Cardiorespiratory capacity and body composition in girls and adolescents practitioners of Rhythmic Gymnastics

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Summary
Introduction: Aerobic capacity is one of the qualities to be developed in rhythmic gymnastics sport which requires huge physical and technical demands, with high loads of training.
Objective: To analyze cardiorespiratory capacity and VO$_2$ max and its relation to body composition: body mass index (BMI), fat percentage, waist circumference in girls and adolescents practicing rhythmic gymnastics
Method: Descriptive, comparative, cross-sectional study involving 116 competition gymnasts between 8 and 17 years old (48.3% were girls and 51.7% were adolescents). For the evaluation of the cardiorespiratory fitness, the Navette Course test was applied, calculating the VO$_2$ max with the results obtained. Body weight, height, waist circumference, sub-scapular folds and triceps were measured. The body mass index (BMI) was calculated with weight and height, with the measures of the folds the percentage of fat and with the waist circumference the waist height ratio (WHR).
Results: 13.8%, and 23.3% of the total sample showed very high aerobic capacity, and high respectively. Significant differences were found between the two age groups for the Course-Navette test ($U = 1214.0 p =.009 r = 2.60$) and for VO$_2$ max ($U = 300.0 p =.000 r = 7.60$). The adolescents gymnasts presented greater aerobic capacity than the girls. Adolescents showed a correlation with BMI ($p =.006$) and weight ($p=.014$). All factors related to a better cardiovascular profile
Conclusions: Gymnasts in general have good aerobic capacity. The Adolescents showed higher levels of aerobic capacity than girls. All have a BMI, waist circumference and fat percentage below the referenced values.

Key words: Cardiovascular capacity.
VO$_2$ max. Body mass index.
Fat percentage.
Rhythmic gymnastics.

Capacidad cardiorrespiratoria y composición corporal en niñas y adolescentes practicantes de gimnasia rítmica

Resumen
Introducción: La capacidad aeróbica es una de las cualidades a desarrollar en gimnasia rítmica, deporte que requiere grandes exigencias físicas y técnicas, con elevadas cargas de entrenamiento.
Objetivo: Analizar la capacidad cardiorrespiratoria y el VO$_2$ Max y su relación con la composición corporal: índice de masa corporal (IMC), porcentaje graso, perímetro de cintura en niñas y adolescentes practicantes de gimnasia rítmica.
Método: Estudio descriptivo, comparativo, de corte transversal donde participaron 116 gimnastas de competición entre 8 y 17 años (el 48,3% eran niñas y el 51,7% adolescentes). Para la evaluación de la capacidad cardiorrespiratoria se aplicó el test Course Navette calculándose el VO$_2$ max con los resultados obtenidos. Para la composición corporal se midió el peso, altura, perímetro de cintura, pliegues sub-escapular y tríceps. Con el peso y la altura se calculó el índice de masa corporal, con las medidas de los pliegues el porcentaje de grasa y con el perímetro de cintura la razón cintura estatura (RCE).
Resultados: El 13,8% y 23,3% de la muestra total mostraron una capacidad aeróbica muy alta, y alta respectivamente. Se encontraron diferencias significativas entre los dos grupos de edad para el test Course-Navette ($U = 1214.0 p =.009 r = 2.60$) y para VO$_2$ max ($U = 300.0 p =.000 r = 7.60$). Las gimnastas adolescentes presentaron mayor capacidad aeróbica que las niñas. Las adolescentes mostraron una correlación con el IMC ($p =.006$) y el peso ($p=.014$). Todas mostraron un RCE menor que 0,55, factores todos relacionados con un mejor perfil cardiovascular.
Conclusiones: Las gimnastas en general presentan buena capacidad aeróbica. Las adolescentes mostraron mayores niveles de capacidad aeróbica que las niñas. Todas tienen un IMC, perímetro de cintura y porcentaje graso por debajo de los valores referenciados.

Palabras clave: Capacidad cardiovascular.
VO$_2$ max. Índice de masa corporal. Porcentaje graso. Gimnasia rítmica.

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Introduction

Aerobic capacity is one of the main health-related components of physical fitness and is key to sports activities.

Rhythmic gymnastics is a highly taxing sport, both physically and technically, which calls for a high level of training. It is, therefore, imperative for gymnasts to be healthy and in optimum overall physical shape in order to pursue it.

For Douda et al., anthropometric characteristics and aerobic capacity are, alongside flexibility and explosive strength, significant determinants of successful performance for these gymnasts.

Several studies have shown that cardiorespiratory fitness is the strongest predictor of mortality and morbidity. It has also been demonstrated that low cardiorespiratory capacity represents the most important cardiovascular risk factor, even surpassing such classics as excess weight or obesity.

There exists evidence of a direct relationship between low cardiorespiratory capacity in childhood and adolescence, and an increased risk of cardiovascular diseases in later life.

Hence the growing interest in improving the cardiovascular fitness of the school population in recent years. Numerous studies have found a relationship between levels of cardiorespiratory fitness and different components of physical fitness: body composition, muscular strength, flexibility, speed-agility and coordination.

Many of these studies also indicate that a build-up of fat in the abdominal region would also appear to be a contributory factor for possible cardiovascular diseases.

However, few studies have been conducted with gymnasts specializing in this sport.

The aim of this study, therefore, was to analyse the cardiorespiratory capacity and VO$_2$max of pre-adolescent and adolescent rhythmic gymnasts and see their relationship with body composition: body mass index and fat percentage.

Material and method

Subjects

A total of 116 female competition gymnasts belonging to 5 clubs in 4 provinces of Andalucía who took part in the 2015 national championship were selected intentionally. 48.3% were pre-adolescents between 8 and 12 years of age, and 51.7% were adolescents of between 13 and 17. They all participated on a voluntary basis with the informed consent of their parents in accordance with the Declaration of Helsinki on ethical principles for research and following current Spanish legislation regulating medical research involving human subjects (Royal Decree 561/1993 on clinical trials).

Procedure

First of all, we spoke with the coaches and parents at the different clubs to inform them about the objective of the study and ask them for their informed consent.
analysed using Spearman’s rho. The data are given in mean ranks. All the forms of analysis were performed using SPSS v 22.0 (SPSS Inc. Chicago IL USA) and the level of significance was 5%.

**Results**

Table 1 shows the descriptive data of all the variables of the gymnasts who participated in the study which were analysed.

The Pan & Cole Index was calculated according to the composition of the sample (Table 2).

Table 3 shows aerobic capacity for the values of VO\(_{\text{max}}\) recorded by the gymnasts, divided into average, good and excellent according to García-Manso et al., cited in Corral et al\(^2\). The Mann-Whitney U test revealed the presence of statistically significant differences in aerobic capacity between the two age groups considered, U = 1,214.0 \(p = 0.009\), \(r = 2.60\). Similarly, a statistically significant difference was found between the age groups and the maximum volume of oxygen (U = 300.0 \(p = 0.000\), \(r = 7.60\)). To be more specific, the adolescent gymnasts gave higher values than the pre-adolescent ones.

Table 1 shows the descriptive data of all the variables of the gymnasts divided into average, good and excellent according to García-Manso et al., cited in Corral et al\(^2\). The principal findings of the study showed that adolescent gymnasts are more aerobically fit than younger gymnasts. They all had low BMI, waist circumference and body fat percentage values, these being more pronounced in the pre-adolescent gymnasts. Correlations were found between weight, height, BMI, waist circumference, body fat percentage and VO\(_{\text{max}}\).

**Discussion**

The principal findings of the study showed that adolescent gymnasts are more aerobically fit than younger gymnasts. They all had low BMI, waist circumference and body fat percentage values, these being more pronounced in the pre-adolescent gymnasts. Correlations were found between weight, height, BMI, waist circumference, body fat percentage and VO\(_{\text{max}}\). WHtR was lower than 0.55 in both age groups.

The percentages of very high, high and average cardiorespiratory capacity scores obtained by the gymnasts were 10.7%, 19.6% and 14.2% for the pre-adolescents, and 16.6%, 26.7% and 40% for the adolescents\(^2\).

Contrasting these data with normal populations in the same age range, it was found that the pre-adolescent gymnasts registered a mean value of 3.45 in the multi-stage fitness test, slightly higher than pre-adolescents between 8 and 11 years of age\(^22,23\), who have values of 2.9 and 3, respectively. Meanwhile, the adolescent gymnasts obtained results slightly higher than those reported by Cuenca et al\(^8\), and Delgado et al\(^21\), with values of 3.84 and 4.
As for \( VO_{2\text{max}} \), the adolescent gymnasts gave slightly higher percentages (45.21 (±3.23) ml/(kg min)) compared to the percentages from Spanish studies carried out on populations in a similar age range suggested by other authors\(^6,23,24\). The total sample had average, good and excellent \( VO_{2\text{max}} \) values (13.8%, 75% and 11.2%) according to the reference values\(^20\) (Table 3).

Adding these percentages together, 44.6% of the pre-adolescent girls and 63.4% of the adolescents had healthy levels. These values are lower than those found for Spanish adolescent girls, 82.7%\(^25\), but higher than the 53% of Portuguese girls\(^26\) aged from 10 to 18.

On comparing our results with the referential values of the ALPHA battery\(^21\), we note that most of the gymnasts aged between 13 and 17 years gave average, high and very high values in terms of aerobic capacity, but that the pre-adolescent girls did not (Table 4). In fact, significant differences existed between the two age groups, the adolescent gymnasts showing greater aerobic capacity (U = 1,214.0, \( p = 0.009 \), \( r = 2.60 \)) and \( VO_{2\text{max}} \) (U = 300.0 \( p = 0.000 \), \( r = 7.60 \)) than the pre-adolescents.

In the ≥13 age group, the sum of the very high and high aerobic capacity percentages exceeded the average percentages, no gymnast giving very low results in the test. However, in the ≤12 group, the percentage of high and very high aerobic capacity was lower than the average, with 16.07% and 39.28% of the sample giving values categorised as very low and low\(^21\) (Table 4). These results do not support the relationship found by Tomkinson et al.\(^27\) between an increase in age and a decrease in aerobic capacity in the normal population. After conducting a meta-analysis with 55 reports studying the trend of cardiovascular fitness (multi-stage fitness test) in children and adolescents from 1980 to 2000, these authors affirmed that aerobic capacity declines as students grow, pointing to a 0.41% drop in aerobic fitness per year for girls, with a much more marked decline in adolescents than in children. Malina\(^28\) reports similar results for the American population. These trends are not observed in this study. Adolescent gymnasts do a greater volume of physical activity than the normal population due to the training they carry out, thereby exercising and enhancing this variable. There exist studies which describe the importance of physical activity and its influence on this characteristic\(^29,30\).

In the ≤12 group, however, low and very low aerobic capacity results are observed. Being gymnasts in younger categories, the competitive level required of them is lower and so their training loads are lighter, allowing us to imagine that the aerobic work they perform is less specific.

### Table 5. Correlation analysis by age group. Spearman’s rho.

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<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Height</th>
<th>BMI</th>
<th>Waist circumference</th>
<th>Body fat percentage</th>
<th>Multi-stage fitness test</th>
<th>( VO_{2\text{max}} )</th>
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</thead>
<tbody>
<tr>
<td><strong>Weight</strong></td>
<td>Rho de Spearman 0.716** 0.805** 0.646** 0.284* -0.070 -0.316*</td>
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<td>Sig. (2-tailed)</td>
<td>0.000 0.000 0.000 0.028 0.596 0.014</td>
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<td><strong>Height</strong></td>
<td>Rho de Spearman 0.807** 0.223 0.362** 0.012 0.005 -0.183</td>
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<td>Sig. (2-tailed)</td>
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<td><strong>BMI</strong></td>
<td>Rho de Spearman 0.642** 0.106 0.598** 0.384 -0.150 -0.354**</td>
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<td>Sig. (2-tailed)</td>
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<td><strong>Waist circumference</strong></td>
<td>Rho de Spearman 0.360** 0.189 0.403** 0.246 0.142 -0.048</td>
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<td>Sig. (2-tailed)</td>
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<td><strong>Body fat percentage</strong></td>
<td>Rho de Spearman -0.074 0.068 -0.171 0.078 0.230 0.136</td>
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<td><strong>Multi-stage fitness test</strong></td>
<td>Rho de Spearman 0.419** 0.471** 0.082 0.069 0.142 0.868**</td>
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<td><strong>( VO_{2\text{max}} )</strong></td>
<td>Rho de Spearman 0.109 0.217 -0.100 -0.169 0.067 0.808**</td>
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<tr>
<td>Sig. (2-tailed)</td>
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</table>

**The correlation is significant at the 0.01 level (2-tailed). *The correlation is significant at the 0.05 level (2-tailed)**

Age group: Adolescents (≥13 y.o.) Age Group: pre-adolescents (≤12 y.o.)
than that of the adolescents. Studies show that the effects of training depend specifically on the exercises done. With regard to the body composition variables, the average BMI was 17.32 kg/m², most of the gymnasts having normal or slightly low weights; “Grade 1 thinness” (Tables 1 and 2) according to the values of Cole et al. These results are similar to those reported in studies with rhythmic gymnasts by Di Cagno et al. and Vernetta et al., but lower than the results obtained by Avila-Carvalho et al., 18.75 kg/m², and Rutkauskaitė et al., 18.5 kg/m²; and slightly higher than the 16.9 kg/m² registered by Soric et al. and the 16.82 kg/m² recorded by Poliszczuk et al.

No significant differences were found between groups of pre-adolescents and adolescents with regard to the categorisation of BMI. However, there is a greater percentage of adolescent gymnasts with a normal BMI and a higher percentage of pre-adolescent gymnasts with Grade 1 thinness (Table 2).

Similarly, the mean waist circumference in the total sample was 60.94 cm, this value being lower than those of Avila-Carvalho et al. and D’Alessandro et al., with 67.05 cm and 66.8 cm respectively, and very similar to the 58.66 cm found in Roman et al.

As for body fat percentage, most of the gymnasts were in the middle and low percentiles according to the reference values. They also gave low BMI values, coinciding with other studies. In general, the lower BMI and waist circumference results of these gymnasts compared to the normal population is correlated with the importance that these athletes give to their weight as part of their body image, rhythmic gymnastics being an aesthetic sport where thinness and good presence are important factors when it comes to succeeding and winning.

Regarding the association between the multi-stage fitness test and VO₂ max (Table 5), the existence of a positive relationship between the test and the VO₂ max (p = 0.000) calculation was found for the total sample. Meanwhile, a negative relationship was found between the VO₂ max, BMI (p = 0.006) and weight (p = 0.014) values in the adolescent gymnasts. However, no statistically significant relationship was found between aerobic capacity and the other anthropometric variables (weight, height, BMI, body fat percentage and waist circumference) paired independently with each of the age groups.

The data obtained from our adolescent gymnasts do not substantiate the relationship between performance in the aerobic multi-stage fitness test and BMI shown in the child-adolescent population. The fact that our gymnasts have good aerobic capacity and a BMI at or slightly below normal weight in both groups may be why no relationship can be found like that in studies which report an inverse relationship between nutritional status or levels of body fat and aerobic capacity in overweight and obese girls.

However, significant relationships have been discovered between maximum oxygen volume, BMI and weight in the adolescents. The relationship is inverse, i.e. the greater the VO₂ max, the lower the Body Mass Index and weight. These results resemble those reported by other authors, who showed that children and adolescents with a lower BMI had greater VO₂ max compared to those who were overweight/obese. Similarly, Ross et al. report that high cardiorespiratory capacity is associated with lower BMI, while Ara et al. describe how active children who are more aerobically fit accumulate less fat during growth both all over the body and in the trunk region.

In our study, all the gymnasts had a low body fat percentage, waist circumference and BMI, and a WhTR of less than 0.55, all factors related to a better cardiovascular profile.

In conclusion, the results of this study show that, in general, the gymnasts had good aerobic capacity when held up against the standard reference values. The adolescent gymnasts had higher aerobic capacities and VO₂ max than the pre-adolescents. They all had low BMIs, waist circumferences and body fat percentages. A relationship existed between the VO₂ max, BMI and weight of the adolescent girls.

In terms of practical application, we can say that in this discipline, which requires early initiation, the evaluation of aerobic capacity as a physical health-related characteristic should be considered a fundamental tool when it comes to identifying fitness and controlling training properly. Aerobic capacity should be worked on at every stage of training, with a special emphasis on the preparatory period, where developing good aerobic capacity is essential to achieving the sport’s specific performance objectives. The high percentage of adolescent gymnasts with good aerobic capacity shows that they are specifically working on this variable with some success. However, the percentage of pre-adolescent gymnasts with a low and very low aerobic capacity highlights the need for improvement by including specific aerobic exercises in their training microcycles.

Finally, in terms of limitations, our data cannot be extrapolated beyond the ranges observed in the study sample. It would, therefore, be good to increase and vary the sample of participants by applying this battery in other Spanish communities. Similarly, considering that gymnasts start rhythmic gymnastics at a young age, other age bands, including younger gymnasts who are just starting and gymnasts at different levels of competition, could be considered. It is also important to understand that the interpretation is based on the measurements taken compared with the reference values established for the non-athlete school population. Consequently, “high” and “very high” AC values may have been obtained with the adolescent gymnasts as a result of using these tables.

Looking ahead, it would be interesting to conduct longitudinal follow-up research on the VO₂ max needs required over gymnasts’ sporting careers and potential variations in aerobic capacity over a training macrocycle in order to establish specific reference values for this gymnastic discipline.

**Acknowledgements**

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Our thanks go to the Andalusian Gymnastics Federation and all the clubs, coaches and gymnasts that took part.