Mood, mileage and the menstrual cycle

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Forty women took part in a study to determine the effects of high-intensity training and the menstrual cycle on mood states. Half of the sample were competitive distance runners following a training load of between 50 km and 130 km running per week. Seven athletes were amenorrhoeic and 13 either eumenorrhoeic or oligomenorrhoeic. The remaining 20 subjects were inactive women who menstruated regularly. The mean age of all 40 subjects was 29 years. Each subject completed two identical Profile of Mood States (POMS) questionnaires. The 33 menstruating subjects completed both a premenstrual and a midcycle form and the amenorrhoeic athletes completed the questionnaires at a 3-week interval, which acted as a control for the potential effects of premenstrual syndrome (PMS) among the menstruating females. Results showed highly significant differences in mood profiles among amenorrhoeic athletes, non-amenorrhoeic athletes and inactive women. The greatest difference was between premenstrual and midcycle measures for the inactive group. PMS appears to cause marked negative mood swings among menstruating women which the POMS inventory is sensitive in detecting. While the lower-intensity-training runners appeared to benefit psychologically from a training distance of approximately 50 km week⁻¹, high-intensity training had an adverse effect on mood.

Keywords: Mood, running, menstrual cycle

A principal development from the recent increase in sports participation among women has been an advance in research into the effects of strenuous exercise on the reproductive system^{1,2}. It is well established that mood changes, that is to say transitory emotional states, occur among a high proportion of women during the few days before menstruation. These, and associated physical symptoms, combine to form what is known as the premenstrual syndrome (PMS) and the benefits of exercise as a means of alleviating PMS have received attention from researchers over a number of years³⁻⁸.

Research into the effects of exercise on mood has generally found that regular, intensive exercise, especially running, causes mood modification⁹⁻¹⁴. Exercise is usually shown to be beneficial in terms of reducing tension and increasing overall psychological well-being, although committed, or so-called

'addicted', runners may not derive similar psychological benefits from such activity. In addition, chronic high-intensity exercisers are frequently affected by disturbance to hormone balance which may produce athletic amenorrhoea (intermenstrual periods of more than 90 days), or oligomenorrhoea (irregular menstrual periods of 40-90 days' interval)^{1,15}.

Where studies have failed to support the benefits of exercise for the generation of positive mood states, this has usually reflected poor control in the nature, extent, and intensity of exercise undertaken. In general, aerobic exercise, interspersed with short periods of anaerobic work taken for approximately 30 min each day, has been found to engender a positive mood. For example, Dyer and Crouch¹⁶ showed that vigorous, but not exhaustive, exercise assisted in coping with stress and was mood-enhancing. However, in such studies it is important to determine whether subjects have negative moods before the commencement of exercise therapy; otherwise research showing that runners are usually less tense or depressed than non-runners may be because tense and depressed individuals are less likely to run than those who are not.

Among women, the effects of exercise on mood is likely to be compounded by the effects of exercise on the menstrual cycle. Although the precise mechanisms of athletic amenorrhoea are not yet fully understood^{1,17}, menstrual irregularities have been found to occur more frequently among athletes than among the general population. Carlberg *et al.*¹⁸, for example, found an incidence of amenorrhoea in up to 51% of athletes, whereas it was not more than 5% among non-athletes.

It can be stated with some confidence that there is a positive correlation between training load and the incidence of athletic amenorrhoea^{19,20}, although it has been suggested that there is a threshold of about 50 km running per week, beyond which no further increases in the severity of amenorrhoea occur^{21,22}. It does appear, however, that the onset of amenorrhoea is associated with the percentage of aerobic capacity at which runners train rather than as a function of training load, *per se*, in terms of distance run^{23,24}.

Having considered the effects of exercise on the menstrual cycle and on mood, the menstrual cycle-mood relationship also requires examination. The responses of athletes to the physical stresses of training and competition are reflected in changes in bodily function. Such stresses are also mirrored in emotional behaviour, influencing hypothalamic function and causing an alteration in menstrual function²⁵.

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Moreover, it has been proposed by Schwartz *et al.*²⁷ that the onset of athletic amenorrhoea is associated closely with psychological stress as well as with intensive training. Severe emotional disturbance, or negative mood thus plays a major role in menstrual dysfunction. Ferstle²⁷ has suggested that psychological trauma, intensive training and rapid weight loss are each important contributors to amenorrhoea in athletes. PMS is therefore considered to be the outcome of several factors, both physical and psychological, and the condition has been described as 'the recurrent somatic or psychic symptoms which may occur in relation to menstruation'³.

From the evidence reviewed, three hypotheses were proposed:

1. Regular and committed women runners possess different mood profiles from inactive women.
2. Amenorrhoeic runners possess different mood profiles from non-amenorrhoeic runners.
3. Among both runners and inactive women, the premenstrual mood profile differs from the mid-cycle profile.

Method

Subjects

The study included 40 women subjects, 20 of whom were runners. Each runner was a regular, competitive, middle-distance or distance athlete of national standard. Subjects were members of the International Athletes' Club, London Road-Runners' Club and other athletic clubs in the UK. All athletes trained daily and a self-report questionnaire revealed that seven were amenorrhoeic, running 50–120 km week⁻¹, with an average of 84 km week⁻¹. The remaining 13 were non-amenorrhoeic and ran between 50 km and 130 km week⁻¹ with an average of 64 km. A second group of 20 subjects was described as inactive – they reported that they did not participate in any physical activity additional to their normal occupations. All members of this group menstruated regularly and normally, and none used an oral contraceptive. The mean age of the 40 subjects was 29 years.

The Profile of Mood States (POMS) questionnaire²⁸ was used to evaluate subjects' moods. POMS is a 65-item adjective checklist-type questionnaire, with responses made on a five-point scale to six mood factors: tension; depression; anger; vigour; fatigue; confusion. The POMS has been used extensively to investigate the moods of various sporting groups and of athletes of varying standards. Although Morgan²⁹ described POMS as being the most predictive psychological tool that he had used with athletes, his studies have principally been of a descriptive rather than a predictive nature. As a predictor of performance in sport, POMS has been used specifically only in the recent study by Cockerill *et al.*³⁰. However, Morgan was instrumental in devising the term 'iceberg profile' to describe the positive mood profile that he considered to be an attribute of the elite athlete – the so-called 'winner's profile'.

All subjects were required to complete two POMS questionnaires before going to bed and at least 2 h after training, since it has been shown by Mackenberg *et al.*³¹, Horne and Ostberg³², and Thayer³³, that performance on a cognitive task varies according to the time of day. Although questionnaire completion was not considered to include a major cognitive component, it was deemed important to require all subjects to perform the task at a similar time of day in order to control for the morning–evening effect. Horne and Ostberg³² have stimulated interest in this effect with the publication of their questionnaire, which tends to show that morning and evening types manifest different levels of energetic arousal according to their classification by the questionnaire. Of the subjects 33 completed one questionnaire within the 5 days before the onset of menstruation and the second 14 days after the cessation of menstruation. The seven amenorrhoeic subjects were also asked to complete the two forms at a 21-day interval. This would enable the presence of an order, or time, effect on mood states to be detected and, in addition, would provide a benchmark or control for any changes in mood of the two menstruating groups over their normal cycle.

The data were analysed on the University of Birmingham's IBM 3090 mainframe computer and the BMDP³⁴ statistical software was used in the analysis. Specifically, the Total Mood Disturbance (TMD) scores were analysed using repeated measures analysis of variance (ANOVA) with the program BMDP2V, and the six mood profiles were analysed simultaneously using multivariate analysis of variance (MANOVA) with the program BMDP4V.

Results

The six mood factors of tension, depression, anger, vigour, fatigue, and confusion were the dependent variables. These six mood states can be combined by deducting the vigour score from the sum of scores for the other five mood factors to produce an overall measure of mood, described as Total Mood Disturbance (TMD)¹. The TMD scores were analysed using repeated measures ANOVA with one between-group factor (amenorrhoeic runners, non-amenorrhoeic runners and inactive subjects) and one within-subject factor (the menstrual cycle phase). The mean TMD scores are given in Table 1.

A significant difference in TMD was found between the subject groups ($F = 3.65$, d.f. = 2,37; $P < 0.05$). This was due mainly to the low TMD score of the non-amenorrhoeic runners. The overall effect of the menstrual cycle was found to be highly significant ($F = 43.43$, d.f. = 1,37; $P < 0.001$), caused by the greatly elevated premenstrual overall mean TMD score, 54.05, compared with the midcycle TMD score of 15.15. However, this pattern was not true for all three groups as shown in Figure 1, and exemplified by the highly significant group-by-cycle interaction ($F = 17.87$, d.f. = 2,37; $P < 0.001$).

The TMD scores give a useful overall measure of each subject's mood state, although there are several ways in which a similar TMD score can be obtained.

Table 1. TMD scores for all three groups at both premenstrual and the midcycle phases

	Amenorrhoeic (n = 7)	Non-amenorrhoeic (n = 13)	Sedentary (n = 20)	Overall mean (n = 40)
Premenstrual	40.71	33.62	72.00	54.05
Midcycle	44.29	4.00	12.20	15.15
Overall mean	42.50	18.81	42.10	34.60

Table 2. Correlation matrices for a premenstrual mood-state measures and b for midcycle mood-state measures

	Tension	Depression	Anger	Vigour	Fatigue
a					
Depression	0.856				
Anger	0.756	0.720			
Vigour	-0.444	-0.391	-0.398		
Fatigue	0.658	0.598	0.528	-0.417	
Confusion	0.790	0.827	0.564	-0.439	0.638
b					
Depression	0.805				
Anger	0.662	0.787			
Vigour	-0.376	-0.400	-0.226		
Fatigue	0.608	0.740	0.584	-0.453	
Confusion	0.797	0.791	0.607	-0.351	0.477

A more detailed analysis of the six individual mood factors is required because many differing mood profiles can produce an identical TMD score. But the six mood factors were found to be highly correlated at the premenstrual and midcycle stages of the menstrual cycle Table 2a,b, so discrete analysis of these six dependent variables would be inappropriate.

A second and more comprehensive procedure for interpreting the data was to compare subjects' mood profiles using multivariate analysis. The experimental design remained the same – the results of the six POMS factors were obtained from a two-factor experiment with repeated measures on one factor – but the scores for each of the six factors were analysed as multiple dependent variables using MANOVA.

The mood profiles for both groups of runners and the sedentary group were found to vary significantly (Wilks' likelihood ratio, $L_{\text{RATIO}} = 0.5058$, d.f. = 12,64; $P < 0.05$) as shown in Figure 2. When individual mood factors were examined, the differences between the three profiles were found to be attributed primarily to significantly lower tension (7.2) and anger (6.4) scores for the non-amenorrhoeic runners when compared with the amenorrhoeic runners' (tension 11.4, anger 12.3) scores and the inactive subjects' (tension 12.6, anger 9.5) scores. In line with group TMD scores, the overall non-amenorrhoeic runners' mood profile displays a much more clearly identifiable iceberg shape than do the overall profiles of the amenorrhoeic runners and the inactive subjects.

The overall premenstrual and midcycle mood

Figure 1. TMD scores for all three groups at the premenstrual and midcycle phases: □, amenorrhoeic; ■ non-amenorrhoeic; ○, inactive **Figure 2.** Overall mood profiles for all three groups: □, amenorrhoeic; ■, non-amenorrhoeic; ○, inactive

Figure 3. Premenstrual, □, and midcycle, ■, mood profiles for all 40 subjects

profiles were also shown to vary significantly (Hotelling's T -squared, $T^2 = 72.52$, d.f. = 6,32; $P < 0.001$) as seen in Figure 3. Indeed, when all six individual mood factors were compared separately, highly significant differences occurred between the premenstrual and midcycle mood states for each factor. Figure 3 reveals that these were caused by the elevated premenstrual mood scores for: tension, 14.3; depression, 16.3; anger, 12.5; fatigue, 11.8; and confusion 10.2; together with a low score for vigour of 10.2. This contrasts with much lower midcycle mood state scores for: tension, 6.9; depression, 7.0; anger, 5.5; fatigue, 6.8; and confusion, 5.6; together with a higher vigour score of 16.1.

The group-by-cycle profile interaction was also found to be highly significant (Wilks' likelihood ratio $L_{\text{RATIO}} = 0.3685$, d.f. = 12,64; $P < 0.001$), indicating that differences between the premenstrual and midcycle profiles were not common to all three groups, as illustrated in Figures 4a–c.

Figure 4 illustrates clearly the marked effects of the menstrual cycle on subjects' mood. When the two POMS test scores for the amenorrhoeic groups were compared in Figure 4a, the difference between scores over the 3-week interval was not significant. Thus, the mood of the group was shown to be consistent over this time span. However, clear differences in mood were observed in Figures 4b and c between the premenstrual and the midcycle stages for all 33 menstruating subjects. In particular, Figure 4c provides a dramatic illustration of the marked differences between premenstrual and midcycle moods of the sedentary subjects.

Discussion

Highly significant differences in mood profiles were found between runners and inactive women and between the premenstrual and the midcycle testing sessions. Thus, the experimental hypothesis that exercise and the menstrual cycle have an effect on mood states was upheld. However, when allocating the runners to two separate groups according to

Figure 4. a Premenstrual, □, and midcycle, ■, mood profiles of the amenorrhoeic runners ($n = 7$); b premenstrual, □, and midcycle, ■, mood profiles of the non-amenorrhoeic runners ($n = 13$); c premenstrual, □, and midcycle, ■, mood profiles of the inactive subjects ($n = 20$)

menstrual status, overall differences in mood were found to be influenced by the menstrual cycle, the extent of exercise, or both. For example, when all subjects were partitioned according to the POMS inventory, being completed either premenstrually or at midcycle, clear observable differences were shown. It is worth noting that the premenstrual profile did not describe a positive mood with, especially, elevated tension, depression and anger and low vigour; whereas Morgan's 'iceberg' was represented clearly at the midcycle stage. The contrast was most marked for the inactive group, whose profile resembled an inverted image of the midcycle shape. When subjects were allocated to groups that represented the amount of running, clear between-group differences were suggested. The lower mileage, non-amenorrhoeic runners were found to be psychologically similar to the amenorrhoeic runners premenstrually, but the former demonstrated a positive mood at midcycle. This was attributed to significantly lower tension, anger and confusion scores and, although not significant, a lower depression score ($P = 0.058$).

It was pointed out earlier that high correlations were obtained between the six mood factors at both the premenstrual and the midcycle stages. The pattern of correlations (positive correlations between tension, depression, anger, fatigue and confusion, but a negative correlation with vigour) supports the use of TMD as a summary mood disturbance indicator as exemplified in *Figure 1*, which shows the apparent benefit of a training programme that is intensive yet does not lead to athletic amenorrhoea. While TMD for the non-amenorrhoeic athletes was greater premenstrually than at midcycle, the premenstrual TMD score for sedentary subjects was even higher. The two POMS tests for amenorrhoeic runners present evidence of acceptable test reliability – non-significant differences between 'premenstrual' and 'midcycle' TMD scores – although this result may have been fortuitous since mood measures are susceptible to variation for reasons other than the influence of the menstrual cycle. In this instance, it appears that such effects on mood were powerful for those subjects who menstruated.

Figure 2 and *Figure 3* may be less informative than *Figures 4a–c*, since they illustrate main effects only, which are inclined to mask the interaction effects illustrated in *Figure 4*. However, the group main effect (*Figure 2*) serves to illustrate that over the course of a normal cycle of approximately 28 days, exercise has a most beneficial effect upon psychological well-being. On the other hand, exercise that is of sufficient intensity to disturb normal hormonal balance among females is psychologically self-defeating, producing a profile that is not superior to that of a group of inactive women. Similarly, *Figure 3* illustrates the overall main effect of the menstrual cycle on mood for all 40 women subjects, 33 of whom had a normal menstrual cycle. The general negative effects of premenstrual mood can be seen clearly when a comparison is made with the midcycle profile.

Figure 4a contains results from only seven subjects, but because the mood profiles of amenorrhoeic

athletes have not, as a rule, been represented in the literature, these data provide a useful base from which to commence psychological studies of amenorrhoeic females. *Figure 4b* depicts clearly that intensive exercise is psychologically beneficial for women. Although it is likely that premenstrual mood will be 'less good' than midcycle mood, negative symptoms are likely to be mild. It is, of course, inappropriate to claim this as a general effect across all non-amenorrhoeic women who run regularly. There will always be some for whom exercise is ineffective in alleviating the effects of premenstrual mood swings. *Figure 4c* presents a strong case for the psychological benefits of exercise, and a next step would be to study inactive women whose individual premenstrual and midcycle profiles are similar to those represented in *Figure 4c*, and to examine the effects of an exercise programme for each subject. It might be found that while exercise has a beneficial within-group effect, there are also marked between-subject differences.

Overall, sedentary females were more tense, depressed and less vigorous than runners, confirming a positive relationship between exercise and mental health^{35–37}. It has been documented that regular physical activity can act as a natural tranquilizer³⁸ and that daily exercise provides relaxation, emotional stability and serves to reduce tension^{39,40}. Such observations should be treated with caution, however, since an interesting finding from the present study was that the amenorrhoeic runners produced a 'less-desirable' profile than either the non-amenorrhoeic runners or the inactive group. In particular, the amenorrhoeic subjects produced a high anger score. This is contrary to Morgan's general contention that anger and hostility are subdued with exercise. Here, from among the three groups, only the menstruating runners' profiles were iceberg-shaped. It is proposed, therefore, that although in general terms running is beneficial to health and psychological well-being, training to the extent and intensity whereby an athlete becomes amenorrhoeic can have detrimental psychological consequences. This view has been supported by Williams and Getty¹⁴. It appears that the amenorrhoeic runners were subjected to greater stress than the other athletes and that this stress was both the cause and the outcome of athletic amenorrhoea. Highet² has suggested recently that stress influences hypothalamic dysfunction and may even disrupt the reproductive system totally.

Gondola and Tuckman⁴¹ have suggested that there may be optimal levels of exercise that will produce the most positive mood. However, the present data suggest that mood may also be influenced more by a fundamental physiological variable, namely the incidence of athletic amenorrhoea among subjects. It was not, of course, possible to obtain premenstrual mood-state measures of amenorrhoeic runners, but when their data were placed alongside those of menstruating runners and inactive females, the amenorrhoeic runners' overall profile was quite similar to that of the inactive group. On the other hand, it was shown that running was probably a contributory factor in alleviating the negative emotional symptoms associated with PMS, with a lower

premenstrual total mood disturbance score among menstruating runners than among inactive subjects. This observation brings into focus the suggestion by Agnew and Levin⁴² that depressed people are unlikely to run, rather than running being a useful vehicle for reducing depression, a view that requires a more thorough investigation.

Perhaps the most interesting finding from the present experiment was the clearly observable difference between the premenstrual and midcycle profiles for the 33 menstruating subjects. The potential benefits from regular exercise in reducing, or even eliminating, PMS⁴³ were confirmed, while Prior *et al.*⁴⁴ have explained that the adverse physical and psychological symptoms of PMS are reduced with athletic conditioning owing to changes in neurotransmitter levels.

In conclusion, it is suggested that given the benefits of exercise in enhancing moods, the extent and intensity of exercise merits further investigation. Also, it will be important to designate the term 'inactive' more specifically and to describe the physical characteristics of athletes more fully, for example in respect of percentage body fat. The finding that amenorrhoeic runners were not psychologically healthier than sedentary subjects was an important one and requires examination, as does the study of mood states among inactive men and men athletes by way of comparison with women. There were also differences between specific mood factors when amenorrhoeic runners were compared with non-amenorrhoeic runners. Such differences did not appear to be a reflection of exercise-induced fatigue, but rather of the incidence of athletic amenorrhoea.

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