

ORIGINAL ARTICLE

Effect of active warm-up duration on morning short-term maximal performance during Ramadan

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Purpose: To examine the effect of active warm-up duration on short-term maximal performance assessed during Ramadan in the morning.

Methods: Twelve healthy active men performed four Wingate tests for measurement of peak power and mean power before and during Ramadan at 09:00 a.m. The tests were performed on separate days, after either a 5-min or a 15-min warm-up. The warm-up consisted in pedaling at 50% of the power output obtained at the last stage of a submaximal multistage cycling test. Oral temperature was measured at rest and after warming-up. Furthermore, ratings of perceived exertion were obtained immediately after the Wingate test.

Results: Oral temperature was higher after the 15-min warm-up than the 5-min warm-up throughout the study. Moreover, peak power and mean power were higher after the 15-min warm-up than the 5-min warm-up before Ramadan. However, during Ramadan, there was no significant difference between the two warm-up durations. In addition, ratings of perceived exertion were higher after the 15-min warm-up than the 5-min warm-up only during Ramadan.

Conclusions: There is no need to prolong the warm-up period before short-term maximal exercise performed during Ramadan in the morning.

Keywords: *fasting; morning; warm-up; anaerobic; power*

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Warm-up is considered by many to be an essential part of any training session or team-sport competition because of its proposed ability to improve subsequent exercise performance and to reduce the incidence of sports-related musculoskeletal injuries (1). Warm-up can enhance performance by increasing muscle temperature and consequently enhancing muscle power (2). This improvement is ensured through increased nerve conduction velocity, decreased joint and muscle resistance, speeding of metabolic reactions, increased blood flow to muscles, greater oxygen unloading to working muscles, postactivation potentiation, as well as through psychological effects (1). Furthermore, many studies focused on the effect of various warm-up durations on morning short-term maximal performance. In this context, Racinais et al. (3) showed that a 12-min warm-up (pedaling at 50% of $\dot{V}O_{2max}$ interspersed with brief 5-sec

accelerations at 4, 7, and 10 min) increased the maximal power determined during a maximal cycling sprint better than a 3-min warm-up (pedaling at 70 rpm at 50% of the $\dot{V}O_{2max}$). Similarly, Souissi et al. (4) found that morning muscle power was higher following a 15-min active warm-up than a 5-min active warm-up (pedaling at 50% of the power output obtained at the last stage of a submaximal multistage cycling test). Moreover, Taylor et al. (5) observed that prolonged warm-up improved jumping performance (counter movement jump with a load of 20 kg on an Olympic lifting bar) in the morning.

Warm-up structure depends on the environmental conditions and the constraints unique to the event (2). Ramadan observance is among the factors that must be taken into consideration when structuring the warm-up because it is characterized by several behavioral changes especially related to the sleep-wake cycle and eating

schedule. Indeed, this religious tenet involves total abstinence from eating and drinking from dawn to sunset for 29–30 days. This sudden delay in the timings of meals may affect the circadian patterns of body temperature and sleep (6, 7) and consequently sport performance (8).

In view of those considerations, it would be interesting to test whether the beneficial effects of prolonging the warm-up period in the morning would be observed during Ramadan. Therefore, the aim of the present study was to examine the effect of active warm-up duration (5 vs. 15 min) on 30-sec Wingate test performance assessed during the month of Ramadan in the morning.

Methods

Subjects

Twelve healthy active men (age 21.11 ± 2.75 years, body mass 70.3 ± 9.1 kg, height 1.73 ± 0.06 m) voluntarily participated in the present study after giving written informed consent. All experimental procedures were approved by the Clinical Research Ethics Committee of the National Center of Medicine and Sciences in Sport of Tunis. We were not able to include a control group who did not fast as most of the available subjects fast during Ramadan.

Study design

Two weeks before the actual measurements, the subjects were familiarized with high-intensity cycling on a cycle ergometer to minimize the learning effect. This study used a within-subjects design consisting of two testing phases: 2 weeks before Ramadan (BR) and the end of the second week of Ramadan (R2). During each period, two test sessions were randomly completed at the same time of day (09:00 a.m.) with a recovery period > 36 h in-between: one session with a 5-min warm-up and another with a 15-min warm-up. Five minutes after warming-up, the subjects performed a 30-sec Wingate test. Ratings of perceived exertion (RPE) were recorded after the Wingate test.

Oral temperature was measured at rest and after each warm-up with a clinical thermometer inserted sublingually for 3 min.

To determine the warm-up intensity, the subjects performed an incremental maximal test on a cycle ergometer (Monark 894^E, Stockholm, Sweden) before the beginning of the experiment. The procedure was as follows: after 3 min of cycling at 50 W, the intensity of the exercise was increased by 25 W every 2 min until exhaustion. The power corresponding to 50% of the power output recorded in the last stage of the incremental test was chosen as the warm-up intensity (4).

Throughout the study, the participants were requested to avoid strenuous activities during the 24 h preceding each test session. During Ramadan, they must take their

last meal (i.e. *suhur*) approximately at 01:00 a.m. and fast from that time until sunset.

Wingate test

The Wingate test was conducted on a friction-loaded cycle ergometer (Monark 894^E) interfaced with a microcomputer. This test requires pedaling for 30 s at maximal speed against a constant force related to body mass (0.087 kg/kg body mass) (9). The test began from a rolling start against minimal resistance. When a constant pedaling rate of 60 rpm was achieved, the test resistance was applied and the subjects were instructed to pedal as fast as they could for 30 s. During the test, they had to remain seated and were strongly encouraged to reach the maximal pedaling rate as quickly as possible.

Peak power (PP) was measured as the highest mechanical power that is elicited in the test, and mean power (MP) as the average power that is sustained throughout the 30-sec period.

Ratings of perceived exertion

Perceived exertion is an indicator of the degree of physical strain (10). The RPE scale used in the present study presents 15 points ranging from 6 (very very light) to 20 (very very hard) (11). The higher the RPE score, the higher the rating of perceived exertion.

Statistical analysis

Data are presented as mean values \pm SD. The Shapiro–Wilk *W*-test for normality revealed that the data were normally distributed. PP, MP, and RPE data were analyzed using a two-way analysis of variance (ANOVA) with repeated measures (2 [Period] \times 2 [Warm-up]). Oral temperature data were analyzed using a three-way ANOVA with repeated measures (2 [Period] \times 2 [Warm-up] \times 2 [Measure]). Where appropriate, significant differences between means were tested using the Fisher's least significant difference test (LSD). Statistical significance was established at $p < 0.05$.

Results

Oral temperature

Oral temperature values measured at rest and after each warm-up, during the two testing phases, are displayed in Fig. 1. The warm-up ($F = 38.48$, $p < 0.001$) and measure ($F = 480.29$, $p < 0.001$) effects were significant. However, the period effect ($F = 1.67$, $p = 0.22$) and the period \times warm-up \times measure interaction ($F = 0.01$, $p = 0.89$) were not significant.

Resting values of oral temperature were not significantly different between BR and R2. Oral temperature increased from before to after the warm-up during all test sessions ($p < 0.001$). Moreover, oral temperature was higher after the 15-min warm-up than the 5-min warm-up both BR and during R2 ($p < 0.001$).

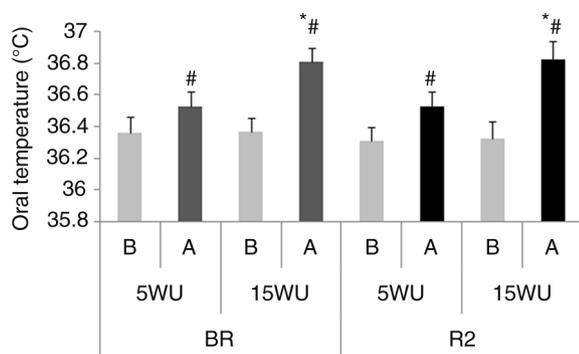


Fig. 1. Oral temperature (°C) (mean \pm SD, $n = 12$) measured before (BR) and during (R2) Ramadan, before (B) and after (A) the 5-min (5WU) and the 15-min (15WU) warm-up. #Significant difference in comparison with before warm-up; *significant difference in comparison with the 5-min warm-up.

Wingate test

Peak power

PP values determined during the 30-sec Wingate test in the four test sessions are shown in Fig. 2. Statistical analysis showed significant main effects of period ($F = 7.02$, $p = 0.022$) and warm-up ($F = 25.14$, $p = 0.0003$) and a significant period \times warm-up interaction ($F = 9.35$, $p = 0.01$).

BR, PP was higher after the 15-min warm-up than the 5-min warm-up ($p < 0.001$). However, there was no significant difference between the two warm-up durations during R2 ($p = 0.11$). When measured after the 15-min warm-up, PP was higher BR than during R2 ($p = 0.002$). This difference was not observed after the 5-min warm-up ($p = 0.69$).

Mean power

MP values determined during the 30-sec Wingate test in the four test sessions are presented in Fig. 3. Significant

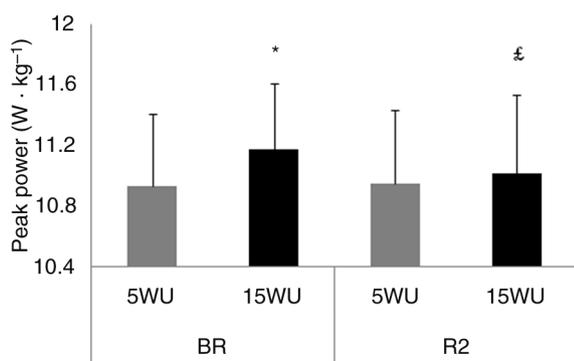


Fig. 2. Peak power (W/kg) (mean \pm SD, $n = 12$) determined during the 30-sec Wingate test, after the 5-min (5WU) and the 15-min (15WU) warm-up, and before (BR) and during (R2) Ramadan. £Significant difference in comparison with BR; *significant difference in comparison with the 5-min warm-up.

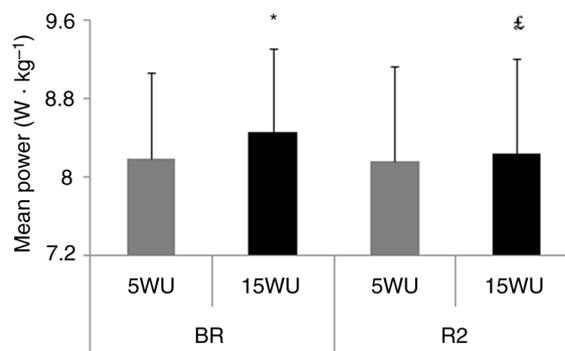


Fig. 3. Mean power (W/kg) (mean \pm SD, $n = 12$) determined during the 30-sec Wingate test, after the 5-min (5WU) and the 15-min (15WU) warm-up, and before (BR) and during (R2) Ramadan. £Significant difference in comparison with BR; *significant difference in comparison with the 5-min warm-up.

main effects of period ($F = 7.73$, $p = 0.017$) and warm-up ($F = 33.58$, $p = 0.0001$) and a significant period \times warm-up interaction ($F = 16.62$, $p = 0.001$) were found.

BR, MP was higher after the 15-min warm-up than the 5-min warm-up ($p < 0.001$). However, there was no significant difference between the two warm-up durations during R2 ($p = 0.05$). Furthermore, MP was higher BR than during R2 after the 15-min warm-up ($p < 0.001$). This difference was not observed after the 5-min warm-up ($p = 0.51$).

RPE scores

RPE scores obtained after the 30-sec Wingate test in the four test sessions are shown in Fig. 4. The period effect was significant ($F = 6.06$, $p = 0.03$). However, the warm-up effect ($F = 1.67$, $p = 0.22$) and the period \times warm-up interaction ($F = 1.96$, $p = 0.18$) were not significant.

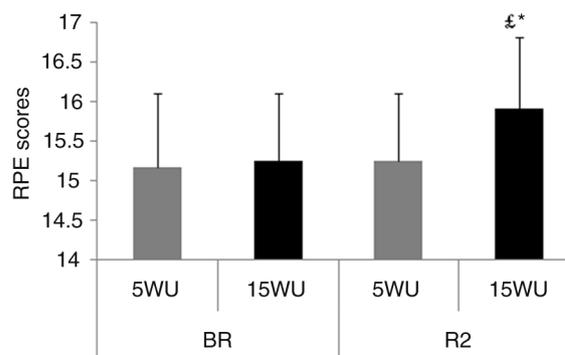


Fig. 4. Rating of perceived exertion (RPE) scores (mean \pm SD, $n = 12$) obtained following the 30-sec Wingate test, after the 5-min (5WU) and the 15-min (15WU) warm-up, and before (BR) and during (R2) Ramadan. £Significant difference in comparison with BR; *significant difference in comparison with the 5-min warm-up.

BR, there was no significant difference between the two warm-up durations ($p = 0.78$). However, during R2, RPE scores were higher after the 15-min warm-up than the 5-min warm-up ($p = 0.04$). Moreover, there was no significant difference between BR and R2 for RPE scores obtained after the Wingate test performed following the 5-min warm-up ($p = 0.78$). However, RPE scores were higher during R2 compared to BR when the Wingate test was performed after the 15-min warm-up ($p = 0.04$).

Discussion

We demonstrated that BR, short-term maximal performance was higher after the 15-min warm-up than the 5-min warm-up. However, this difference between the two warm-up durations was not observed during Ramadan. Moreover, RPE scores were not significantly different between the two warm-up durations BR, and were higher after the 15-min warm-up than the 5-min warm-up during R2.

We confirm that BR, short-term maximal performance assessed by the Wingate test is higher after the 15-min warm-up than the 5-min warm-up in the morning. The greater muscle power observed after the 15-min warm-up could be explained by the increase in core temperature. In this context, our findings confirm those of previous studies (3, 4) and show that the 15-min warm-up increases core temperature better than the 5-min warm-up. Likewise, Taylor et al. (5) found that the increase in core temperature was greater when the warm-up was prolonged. The benefits of higher body temperature are multiple and may include faster nerve conduction velocity, higher enzymatic activity (12), a decrease in the viscous resistance of muscles, a speeding of the rate-limiting oxidative reactions, and an increase in oxygen delivery to muscles (2). This may result in better motor coordination and so produce higher muscle power output (13).

The findings of the present study showed that short-term maximal performance was not significantly different between the two testing periods after the 5-min warm-up. However, PP and MP were lower during R2 compared to BR after the 15-min warm-up. These results agree, in part, with previous research showing that short-term maximal performance was not affected by Ramadan fasting in the morning (14–16). Nevertheless, these latter studies did not contain information about the warm-up procedure.

The insignificant difference between the two warm-up durations during R2 is likely due to a reduced performance after the 15-min warm-up rather than an improved performance after the 5-min warm-up. The decrement in PP and MP observed after the 15-min warm-up during R2 could be attributed to psychological factors. Indeed, the thought of going on for the next 8–9 h without food and fluid intake after an intense exercise preceded by a prolonged warm-up might cause the fasting athletes to conserve their efforts (17). Moreover, as the present study

was conducted in summer, the high environmental temperatures that characterize this season in our country may have reduced the subjects' readiness to perform the test preceded by the prolonged warm-up, as no fluid intake is allowed during the daylight hours during Ramadan. Motivation is a key factor for anaerobic power tests (16). Lack of motivation is probably at least partly responsible for the reduction in physical performance (18, 19). Along with demonstrating a performance decrement after the 15-min warm-up during Ramadan, our findings showed that RPE scores obtained after the Wingate test were higher after the 15-min warm-up than the 5 min warm-up.

Conclusions

This study conducted on non-athlete subjects showed that a prolonged active warm-up (i.e. 15 min) is better for short-term maximal exercise performed outside Ramadan in the morning. However, during Ramadan, when food and fluid intake is limited to the hours of darkness, the beneficial effect of the prolonged warm-up is no longer observed. Therefore, there is no need to prolong the warm-up period during Ramadan in the morning.

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Conflict of interest and funding

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