The effect of menstruation on psychological and physiological correlates of endurance performance

K. Isherwood[1], L. Fung[2], S. Walker[3], L. J. Cameron*[4] & M. Cotterrell[1]

[1]Centre for Exercise and Nutrition Science, Chester College, UK, [2]Department of Physical Education,Hong Kong Baptist University, [3]Research Department of the Hong Kong Sports Development Board, [4]School of Medicine, Flinders University of South Australia

Introduction

Menstruation has become less of a barrier to achieving sports goals for women in recent times. Menstruation has historically been a taboo subject in sports science and in the coach-female athlete relationship, with embarrassment and lack of empathy from male coaches being prevalent [1]. Despite abundant research addressing the effects of exercise on menstruation, including menstrual irregularities resulting from training, less is known about how menstruation affects women's athletic training and competition. These cyclic hormonal fluctuations may affect physiological, physical and psychological potential and ultimately impact on sports performance.

The female athlete has a complex and continuously changing chemical mix of female steroid sex hormones, with individual, interactive and sometimes conflicting physiological responses (particularly on substrate utilisation, electrolyte and water balance, nervous system, blood sugar and circulation) with potential implications for athletic training [2]. Early retrospective studies on the effect of the menstrual cycle on performances found a variety of responses. Lebrun's [3] review of research found substantial differences in the effects reported by studies; from 8% to 69.7% of women found a decrement in performance during menstruation, while 13% to 43% had enhanced performance. The best performances were mostly during the immediate postmenstrual days, while the worst performances were in the pre-menstrual phase and during the first few days of the menstrual period. The most common reason for reduced performance cited in these studies was lethargy and fatigue, disrupted concentration and severely reduced levels of motivation. For elite female athletes even small differences in performance may be critical to athletic success [3].

Changes in physiological parameters have been extensively reported in the literature at different phases of the menstrual cycle, including cardiovascular, haemodynamic, respiratory, metabolic, strength, biochemical and endocrine, but in general have not shown a consistent variations with specific phases. However, there is still a lack of understanding regarding women, sports performance and gynaecological issues. In early studies, many of the variation could be accounted for by varying nutritional status of the athletes: substrate utilisation is clearly influenced [4]. Psychological changes have reportedly had a more consistent variation in the premenstrual and menstrual period. For example, major psychological problems reported pre-menstrually and during menstruation were irritability (40% of the subjects), mood swings (38% of

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the subjects), fatigue (30% of the subjects) and depression (28% of the subjects) in an Australian Olympic team [5]. Another study found no significant differences in performance times during a sixty-minute bicycle test at 65% VO2max, but an increase in RPE was reported during menstruation [6]. POMS scores and running economy were found to be significantly different between phases of the menstrual cycle [7]. Conversely, symptoms of dysmenorrhoea premenstrual syndrome may be relieved by exercise, possibly due to changes in central neurotransmitter or modulation of prostaglandin synthesis [8]. However, in general the literature to support this has not described elite athletes, rather, the sedentary versus the physically active woman..

Although early studies of the impact of menstruation on performance have contributed much to the understanding of this topic, limitations of this work are also evident. Results from early studies are difficult to interpret, owing to the small subject pools, wide ranges of fitness levels, variability in methodology and inadequately controlled experimental designs. Moreover, researchers did not document any significant changes in measurements of athletic performance as a function of the timing of measurements during the menstrual cycle. It is difficult to determine from retrospective studies if the reported effects were physiologically or psychologically induced. Only a few investigations have been carried out on highly trained athletes. Few studies have measured in the field effects on physiological and psychological correlates of endurance performance. Furthermore, no studies have been found that focus on Asian athletes. Therefore, a study that combines psychological and physiological measures is warranted in order to provide a better understanding of this topic.

Statement of the Problem

It is proposed that menstruation (including the pre-menstrual phase) has negative effects on physiological and psychological correlates of endurance performance. The physiological effects may be subtle, but at elite level sufficient to influence performance. The psychological correlates may be affected more obviously and more detrimentally.

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Methods

A total of 20 elite-level athletes were recruited from four endurance sports - triathlon, swimming, distance running, and rowing based on the criteria that they: 1) volunteered for the study, 2) were undergoing endurance training in a range of 12 -25 hours per week at the time of data collection, 3) were nationally ranked in their sport, 4) were of Asian or Eurasian ethnic origin, and 5) had been involved in national-level training for at least 3 years prior to the commencement of the study. Demographic data are presented in Table 1.

Ethical Approval was provided by the Hong Kong SDB Sports Institute and Chester College. All subjects provided written informed consent. Those under 18 also provided parental consent. Written permission for the athletes to be participants of the study was also obtained from the relevant Head Coaches.

A one-group, repeated measures research design was used, to measure a range of physiological and psychological variables:

- Ratings of Perceived Exertion (RPE) were assessed using a 5 level rating scale that was convenient, quick and importantly very familiar to the athletes. This scale is a retrospective assessment extensively used at the Hong Kong Sports Institute. It is reported after training and is abbreviated in the number of response levels to minimise interference with the coaches timing and programme (permission to work with elite athletes in real life training sessions was only granted if there was no hindrance).
- Heart Rate at rest (RHR) self-recorded in the morning and, 3). Training Heart Rate (THR) which were both measured in beats per minute (BPM) using Polar Heart Rate monitors (Polar Electro Inc. U.S.A.).The athletes are very familiar with the procedures and adept at using heart rate monitors and recording values.
- Time/Speed for performing specific workouts in training, which were measured in minutes and seconds by the stopwatch function of the Polar Heart Rate monitor, and by the Coaches timing, and later recorded as a graded rating scale.
- Tension-Anxiety; Fatigue; Vigour; and Depression these were measured using the abbreviated POMS scale [9]. To gain additional information, five more items (Esteem Related Affects)[10] were included to assess self-esteem and confidence.

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- Total Mood Disturbance (TMD): calculated by subtracting the Vigour subscore from the five constructs of Tension, Depression, Fatigue, Anger and Confusion in the POMS. The higher the TMD score the worse the overall Mood State.

All the physiological measurements, (except RHR) were recorded for each training session of the day. An overall rating was then recorded on the questionnaire /record sheet at the end of all the daily training. Although precise THR, Time/Speed and RPE measurements were recorded the reported responses were comparative, e.g. in general for today's workouts, compared to similar workouts on other occasions THR was similar/same, higher, lower etc.

Data from the 20 subjects were collected over a period of two full menstrual cycles (i.e. 8 weeks). All variables were recorded every two days. The menstruation data included selected days of the menstrual flow (menses) and the pre-menstrual phase, which was taken as the four days prior to the onset of the period (menses). All subjects were provided with two sets of record sheet /questionnaire for recording responses over two menstrual cycles. The athlete was required to fill in responses every other day at the end of daily training. All training sessions were conducted in Hong Kong and supervised by the National Coach of each sport. Data collection was carried out during the training phase of Aerobic and Anaerobic Base Conditioning, allowing for access to regular training days, standardised nutritional intake, and structured daily program at the Sports Institute. Levels of quality (completeness, comprehension and honesty) of questionnaire data were controlled for with a variety of tests and follow ups.

A descriptive analysis was performed to determine mean scores for each of Phase 1 and Phase 2 for Cycle A, and Phase 1 and Phase 2 for Cycle B, followed by 2-way Repeated Measures ANOVA to test for differences between the four sets of data. The mean scores for Cycle A and Cycle B were pooled, i.e. Phase 1 (Cycle A + Cycle B) Phase 2 (Cycle A + Cycle B), to provide a two-way comparison. Simple comparison of the mean scores, and Student *t*-test were used to establish whether or not the differences between the means were statistically different and the direction of the differences. The level of significance for all tests was set at $p < 0.05$.

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Table.1: Descriptive characteristics of the 20 National-level endurance athletes n = 20: Triathlon n = 6, Rowing n = 6, Running n = 4, Swimming n = 4

Variable	Mean ± SD
Age (yr)	23.15 ± 9.04
Height (m/cm)	1.66 ± 0.05
Weight (kg)	56.09 ± 4.91
Years of training (yr)	8.60 ± 7.71
Hours of training per week (hr/min)	20.33 ± 4.66
Months since first menstrual period	115.20 ± 98.27

Results and Discussion

Results from psychological variables (Table 2) demonstrated that Tension, Depression, Fatigue, and TMD all showed values significantly higher (*$p < 0.05$) in Phase 1 than in Phase 2, while Vigour values were significantly lower in Phase 1 than Phase 2. Esteem-Confidence values showed no significant differences between phases. For all variables no statistical differences were found between Cycles A and B (Month 1 and Month 2).

Pooled data revealed significant differences between Phase 1 and Phase 2 for all the dependent variables, with no significant difference between the Cycles and when analysed by 2-way repeated measures ANOVA.

Table.2: Mean Standard Deviation of Psychological Variables

	Cycle A		Cycle B	
	Phase 1	Phase 2	Phase 1	Phase 2
Source	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Tension	6.89 ± 4.45	*4.65 ± 3.98	6.99 ± 4.48	*4.53 ± 4.16
Depression	7.24 ± 5.84	*3.85 ± 4.41	6.94 ± 5.83	*4.53 ± 5.30
Vigour	4.91 ± 2.59	*9.25 ± 3.78	4.72 ± 3.52	*8.73± 3.49
Fatigue	8.46 ± 4.38	*3.96 ± 2.46	9.56 ± 3.48	*4.55 ± 3.60
TMD	27.95 ± 21.82	*9.74 ± 17.27	29.17 ± 20.39	*12.89 ± 20.69
Esteem	5.42 ± 2.96	7.10 ± 3.03	5.83 ± 4.19	6.80 ± 3.96

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Examination of the physiological variables (Table 3) revealed no differences between Cycle A and B, or for any of the Resting Heart Rate (RHR) data. Significant differences (*$p<0.05$)were found between Phase 1 and 2 however, in Training Heart Rate (THR), Rating of Perceived Exertion (RPE) and the Time/ Speed variable. Phase 1 data revealed lower THR, higher RPE and slower Time/Speed. Phase 1 data also revealed statistically higher values for abdominal pain in compared with Phase 2, and no statistical differences between cycles. These differences were emphasised in the pooled data.

Table.3: Mean and Standard Deviation of Physiological Variables

	Cycle A		Cycle B	
	Phase 1	Phase 2	Phase 1	Phase 2
Source	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Abdominal Pain	0.98 ± 0.80	*0.21 ± 0.51	0.89 ± 1.00	*0.21 ± 0.52
RHR	2.16 ± 0.80	2.05 ± 0.36	1.94 ± 0.58	1.93 ± 0.29
THR	1.86 ± 0.75	*2.09 ± 0.29	1.73 ± 0.70	*2.06 ± 0.27
RPE	2.30 ± 0.71	*1.94 ± 0.55	2.29 ± 0.80	*1.94 ± 0.33
Time/Speed	1.59 ± 0.71	*2.14 ± 0.50	1.66 ± 0.59	*2.16 ± 0.51

These psychological differences and the increased levels of RPE, decreased THR, and decreased speed during menstruation could negatively effect performance. When the average of POMS subscales was analysed in the non-menstruation phase of the menstrual cycle, the graph resembled the iceberg profile model, similar to that reported for female elite distance runners [11. However, in this study, the iceberg is inverted for the menstrual phase, with the Vigour score decreasing, and tension, depression and fatigue all positioning at higher levels on the scale. These changes portray a less positive mental/emotional health profile during the time of the menstrual/pre-menstrual period. An inverted iceberg shape may be associated with poor mental health and diminished performance.

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Increased tension and anxiety, combined with high levels of fatigue, increased TMD, reduced vigour, along with the increased in depression, occurring during the menstrual/phase pre-menstrual (all of which impact on motivation, a critical element of peak performance), would almost certainly produce a cocktail of negative mood conditions, and increased stress, which could be profoundly detrimental to optimum endurance performance. Vigour (strength and energy) is directly related to enthusiasm and motivation: any factor that reduces vigour and motivation will negatively effect endurance performance. The findings of this current study appear to be in agreement with a range of authors who all found psychological disturbance and mood deterioration, which impacted on the ability to perform at full capacity in athletes during the late luteal (pre-menstrual) and early follicular (menstrual) phases of the cycle.

The lower values of THR in the menstruation/premenstruation phase differs from a range of studies (eg. [3]) which reported increased values or no difference. The reason/s for this remain unclear. No significant differences between phases were found for RHR in the present study. However, in reviewing the raw data it appears that many participants experience distinct changes in RHR during the menstrual phases. Greater precision in reporting actual heart rate values, rather than comparative values, may add strength to these variables. The evaluation of heart rates, for both THR and RHR is difficult. Heart rate is susceptible to many influences, regardless of the menstrual cycle, and results are easily confounded. In this and other research the association between training and resting heart rates, and the menstrual cycle remains ill defined.

Ratings of Perceived Exertion (RPE) were higher in the menstrual/pre-menstrual phase at comparative work loads, which is in agreement with some literature and at odds with other reports. Some of this may be due to the slight variation in the RPE scale used, as well as other variation in methodology. The results for the variables abdominal and/or back pain , demonstrating an increase during the menstrual phase, could profoundly affect performance: comprehensive anecdotal evidence supports the negative influence of pain on endurance performance [2].

The dependent variable of Time/speed is a direct measure of endurance performance outcome. Whilst the measurement was precise, the results were reported in a comparative mode to enable homogeneity between different sports and training sessions. Significant differences were found between phases, with the slowest times found in the menstruation/pre-menstruation phase. This present study is in agreement with a range of studies, (eg. [7]) who reported fastest performances during the non-menstrual phase. However, reduced performances and no change in performances can also be found in the literature.

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As with the psychological variables, the physiological variables can negatively effect endurance performance during the menstrual/pre-menstrual phase, either as an isolated effect, or more commonly as a cocktail of several effects. The complex, inseparable relationship and interaction between psychological and physiological variables (and vice-versa) must be considered when evaluating effects on endurance performance.

The different exercise protocols (type, duration, and intensity) and participant pools (levels of training and definition of levels of training), as well as differences in methodologies, contribute to the difficulties of comparing results between studies. Such differences between studies raise the question of what testing protocol is long and/or intense enough to elicit responses, and/or statistically significant results. Despite the recognised difficulties of recruiting elite-level athletes to take part in research that intervenes with their normal training programme, a greater level of accuracy would be achieved if standardised laboratory controlled tests and time trials could supplement the “in the field” nature of the current study. This, combined with a larger subject pool (adding potential for between subjects analysis), would provide a higher degree of strength to the results.

Conclusion

The results of the present study demonstrate that the menstruation/premenstruation phase of the menstrual cycle can affect levels of Tension-anxiety, Depression, Fatigue, Vigour and Total Mood Disturbance, that would be potentially detrimental to endurance performance. The results from the POMS data suggest that the menstrual cycle phase should be included when physiological data are being obtained for female athletes. The physiological variables of THR, RPE, Time/speed, and abdominal /back pain were also affected in a manner that could negatively influence performance. While the present study was not designed to assess precisely whether or not menstrual cycle changes influence actual endurance performance, the fact that the comparative time/speed correlates were significantly slower during the menstrual/pre-menstrual period allows speculation that there is a marked influence of menstrual cycle on endurance performance.

In a society in which emphasis is placed on winning, where athletes dedicate their lives to that end, and in endurance events in which feeling even slightly below par could equal defeat, the implications of menstrual cycle changes are large, and merit further investigation.

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INTRODUCTION: Menstruation has become less of a barrier to achieving sports goals for women in recent times. Menstruation has historically been a taboo subject in sports science and in the coach-female athlete relationship, with embarrassment and lack of empathy from male coaches being prevalent [1]. Despite abundant research addressing the effects of exercise on menstruation, including menstrual irregularities resulting from training, less is known about how menstruation affects women's athletic training and competition. These cyclic hormonal fluctuations may affect physiological, physical and psychological potential and ultimately impact on sports performance.

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METHODS: A total of 20 elite-level athletes were recruited from four endurance sports - triathlon, swimming, distance running, and rowing based on the criteria that they: 1) volunteered for the study, 2) were undergoing endurance training in a range of 12 - 25 hours per week at the time of data collection, 3) were nationally ranked in their sport, 4) were of Asian or Eurasian ethnic origin, and 5) had been involved in national-level training for at least 3 years prior to the commencement of the study. Demographic data are presented in Table 1.

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A descriptive analysis was performed to determine mean scores for each of Phase 1 and Phase 2 for Cycle A, and Phase 1 and Phase 2 for Cycle B, followed by 2-way Repeated Measures ANOVA to test for differences between the four sets of data. The mean scores for Cycle A and Cycle B were pooled, i.e. Phase 1 (Cycle A + Cycle B) Phase 2 (Cycle A + Cycle B), to provide a two-way comparison. Simple comparison of the mean scores, and Student *t*-test were used to establish whether or not the differences between the means were statistically different and the direction of the differences. The level of significance for all tests was set at $p < 0.05$.

Table.1 Descriptive characteristics of the 20 National-level endurance athletes n = 20: Triathlon n = 6, Rowing n = 6, Running n = 4, Swimming n = 4

Variable	Mean ± SD
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Height (m/cm)	1.66 ± 0.05
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Years of training (yr)	8.60 ± 7.71
Hours of training per week (hr/min)	20.33 ± 4.66
Months since first menstrual period	115.20 ± 98.27

RESULTS AND DISCUSSION: Results from psychological variables (Table 2) demonstrated that Tension, Depression, Fatigue, and TMD all showed values significantly higher (*$p < 0.05$) in Phase 1 than in Phase 2, while Vigour values were significantly lower in Phase 1 than Phase 2. Esteem-Confidence values showed no significant differences between phases. For all variables no statistical differences were found between Cycles A and B (Month 1 and Month 2).

Pooled data revealed significant differences between Phase 1 and Phase 2 for all the dependent variables, with no significant difference between the Cycles and when analysed by 2-way repeated measures ANOVA.

Table.2 Mean Standard Deviation of Psychological Variables

	Cycle A		Cycle B	
	Phase 1	Phase 2	Phase 1	Phase 2
Source	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Tension	6.89 ± 4.45	*4.65 ± 3.98	6.99 ± 4.48	*4.53 ± 4.16
Depression	7.24 ± 5.84	*3.85 ± 4.41	6.94 ± 5.83	*4.53 ± 5.30
Vigour	4.91 ± 2.59	*9.25 ± 3.78	4.72 ± 3.52	*8.73± 3.49
Fatigue	8.46 ± 4.38	*3.96 ± 2.46	9.56 ± 3.48	*4.55 ± 3.60
TMD	27.95 ± 21.82	*9.74 ± 17.27	29.17 ± 20.39	*12.89 ± 20.69
Esteem	5.42 ± 2.96	7.10 ± 3.03	5.83 ± 4.19	6.80 ± 3.96

Examination of the physiological variables (Table 3) revealed no differences between Cycle A and B, or for any of the Resting Heart Rate (RHR) data. Significant differences (*$p<0.05$)were found between Phase 1 and 2 however, in Training Heart Rate (THR), Rating of Perceived Exertion (RPE) and the Time/ Speed variable. Phase 1 data revealed lower THR, higher RPE and slower Time/Speed. Phase 1 data also revealed statistically higher values for abdominal pain in compared with Phase 2, and no statistical differences between cycles. These differences were emphasised in the pooled data.

Table.3 Mean and Standard Deviation of Physiological Variables

	Cycle A		Cycle B	
	Phase 1	Phase 2	Phase 1	Phase 2
Source	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Abdominal Pain	0.98 ± 0.80	*0.21 ± 0.51	0.89 ± 1.00	*0.21 ± 0.52
RHR	2.16 ± 0.80	2.05 ± 0.36	1.94 ± 0.58	1.93 ± 0.29
THR	1.86 ± 0.75	*2.09 ± 0.29	1.73 ± 0.70	*2.06 ± 0.27
RPE	2.30 ± 0.71	*1.94 ± 0.55	2.29 ± 0.80	*1.94 ± 0.33
Time/Speed	1.59 ± 0.71	*2.14 ± 0.50	1.66 ± 0.59	*2.16 ± 0.51

These psychological differences and the increased levels of RPE, decreased THR, and decreased speed during menstruation could negatively effect performance. When the average of POMS subscales was analysed in the non-menstruation phase of the menstrual cycle, the graph resembled the iceberg profile model, similar to that reported for female elite distance runners [11. However, in this study, the iceberg is inverted for the menstrual phase, with the Vigour score decreasing, and tension, depression and fatigue all positioning at higher levels on the scale. These changes portray a less positive mental/emotional health profile during the time of the menstrual/pre-menstrual period. An inverted iceberg shape may be associated with poor mental health and diminished performance.

Increased tension and anxiety, combined with high levels of fatigue, increased TMD, reduced vigour, along with the increased in depression, occurring during the menstrual/phase pre-menstrual (all of which impact on motivation, a critical element of peak performance), would almost certainly produce a cocktail of negative mood conditions, and increased stress, which could be profoundly detrimental to optimum endurance performance. Vigour (strength and energy) is directly related to enthusiasm and motivation: any factor that reduces vigour and motivation will negatively effect endurance performance. The findings of this current study appear to be in agreement with a range of authors who all found psychological disturbance and mood deterioration, which impacted on the ability to perform at full capacity in athletes during the late luteal (pre-menstrual) and early follicular (menstrual) phases of the cycle.

The lower values of THR in the menstruation/premenstruation phase differs from a range of studies (eg. [3]) which reported increased values or no difference. The reason/s for this remain unclear. No significant differences between phases were found for RHR in the present study. However, in reviewing the raw data it appears that many participants experience distinct changes in RHR during the menstrual phases. Greater precision in reporting actual heart rate values, rather than comparative values, may add strength to these variables. The evaluation of heart rates, for both THR and RHR is difficult. Heart rate is susceptible to many influences, regardless of the menstrual cycle, and results are easily confounded. In this and other research the association between training and resting heart rates, and the menstrual cycle remains ill defined.

Ratings of Perceived Exertion (RPE) were higher in the menstrual/pre-menstrual phase at comparative work loads, which is in agreement with some literature and at odds with other reports. Some of this may be due to the slight variation in the RPE scale used, as well as other variation in methodology. The results for the variables abdominal and/or back pain , demonstrating an increase during the menstrual phase, could profoundly affect performance: comprehensive anecdotal evidence supports the negative influence of pain on endurance performance [2].

The dependent variable of Time/speed is a direct measure of endurance performance outcome. Whilst the measurement was precise, the results were reported in a comparative mode to enable homogeneity between different sports and training sessions. Significant differences were found between phases, with the slowest times found in the menstruation/pre-menstruation phase. This present study is in agreement with a range of studies, (eg. [7]) who reported fastest performances during the non-menstrual phase. However, reduced performances and no change in performances can also be found in the literature.

As with the psychological variables, the physiological variables can negatively effect endurance performance during the menstrual/pre-menstrual phase, either as an isolated effect, or more commonly as a cocktail of several effects. The complex, inseparable relationship and interaction between psychological and physiological variables (and vice-versa) must be considered when evaluating effects on endurance performance.

The different exercise protocols (type, duration, and intensity) and participant pools (levels of training and definition of levels of training), as well as differences in methodologies, contribute to the difficulties of comparing results between studies. Such differences between studies raise the question of what testing protocol is long and/or intense enough to elicit responses, and/or statistically significant results. Despite the recognised difficulties of recruiting elite-level athletes to take part in research that intervenes with their normal training programme, a greater level of accuracy would be achieved if standardised laboratory controlled tests and time trials could supplement the “in the field” nature of the current study. This, combined with a larger subject pool (adding potential for between subjects analysis), would provide a higher degree of strength to the results.

CONCLUSION: The results of the present study demonstrate that the menstruation/premenstruation phase of the menstrual cycle can affect levels of Tension-anxiety, Depression, Fatigue, Vigour and Total Mood Disturbance, that would be potentially detrimental to endurance performance. The results from the POMS data suggest that the menstrual cycle phase should be included when physiological data are being obtained for female athletes. The physiological variables of THR, RPE, Time/speed, and abdominal /back pain were also affected in a manner that could negatively influence performance. While the present study was not designed to assess precisely whether or not menstrual cycle changes influence actual endurance performance, the fact that the comparative time/speed correlates were significantly slower during the menstrual/pre-menstrual period allows speculation that there is a marked influence of menstrual cycle on endurance performance.

In a society in which emphasis is placed on winning, where athletes dedicate their lives to that end, and in endurance events in which feeling even slightly below par could equal defeat, the implications of menstrual cycle changes are large, and merit further investigation.

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