RELATIONS BETWEEN MENSTRUAL PHASE AND PERFORMANCE OF AN INTENSE INTERMITTENTACTIVITY

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[Relazione tra fase del ciclo mestruale e livelli prestazionali nel corso di una intensa attività intermittente]

SUMMARY

Game sport and training require repeated high intensity bursts. This study examined differences between high intensity, intermittent work in two phases of the menstrual cycle. Seven physically active young women (age 19-29 years) performed 10 6-s sprints on a cycle ergometer in both the mid-follicular (FP; days 6-10) and late-luteal phases (LP; days 20-24) of the menstrual cycle. Work, power, oxygen intake (VO_2) parameters, and capillarized blood lactate were measured. Data are analyzed using the Friedman and Wilcoxon matched pairs tests. There was no difference between menstrual phases in peak 6-s power (6.8 ±0.6 W kg^{-1} in FP, 6.9 ±0.6 W kg^{-1} in LP), the drop off in work (1.2 ±3.5 J kg^{-1} in FP and 1.0 ±2.7 J kg^{-1} in LP), or in the sprint VO_2 (23.7 ±1.5 mLkg^{-1} min^{-1} in LP and 24.3 ±2.4 mLkg^{-1} min^{-1} in FP). Capillarized blood lactate was also similar in both phases of the menstrual cycle both at 1 min (9.2 ±2.7 mmol L^{-1} in FP, 9.2 ±3.1 mmol L^{-1}) and at 3 min (9.0 ±2.2 mmol L^{-1} in FP, 9.2 ±2.2 mmol L^{-1} in LP). However, the average 6-s work was greater in the LP(39.3 ±3.4 J kg^{-1}) than during the FP(38.3 ±3.1 J kg^{-1}; P = 0.023). The recovery VO_2 was also greater in the LP than the FP (26.3 ±2.4 mL kg^{-1} min^{-1} in LP, 25.0 ±2.6 mL kg^{-1} min^{-1} in FP; P = 0.023). Average work over a series of sprints and the VO^2 consumed between sprints may be slightly greater during the LP than the FP of the menstrual cycle.

Key words: Menstrual cycle, menstrual phase, intermittent activity, performance, sport

RIASSUNTO

Gli sport agonistici e il loro allenamento richiedono ripetuti incrementi prestazionali ad alta intensità. Questo studio esamina le differenze tra un lavoro intermittente ad alta intensità in due diverse fasi del ciclo mestruale. Sette giovani donne fisicamente attive (età 19-29 anni) eseguivano 10 sprint di 6 s su di un cicloergometro, sia in fase medio follicolare (FP; 6°-10° giorno) che nella fase luteale tardiva (LP; 20°-24° giorno) del ciclo mestruale. Venivano misurati lavoro, potenza consumo di ossigeno (VO_2) e lattacidemia. I dati venivano valutati con il test appaiato di Friedman e Wilcoxon. Non si sono osservate differenze significative in termini di potenza massima (6.8 ±0.6 W kg^{-1} in FP, 6.9 ±0.6 W kg^{-1} in LP), nella perdita (drop off) della capacità di lavoro(1.2 ±3.5 J kg^{-1} in FP and 1.0 ±2.7 J kg^{-1} in LP), o nel VO_2 durante lo sprint (23.7 ±1.5 mLkg-1min^{-1} in LP and 24.3 ±2.4 mL kg^{-1} min^{-1} in FP). Anche il lattato ematico era simile in entrambe le fasi del ciclo mestruale, sia dopo 1 min (9.2 ±2.7 mmol L^{-1} in FP, 9.2 ±3.1 mmol L^{-1}) che dopo 3 min (9.0 ±2.2 mmol L^{-1} in FP, 9.2 ±2.2 mmol L^{-1} in LP). Tuttavia, il lavoro medio durante i 6 s era maggiore in LP (39.3 ±3.4 J kg^{-1}) che in FP (38.3 ±3.1 J kg^{-1}; P = 0.023). Anche il recupero del VO_2 era maggiore in LP che in FP (26.3 ±2.4 mL kg^{-1} min^{-1} in LP, 25.0 ±2.6 mL kg^{-1} min^{-1} in FP; P = 0.023). Si può concludere che il lavoro prodotto e l'ossigeno consumato durante una serie di sprint sono leggermente maggiori durante la fase luteale tardiva rispetto alla fase medio follicolare del ciclo mestruale.

***Parole chiave**: Ciclo mestruale, fase mestruale, attività intermittente, prestazione, sport*

Introduction

Women, during the reproductive years, are characterized by the cyclical variation of reproductive hormones. Usually, the levels of these hormones during the menstrual cycle is generally predictable (Frankovich and Lebrun 2000). Exercise is associated with alteration in circulat-ing hormone concentration (Bonen et al. 1979; Jurkowski et al. 1978), hormone metabolism (Keizer et al. 1980), and menstrual irregularities (Bonen et al. 1983, Keizer et al. 1980). Although the effect of intense training on the menstrual cycle has been extensively studied, the relationship between the menstrual cycle and many types of physical performance is still unclear (Lebrun and Rumball 2001).

High-intensity intermittent activity is present in most game sports, for example, rugby, hockey, and

soccer, where intense bursts of effort are interspersed with periods of low-intensity activity or rest. In addition, training sessions for many sports include interval train-ing. High-intensity intermittent activity requires re-peated bouts of high-quality performance and rapid recovery. According to Parkhouse and McKenzie (1984), high-rate performance requires a high rate of adenosine triphosphate (ATP) synthesis, clearing of metabolites and cofactors, and adequate buffering of protons (H^+).

Only two studies, however, have examined the effects of the menstrual cycle on intermittent performance. Neither found a significant effect of menstrual phase on performance, although each has features that might limit the validity of this conclusion. Lynch and Nimmo (1998) used intervals of progressive intensity, which is not a valid simulation of game sport. The primary purpose of the Sunderland and Nevill (2003) study was to monitor the ability of the participants to cope with heat in the (late-luteal; LP) and the mid-follicular phases (FP) and used intervals of varying intensities, maximal sprints, cruising (~95% VO_2 max), jogging (~55% VO_2 max), and walking. However, they did not monitor the performance in each interval. The effect of menstrual phase may be different on different intensities of effort.

High-intensity intermittent activity may be enhanced by increased recovery between intervals during the luteal phase. There is some evidence of enhanced lactate clearance at high intensities (Jurkowski et al. 1981; McCracken et al.1994) and increased excess post-exer-cise oxygen consumption (EPOC) after prolonged exer-cise (Matsuo et al. 1999) during the LP relative to the FP. A portion of the EPOC includes the oxygen that is being used to replenish energy stores. A portion of the EPOC will reflect phosphocreatine (PCr) recovery (Taylor et al 1983), which funds ATP replenishment. Another portion will reflect the removal of lactate and H^+ (Gaesser and Brooks 1984; Sahlin 1992).

The purpose of this study was to determine:

• the difference between work and power production during high-intensity intermittent activity in the FP and the LP of the menstrual cycle;

• the difference between the ability to resist fatigue over repeated sprints in the FP and the LP of the menstrual cycle;

• the difference between oxygen consumption VO_2 during and between repeated sprints in the FP and the LP of the menstrual cycle. It is suggested that recovery be-tween intervals and, consequently, overall performance may be greater during the LP than the FP of the menstrual cycle.

Methods

Subjects

Seven women were recruited from the University of Catania for this study. The Research Ethics Committee of the University approved the project and written informed consent was obtained from each sub-ject.

Inclusion criteria were:

• female between 19 and 29 years;

• participated in moderate physical activity at least four times a week;

• free of metabolic, car-diovascular, or respiratory disease;

• non-smoker;

• not an oral contraceptive user for a minimum of 6 months;

• eumenorrheic menstrual cycles for 1 year or more;

• menstruating for at least 3 years. Eumenorrhea was operationally defined as regularly occurring menstrual cycles, 24 to 35 days in length (Lebrunet al.1995).

Apparatus

All exercise tests were performed on a friction-loaded cycle ergometer (model 818, Monark) interfaced with an electronic revolution counter (Micro Projects). The product of flywheel revolutions and the load was used to determine work and power measures. The cycle ergom-eter allowed us to measure maximal power output more accurately than a treadmill.

Expired gases were collected through a low resistance valve (Rudolph 2700) using breath-by-breath mode with a Vmax 229 Metabolic Measurement Cart (Sensormedics) for the determination of VO_2 MDS Metro Lab Services tested pre-exercise blood progesterone levels via radioimmunoassay. Capillarized blood lactate was tested by finger tip (Lactate Pro).

Design

Subjects participated in three laboratory sessions: a familiarization session, a LP testing session, and a FP testing session. Day 1 of the menstrual cycle was char-acterized by the beginning of the menstrual bleeding, the FP session was at 6-10 days and the LP session at 20-24 days after the beginning

of menstrual bleeding. The menstrual phase was confirmed by serum progesterone levels (Enzyme Immunoassay, FP 1, LP>8nmol L^{-1}). The LP and the FP sessions were in a randomly assigned order. All sessions were identical except that blood testing did not occur prior to the familiarization session.

Procedures

Each session took place after a 2-h fast to reduce the thermogenic effect of food on VO_2. Both testing sessions took place at the same time of the day. Subjects traveled to the laboratory by motorized vehicle to eliminate unnecessary activity (Gore and Withers 1990). Subjects also abstained from caffeine, alcohol, and drugs for the 24h prior to the testing session and from intense physical exercise for 24 h prior to the session (Short and Sedlock 1997).

Blood was drawn for pre-exercise testing during a 30-min rest period upon arrival to the exercise laboratory. The average VO_2 during the last 10 min of the rest period was taken as resting VO_2. Next, the subject per-formed a submaximal cycling warm-up consisting of 5 min at 50 rpm against a resistance of 0.5 kp. A moderate intensity warm-up followed, consisting of two 30-s periods of submaximal cycling, one at 85 and one at 115 rpm separated by 60s of recovery. Finally, the warm-up was completed by a 5-min stretching period. A similar warm-up has been shown to result in only minor metabolic disturbances (Wootton and Williams 1983).

The intense intermittent exercise test consisted of ten maximal 6-s sprints interspersed with 30 s of recovery. The cycling ergometer was loaded with 0.075 kp kg^{-1}. Tomlin and Wenger (2002) previously used this loading with female subjects. To standardize the measure, the subjects started each sprint from a stationary, seated position with the same starting pedal position. Each sprint was performed in a seated position with feet se-cured to pedals with toe clips. Subjects were instructed to ensure that they breathed during the sprints and were verbally encouraged during each sprint to give maximal effort. During the 30-s rest period, the subjects remained quietly seated on the cycle ergometer. VO_2, VCO_2, VE and RER were monitored, measured on a breath-by-breath basis during the sprints and rest. Following the 10 sprints, the subjects remained seated until the lactate tests were completed. Capillarized blood lactate levels were measured at 1 min and 3 min into the post-exercise rest period.

A similar protocol has been used previously in several studies to simulate game performance (Balsom et al.1994; Gaitanos et al.1993; Hamilton et al. 1991; Tomlin and Wenger 2002). Repeated 6-s cycle ergometer sprints have been positively correlated to game sport 15 m sprint performance (Bishop et al. 2001).

Statistical analyses

All values are expressed as means (±SD). A distribution test for all variables [W (average 6-s work over ten tri-als), PP (peak 6 s average power), DO (drop off in performance between the average W of the first three trials and the average W of the last three trials), lactate, sprint VO_2 and recovery VO_2] was performed using the Kolmogorov-Smirnov test. The differences between menstrual phases were assessed using the Friedman Test and Wilcoxon matched-pairs, signed ranks test. Statistical significance was set at 0.05.

Results

The subjects aged 24.5 ±3.1 years. Their mass was not significantly different between menstrual phases (71.7 ±7.6 kg in FP and 72.0 ±7.4 kg in LP). The progesterone levels of the subjects were significantly higher during the LP (19.0 ±6.7 nmol L^{-1}) than during the FP (1.2 ±0.4 nmol L^{-1}). The progesterone levels were high enough in the LP and low enough in the FP to confirm menstrual phase (Enzyme Immunoassay, FP<5nmol L^{-1}, LP>8 nmol L^{-1}).

The W over the series of ten sprints was significantly greater in the LP (39.3 ±3.4 J kg-1) than in the FP (38.2 ±3.1 J kg^{-1}) (P = 0.023). This difference was only sig-nificant in individual sprints 4 (38.7 ±3.3 J kg^{-1} in FP, 40.4 ±3.4 J kg^{-1} in LP, P = 0.23) and 6 (37.2 ±3.8 J kg^{-1} in FP, 39.3 ±3.7 J kg^{-1} in LP, P = 0.038). There was no significant difference between the menstrual phases in PP (6.8 ±0.6 W kg^{-1} in FP, 6.9 ±0.6 W kg^{-1} in LP) or in DO (1.2 ±3.5 J kg^{-1} in FP, 1.0 ±2.7 J kg^{-1} in LP).

The lactate samples were not significantly different between menstrual phases either at 1 min (9.2 ±2.7 mmol L^{-1} in FP, 9.2 ±3.1 mmol L^{-1} in LP) or at 3 min (9.0 ±2.2 mmol L^{-1} in FP, 9.2 -2.2) mmol L^{-1} in LP). The change in lactate from minute 1 to 3 was also similar between menstrual phases (-0.2 ±0.8 mmol L^{-1} in FP, 0.0 ±1.4 mmol L^{-1} in LP).

To discount the delayed VO_2 response, the sprint and recovery VO_2 were measured over

sprints 2-10. The average VO_2 during the recovery periods was signifi-cantly higher during the LP (26.3 ±2.4 mL kg^{-1} min^{-1}) than in the FP (25.0 ±2.6 mL kg^{-1} min^{-1}) (P = 0.023) (Fig. 1).

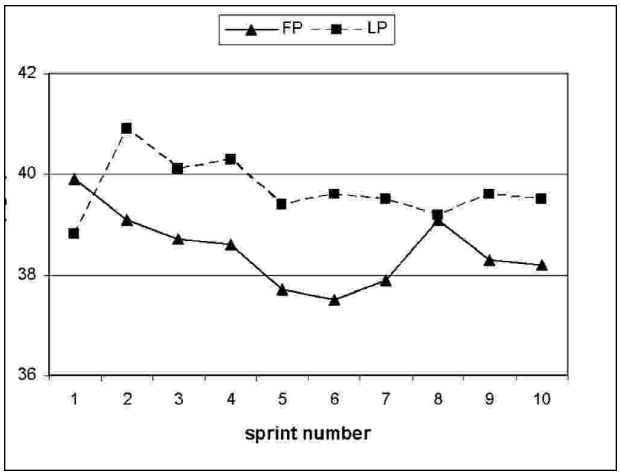

Fig. 1: A comparison of work performed during each sprint in a series of ten 6-s sprints during the FP and the LP

This difference was significant in individual sprints 2 (21.7 ±8.0 mL kg^{-1} min-1 in FP, 24.2 ±8.6 mL kg^{-1} min^{-1} in LP, P = 0.014), 4 (24.1 ±7.9 mL kg-1 min^{-1} in FP, 24.2 ±8.6 mL kg^{-1} min^{-1} in LP, P = 0.038), 6 (24.7 ±7.5 mL kg^{-1} min^{-1} in FP, 25.5 ±9.5 mL kg^{-1} min^{-1} in LP, P = 0.023), 7 (25.0 ±7.2 mL kg^{-1} min^{-1} in FP, 26.6 ±7.8 mL kg^{-1} min^{-1} in LP, P = 0.034), 9 (25.7 ±6.9 mL kg^{-1} min^{-1} in FP, 27.4 ±7.3 mL kg^{-1} min^{-1} in LP, P = 0.038), 10 (25.8 ±6.9 mL kg^{-1} min^{-1} in FP, 28.5 ±7.6 mL kg^{-1} min^{-1} in LP, P = 0.023). However, there was no significant difference in sprint VO_2 (24.3 ±2.4 mL kg^{-1} min^{-1} in FP and 23.7 ±1.5 mL kg^{-1} min^{-1} in LP).

Discussion

In this study, we found a significant enhancement in W over a series of ten 6-s sprints in LP relative to the FP. The VO_2 consumed during the recovery between the sprints was also greater in the LP. These two elements may be related but that will be determined in future research.

Our data must be interpreted with caution. Although the study was small, the sample is well characterized, and is in the range of similar studies (Sunderland and Nevill 2003: seven subjects; Lynch and Nimmo 1998: five subjects). Moreover, even a study of this size found statistically significant and complementary differences. The use of clipped pedals may have limited the maxi-mum power achieved by the subjects.

However, the trends in work and power should be impervious to pedal styles.

Compared to female soccer players completing a similar protocol (Tomlin and Wenger 2002), both MW and PP are slightly lower in both menstrual phases (averages of 44.3 J kg^{-1} and 7.9 W kg^{-1} in the Tomlin and Wenger study versus 38.8 J kg^{-1} and 6.8 W kg^{-1} in this study). However, the subjects in the Tomlin and Wenger study used clipless shoes. This may have al-lowed for more efficient power transfer to the pedals. The VO_2 during and between the sprints was similar to that of the women in the low aerobic power group in the Tomlin and Wenger study (21.8 mL kg^{-1} min^{-1} in Tomlin and Wenger versus 21.5 mL kg^{-1} min^{-1} in this study).

There was no significant difference between PP in the FP and LP in this study. Similarly, in a study examining maximal anaerobic performance, there was no difference between the menstrual phases for peak power in an 8 s bicycle ergometer sprint (Giacomoni et al. 2000) or in a 10 s rowing ergometer test (Redman and Weatherby 2004). The study by Giacomoni et al. also found that maximum power, as measured by a multi-jump test or a squat jump test, was similar over the menstrual cycle phases.

The W was greater during the LP (39.3 ±3.4 J kg^{-1}) than the FP (38.3 ±3.1 J kg^{-1}). No previous studies have examined work over a series of sprints relative to the menstrual phase. Higher PCr and adenosine triphos-phate (ATP) stores would explain the higher W during LP. According to Gaitanos et al. (1993), 84% of the anaerobic ATP production in the last of ten sprints is from phosphagen stores. Therefore, increased PCr and ATP stores may sustain higher ATP utilization levels and allow for more consistent work levels. Higher PCr and ATP levels have been associated with high estrogen levels in the hamster uterus (Shivaji et al. 1995) as present in the LP relative to the FP but not in humans or skeletal muscles.

Another source of energy for repeated sprints is gly-cogen. In secondary analysis, the respirator exchange ratio (RER) was lower during the LP (1.17 ±0.06) than the FP (1.19 ±0.06) (P = 0.04), in agreement with some previous studies (Hackney et al. 1994, Redman et al. 2003).

This indicates that less carbohydrate was used relative to fat in the luteal phase relative to the follicular phase. However, the contribution of fat to the energy used for this type of activity is minimal (Gaitanos et al. 1993). The lower RER probably indicates that less gly-cogen was used.

Since glycogen, ATP, and PCr are the three main energy contributors to exercise of this type (Gaitanos et al. 1993), it is likely that more energy was derived from phosphagen stores, supporting our hypothesis.

Two other studies have examined intermittent activ-ity (Lynch and Nimmo 1998; Sunderland and Nevill 2003). Unlike the present study, neither found a signif-icant difference in performance between menstrual phases. However, unlike the current study, work and power were not measured for each interval, nor was maximal exertion required in every interval.

Lynch and Nimmo (1998) had subjects perform work intervals of progressive intensity to exhaustion, meaning only the last interval or two were of maximal exertion. Both the work interval (20 s) and the rest interval (100 s) were far longer than in the current study. Intervals of different length will influence the energy sources that the body uses. Repeated sprints of 6 s such as in this study have been found to predict game sport 15m sprint per-formance (Bishop et. al 2001).

Sunderland and Nevill (2003), required participants to complete 20 m intervals of varying speed for repeats of 15 min until exhaustion. Although some of the intervals were maximal sprints, others were walk, jog (~55%), or cruising (~ 95% VO^{2max}) speed. Intervals at each speed contributed to the final performance re-sults (total distance completed). In contrast to the present study, they found no difference in performance.

It may be the contribution of the sub-maximal intervals that caused these findings with no significant difference in performance between menstrual phases. Time to exhaustion at submaximal VO_2 has previously been found to be similar in the FP and in the LP (De Souza et al. 1990; Lebrun et al. 1995; McCracken et al. 1994). Recovery VO_2 between intervals may also contribute to the ability to maintain power through a series of sprints by replenishing phosphagen stores (McMahon and Jenkins 2002). The fast phase of recovery, lasting 10 s to 5 min is associated with phosphagen (ATP, PCr) recovery (Gaesser and Brooks 1984). Similar to Matsuo et al. (1999) who found EPOC to be greater during LP than FP, the average recovery period VO_2 in this study was significantly greater during the LP (26.3 ±2.4 mL kg^{-1} min^{-1}) than the FP (25.0 ±2.6 mL kg^{-1} min^{-1}) as seen in Fig. 2.

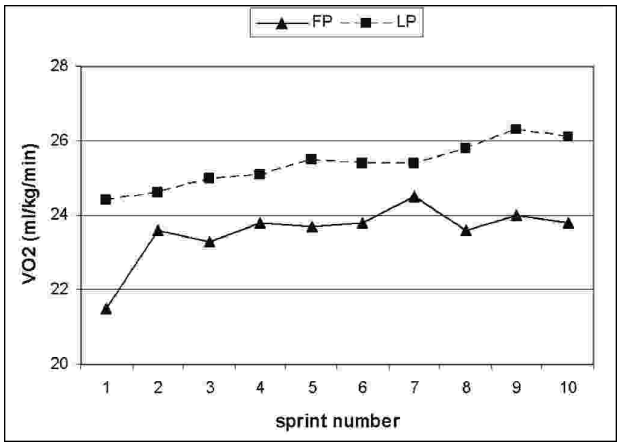

Figure 2: Comparison of VO_2 consumed between sprints in a series of ten 6-s sprints during the FP and the

We speculate that the increased VO_2 may have allowed for increased phosp-hagen replenishment.

Since ATP and PCr produce energy more quickly than other energy systems, an increase in phosphagen stores would allow power production to be better maintained over a series of sprints

Despite the higher W during the LP, there was no significant difference in the DO in the FP and in the LP. It was hypothesized that there would be less DO during the LP due to enhanced lactate clearance at high inten-sities (Jurkowski et al. 1981; McCracken et al. 1994) and increased EPOC (Matsuo et al. 1999) associated with the LP.

Enhanced lactate clearance is associated with the LP at intensities above 90% VO2max (Jurkowski et al. 1981; McCracken et al. 1994) but not at lower intensities (Bonen et al. 1983; DeSouza et al. 1990; Hessemer and Bruck 1985). Despite the maximal effort in this study, there was no difference in lactate clearance between menstrual phases.

The intermittent protocol versus the steady-state protocol of previous studies may have caused this conflict in results.

Despite the small difference in W, it is significant in terms of performance. Firstly, every subject exhibited enhanced performance during the luteal phase. Sec-ondly, if translated to running, this difference in work would translate into approximately 1 m difference in a 6-s sprint. In a game sport, this may make the difference in reaching the ball, puck, or net first.

Future research may investigate whether increased phosphagen stores may have contributed to the increase in W and whether higher recovery VO_2 may help recovery of energy stores.

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