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EFFECTS OF RAMADAN FASTING ON POSTURAL BALANCE AND ATTENTIONAL CAPACITIES IN ELDERLY PEOPLE

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Abstract: *Objective:* To evaluate the effects of Ramadan fasting on postural balance and attentional capacities in older adults. *Setting:* the Neurophysiology department of a University Hospital. *Participants:* Fifteen males aged between 65 and 80 years were asked to perform a postural balance protocol and a simple reaction time (SRT) test in four testing phases: one week before Ramadan (BR), during the second (SWR) and the fourth week of Ramadan (FWR) and 3 weeks after Ramadan (AR). *Measurements:* Postural balance measurements were recorded in the bipedal stance in four different conditions: firm surface/eyes open (EO), firm surface/eyes closed (EC), foam surface/EO and foam surface/EC using a force platform. *Results:* Results of the present study demonstrated that center of pressure (CoP) mean velocity (CoPVm), medio-lateral length (CoPLX) and antero-posterior length (CoPLY) were significantly higher during the SWR than BR. Likewise, values of CoPVm and CoPLX increased significantly during the FWR compared to BR. The CoPLX decreased significantly in the FWR compared to the SWR. Values of CoPVm and CoPLX were significantly higher AR in comparison with BR. In addition, SRT values increased significantly during the SWR and the FWR than BR. *Conclusion:* Ramadan fasting affects postural balance and attentional capacities in the elderly mainly in the SWR and it may, therefore, increase the risk of fall and fall-related injuries. More than three weeks are needed for older adults to recover postural balance impairment due to Ramadan fasting.

Key words: Elderly, postural balance, ramadan fasting, attentional capacities.

Introduction

The total number of older people around the world will increase dramatically over the next few decades (1). In light of this increase, health care professionals must address diverse problems occurring within this particular population to improve their quality of life (2).

Aging process is generally associated with a progressive decline in health status (3) and functional performance (4). Several studies reported that ageing has a detrimental effect on postural balance. In this context, it has been proposed that age-related changes in sensory and cognitive domains may lead to balance and gait impairments (5, 6). In addition, declines in muscular strength could further accentuate balance deterioration (7) and may affect the major postural functions in older adults (8). The postural balance impairment has been identified as the main intrinsic risk factor of falling (9). In the elderly, falls frequently lead to injury, increased dependence, associated illness and early death (10). Consequently, the elderly population develops a fear of falling complex so a decline in self confidence to perform normal activities of daily living (11). Detection of fall risk factors is required to provide effective and specific fall prevention strategies (12).

Ramadan fasting is one of the five main religious practices of Islam. Each year, all over the world, over one billion of Muslims undergo Ramadan fasting (13) in very different circumstances. During Ramadan, healthy adolescents, adults and old people abstain from food, drink, medicaments and smoking every day between dawn and sunset. For approximately one month, eating behaviors change from three balanced daily meals to two nocturnal meals (14). Changes in meals schedules and increased activity at night induce several chronobiological modifications (15) which disturb sleep (16) and affect daytime performances (17). In fact, as a result of the delayed bedtime, partial sleep deprivation can be expected to occur during this month (18). Thus, daytime sleepiness increases during Ramadan among fasting subjects (19) which could have harmful consequences into the daytime. Previous studies also, proved that subjective alertness, memory, and functional attention are adversely affected during Ramadan (15, 20, 21).

On the other hand, it has been established that postural control changes by the level of vigilance or sleepiness (22, 23, 24, 25, 26). In fact, sleep deprivation can be a contributing factor to decreased postural control and falls (27). Recently, Robillard et al. (28) showed that the effect of sleep deprivation on postural control is more pervasive in older than in young adults. They suggested that sleep deprivation is a serious risk factor of fall in the elderly.

In addition, attentional demands are required to maintain postural balance (29). These demands vary depending on the postural task, the age of the individuals and their balance abilities (29). In this context, it has been shown that performing motor tasks becomes less automatic and requires higher attentional demands in elderly people (30, 31). Cognitive decline has been considered as another independent risk factor for falls (32).

While many studies have investigated Ramadan fasting effects on health and physical performance, surprisingly little

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is known about the effect of Ramadan fasting on postural control. To our best knowledge, there are only two scientific works (33, 34) that have been interested to this topic. Findings of these studies proved that static and dynamic postural control of young judo athletes were impaired during the second week of Ramadan (SWR), but these negative effects disappeared 3 weeks after the end of Ramadan (34). Despite the fact that ageing is widely associated with an increasing risk of chronic diseases, disability, cognitive decline, poor postural balance and falls (35, 36), elderly individuals usually insist to fast because of the very strong habits and the social exclusion fear. As postural balance is crucial for the efficient and effective performance of all daily activities (37), it seems then important to investigate Ramadan fasting effects on the postural balance of older adults to help provide practical recommendations to prevent them from fall risks during this month.

In view of these observations, the aim of the present study was to investigate the effects of Ramadan fasting on postural balance and attentional capacities in elderly people. We hypothesized that fasting during Ramadan may impair postural balance of older adults and that these impairments may be more marked in the end of this month.

Methods

Participants

Fifteen sedentary older adults aged between 65 and 80 years voluntary participated in this study. The mean age, body mass and height of participants were 73.33 ± 5.24 years; 66.45 ± 6.10 kg and 1.64 ± 0.06 m, respectively. A questionnaire was performed among subjects medical history, type of prescribed medication treatment, activities of daily living of each participant, fasting recommendation, sleep pattern and eating schedules. They were healthy and none of them have a history of fall within the last 6 months. Moreover, they are autonomous, could perform their daily activities by themselves and have the same socio-cultural level. All participants have the same eating schedules and numbers of sleep hours per night (7-8 hours). They were non-smokers and did not drink alcohol or caffeine. Exclusion criteria were: serious visual impairments, pathology of the central nervous system, orthopedic disorders of the lower limbs and metabolic disorders. After receiving a complete explanation of the benefits and risks of the study, subjects gave their written informed consent before testing.

Study design

This study was performed in 2014, when Ramadan started on the 29th of June to the 28th of July. The time spent on fasting was approximately 17 hours.

One week before actual measurements, all subjects were familiarized with the experimental protocol in order to minimize the learning effect. The study consisted of four testing phases: one week before Ramadan (BR), the SWR and the fourth week of Ramadan (FWR) and 3 weeks after Ramadan (AR). In each testing phase, participants performed a simple reaction time (SRT) test; then after 1 min of rest, they performed postural balance tests. All measurements were made at 05:00 p.m.

Simple reaction time measurements

Attentional capacities were evaluated by a SRT test, using a ‘‘Superlab 4.5’’ program (Cedrus, San Pedro, USA). Participant sat on a comfortable chair 0.4 to 0.5 m in front of the computer screen. After 10 familiarization trials, each subject performed randomly 20 trials of SRT tests. The appearance of a white square on the screen was served as a starting signal. Each participant was asked to press a specific bar of the keyboard, using his preferred hand, as quickly as possible when a black square (i.e. the stimulus) appeared at the center of the screen. The stimulus was presented for 50 ms. The interval between two consecutive stimuli was randomized (average 1.5 s). The score was determined by calculating the mean reaction time for the correct trials. In order to avoid any effects of anticipation or temporary laps of concentration, SRT values of less than 150 ms and more than 800 ms were eliminated from analysis. Lower scores reflect better performance.

Posturographic assessments

Postural balance was measured using a static stabilometric platform (PostureWin©, Techno Concept ®, Cereste, France; 40 Hz frequency, 12-bits A/D conversion) that recorded center of pressure (CoP) excursion with three strain gauges. Subjects were asked to stand barefoot on the force platform as immobile as possible on upright bipedal posture with their arms comfortably placed at their sides. Foot position was traced to guarantee that feet placement was constant across trials. Postural measurements were collected in two vision conditions. In the eyes open (EO) condition, participants were instructed to keep their gaze horizontal in a visual target positioned 2m away. In the eyes closed (EC) condition, vision was eliminated by wearing a blindfold and they were asked to keep their gaze straight-ahead. For each of the eyes conditions, subjects were tested under two surfaces conditions: firm surface and foam surface. The foam surface consisted of a foam block (466 mm length × 467 mm width × 134 mm height above ground) with a density of 21.3 kg/m3 and an elastic modulus of 20.900 N/m2. Three trials were conducted in each experimental condition, resulting in a total of 12 trials per participant. The duration of each trial was 25.6 s following French Posturology Association norms. To cancel fatigue and learning effect, 30 s of rest was respected between trials. During measurement, the rater stayed near the participant for security without adducing additional directions. All experiments were assessed by the same rater.

The CoP mean velocity (CoPVm), medio-lateral length (CoPLX) and antero-posterior length (CoPlY) were selected as postural balance parameters. The CoPVm corresponded to the sum of the CoP displacement scalars divided by the sampling time, the CoPLX and the CoPlY corresponded to the sum of the CoP displacement scalars in the medio-lateral and antero-posterior directions respectively. These parameters were averaged for the three trials per condition and per subject to obtain a representative measure of the postural balance. The best postural balance is for the lower values of these parameters.

Statistical analyses

Statistical tests were processed using STATISTICA Software (StatSoft, France). Mean and standard deviation (SD) were calculated for the selected variables. The Shapiro-Wilk W-test of normality revealed that the data were normally distributed. Once the assumption of normality was confirmed, parametric tests were performed.

The CoP data were analyzed using a three-way repeated measures analysis of variance (ANOVA) [4 testing phases × 2 standing surfaces × 2 visions]. For the SRT scores, a one-way ANOVA (4 testing phases) was performed to compare the SRT values. The testing phase factor has four levels: BR, SWR, FWR and AR. The standing surface factor has two levels: firm surface versus foam surface. The vision factor has two levels: EO versus EC.

Pearson's coefficients of correlation were used to assess the relationship between the SRT and the CoPVm values. When significant differences were observed, a post-hoc Tukey HSD tests were used. Effect sizes were calculated as partial eta-squared $\eta p2$ to assess the practical significance of our findings. Statistical significance was set at a probability level of $P<0.05$.

Results

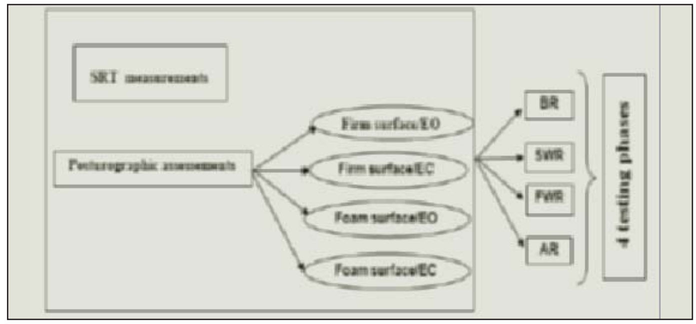
Simple reaction time scores

The one way ANOVA revealed a significant ($F=7.5$, $\eta p2=0.40$, $P<0.001$) testing phase effect on the SRT scores. Post-hoc analysis showed that the SRT values increased significantly during the SWR ($P<0.001$) and the FWR ($P<0.05$) in comparison with those observed BR (Table 1). No significant ($P=0.9$) difference was found between the SRT values recorded BR and those recorded AR (Table 1). The SRT values decreased during the FWR compared to the SWR without any significance ($P=0.4$) (Table 1).

Postural balance results

The three-way ANOVA showed a main significant effects of testing phase, vision, standing surface; and a significant testing phase × standing surface and vision × standing surface interactions on all the postural balance parameters (Table 2). No significant testing phase × vision and testing phase × standing surface × vision interactions on the postural balance parameters were observed (Table 2).

Figure 1
Study design



Concerning the effect of testing phase, post-hoc analysis showed that CoPVm values were significantly higher during the SWR in comparison with those observed BR in all postural conditions (firm surface/EO; $P<0.05$; firm surface/EC; $P<0.05$, foam surface/EO; $P<0.001$ and Foam surface/EC; $P<0.001$) (Fig. 2). Similarly, CoPLX values (foam surface/EO; $P<0.001$; foam surface/EC; $P<0.001$) and CoPLY values (foam surface/EO; $P<0.001$; foam surface/EC; $P<0.001$) were significantly higher during the SWR than BR in the foam surface conditions (Fig. 3, Fig. 4). In these latter conditions, CoPVm (foam surface/EO; $P<0.05$; foam surface/EC; $P<0.001$) and CoPLX (foam surface/EO; $P<0.001$; foam surface/EC; $P<0.001$) increased significantly during the FWR compared with those found BR (Fig. 2, Fig. 3). Moreover, CoPLX values (foam surface/EO; $P<0.01$, foam surface/EC; $P<0.05$) decreased significantly between the SWR and the FWR (Fig. 3). CoPVm (foam surface/EO; $P<0.05$; foam surface/EC; $P<0.001$) and CoPLX (foam surface/EO; $P<0.001$; foam surface/EC; $P<0.001$) values were significantly higher AR than those observed BR in the foam surface conditions (Fig. 2, Fig. 3).

Concerning the effect of standing surface, post-hoc analysis showed significant increase for all postural balance parameters when standing on the foam surface irrespective to the vision condition and testing phase (Fig. 2, Fig. 3, Fig. 4).

Suppression of vision significantly increased all postural parameters in the foam surface condition (Fig. 2, Fig. 3, Fig. 4).

Regarding the testing phase × standing surface interaction,

Table 1
Mean values and standard deviation (SD) of the simple reaction time (SRT) (n = 15) recorded before Ramadan (BR), during the second (SWR) and the fourth (FWR) week of Ramadan and three weeks after Ramadan (AR)

	BR	SWR	FWR	AR
SRT (ms) ± (SD)	434.29 ± (49.92)	528.86 ± (50.77)	498.76 ± (56.90)	447.56 ± (46.05)

Table 2
A summary of the statistical analysis results

Parameters	CoPVm F, P, ηp2	CoPLX	CoPLY
Testing phase	20.4, <.0001, 0.65	23.3, <.0001, 0.67	8.9, <.001, 0.44
Standing surface	257.4, <.0001, 0.95	395.3, <.0001, 0.97	257.7, <.0001, 0.95
vision	64.5, <.0001, 0.85	95.8, <.0001, 0.89	57.2, <.0001, 0.83
Testing phase*standing surface	5.7, =.002, 0.34	13.2, <.0001, 0.54	4.1, =.01, 0.27
Testing phase*vision	1.5, NS	1.3, NS	0.1, NS
Standing surface*vision	23.9, <.001, 0.68	85.7, <.0001, 0.88	13, =.004, 0.54
Testing phase*standing surface* vision	0.5, NS	0.5, NS	0.1, NS

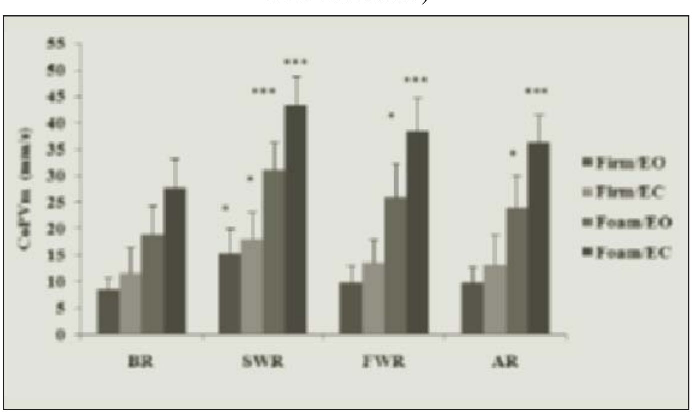
Note: F, P and ηp2 values are indicated for significant main effects and interactions of testing phases, standing surface and vision as appropriate and are marked NS where not significant

post-hoc analysis showed that the effect of testing phase on CoPVm is significantly higher in the foam surface conditions than in the firm surface conditions (Fig. 2, Fig. 3, Fig. 4).

However, no significant interaction testing phase × vision was observed (Fig. 2, Fig. 3, Fig. 4).

Concerning the significant interaction standing surface × vision, post-hoc analysis revealed that postural balance values were higher in the EC condition compared to the EO condition when standing on a foam surface (Fig. 2, Fig. 3, Fig. 4).

Figure 2
Mean values and standard deviations of center of pressure mean Velocity (CoPVm) for each postural condition (Firm/EO, Firm/EC, Foam/EO and Foam/EC) and during the four testing phases (BR: before Ramadan, SWR: the second week of Ramadan, FWR: the fourth week of Ramadan, AR: 3 weeks after Ramadan)

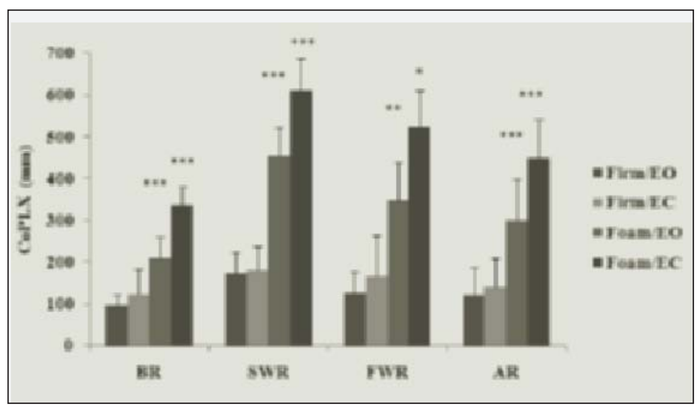


*: significant difference in comparison between the SWR/BR; the FWR/BR and AR/BR at p<0.05. ***: significant differences in comparison between the SWR/BR, the FWR/BR and AR/BR at p<0.001

Correlations

The Person's coefficient of correlations revealed that the CoPVm values are positively correlated with the SRT values (Fig. 5) in the firm surface/EO (r=0.51), in the firm surface/EC (r=0.43) and in the foam surface/EO (r=0.48).

Figure 3
Mean values and standard deviations of center of pressure medio-lateral length (CoPLX) for each postural condition (Firm/EO, Firm/EC, Foam/EO and Foam/EC) and during the four testing phases (BR: before Ramadan, SWR: the second week of Ramadan, FWR: the fourth week of Ramadan, AR: 3 weeks after Ramadan)

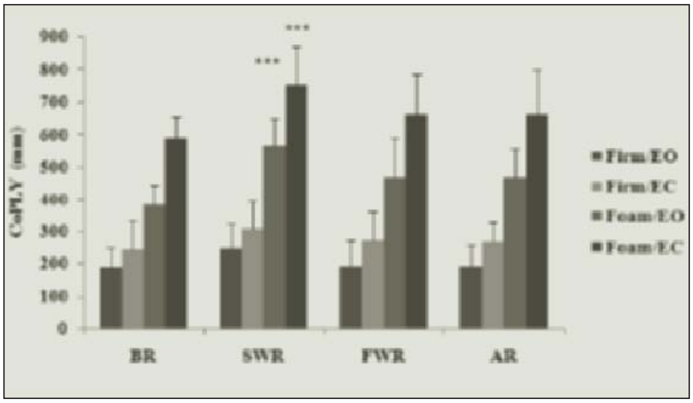


*: significant difference in comparison between the SWR/FWR at p<0.05. **: significant difference in comparison between the SWR/FWR at p<0.01. ***: significant differences in comparison between the SWR/BR, the FWR/BR and AR/BR at p<0.001

Discussion

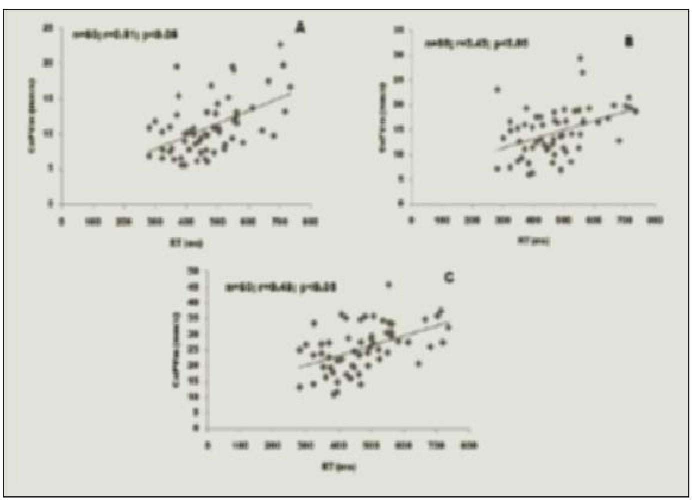
One of the major goals of health professionals and geriatricians is to enhance old adult's quality of life by decreasing dependency and preserving health. Despite the fact that Ramadan fasting is practiced by more than one billion Muslims all over the world (13), data concerning the effects of Ramadan fasting on postural balance are still limited. The main purpose of the present study was to examine the effects of Ramadan fasting on postural balance and attentional capacities of elderly people.

Figure 4
Mean values and standard deviations of center of pressure antero-posterior length (CoPLY) for each postural condition (Firm/EO, Firm/EC, Foam/EO and Foam/EC) and during the four testing phases (BR: before Ramadan, SWR: the second week of Ramadan, FWR: the fourth week of Ramadan, AR: 3 weeks after Ramadan)



***: significant differences in comparison between the SWR/BR at p<0.001

Figure 5
Pearson's correlations between the simple reaction time (SRT) values and the center of pressure mean velocity (CoPVm) values in the Firm surface/EO (A), in the Firm surface/EC (B) and in the Foam surface/EO (C)



Our results clearly showed that postural balance performance and SRT of older adults were altered by fasting during Ramadan. Similar postural balance alterations have been found in young Judo athletes during Ramadan (33, 34). These impairments could be explained by changes in lifestyle, meal and activity schedules leading to mainly chronobiological modifications during Ramadan (19). Importantly, fasting subjects retard their bedtime in order to remain awake and have more opportunities to eating, drinking and socializing during dark hours (14). Exclusive eating at night has been proposed to increase body temperature at night and thereby delay the circadian patterns of body temperature and sleep (18). Accordingly, partial sleep deprivation can be expected to occur during this month (18). Reduction in sleep quality and recurrent sleep loss were reported too (38). Similarly, in our study, sleep duration of participants was reduced because they were consuming food later at night.

On the other hand, previous studies proved that postural stability and motor control were affected by sleep deprivation (23, 24). Notably, sleep deprivation effects on postural control could be resulted from impairment in visual input (39), decrease in the vestibular system efficiency (40) and alteration in muscular and nerve function (41). Effects of sleep deprivation on postural control were more pervasive in older than young adults (28).

It has been proposed that psychomotor and cognitive performances of young adults were affected by Ramadan fasting. In fact, some indicators of these performances such as day time alertness (15, 42), reaction time and mood (15) and functional attention (21) were impaired by Ramadan fasting. Data from the current study extended these findings by showing that the SRT in elderly individuals was significantly altered during this month. The same results have been found in young trained adults (43). Moreover, Roky et al. (15) showed that the choice reaction time of young subjects slowed only at the beginning of Ramadan. The decrease in attentional capacities during Ramadan may be due to the sleep alteration, heat, composition and schedule of meals and lifestyle changes (44, 45, 46). In the present study, the participants practiced the Ramadan fast in summer with high environmental temperature and long hours spent on fasting (17 hours) which seems to induce hypohydration. It has been shown that even low levels of hypohydration may negatively affect attention and memory in older adults (47). Previous studies demonstrated that attention plays a role in postural control (48, 49). Therefore, the slower SRT observed in our participants could be a contributor factor for the postural balance deterioration noted during Ramadan. The positive correlation found between SRT and CoPVm values in the present study confirms this finding.

Importantly, our findings showed lower postural sway during the FWR compared to the SWR but remain higher compared to those observed BR. This finding did not confirm our primary hypothesis that postural sway would be greater during the FWR than during the SWR. The confrontation of this result seems to be difficult due to the absence of similar studies conducted in older adults. Overall, this finding suggests a probable beginning of physiological adaptation of the body in the end of Ramadan. Adaptation is described as the capacity of the central nervous system to modify its own structural organization and functioning as a result of internal or external (environmental) changes (50). In young adults, a subjective alertness decrease has been found only at the beginning of Ramadan suggesting an adaptation mechanism to Ramadan fasting (42). It has been also reported that after ten days of fast, diabetics begin to adapt to fasting (51).

More importantly, our results showed that postural balance parameters decreased slightly AR but did not restore their normal values observed BR even after 3 weeks. This result was in contrast with those of Souissi et al. (34) who found no significant difference in dynamic postural control of young judo athletes between BR and 3 weeks AR. Likewise, Chennaoui et al. (52) indicated that in young adults all the physiological and metabolic parameters return to their initial state AR. Elderly people seem to be less flexible and adaptive than younger people (53) and do not adapt optimally to changing internal and external conditions (50). Probably, more than 3 weeks are needed for older adults to recover balance impairment due to Ramadan fasting.

Identifying the conditions that modulate the effect of Ramadan fasting on postural balance could provide practical evidence for prevention strategies. Interestingly, our results indicated a decrease in postural balance in all testing phases and irrespective to vision condition when the proprioceptive inputs were altered. In accordance with previous studies, standing on an unstable surface increased the difficulty to maintain stability in the elderly (54, 55). It is known that changes in postural performance after standing on a foam surface reflect the importance of the proprioceptive contribution to postural control. Thus, this result suggests that elderly adults are very dependent on proprioceptive information to control their posture. Likewise, proprioceptive information seem to be vital and the most contributor for postural control in the elderly (56, 57).

An interaction vision × standing surface was observed in the present study. In all testing phases, higher postural sway was found in the absence of vision mainly in the foam surface. This finding suggests that postural balance becomes more impaired by the removal of vision when the difficulty of the standing surface increased. This is in agreement with several studies pointing to an increased postural balance alteration of elderly individuals when both visual and proprioceptive inputs were manipulated (58, 59). When standing on a foam surface, contribution of the planter cutaneous information decreases (60). Closing the eyes in this condition seems to cancel the input of the visual system on postural control and sensory weighting to vestibular information increase. Decreased vestibular function could be important due to aging (61) which may explain the greater deterioration of postural balance during this challenging condition and the higher contribution of proprioceptive and visual cues on postural regulation in the elderly.

No significant vision × testing phase interaction was proved suggesting that in all testing phases the remove of vision impairs postural balance of our older adults similarly.

Additionally, a standing surface × testing phase interaction was revealed in the present study. Elderly people have more difficulties in controlling their postural balance during Ramadan when proprioception was perturbed by standing on a foam surface. Altering proprioceptive inputs could amplify the postural balance decrease induced by Ramadan fasting. Consequently, the risk of balance impairment and falling in the elderly may be greater during Ramadan and even AR when the proprioceptive condition is complex or inadequate.

Practical implications

Fasting during the month of Ramadan is an obligation for healthy Muslim geriatric population. Our findings showed greater postural sway and slower SRT in the elderly during this month particularly in the beginning (i.e., SWR). So, they are recommended to be careful during this month to prevent fall risks. As fasting effects on postural balance tend to decrease in the FWR, a pre-Ramadan fasting training consisting of changes in life style, meal and activity schedules that approximate Ramadan conditions could be suggested. Such training is encouraged in order to promote adaptations that may probably minimize the effects of fasting during Ramadan on postural balance. Moreover, elderly adults are recommended to maintain a healthy lifestyle practice (i.e. sleep quality and quantity) before and during Ramadan. Optimal sensory environmental conditions (i.e. proprioceptive and visual) should be available and maintained during and after this month in order to minimize the risk of fall and to fast safely.

Limitations

This study has some limitations that need to be considered. In the present study we did not include a control group who did not fast because the nonfasting Muslim subjects do not avow themselves as nonfasters. As well, some parameters such as sleep quality and quantity could be confounder factors that may influence the results. Thus, these parameters should be controlled in future studies to more understand if these impairments of postural balance and SRT in the elderly are inevitable consequences of fasting or they resulted from life style changes characterizing this month. Furthermore, it would be better to assess the quantity and quality of food ingested BR and after the sunset during Ramadan in the attempt to find other possible explanations to our findings. Finally, it has been found that a large percentage of falls occur during locomotion (62). Thus, our results might be stronger and more reliable to the daily activities if the effects of Ramadan fasting on gait characteristics had been examined.

Conclusion

In conclusion, our data suggest that Ramadan fasting alters postural balance and attentional capacities of elderly people. These decrements were more pervasive particularly in the beginning of Ramadan. Importantly, postural balance of fasting elderly subjects was more deteriorated when sensory inputs were altered. Three weeks seem to be insufficient to recover from the effect of fasting on postural balance. These findings suggest that Ramadan fasting could accentuate the risk of falling in the elderly mainly in challenge sensory conditions (i.e. foam surface/EO and foam surface/EC).

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Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical standards: The authors declare that the experiments comply with the current laws of the country in which they were performed.

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