF had a minor effect on overall cardiac ANS. HRV was slightly affected by WF training indicating no significant change in the cardiac ANS activity. Therefore, our finding suggests a slight cardiac adaptation process in response to WF while fasting.

Our results corroborate in part with existing studies (Cansel et al., 2014; Hammoud et al., 2020) on the impact of Ramadan on HRV in healthy subjects. A study conducted on 80 women reported no significant difference in HRV parameters between the first and last week of Ramadan (Hammoud et al., 2020). In this study, some changes in ANS indices (e.g., HR, SDNN, RMSSD, PNN50) were observed during the fasting days between noon and shortly before the sunset [the end of the fasting period), indicating that there was a difference in ANS activity between early and late fasting (Hammoud et al., 2020). No significant difference was identified in the HRV indices between fasting and nonfasting times, except for a significantly decreased HR during fasting time (Hammoud et al., 2020). However, this result contradicts the study of Cansel et al. (2014) who reported an increase in some HRV parameters (e.g., SDNNI, RMSSD, pNN50, T power, LF, LFnu, HF, and HFnu) induced by fasting compared with the post-Ramadan period, indicating a stimulation of the parasympathetic nervous system activity in these subjects. This was due to catecholamine inhibition during fasting, which resulted in a decrease in sympathetic nervous system activity in fasting healthy subjects (Cansel et al., 2014). These findings are relatively consistent with the results of the present study as an increase was reported in mean RR, LF, and HF AR and DR compared with BR. The discrepancy between our findings and those of the aforementioned studies could be attributed to the difference in the study participants (men vs. females), and the period and the time of day of HRV measurements.

Football is an effective way to improve health (Krustrup et al., 2013). It increases cardiovascular and musculoskeletal fitness, improves postural balance and generates high aerobic activity (Krustrup et al., 2010). However, such benefits are still to be verified in WF. To date, only a few studies have investigated the effect of WF on health conditions. One study reported no effect of a weekly WF session of 1 hr over 12 weeks on either health status or cognitive performance (Reddy et al., 2017). Another study reported a decrease in fat percentage and a rise in time to exhaustion following 12 weeks of a weekly WF session of 2 hr (Arnold et al., 2015). The influence of WF in a fasted state has not been investigated particularly for HRV parameters. This study reported that WF exercising caused no significant changes in HRV parameters. HRV is rather influenced by diet, smoking, disturbed sleep patterns (Guiraud et al., 2013; James et al., 2012), regular exercise, and exercise intensity (Hedelin et al., 2000; Madsen et al., 2021).

The 4 weeks of exercise training and the intensity of WF training, based on brisk walking, are not sufficient to affect HRV indices. Moreover, the possible sleeping habit deterioration DR could account for the absence of WF affecting health outcomes in the present study. Two previous studies on the effects of WF in older adults did not report the same health-related changes induced by traditional running football. This might be due to differences in training intensity but could also be related to differences in the volume, duration, and frequency of the training sessions (Andersen et al., 2014; Arnold et al., 2015; Reddy et al., 2017). A recent study associated a significant increase in the RMSSD index with training intensity, *which* means that a slight increase in intensity improves the regulation of cardiac function (Tornberg et al., 2019). Melanson and Freedson (2001) reported a significantly higher HRV [RMSSD, SDNN) in moderate and high-intensity aged groups. Twelve months of supervised exercise [3 months of stretching and 9 months of 5 hr/week aerobic exercise at approximately 70% of VO2max) increased total HRV in older adults (Stein et al., 1999). In addition, our participants were exercising on an empty stomach. No changes in ANS activity were reported under these circumstances.

Physical training and fasting are credited for their positive impacts on body composition and health outcomes (Zouhal et al., 2020). Fasting and aerobic exercise training are two common ways of increasing lipolysis in adipose and muscular tissue, which reduces body fat mass (Zouhal et al., 2020). In the present study, body composition improved in both groups. Indeed, Body mass was significantly lower DR ($p = .000$) and AR ($p = .000$) compared with BR in WF and DR compared with BR in CON ($p = .004$). BMI was significantly lower DR ($p = .000$) and AR ($p = .005$) compared with BR in WF. Lean mass increased only in the WF group DR compared with BR ($p = .005$) while AR it increased for both groups ($p = .001$ for WF; and $p = .004$ for CON). Fat mass (%) was significantly lower AR compared with BR in CON ($p = .016$). WF training while fasting was revealed to improve body mass and BMI for the WF group. The results of the present study are consistent with previous reports (Arnold et al., 2015; Reddy et al., 2017). Reddy et al. (2017) reported that WF training for 12 weeks in older adults (50–65 years old) reduced visceral fat (−1.5 kg), and fat mass (−0.38%). In addition, 12 weeks of WF training increased lean mass (+2.5 kg) and decreased body mass (−1.8), fat mass (−3%), and BMI (−1) in older adults (66 years old) with various comorbidities (Arnold et al., 2015). Thus, WF training is effective for all age groups, regardless of their health status. However, changes in body composition are rather related to RF than WF training. Compared with the pre-Ramadan period, a decrease in body mass, BMI, and fat mass (%) at the end of Ramadan has been reported (Nachvak et al., 2019). The effects of Ramadan may vary according to environmental conditions such as fasting duration, temperature, and habits (Addin Akbari et al., 2021; Faris et al., 2019, 2020; Farooq et al., 2010; Ghram et al., 2021). A previous investigation of the variations in body composition in adults during Ramadan, in a hot (45°C) and dry environment reported no significant changes in body mass, BMI, lean body mass, and TBW (Al-Barha & Aljaloud, 2019). Another study reported that RF decreased body mass, BMI, and skeletal muscle mass (Nugraha et al., 2017). Still more, another study reported a decrease in water and fat mass in obese adults after RF (Sezen et al., 2016). RF improved the body composition of obese more than of lean individuals (Harder-Lauridsen et al., 2017). Geographical, social, and cultural variables between Muslim countries and groups seem to account for the variability of results between studies.

The WF training during Ramadan reported a significant improvement in the 6MWD in the WF group. This increase in physical capacity is associated with a significant increase in the maximum HR in WF group. Data about the effects of RF on the cardiorespiratory response to exercise in sedentary adults are controversial. A small reduction (Ramadan, 2002; Ramadan & Barac-Nieto, 2000) or no impact on maximal exercise capacity and walking deficiency (Ramadan, 2002; Sweileh et al., 1992) has been reported. The causes for such inconsistent outcomes are still unknown. However, factors such as sleep deprivation or fatigue during Ramadan are crucial concerns. No significant change was observed in the gripping force, while the lumbar strength was significantly higher AR compared with BR in WF group. In line with our findings, the levels of muscle strength (grip strength) remain unchanged during Ramadan (Bouhlel et al., 2013). Our findings demonstrate a minimal change in performance measures in WF after Ramadan, except for a substantial improvement in agility in WF group. These findings are consistent with the study of Kordi et al., who argued that the higher agility fitness level in pre-Ramadan may be due to a reduction in body mass (Kordi et al., 2011).

To the best of the authors' knowledge, this is the first study to investigate the concomitant effects of RF and WF practice on HRV parameters in middle-aged adults. The findings of the present study should be interpreted with the following limitations in mind; First, the sample size was small and the fasting and training periods were relatively short, which may partly account for the absence of significant differences between groups in most of the verified parameters. Second, the fact that all participants were males, eliminates the effect of female reproductive hormone levels on HRV and physical performance. Future studies should evaluate the effects of intermittent fasting and practice in larger male and female groups and control factors such as calorie intake, sleep pattern, psychological variables, and circadian rhythm.

Conclusion

This study reported significant improvements in HRV and physical fitness parameters after 4 weeks of WF during RF in middle-aged males. Exercise training while fasting enhances physical fitness and cardiovascular autonomic balance, which might imply that WF practice in a fasted state may contribute to exercise-induced cardio-protection. This study should prompt future investigations on the significance of ANS regulation during training exercises in a fasted state.

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Author Contributions

Conceptualization, N.K., O.H., and M.C.; methodology, N.K., OH; validation, N.K., O.H.; formal analysis, N.K., S.H., A.G., L.M.; resources, S.H.; data curation, L.M.; writing—original draft preparation, N.K., S.H., and A.G.; writing—review and editing, M.C., O.H, B.K., KW; AA and T.D; supervision, M.C., OH. All authors have read and agreed to the published version of the manuscript.

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