The Effect of Eumenorrheic Menstrual Cycle Phase on Physiological Responses to a Repeated Lifting Task

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Catalogue Data

Key words: lifting, maximal oxygen consumption, subjective response, effect size
Mots-clés: manutention, consommation maximale d’oxygène, perception, importance de l’effectif

Abstract/Résumé
Cyclic variations in physiological and endocrinological baselines are known to be consistent with the eumenorrheic (healthy) menstrual cycle. The aim of this study was to examine the interaction of these variations with the physiological responses to repeated lifting. Sixteen females visited the laboratory in each of five phases of their menstrual cycle. During each visit, subjects performed a repetitive lifting task, lifting a weighted box, from knee to shoulder height, at six repetitions per minute for 10 min. Oxygen consumption, minute ventilation, heart rate (HR), and perceived exertion were monitored throughout the task. The variation in physiological and subjective responses to lifting with menstrual cycle phase did not reach statistical significance (p > .05). However, the HR response to lifting was elevated by approximately 10 beats \textsuperscript{-1} min\textsuperscript{-1} in the postovulatory phases of the cycle (effect size > 0.61). Although the impact of the menstrual cycle upon lifting performance is minimal, alterations in HR must be taken into account in determining new international standards for manual handling.

Des variations cycliques du niveau de base de variables physiologiques et endocrinologiques sont normales chez la femme euménorhéeique. Le but de cette étude est d’examiner les
interactions de ces variations avec les ajustements physiologiques au cours d'une manutention de charge répétée. Seize femmes se présentent au laboratoire à chacune des cinq phases de leur cycle menstruel. Durant 10 min à chacune des visites, les femmes lèvent une boîte des genoux aux épaules à une fréquence de 6 fois par minute. La consommation d'oxygène, le débit ventilatoire, la fréquence cardiaque, et la perception de l'effort sont évalués tout au long de la tâche. Aucune valeur des variables précédentes ne varie suffisamment pour atteindre le seuil de signification statistique (p > .05). La fréquence cardiaque au cours de la tâche est cependant plus haute de quelques 10 bpm pendant la phase post-ovulatoire (importance de l'effectif > 0,61). Bien que les répercussions du cycle menstruel soient peu importantes au cours d'une tâche de manutention, les variations de fréquence cardiaque doivent être prises en compte pour établir des nouveaux standards internationaux en matière de manutention.

Introduction

The endocrinological processes involved in the female reproductive cycle, and the physiological variations interacting with these processes have been extensively reviewed (Nicklas, 1989; Southam and Gonzaga, 1965). Even with considerable individual variation, episodic alterations of both anterior pituitary and ovarian steroid hormones during the menstrual cycle may interrelate with strenuous muscular performance. Fluctuations in functional capacity throughout the cycle and across the span of reproductive life pose numerous concerns for the health and safety of the female performing manual handling and repetitive lifting activities.

The most consistent variations throughout the menstrual cycle are in body temperature and body mass (Abramson and Torghele, 1961; Marshall, 1963). The monthly rhythm in these variables mirrors the cyclic secretion of the female sex hormones, progesterone and estrogen. These hormones are prominent, after the occurrence of ovulation, in the second half (the luteal phase) of the average 28-day cycle. Both body mass (+0.5–1.0 kg) and body temperature (+0.5 °C) are elevated in this phase compared to the first half of the cycle (the follicular phase).

Research has further implicated the steroid sex hormones in a cyclic fluctuation in the cardiorespiratory response to aerobic performance. An increased ventilatory response to progesterone has been shown in both males (Schoene et al., 1980) and females (Dombovy et al., 1987) at rest and during exercise, while elevations in the heart rate response to physical performance in the presence of both estrogen and progesterone (luteal phase) have also been reported (Hessemer and Brück, 1985; Pivarnik et al., 1992). These elevations have been as high as 10 beats · min⁻¹ greater than during the follicular phase and would appear to indicate greater cardiovascular strain at this time.

Menstrual cycle phase alterations in the heart rate response to physical performance were also reported by Birch et al. (1993). Subjects performed a maximal and isometric endurance lifting task at both knee and waist height, followed by a 10-min repetitive lifting task in five phases of the menstrual cycle. The repetitive lifting task involved lifting a tote box (30 cm³) from knee to shoulder height at six repetitions per minute. The weight of the box was self-selected as the maximal acceptable load (MAL) felt to be “comfortable to lift in these circumstances, without
becoming unusually tired, overheated, weakened or out of breath” (Snook, 1978, p. 969). The maximal isometric lift, isometric endurance performance, and the selected MAL did not differ with menstrual cycle phase ($p > .05$). The heart rate response to the maximal and isometric endurance lifting tasks averaged 9 beats·min$^{-1}$ greater in the postovulatory phases than prior to ovulation ($p < .05$). This response was mirrored in the dynamic repetitive lifting task ($p > .05$).

Clearly, the physiological response to aerobic physical performance can interrelate with alterations in the female hormonal environment. In the lifting tasks described by Birch et al. (1993), distinct variations in the heart rate response to lifting, in the absence of alterations in exercise intensity, were reported over menstrual phases. What is not clear is whether subjects were working at differing percentages of their aerobic power throughout their cycle, or whether these differences would be apparent during a standardized, rather than self-selected, lifting task. With the current impetus to establish international and European standards for repeated lifting tasks (Dickinson, 1995) applicable to safety and comfort of both male and female populations, any disadvantage the female may experience as a consequence of the reproductive cycle must be recognized and confronted. The purpose of this study was thus to examine both the physiological and subjective responses to standardized dynamic repetitive lifting performance over five phases of the eumenorrheic (regular and healthy) menstrual cycle.

**Methods**

Sixteen females, ages 18–26 years (body mass = 59.2 ± 7.4 kg; fat free mass = 44.9 ± 5.3 kg), who were inexperienced in repeated lifting tasks, volunteered to participate in the study. All subjects reported a regular and healthy (eumenorrheic) menstrual cycle (29 ± 3 days) and none were presently using any form of oral contraceptive. Informed consent was gained from all subjects, and the study was approved by the Ethics Committee of the Royal Liverpool Hospital, Liverpool, England.

Each subject’s menstrual cycle was divided into five phases by one month’s daily measurement of oral temperature. Subjects were instructed to monitor their oral temperature each morning before rising and before consumption of food or drink. Day 1 of the cycle was the first day of menstrual bleeding, and ovulation was detected by a midcycle elevation in temperature of 0.5 °C or above (Marshall, 1963). Temperature elevation, as a method of detecting ovulation, has been verified by assays recording concomitant rises in progesterone (Nicklas, 1989; Prior et al., 1990). Further to this, subjects were asked to monitor moliminal symptoms (e.g., breast tenderness, water retention) and alterations in cervical mucus as an additional confirmation for the occurrence of ovulation. Consistent midcycle elevations and maintenance of temperature were found in the subject sample as required by McCarthy and Rockette (1983). Consequently, subjects were examined in each of the following five phases: (a) the follicular phase preceding ovulation, (b) ovulation, (c) the luteal phase following ovulation, (d) premenses (late luteal phase) 72 hours preceding predicted menses, and (e) menses or menstrual bleeding.
Prior to evaluation, each subject undertook an incremental treadmill run to volitional exhaustion for measurement of maximal oxygen uptake (VO₂max). It is generally understood that VO₂max is not affected by menstrual cycle phase (Dombovy et al., 1987); therefore, the test was undertaken in the follicular phase only. Subjects began the test by running at 8 km·h⁻¹ on a gradient of 0°. The speed of the treadmill was increased by 2 km·hr⁻¹ every 2 min until volitional exhaustion. Subjects reaching a speed of 16 km·hr⁻¹ completed the test at this speed with the 2-min increments becoming gradient increases of 2.5%. Maximal oxygen consumption was defined as the point where (a) there was no further increase in oxygen uptake with further increases in treadmill speed or gradient, and (b) the subject attained a respiratory exchange ratio (RER) above 1.15 (Åstrand and Rodahl, 1986). In the case of 3 subjects, the plateau in VO₂ did not occur, and VO₂peak was recorded for volitional exhaustion.

Each subsequent visit to the laboratory was timed to coincide with the midpoint of a specific menstrual cycle phase. The five visits were conducted over two consecutive cycles, with subjects repeating the follicular phase test in the second cycle for purposes of assessing reliability. It has been suggested that performance variables are least affected by the menstrual cycle during this phase (Nicklas, 1989). All experiments were undertaken at the same time of day, and the order of testing randomized to eliminate any circadian or order effects. Subjects were instructed to eat a light meal 3 hours prior to attending the laboratory and to refrain from consuming drinks containing caffeine during the same time period.

During each visit to the laboratory, subjects were required to lift a weighted tote box (30 cm³), with handles (padded) on the side, from knee (tibial tuberosity of the straight leg) to shoulder (acromial) height at a frequency of six lifts per minute for a duration of 10 min. This frequency incorporated both a lifting and a lowering action with each lift beginning at shoulder height. Lifting through this distance engaged a series of muscle groups and precipitated a strenuous isometric element in the first and final moments of lifting (Pytel and Kamon, 1981). Further to this, at a lifting frequency above three lifts per minute, strength alone is no longer the limiting factor to performance (Mital et al., 1986). This selection of lifting height and frequency thus matched the purpose of the study: to explore the effect of the reproductive cycle upon the physiological responses to lifting.

Nine subjects (Group 1) lifted 8 kg over the initial 5 min of lifting, followed immediately by 11 kg over the final 5 min (lifting distance ranged from 94 to 96 cm). Seven subjects (Group 2) lifted 5 and 8 kg over the same time periods (lifting distance: 84 to 87 cm). Subjects were grouped according to ability and body size established during familiarization studies where the load to be lifted (8 kg) corresponded to the mean self-selected load established in previous research (Birch et al., 1993). Individuals who failed to lift the 8 kg comfortably over a 10-min lifting period were placed into Group 2. The final group characteristics for Group 1 and 2 respectively were: 169.5 ± 5.4 vs. 157.7 ± 6.6 cm for height; 65.3 ± 4.4 vs. 52.3 ± 2.5 kg for body mass; and 49.0 ± 2.7 vs. 39.6 ± 1.6 kg for fat free mass. Fat free mass was estimated from skinfold measures taken with Harpenden callipers according to Durmin and Womersley (1974). The noticeable differences in body size
between the groups indicate the strong relationship of stature, body mass, and fat free mass to dynamic lifting performance (Mital and Ayoub, 1980).

Throughout both the maximal oxygen consumption and dynamic lifting tests, the subjects' expired air passed through an on-line gas analyzer (Sensormedics, CA, U.S.A.). This allowed continuous measurement of minute ventilation (VE), oxygen uptake (VO₂), and carbon dioxide production (VCO₂). All experiments were conducted at room temperature. Heart rate and perceived exertion were recorded throughout the dynamic lifting task using short-range radio telemetry (Sports Tester PE 3000, POLAR ELECTRO, Finland) and the Borg 6–20 point scale (Borg, 1962), respectively. Random error for the measurement of VO₂ was assessed with the technical error of measurement (TEM) established from examination of the consecutive follicular phases. Technical error equated to 84.0 ml (R = .99).

Analysis of Data

As N differed between groups, data for each group were treated separately with repeated measures ANOVA for the five phases of the menstrual cycle. The ANOVA was computed for each variable at rest and following both 5 and 10 min of lifting. Ratings of perceived exertion were treated with a Freidman two-way ANOVA. Examination of group differences was undertaken for data collected in the follicular phase using independent t tests, while differences across time were examined within subjects using paired t tests. Level of significance was accepted as p < .05. Due to the small sample sizes within the investigation magnitude of effects (simple effect size; Thomas et al., 1991) was examined where appropriate, using the following formula: \((Mean_1 - Mean_2)/[(SD_1 + SD_2)/2]\). This enabled the results to be evaluated for “meaningfulness.” In this manner, variables differing across menstrual phases may, in fact, be described as biologically significant, and meaningful, as opposed to statistically significant. All statistical analysis was undertaken using SPSS 6.0 for Windows.

Results

The mean (±SD) VO₂max measured during running on the treadmill was 42.4 ± 4.9 ml · kg⁻¹ · min⁻¹. The oxygen consumption measured throughout the lifting tasks, in both subject groups, ranged from 32% maximum after 2 min of lifting to 41% after the 10 min lifting duration. No significant difference in percent VO₂max was reported with menstrual cycle phase (p > .05).

The oxygen consumption (ml · kg⁻¹ body mass · min⁻¹) throughout lifting in each phase of the menstrual cycle is displayed in Table 1 for both groups of subjects. The VO₂ response of subjects in Group 1 (lifting 8 and 11 kg) was significantly greater than that of the subjects in Group 2 (lifting 5 and 8 kg) following every second minute of lifting (p < .05). The rise in VO₂ between each of these time increments was significant in both groups of subjects (p < .05). This difference was not evident between the 8th and 10th minute of lifting, indicating the
### Table 1  Oxygen Consumption (VO₂) and Heart Rate Response Following 5 and 10 min of Lifting in Each Phase of the Menstrual Cycle

<table>
<thead>
<tr>
<th></th>
<th>Menses</th>
<th>Follicular</th>
<th>Ovulation</th>
<th>Luteal</th>
<th>Premenses</th>
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<tbody>
<tr>
<td><strong>Lifting 5 &amp; 8 kg</strong></td>
<td></td>
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<tr>
<td>5-min VO₂</td>
<td>13.13 ± 1.48</td>
<td>13.27 ± 1.51</td>
<td>12.54 ± 1.56</td>
<td>12.51 ± 2.06</td>
<td>12.34 ± 1.05</td>
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<tr>
<td>HR</td>
<td>108 ± 12</td>
<td>115 ± 13</td>
<td>114 ± 13</td>
<td>118 ± 15</td>
<td>118 ± 16</td>
</tr>
<tr>
<td>10-min VO₂</td>
<td>15.28 ± 1.41</td>
<td>16.35 ± 2.12</td>
<td>15.83 ± 2.27</td>
<td>15.95 ± 2.36</td>
<td>15.53 ± 1.56</td>
</tr>
<tr>
<td>HR</td>
<td>127 ± 15</td>
<td>134 ± 15</td>
<td>133 ± 14</td>
<td>140 ± 15</td>
<td>136 ± 17</td>
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<tr>
<td><strong>Lifting 8 &amp; 11 kg</strong></td>
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<tr>
<td>5-min VO₂</td>
<td>14.44 ± 1.91</td>
<td>14.27 ± 0.98</td>
<td>14.38 ± 1.8</td>
<td>13.95 ± 1.77</td>
<td>14.48 ± 2.02</td>
</tr>
<tr>
<td>HR</td>
<td>118 ± 11</td>
<td>121 ± 11</td>
<td>122 ± 13</td>
<td>128 ± 14</td>
<td>125 ± 16</td>
</tr>
<tr>
<td>10-min VO₂</td>
<td>17.42 ± 4.63</td>
<td>17.91 ± 2.18</td>
<td>17.02 ± 1.83</td>
<td>16.13 ± 2.26</td>
<td>17.02 ± 2.62</td>
</tr>
<tr>
<td>HR</td>
<td>134 ± 13</td>
<td>136 ± 12</td>
<td>137 ± 13</td>
<td>142 ± 15</td>
<td>140 ± 16</td>
</tr>
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</table>

*Note. VO₂ is measured in ml · kg⁻¹ · min⁻¹. Heart rate (HR) is in beats · min⁻¹. Values are listed as M ± SD.*
achievement of steady state. Oxygen consumption was independent of menstrual cycle phase in both groups \((p > .05)\), with a range of approximately \(2 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}\) across the five phases.

No significant difference was found in the RER between groups \((p > .05)\). The RER ranged from approximately 0.75 after 2 min of lifting to approximately 0.85 at the cessation of lifting. No alteration with menstrual cycle phase was evident \((p > .05)\).

The mean (±SD) minute ventilation (VE) recorded after the second minute of lifting was \(21.7 ± 3.5\) and \(16.8 ± 1.9 \text{ L} \cdot \text{min}^{-1}\) for Groups 1 and 2, respectively. These values increased, reaching a steady state in the 8th minute, to \(28.9 ± 6.1\) and \(22.5 ± 2.6 \text{ L} \cdot \text{min}^{-1}\), respectively at the cessation of lifting. Rates of VE were larger in Group 1 than in Group 2 \((p < .05)\). There was no effect of menstrual cycle phase upon VE in either group \((p > .05)\), with a range of \(1.6–2.0 \text{ L} \cdot \text{min}^{-1}\) across the five phases.

The heart rate recorded throughout the lifting task increased incrementally, reaching a steady state in the 8th minute. There was no significant difference in the heart rate response to lifting between the two groups \((p > .05)\). The mean heart rate recorded at the cessation of lifting, in each phase of the cycle, is displayed in Figure 1. Resting heart rate and the heart rate response to lifting did not fluctuate with menstrual cycle phase \((p > .05)\). Post hoc power analyses for both group ANOVAs revealed low power (0.44 and 0.38 for Groups 1 and 2, respectively), increasing the likelihood of committing a Type II error in the evaluation. Moreover, it is evident in the figure that the heart rate response following 10 min of lifting, in both groups, was elevated in the luteal phase, specifically when compared to menses. Comparison via paired \(t\) test indicated that the difference between these phases approached significance \((p = .08, 95\% \text{ confidence interval} – 1.0 \text{ to } 19 \text{ beats} \cdot \text{min}^{-1} \text{ in Group 1}; p = 0.1, 95\% \text{ confidence interval} – 28 \text{ beats} \cdot \text{min}^{-1} \text{ in Group 2})\). Indeed the absolute differences (13 beats \cdot \text{min}^{-1} \text{ in Group 1 and } 8 \text{ beats} \cdot \text{min}^{-1} \text{ in Group 2}) displayed an effect size of 0.61 in Group 1 \((n = 9)\) and 0.85 in Group 2 \((n = 7)\). Effect sizes of this magnitude would indicate that the heart rate differences between the luteal phase and menses, although statistically non-significant, were realistically meaningful (Thomas et al., 1991).

The rating of perceived exertion (RPE) recorded after both 5 and 10 min of lifting averaged 12 and 15, respectively, in Group 1, and 11 and 15 in Group 2. As there was no obvious difference between the categories, a Freidman two-way ANOVA was undertaken on the data for the whole sample. Results revealed no significant variation in RPE throughout the five phases of the menstrual cycle \((p > .05)\).

**Discussion**

The methodology chosen for this study was deliberately designed to elicit an intensity of lifting somewhat greater than the physical exposure recognized in industry (Karlvqvist et al., 1994; Winkel and Mathiassen, 1994). Further, it was also recognized that the definition of repetitive lifting tasks utilized within the study
Figure 1. Mean heart rates recorded at the cessation of lifting in five phases of the menstrual cycle: M = menses, F = follicular, OV = ovulation, L = luteal, PM = premenses. Group 1 lifted 8 and 11 kg (bold bars), and Group 2 lifted 5 and 8 kg (shaded bars) over a 10-min time period.

included only one element (i.e., lifting and lowering) of the usual working definition (manual handling) regarding proposed international and European standards (Dickinson, 1995). Indeed, Dickinson challenged “ergonomists working on the development of standards to define the loads and circumstances (for repetitive lifting tasks) on which the consensus viewpoint determines what is a level of unacceptable risk” (p. 265) for employees. In this manner, the present study aimed to control repeated measures of an element of repetitive lifting tightly, utilizing lifting loads at the extreme end of existing safety recommendations, in order to determine whether menstrual cycle phase could be a “circumstance” that may affect the determination of the level of unacceptable risk for the female.

The mean percentage VO\textsubscript{2}max elicited in the 10th minute of the task ranged from 38 to 41\% over the five phases of the cycle. Mital (1984) maintained that the upper limit of tolerance for females performing repetitive lifting over an 8-hour working day was 28\% of VO\textsubscript{2}max measured on a cycle ergometer. Micheal et al. (1961) have reported tolerance limits of 35\% of VO\textsubscript{2}max measured using treadmill tasks. Given that repeated lifting operations involve work, both static and dynamic, from the legs, arms, shoulders, and back, and that the VO\textsubscript{2}max that can be attained from lifting is some 20-40\% lower than the maximal value attainable
on cycle or treadmill tasks (Petrofsky and Lind, 1978; Jorgenson and Poulsen, 1974), the upper limit of tolerance is usually quoted as 30–35% of conventionally measured VO$_2$ max. As the current investigation required an intensity great enough to be able to identify menstrually related alterations in physiological responses, the oxygen consumptions reported fall above tolerance limits.

The physiological responses to repeated lifting of this intensity would appear to be corroborated by examples of previous research utilizing female samples. Williams et al. (1982) recorded a VO$_2$ of 0.52 ± 0.11 L·min$^{-1}$ and a heart rate of 98 ± 12 beats·min$^{-1}$, following 5 min of lifting 6.8 kg from floor to 60 cm at a frequency of seven lifts per minute. Mital (1984) further reported VO$_2$ and heart rate as 0.55 ± 0.2 L·min$^{-1}$ and 108 ± 15 beats·min$^{-1}$, respectively, following 8 hours of lifting a 9.2-kg, 30-cm$^3$ box from knuckle to shoulder height, eight times per minute. Absolute VO$_2$ and heart rate response (in Groups 1 and 2, respectively) in the current study were approximately 0.95 and 0.65 L·min$^{-1}$, and 123 and 115 beats·min$^{-1}$, following 5 min of lifting, and 1.1 and 0.82 L·min$^{-1}$ and 138 and 134 beats·min$^{-1}$ at the cessation of lifting. The consistently larger physiological response in this study is indicative of the combination of a greater load to lift and the incorporation of both a lifting and lowering action within each repetition. In addition, the box had to be moved through a distance relative to 56 ± 2% stature and thus involved greater use of the leg and back musculature at the height of the knee, and the shoulder and upper limb musculature when lifting at shoulder height (Kumar, 1980; Mital and Fard, 1986).

The oxygen consumption demanded from dynamic lifting was independent of eumenorrheic menstrual cycle phase in both experimental groups. Studies performed on the conventional cycle ergometer and treadmill have suggested that the oxygen cost of strenuous muscular performance is unaffected by fluctuations in the female hormonal milieu (Eston and Burke, 1984; Nicklas, 1989; Stephenson et al., 1982). Consistency in substrate utilization (RER) throughout the menstrual cycle also corroborates the work of Bonen et al. (1983) and Bisdee et al. (1989).

The findings of previous research (Birch et al., 1993) indicated a menstrual cycle variation in the heart rate response to isometric lifting ($p < .05$) but not to dynamic lifting. The results of the present study corroborate this and the work of both Wells and Horvath (1974) and De Souza et al. (1990), who found no variation with menstrual cycle phase in the heart rate response to treadmill or cycle ergometer exercise. Recomputation of the heart rate response in the current study does, however, suggest a trend of increased heart rate during those menstrual phases following ovulation. This trend directly mirrors the heart rate response to isometric endurance lifting noted by Birch et al. (1993) and results in large effect sizes for both groups between the luteal and menstrual phases. Indeed, these phase differences of 9 and 13 beats·min$^{-1}$ remain as large as 5 beats·min$^{-1}$ when comparing the mean response pre- and postovulation (i.e., pooling the data from the menstrual and follicular phase and from the ovulatory, luteal, and premenstrual phases). This heart rate difference may well have been greater if the data could have been separated by the exact point of ovulation. Indeed, although the authors were confident that ovulation had occurred in each member of the sample, further studies
aiming to identify exact menstrual phases should attempt to incorporate hormonal assaying techniques into the methods.

Elevated heart rate response to strenuous muscular exercise in the luteal phase has also been reported by Hessemer and Brück (1985) and Pivarnik et al. (1992). Both experiments involved cycle ergometry with eumenorrheic females working at 70–75% VO2 max for 15 min or 60 min, respectively. The elegance of these studies lay in the tight control of extraneous variables (ambient temperature and time of day), enabling true menstrual cycle variations to be evaluated. Hessemer and Brück reported an increased sweat rate and onset of sweat threshold in the luteal phase with a corresponding increase in heart rate of 6 beats·min⁻¹. Pivarnik and coworkers maintained that subjects could not reach thermal equilibrium in the luteal phase resulting in a heart rate 10 beats·min⁻¹ greater in this phase than the follicular phase.

Elevations in the heart rate response to strenuous muscular activity may only be partially explained by a Q₁₀ effect of temperature in the luteal phase of the cycle. Estrogen-related vasodilation, increased capillary membrane permeability/reactivity and possible shifts in plasma volume in the luteal phase (Stephenson et al., 1989) may also require cardiovascular compensation. The measures required to substantiate these proposed mechanisms were not secured in the present study.

The steroid hormones consistent with the latter phases of the menstrual cycle, specifically progesterone, have been implicated in an increased alveolar ventilation (Dutton et al., 1989; Hasselbach and Gammeltoft, 1915). Schoene et al. (1981) and Dutton et al. (1989) have suggested that this is due to an increased central and peripheral sensitivity to carbon dioxide in the luteal phase. The increased ventilatory response seems to be overshadowed by the physiological responses to exercise (Jurkowski et al., 1978; Nicklas, 1989). This is evident in the ventilatory response (VE) to lifting throughout the menstrual cycle in the present study and would perhaps be expected during repetitive lifting activities demanding such relatively low aerobic capacities.

The trend for an increased luteal heart rate response to dynamic lifting in comparison to during the follicular phase was not mirrored by the perceived effort reported by the subjects. Lifting tasks used for preemployment screening, or indeed repetitive lifting activities experienced over the working day, are unlikely to demand a greater stress than imposed during this study. It would therefore seem reasonable to suggest that the impact of the eumenorrheic menstrual cycle upon the physiological and subjective response to dynamic repetitive lifting performance is minimal. The effect of the episodic alterations in the ovarian steroid hormones on the heart rate response to dynamic lifting must, however, be recognized. Shifts of 10 beats·min⁻¹ across menstrual phases provide a clear rationale for preemployment screening tasks and, more importantly, risk and health monitoring to be controlled for menstrual phase. Indeed, all international and national standards for medical and physical/physiological guidelines in the workplace are based on “the basis of a careful study of the published literature” (Health and Safety Executive, 1994, p. 42). For this reason, studies utilizing heart rate as a variable in examining fatigue and risk of injury during repetitive lifting, or predicting oxygen
consumption or maximal acceptable loads to be lifted safely, must account for female menstrual cycle phase. Given that the characteristics of the female menstrual cycle may vary between individuals—including eumenorrhea (healthy), dysmenorrhea (painful menses), amenorrhea (loss of menses), and the premenstrual syndrome—the development of new standards for repetitive lifting tasks must therefore give due consideration to female endocrinology.

References


**Acknowledgment**

This work was supported by a grant from the Health and Safety Executive, England. This funding is gratefully acknowledged.

*Received April 17, 1996; accepted in final form November 21, 1996.*