Onset of puberty, menstrual frequency, and body fat in elite rhythmic gymnasts compared with normal controls

P Klentrou, M Plyley

Objectives: To assess the prevalence of delayed menarche and abnormal menstrual patterns, as well as the association of menstrual status with physical training in elite rhythmic gymnasts from Greece and Canada.

Methods: Fifteen Greek (mean (SEM) age 14.5 (0.2) years) and 30 Canadian (mean (SEM) age 14.7 (0.4) years) rhythmic gymnasts were surveyed for age at menarche, menstrual frequency, and training profile, and measured for height, weight, and percentage body fat (%BF). Seventy eight healthy adolescents served as country specific non-active controls: 38 Greek non-athletes (mean (SEM) age 14.5 (0.1) years) and 40 Canadian non-athletes (mean (SEM) 14.2 (0.1) years).

Results: Of the Greek gymnasts, 79% had not yet menstruated compared with 34% of the Canadian gymnasts. Menarche was significantly (p<0.01) delayed in the rhythmic gymnasts (composite mean 13.8 (0.3) years, n = 45) compared with the controls (composite mean 12.5 (0.1) years, n = 78). There was no significant difference between Greek and Canadian gymnasts for the age at menarche (14.2 (0.3) v 13.6 (1.2) years respectively). Menstrual irregularities were reported in 78% (61% oligomenorrhoeic and 17% amenorrhoeic) of the menarcheal athletes. Menarcheal gymnasts were found to be significantly (p<0.05) taller and heavier, with a higher %BF and a lower training frequency and training duration (p<0.05) than the premenarcheal gymnasts. Overall, the mean %BF of the gymnasts was significantly lower (p<0.05) than that of the control subjects. The Canadian controls exhibited a significantly (p<0.05) greater %BF than the Greek controls of the same age.

Conclusion: Delayed menarche, menstrual irregularities, and low body fat are common in elite rhythmic gymnasts. Premenarcheal gymnasts train more often and for longer, and have a lower body mass index and less body fat, than menarcheal gymnasts. Prospective studies are needed to explore further these and other factors associated with delayed menarche and menstrual irregularities in female athletes.
37% of the variance in the age at menarche was found to be attributed to additive genetic factors. In addition, the correlation between the additive genetic effects on age at menarche and body mass index (BMI) was 0.57, indicating that a substantial proportion of genetic effects are common.26

In rhythmic gymnastics, intense training usually starts long before menarche, and success is strongly influenced by visual appeal and body aesthetics. Rhythmic gymnasts are often required to meet unrealistic weight goals to attain or maintain a favourable physique. Hence, they are at risk of developing poor eating habits ranging from poor nutrition and/or insufficient energy intake to serious eating disorders. Few or no data exist on either menstrual disorders or eating habits of girls involved in rhythmic sports gymnastics programmes. In artistic gymnasts, who also often start high intensity training before puberty, there is considerable controversy as to whether growth potential is affected by training. Growth potential has been found to be reduced and menarche has been reported to be delayed in artistic gymnasts.17–19 However, this delay may not be attributed to gymnastics per se, but rather to genetic factors or energy intake that is inadequate to meet the demands of both growth and sport.20,21 On the other hand, BMI was found to be decreased in a study of gymnasts aged 7–10 years, but the difference was suggested to be the result of selection of lean athletes.22 This is also supported by a study by Damsgaard et al23 in which longitudinal data indicated that the individual differences in body size among sports participants already exists at an early age (2–4 years) suggesting genetic influences.

The aims of this study were: (a) to investigate the occurrence of delayed menarche and abnormal menstrual patterns among elite adolescent rhythmic sports gymnasts from Canada and Greece; (b) to compare the two groups of athletes, both with each other and with a sample of age and country specific non-athletes; (c) to examine the relation between physical training characteristics and menstrual status in elite rhythmic gymnasts.

METHODS
Fifteen elite Greek rhythmic gymnasts from the National Training Center in Athens and 30 elite rhythmic gymnasts from clubs across Canada, including athletes from two National High Performance Centers (Ontario and Manitoba), were invited to participate in the study. Age at menarche, the pattern of their menses, details of training history, and volume of training were recorded. The gymnasts were also asked to complete a non-validated questionnaire of medical history, which included questions about use of oral contraceptives and past medical history. All athletes were also invited to complete a non-validated questionnaire of eating habits (haes), a validated questionnaire that assesses all aspects of nutritional status and eating habits, and a validated questionnaire that assesses all aspects of nutritional status and eating habits (SPQ), a validated questionnaire used to estimate the amount of physical activity and the nature of the participation in children; (c) the habitual activity estimation scale (HAES), a validated questionnaire that assesses all forms of habitual activity in terms of the number of hours of activity a day.24,25 The HAES has been used previously to measure the duration and intensity of daily activity of children from infancy through adolescence.24,25 Both the SPQ and HAES have a demonstrated test-retest reliability in excess of 0.80 when reported for two days.24,25

The following anthropometric measurements were made on all subjects: total body height (in cm) and body mass (in kg) were measured using standard techniques, and BMI was calculated. Skinfold thickness (in mm) was assessed at two sites (triceps and subscapular) using a Harpenden calliper, and the percentage of body fat (%BF) was calculated using the prediction equations developed for children ≤18 years of age by Slaughter et al.27

Descriptive statistics were used to describe the menstrual profile. One way analyses of variance were used to test differences among groups. The relation (Pearson product-moment correlation) between physical/training characteristics and the frequency of menses was examined using linear regression analysis.

RESULTS
Table 1 gives the mean age, height, weight, BMI, and %BF for both the rhythmic gymnasts and the age matched control, for each country. The mean (SEM) age of the gymnasts was 14.5 (0.2) and 14.7 (0.4) years for the Greek and Canadian groups respectively. The mean body weight, BMI, and %BF of the gymnasts from each country were significantly lower (p<0.05) than of the country specific controls of the same age (table 1). The Canadian controls had a significantly higher BMI and %BF than the Greek control group (table 1). None of the subjects reported use of oral contraceptives or having been medically diagnosed with eating disorders.

Among the Greek rhythmic gymnasts, 79% had not yet begun to menstruate compared with 34% (p<0.05) of the Canadian athletes (fig 1). The mean age at menarche for all rhythmic gymnasts was 13.8 (1.3) years. This represents a significant (p<0.05) delay compared with the controls (12.5 (0.1) years), with no significant difference between countries.

All girls from both control groups had achieved regular menstruation at the time of the study and none reported any menstrual irregularities, whereas a considerable percentage (78%) of the menarcheal athletes reported menstrual irregularities. A significantly (p<0.01) higher incidence of oligomenorrhoea and amenorrhoea was found in the rhythmic gymnasts than the controls. Oligomenorrhoea was reported in 61% and secondary amenorrhoea was reported in 17% of these gymnasts. Figure 1 shows the menstrual status for the rhythmic gymnasts of each country.

One way analyses of variance revealed significant differences between menarcheal and premenarcheal rhythmic gymnasts in terms of height (p<0.01), weight (p<0.01), BMI (p<0.01), and %BF (p<0.01), as well as training frequency and duration (p<0.05), yet both groups had been training for a similar period (table 2). All of the gymnasts had been competing for 3–9 consecutive years, with training ranging from 15 to 36 hours a week.

No significant differences were found in %BF, height, weight, BMI, training experience, training frequency, or duration between the eumenorrhoeic and oligomenorrhoeic athletes (table 3).

DISCUSSION
Age of menarche
The age of menarche for those rhythmic gymnasts who had achieved menarche was delayed compared with both the controls in this study (p<0.05) and the controls in other studies (table 4).17,28,29 However, 79% of the Greek and 34% of the Canadian gymnasts had not yet started to menstruate; the mean age of these groups was 14.5 and 14.7 years respectively. Although there are no available data on the menstrual patterns in rhythmic gymnasts, an examination of...
the literature (table 4) reveals that the age at menarche of the Greek rhythmic gymnasts is similar to that reported for female artistic gymnasts and ballet dancers, which has been reported to be significantly (p<0.05) delayed compared with controls. The age at menarche of the Canadian rhythmic gymnasts is similar to that also reported as delayed for other athletes including more recent data for ballet dancers. The most delayed age at menarche in our study was recorded among the oligomenorrhoeic (13.8 (1.2) years) and amenorrhoeic (14.4 (1.0) years) rhythmic gymnasts.

It is interesting that the menarcheal gymnasts had a significantly lower training frequency and training duration than the premenarcheal gymnasts (table 2). Theintz et al have suggested that gymnasts advance through puberty without a normal pubertal growth spurt. They hypothesised that when puberty is temporarily interrupted by exercise, skeletal age maturation often stalls as growth slows and sex steroids fall to low levels. However, growth potential may not be affected below a certain threshold of training intensity, which may explain the difference in training duration and training frequency between the menarcheal and premenarcheal gymnasts. As reported elsewhere, girls who mature later often self select sports that require a high relative strength and small bodies, such as gymnastics. The late maturing, premenarcheal body type favours athletic success in this type of activity. This observation is in accordance with the present data in that the premenarcheal gymnasts were not only significantly thinner, but were also significantly shorter, than the menarcheal gymnasts (table 2).

Previous studies have also suggested that the age of the onset of pubertal development varies greatly, and is influenced by nutrition, heredity, state of health, percentage of body fat, and other factors. The rhythmic gymnasts who had not yet reached menarche exhibited a significantly lower BMI and less body fat than both the menarcheal gymnasts and the non-athletes of the same age, both of which achieved regular menstruation. As reported, while engaging in intensive training, many young elite athletes, including gymnasts, have an unsatisfactory nutritional status and very low body fat.

### Menstrual frequency

Frisch et al have reported that college age girls who began training before menarche were more prone to delayed menarche and secondary amenorrhoea than those who began training after menarche. All gymnasts in our study reported training for an average of 23–24 hours a week, and most of them began training at an early age (7–8 years)—that is, several years before puberty. It was therefore not surprising that only 21% of the gymnasts in this study reported regular menstrual cycles.

Two of the three Greek menarcheal gymnasts reported secondary amenorrhoea; their mean age of menarche was 13.9 (0.7) years, and at the time of the study their mean chronological age was 14.2 (0.3) years. As irregular menses immediately after the onset of menarche are not uncommon, this result may complicate the findings from those gymnasts that were only one year postmenarche. On the other hand, 65% of Canadian gymnasts indicated oligomenorrhoea; these gymnasts had a mean age of menarche of 13.6 (1.2) years, and at the time of the study, their mean age was 16.4 (1.3) years. In this case, the findings have more significance in terms of interpreting oligomenorrhoea.

### Table 1 Chronological age, physical characteristics, and body fat of rhythmic gymnasts and non-athletes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rhythmic gymnasts</th>
<th>Non-athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greek (n = 15)</td>
<td>Canadian (n = 30)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>14.5 (0.2)</td>
<td>14.7 (0.4)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>160.0 (1.2)</td>
<td>163.4 (1.8)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>43.4 (1.3)*</td>
<td>45.9 (1.7)*</td>
</tr>
<tr>
<td>BMI (kg/m)</td>
<td>16.9 (0.3)*</td>
<td>17.2 (0.3)**</td>
</tr>
<tr>
<td>%BF</td>
<td>14.3 (0.5)*</td>
<td>16.2 (0.4)*</td>
</tr>
</tbody>
</table>

*Values are means (SEM). **p<0.05, *p<0.01 between groups; †p<0.05 between countries.

BMI, Body mass index; %BF, percentage body fat.

### Figure 1 Distribution (%) of menstrual status and menarcheal status reported by rhythmic gymnasts from Greece (GRG) and Canada (CRG).

*Significant difference (p<0.05) within groups. There were no eumenorrhoeic Greek gymnasts so this bar does not appear.

### Table 2 Physical and training characteristics of menarcheal (M-RG) and premenarcheal (PM-RG) gymnasts

<table>
<thead>
<tr>
<th>Variable</th>
<th>PM-RG (n = 22)</th>
<th>M-RG (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>39.5 (2.3)**</td>
<td>49.7 (1.7)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>156.1 (2.2)**</td>
<td>167.3 (1.5)</td>
</tr>
<tr>
<td>BMI (kg/m)</td>
<td>16.3 (0.3)***</td>
<td>18.0 (0.3)</td>
</tr>
<tr>
<td>%BF</td>
<td>13.9 (0.4)**</td>
<td>17.5 (0.4)</td>
</tr>
<tr>
<td>Training experience (years)</td>
<td>6.8 (1.8)</td>
<td>6.7 (3.4)</td>
</tr>
<tr>
<td>Training frequency (days/week)</td>
<td>6.4 (0.8)*</td>
<td>5.0 (0.1)</td>
</tr>
<tr>
<td>Training duration (h/day)</td>
<td>5.6 (0.6)</td>
<td>4.5 (0.3)</td>
</tr>
</tbody>
</table>

*Values are means (SEM). **p<0.05, *p<0.01 compared with M-RG.

BMI, Body mass index; %BF, percentage body fat.
These findings are in accordance with those of Lindboe and Slettebo, who examined eight elite rhythmic gymnasts in Norway, with 50% of them reporting secondary amenorrhea. Available data from artistic gymnastics have also shown amenorrhea in 33% of female gymnasts, and irregular cycles in 53% of them.

Body composition

In reference to body composition, females who are physically active and are excessively lean, increase their chances of oligomenorrhea or amenorrhoea. The rhythmic gymnasts had a similar mean body weight to that of the controls. As in our study, the rhythmic gymnasts reported by Damsgaard and BMI to that of the controls. In our study the gymnasts in the study by Lindboe and Slettebo were not contrast with the study of Lindboe and Slettebo in which athletes, such as swimmers and handball players. This is in accordance with those of Lindboe and Slettebo, who examined eight elite rhythmic gymnasts in Germany, and menstrual irregularities were reported in 78% of the menarcheal athletes (61 oligomenorrheic and 17% amenorrheic). All gymnasts were found to weigh significantly less than controls. The premenarcheal gymnasts had lower BMI and less body fat than the menarcheal athletes, yet the oligomenorrheic and amenorrhoeic gymnasts did not differ in body size or composition from the eumenorrhoeics. The premenarcheal gymnasts trained more often and for longer than the menarcheal gymnasts. However, because of the cross sectional nature of this study, a cause-effect relation between intense training and the development of the reproductive cycle cannot be made, but further study is warranted.

Future research should include a detailed nutritional profile of these athletes. Recent research suggests that athletic amenorrhea may be prevented or reversed by an improved energy balance. Although research in the area is still inconclusive, an energy deficit state is suggested to be the primary mechanism responsible for the hypothalamic reproductive dysfunction in athletes. Finally, an in depth hormonal analysis would help to further evaluate menstrual dysfunction among elite rhythmic gymnasts. Given the potential problems of hormonal dysfunction and energy deficit for reproductive health and bone, further research is warranted in young female athletes.

### Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>AO-RG (n = 18)</th>
<th>E-RG (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>49.2 (1.8)</td>
<td>49.6 (1.8)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.4 (1.8)</td>
<td>166.3 (2.2)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>17.7 (0.4)</td>
<td>18.2 (0.5)</td>
</tr>
<tr>
<td>%BF</td>
<td>17.5 (0.4)</td>
<td>17.5 (0.6)</td>
</tr>
<tr>
<td>Training experience (years)</td>
<td>6.8 (1.8)</td>
<td>6.7 (1.4)</td>
</tr>
<tr>
<td>Training frequency (days/week)</td>
<td>6.4 (0.9)</td>
<td>6.0 (0.0)</td>
</tr>
<tr>
<td>Training duration (h/day)</td>
<td>3.6 (0.6)</td>
<td>3.7 (0.3)</td>
</tr>
</tbody>
</table>

Values are means (SEM). No significant differences were found between variables.

### Take home message

High performance rhythmic gymnasts have a lower body mass index and percentage body fat than non-training girls of the same age. The intense physical training of those involved in rhythmic gymnastics is associated with delayed development of the normal menstrual pattern, with menarche being delayed by as much as 1.5–2.0 years.

An unexpected finding of this study was the significant difference observed between BMI and %BF between the Canadian and Greek control groups. Canadian girls not involved in competitive sports seem to be heavier and have more body fat than Greek non-athletes of similar age. This is an important finding that may reveal a combined effect of habitual physical inactivity and environmental and/or nutritional factors and requires further investigation.

In conclusion, menarche was delayed in 32 of 45 elite rhythmic gymnasts, and menstrual irregularities were reported in 78% of the menarcheal athletes (61 oligomenorrheic and 17% amenorrheic). All gymnasts were found to weigh significantly less than controls. The premenarcheal gymnasts had lower BMI and less body fat than the menarcheal athletes, yet the oligomenorrheic and amenorrhoeic gymnasts did not differ in body size or composition from the eumenorrhoeics. The premenarcheal gymnasts trained more often and for longer than the menarcheal gymnasts. However, because of the cross sectional nature of this study, a cause-effect relation between intense training and the development of the reproductive cycle cannot be made, but further study is warranted.

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