The effect of Ramadan intermittent fasting on dynamic postural control in judo athletes

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The aim of this study was to evaluate Ramadan intermittent fasting (RIF) effects on dynamic postural control in male judo athletes. In a randomized order, 11 male judokas (22.5 ± 2.8 years, 173.8 ± 6.9 cm, and 70.3 ± 4.4 kg; mean ± SD) were asked to perform four protocols of dynamic postural control, i.e., sit to stand test (STS), step up and over test (SUO), step quick turn test (SQT), and forward lunge test (FL), one week before RIF (BRF), during the second week (SWR) of RIF, and three weeks after RIF (AR). The results of the present study showed that during the dynamic balance tests, the movement time, lift-up index, and impact index during the STS test were significantly higher during SWR in comparison with BRF and AR (p < 0.05). However, those measured during the SUO test appeared independent of RIF. The turn time and turn degree during the SQT test and the distance, the impact index, the contact time, and the force impulse increased significantly from BRF and AR to the SWR (p < 0.05). However, no significant difference was observed in all tests (i.e. STS, SUO, SQT, and FL) between BRF and AR. In conclusion, the present study suggested that RIF may negatively affect the postural control of judo athletes.

Keywords: dynamic balance; Ramadan intermittent fasting; Judoists

Introduction

Ramadan intermittent fasting (RIF) is an Islamic practice, observed by over one billion people worldwide (Alou et al. 2013; Hammouda et al. 2013). Each year during the lunar month of RIF, Muslims abstain from eating, drinking, smoking, or having sexual relationship during the daytime, between sunrise and sunset (Chtourou et al. 2012). This leads to alterations in feeding habits, sleep duration, pattern, and architecture (Roky et al. 2003; Waterhouse 2010).

Well-documented effects of RIF include changes in circadian rhythms (Reilly & Edwards 2007; Roky et al. 2012), physiological (Roky et al. 2004), metabolic, and immune function (Leiper et al. 2008; Chennaoui et al. 2009; Abedelmalek et al. 2011), as well as reductions in daytime hydration, blood glucose, and body temperature (Leiper et al. 2003) physical and cognitive performances are also affected (Chtourou et al. 2011; Hammouda et al. 2012). As major sporting calendars do not take religious observances into account, many athletes continue to train or compete while fasting (Chaouachi et al. 2012).

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Partial sleep deprivation can be expected to occur in RIF. Indeed, some studies have demonstrated that during this month, sleep duration decreased and sleep timing shifted (BaHammam 2005, 2006). Recently, Waterhouse (2010) showed that the RIF is associated with change in sleep habits and increased sleepiness. More recently, Rocky et al. (2012) showed that accumulated sleep loss has negative impacts on cognitive function, mood, daytime sleepiness, and performance. In this context, BaHammam (2005, 2006) and Roky et al. (2003) showed an increase in the sleep latency and proportion of non-rapid eye movement sleep, a modification of sleep architecture, and a reduction in the total sleep time and slow-wave sleep. Likewise, during this month, the normal sleep-wake cycle was disrupted by the RIF (Souissi et al. 2008) due to rising earlier and/or retiring later, which can cause partial sleep deprivation (Waterhouse 2010).

Thus, sleep loss results in drop in the level of performance during tasks requiring sensorimotor coordination, cognitive processes, and physical performance (Souissi et al. 2008; Reilly & Waterhouse 2009; HajSalem et al. 2013; Jarraya et al. 2013; Abedelmalek et al. 2012). Moreover, sleep loss may affect the balancing ability of the athlete (Bougard & Davenne 2011). More recently, Smith et al. (2012) suggested that extended wake may increase the risk of a fall or other consequences of impaired postural control. In addition, the rhythm of postural control might be influenced by either vigilance and/or body temperature (Avni et al. 2006; Forsman et al. 2007).

Several studies have investigated the effects of sleep deprivation on postural control using center of pressure, center of pressure area, and center of pressure velocity as stabilometric indexes (Uimonen et al. 1994; Caldwell et al. 2003; Gribble & Hertel 2004). The literature indicates that postural control efficiency decreases during the night, while postural sways can be correlated to sleepiness (Liu et al. 2001; Nakano et al. 2001). Bougard and Davenne (2011) showed that one night of partial sleep deprivation reduced the ability to maintain balance (i.e. during the stork stand test of the dominant leg) when tests were performed at 18:00 h.

The majority of the studies described previously focused on analyzing the effects of circadian rhythm or sleep deprivation on postural control. To our knowledge, no study has investigated the effect of RIF on dynamic postural control in judokas elites. In this context, we recently found that static postural control is affected by RIF (Souissi et al. 2013).

It is therefore critical to investigate the effect of RIF on postural control using dynamic tests. Paillard et al. (2002) showed that no differences in static balance are evident in judoists performing at the regional level and judoists performing at the national and international levels. Moreover, Perrin et al. (2002) focused on the differences between judo and dance activities concerning balance control abilities. They found that with eyes open, both judoists and dancers showed better static and dynamic stance than a control group not involved in any sport activity; with eyes closed, only judoists have a significant better stance. This indirectly demonstrated that both activities stimulate different proprioceptive canals.

Thus, the ability to maintain equilibrium represents a significant component of success during a judo match. In light of these observations, it is critical to examine the relation between RIF and dynamic postural control.

**Materials and methods**

**Participants**

Eleven judo athletes (22.5 ± 2.8 years, 173.8 ± 6.9 cm, and 70.3 ± 4.4 kg) volunteered to participate in this study. They were given a thorough explanation of the protocol before
signing an informed consent form. The participants were also selected based on their chronotype using a sleep questionnaire (Horne & Östberg 1976). They had an intermediate chronotype (i.e. sleep duration between 22:30 ± 1:00 and 07:00 ± 1:00 h). Their mean period of practising judo was 11 ± 6.2 years. The participants’ technical levels were first kyu (brown belt) or first dan (black belt). They competed in 73 kg weight category. Based on results of a self-reported questionnaire, no subject had been treated with any drug that is known to affect immune function, had experienced acute illness from infection during the prior three months, or had smoked tobacco regularly. All judokas participated in official judo competitions during this year and trained 4–5 times per week.

**Experimental design**

In randomized design, participants participated in three experimental conditions: one week before RIF (BRF), during the second week of RIF (SWR), and three weeks after RIF (AR). During each session, the judokas were asked to complete four dynamic tests: the sit to stand test (STS), the step quick turn test (SQT), the step up and over test (SUO), and the forward lunge test (FL) (i.e. 3 trials with 15-s rest interval between repetitions). To avoid the effect of time-of-day on postural control (Gribble et al. 2007), testing was conducted at the same time-of-day between 08:00 and 09:00 h. Before the test session, all participants came to the laboratory to become fully familiarized with the procedure and tests involved so as to minimize the learning defects during the experiment.

Before each session, body weight was measured to the nearest 0.1 kg using a Tanita digital scale (Tanita, Tokyo, Japan). Instructions concerning sleep, diet, and physical activity were given to the participants prior to experimentation. Before the month of RIF, participants were synchronized with a nocturnal rest from 23:00 ± 1 to 07:00 h. During the month of RIF, the participants had to go to sleep before 01:30 h and to wake at 07:00 h after a night of uninterrupted sleep. All participants kept the same hours of sleep during the three weeks of the experiment. Spontaneous body movement was assessed continuously by wrist actigraphy (Actiwatch Sleep & Activity software, version 5.32; Cambridge Neurotechnology, Cambridge, UK). Total sleep duration decreased significantly from BRF (07:30 ± 00:30 h) to SWR (05:41 ± 00:20 h). The average (Mean ± SD) sleeping time of the participants was 01:54 ± 00:25 h less during SWR compared with BRF and AR, during which the participants had refrained from eating or drinking during the daytime. All meals were eaten at a standard time within the participant’s usual schedules and RIF customs. There were also dietary restrictions prohibiting any food or drink that could enhance wakefulness, or agents such as alcohol. The participants were required to record their food intakes in a diary over a span of three days for each week of physical testing.

**Posturographic assessments**

The measurement of postural stability was done using NeuroCom®Balance Master® (NeuroCom International; Software Version 7). Protocols were selected from a broad spectrum, and each parameter was measured as a three-trials average (Mean ± SD) score during the four dynamic tests (i.e. STS, SQT, SUO, and FL).
**Dynamic balance testing**

**The STS test**

During the STS, the subject was asked to sit on a height-adjustable seat, the level of which was set at knee height and located on a force platform, followed by extension of the body to an erect standing position. Participants were asked to position their feet parallel on the force platform and forming a 90° angle with the shank and to keep their trunk vertical and their arms folded across their chest. Feet positions were traced on the plate to ensure exact repositioning after each trial. The measured parameters are weight transfer time, rising index (force exerted to rise), and sway velocity during the rising phase.

**The SQT test**

During the SQT, the subject took two steps forward and quickly pivoted 180° on the test leg and returned to the starting position at the head of the force plate. Turn time, or the time it took the subject to complete only the turn and turn sway, the postural stability during the turn time were recorded.

**The SUO test**

During the SUO, the subject stood behind a 30-cm high box placed laterally across the force plate. The subject stepped onto the box with the designated leg and lifted the opposite leg over to the other side of the box and back onto the force plate. The lift-up index, movement time, and impact index were measured. The lift-up index was defined as the maximum concentric lifting force (percent body weight) exerted by the leading leg. Movement time was defined as the number of seconds between the initial weight shift of the non-stepping leg and the contact of the same leg with the force platform. In theory, an unstable lower extremity should be less able to “control” the descent of the opposite leg and result in higher lift-up and impact indexes (Chu & Held 1999).

**The FL test**

Participants performed the FL by taking a stride forward and flexing the hip and knee of the forward leg up to 90° and then returning upright to the starting position. The test was performed on the left and then the right leg. The distance, impact index, contact time, and force impulse of the lunging extremity were recorded. The distance that the center of gravity moved forward was expressed as a percentage of the subject’s height. The impact index was the maximum vertical force exerted onto the force plate during landing and was expressed as a percentage of body weight. Contact time was the duration of the lunging leg in contact with the force plate. Force impulse was a measure of the total work performed by the lunging leg during the landing and thrust phases of movement (percent body weight × seconds force was exerted).

**Statistical analyses**

Statistical tests were processed using STATISTICA software (StatSoft, France). Data were reported as mean ± SD. 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. All parameters (i.e. movement time, lift up index, impact index, turn time, turn degree, distance, contact time, and force impulse) were
analyzed using a one-way analysis of variance (ANOVA). When appropriate, significant differences among means were tested using the least significant difference post hoc test. The level of statistical significance was set at \( p < 0.05 \).

Results

Dynamic balance testing

Data of the movement time, lift-up index, and impact index during the STS, SQT, SUO, and FL tests and during the two test sessions (i.e. BRF, SWR, and AR) are presented in Tables 1, 2, 3, and 4 respectively.

Concerning STS test, ANOVA showed that the movement time (\( p < 0.05 \)), lift-up index (\( p < 0.05 \)), and impact index (\( p < 0.01 \)) were significantly higher during SWR in comparison with BRF and AR. Likewise, the data of the turn time and turn degree on the right and left foot during the SQT showed that these parameters increased significantly from BRF and AR to SWR (\( p < 0.05 \)).

Concerning FL, statistical analysis showed that distance, impact index, contact time, and force impulse of the left foot were significantly higher during SWR in comparison with BRF and AR (\( p < 0.05 \)). However, no significant difference was observed for the distance and impact index of the right foot between BRF and SWR. Moreover, no significant difference was observed for the movement time, lift-up index, and impact index on the right and left feet during the SUO test between BRF, SWR, and AR. Likewise, for all parameters, no significant differences were observed between BRF and AR.

Discussion

The main purpose of this study was to evaluate the influence of RIF on postural control during dynamic balance tests in judo athletes. The results showed that RIF seems to influence measures of postural control of judokas during the four dynamic tests (i.e. STS, SQT, SUO, and FL).

To our knowledge, the effects of RIF on postural control during dynamic tests have not been investigated. In a recent study we showed a significant effect of RIF on the

Table 1. Movement time, lift-up index, and impact index during the STS test measured during BRF, SWR, and AR (mean ± SD; \( n = 11 \)).

<table>
<thead>
<tr>
<th>Weight transfer time (s)</th>
<th>BRF (0.38 ± 0.26)</th>
<th>SWR (0.58 ± 0.28(^*))</th>
<th>AR (0.36 ± 0.35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising index (% of body weight)</td>
<td>BRF (34.67 ± 10.3)</td>
<td>SWR (41.79 ± 7.55(^*))</td>
<td>AR (32.67 ± 7.1)</td>
</tr>
<tr>
<td>Sway velocity (deg/s)</td>
<td>BRF (2.7 ± 0.95)</td>
<td>SWR (3.91 ± 0.56(^**))</td>
<td>AR (2.2 ± 0.88)</td>
</tr>
</tbody>
</table>

\(^*\): significant difference with SWR at the level of \( p < 0.05 \) and \( p < 0.01 \), respectively.

Table 2. Turn time and turn degree on the right and the left foot during the SQT test measured during BRF, SWR, and AR (mean ± SD; \( n = 11 \)).

<table>
<thead>
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<th>Left foot</th>
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<tbody>
<tr>
<td>BRF</td>
<td>SWR</td>
</tr>
<tr>
<td>Turn time (s)</td>
<td>0.64 ± 0.19</td>
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<tr>
<td>Turn sway (deg)</td>
<td>18.68 ± 4.52</td>
</tr>
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</table>

\(^*\): significant difference between before and during RIF at the level of \( p < 0.05 \).
static postural control tests (Souissi et al. 2013). It is, therefore, difficult to compare our results referring to the literature. In addition, the mechanism responsible for such an effect is difficult to understand at present. However, it seems possible to propose some hypotheses. As Muslims rise earlier and/or retire late during RIF, the normal sleep-wake cycle is disturbed, and this can cause a partial sleep deprivation (Roky et al. 2003; BaHammam 2005, BaHammam et al. 2010; Waterhouse 2010). In this context, numerous studies have reported impaired postural control, following sleep deprivation (Liu et al. 2001; Nakano et al. 2001; Patel et al. 2007).

Gomez et al. (2008) showed that 36 h of sleep deprivation could negatively affect the postural control. To date, the results of the scientific literature concerning the effect of sleep deprivation on balance abilities recorded in the morning (between 08:00 and 09:00 h), as in the present study, are controversial. In fact, although some studies highlighted a deleterious effect (Nakano et al. 2001; Avni et al. 2006; Patel et al. 2008), others found no effect (Uimonen et al. 1994; Gribble & Hertel 2004; Patel et al. 2008; Bougard & Davenne 2011; Bougard et al. 2011) or observed a decrease in postural efficiency only under particularly demanding conditions (Bougard & Davenne 2011; Bougard et al. 2011).

Our results show no significant differences in all parameters. These findings are in accordance with Chennaoui et al. (2009) who showed that all the physiological and metabolic parameters return to their initial state after three weeks of RIF.

Various assumptions have been made to explain sleep deprivation effects on postural control. In this context, previous studies suggested that the increase in postural sway, following sleep deprivation, is due to the decrease in vestibular system efficiency (Kohen-Raz et al. 1996; Avni et al. 2006; Morad et al. 2007) and/or the integration of the various sensory inputs (Teasdale & Simoneau 2001). In fact, maintaining a stable base of support during a balance control task (i.e. static and dynamic) requires the integration of sensory input to create the appropriate motor responses needed to make limb and trunk corrections (Gribble et al. 2007).

It has been shown that psychomotor performances, such as critical flicker fusion (Ali & Amir 1989), subjective alertness (Lagarde et al. 1996), and memory (Hakkou et al. 1988, 1994), were reduced during RIF. These RIF-related changes might, in part, explain the findings of the present study. In fact, the task of minimizing one’s base of support require a heightened level of attention (Gribble et al. 2007). Recently, Dolu et al. (2007) showed that attention levels decreased during RIF. In this context, previous studies showed that alertness is impaired by caloric restriction or sleep length limitation

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<tr>
<td></td>
<td>BRF</td>
<td>SWR</td>
<td>AR</td>
<td>BRF</td>
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<tr>
<td>Movement time (s)</td>
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<tr>
<td></td>
<td>1.42 ± 0.25</td>
<td>1.49 ± 0.24</td>
<td>1.43 ± 0.19</td>
<td>1.44 ± 0.2</td>
</tr>
<tr>
<td>Lift up index (% of body weight)</td>
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<td></td>
<td>48.15 ± 7.53</td>
<td>51.67 ± 9</td>
<td>49.16 ± 6.38</td>
<td>55.7 ± 10.27</td>
</tr>
<tr>
<td>Impact index (% of body weight)</td>
<td></td>
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<tr>
<td></td>
<td>67.47 ± 10.08</td>
<td>69.83 ± 11.26</td>
<td>68.46 ± 9.6</td>
<td>64.37 ± 12.01</td>
</tr>
</tbody>
</table>
Table 4. Distance, impact index, contact time, and force impulse on the right and the left foot during the FL test during BRF and SWR (mean ± SD; n = 11).

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<tr>
<td></td>
<td>BRF</td>
<td>SWR</td>
<td>AR</td>
<td>BRF</td>
</tr>
<tr>
<td>Distance (% of body height)</td>
<td>50.24 ± 3.39</td>
<td>51.64 ± 3.81*</td>
<td>50.43 ± 1.17</td>
<td>51.39 ± 4.29</td>
</tr>
<tr>
<td>Impact index (% of body weight)</td>
<td>33.03 ± 6.27</td>
<td>37.95 ± 7.75**</td>
<td>34.3 ± 6.32</td>
<td>35.12 ± 5.44</td>
</tr>
<tr>
<td>Contact time (s)</td>
<td>0.94 ± 0.13</td>
<td>1.07 ± 0.23*</td>
<td>0.92 ± 0.6</td>
<td>0.89 ± 0.1</td>
</tr>
<tr>
<td>Force impulse (% of body weight/s)</td>
<td>106.91 ± 2.8</td>
<td>117.67 ± 23.16*</td>
<td>108.87 ± 3.4</td>
<td>101.52 ± 8.32</td>
</tr>
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</table>

*, **: significant difference between before and during RIF at the levels of p<0.05 and p<0.01, respectively.
(Pilcher & Huffcutt 1996; Dinges et al. 1997). Since there is a diurnal variation in alertness as measured by subjective rating scale (Monk 1994), by immediate memory test (Folkard & Monk 1980), logical reasoning test (Folkard et al. 1983), and manual dexterity test, the decrease in alertness in the morning during RIF could be related to two factors: (1) the delay in rising time (i.e. sleepiness, especially in the morning) and (2) the abstinence of breakfast with its usual coffee drink content (Smith et al. 1994; Benton & Parker 1998; Roky et al. 2000, 2003).

Our study was limited to a small group of athletes; furthermore, the participants were well-trained males, and it remains unclear whether the results can be applied to sedentary or patient participants.

In conclusion, the present study suggested that RIF may negatively affect the postural control of judo athletes. In fact, dynamic equilibrium was worthy during SWR, in comparison with BRF. This effect might, in part, result in a clearly decreased performance of judoka during competitions scheduled in RIF. This is an important point for coaches who plan training programs, and it may benefit athletes because it implies that all training sessions must be programed throughout the day taking into consideration the effect of RIF on judoka’s postural control.

Acknowledgments
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References


