

INDICES OF PHYSICAL FITNESS IN RHYTHMIC GYMNASTICS ATHLETES

ÍNDICES DE APTIDÃO FÍSICA NOS ATLETAS DE GINÁSTICA RÍTMICA

ÍNDICES DE APTITUD FÍSICA EN ATLETAS DE GIMNASIA RÍTMICA



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ABSTRACT

Introduction: Rhythmic gymnastics uses the body as a tool for expression and choreographed beauty. Athletes use various body movements and beautiful voices to create a competitive sport that combines technology and art. This high-level sports performance set results from much targeted fitness training. Yet, the sport lacks research relating fitness to the difficulties of the new rules. **Objective:** This paper explores the choreographic differences in rhythmic gymnastics under the current rules. The differences in athletes' body fitness are also evaluated. **Methods:** The fitness indices of 120 rhythmic gymnasts were evaluated by a developed method encompassing the upper body, trunk and lower limbs. A general analysis of the movement organization characteristics of Chinese rhythmic gymnasts was also performed. Armed with these data, the mathematical statistics method was adopted to conduct empirical research. **Results:** The 10-second long jump, standing jump, lifting, plank, and other 10-s performances in elite athletes were significantly more expressive than those in ordinary athletes ($P < 0.01$). In the lifting test, elite athletes were significantly better than ordinary athletes ($P < 0.01$). There was a significant difference between elite and ordinary athletes in the plank stand ($P < 0.05$). There was no significant difference in the remaining individual scores. **Conclusion:** The critical period of the upper limb development of rhythmic gymnasts is significantly lagged compared to the lower limbs. The artistic arrangement of rhythmic gymnastics is fundamental to its good presentation. The innovations and diversified changes evidenced an advance in rhythmic gymnastics that athletes must absorb to achieve better competitive results. **Level of evidence II; Therapeutic studies - investigation of treatment outcomes.**

Keywords: Gymnastics; Athletes; Resistance Training; Physical Fitness.

RESUMO

Introdução: A ginástica rítmica utiliza o corpo como uma ferramenta de expressão e beleza coreografada. Os atletas utilizam vários movimentos corporais e belas vozes para criar um esporte de competição que combina tecnologia e arte. Esse conjunto de desempenho esportivo de alto nível é resultado de muito treinamento de aptidão física direcionado. Ainda assim, o esporte carece de pesquisas relacionando a aptidão física às dificuldades das novas regras vigentes. **Objetivo:** Este artigo explora as diferenças coreográficas da ginástica rítmica sob as diferentes regras atuais. As diferenças na aptidão física corporal dos atletas também são avaliadas. **Métodos:** Os índices de aptidão física de 120 ginastas rítmicos foram avaliados por um método desenvolvido que englobou a parte superior do corpo, o tronco e os membros inferiores. Também se efetuou uma análise geral das características de organização do movimento dos ginastas rítmicos chineses. Munidos desses dados, adotou-se o método de estatística matemática para realizar pesquisas empíricas. **Resultados:** Os 10 segundos de salto em distância, salto em pé, elevações, prancha e outros 10-s de desempenho nos atletas de elite foram significativamente mais expressivos do que nos dos atletas comuns ($P < 0,01$). No teste de elevação, os atletas de elite foram significativamente melhores do que os atletas comuns ($P < 0,01$). Houve uma diferença significativa entre atletas de elite e atletas comuns no suporte de prancha ($P < 0,05$). Não houve diferença significativa nas pontuações individuais restantes. **Conclusão:** O período crítico do desenvolvimento dos membros superiores dos ginastas rítmicos está significativamente defasado em comparação com os membros inferiores. O arranjo artístico da ginástica rítmica demonstrou-se fundamental para a sua boa apresentação. As inovações e mudanças diversificadas evidenciaram um avanço na ginástica rítmica que deve ser absorvido pelos esportistas visando melhores resultados competitivos. **Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.**

Descritores: Ginástica; Atletas; Treinamento de Força; Aptidão Física.

RESUMEN

Introducción: La gimnasia rítmica utiliza el cuerpo como herramienta de expresión y belleza coreográfica. Los atletas utilizan diversos movimientos corporales y bellas voces para crear un deporte de competición que combina tecnología y arte. Este conjunto de rendimiento deportivo de alto nivel es el resultado de un entrenamiento físico muy específico. Sin embargo, el deporte carece de investigaciones que relacionen la aptitud con las dificultades de las nuevas normas vigentes. **Objetivo:** Este trabajo explora las diferencias coreográficas en la gimnasia rítmica bajo las diferentes reglas actuales. También se evalúan las diferencias en el estado físico de los atletas. **Métodos:** Se evaluaron los índices de aptitud física de 120 gimnastas rítmicas mediante un método desarrollado que abarcaba la parte superior del cuerpo, el tronco y las extremidades inferiores. También se realizó un análisis general de las características



de organización del movimiento de las gimnastas rítmicas chinas. Con estos datos, se adoptó el método de la estadística matemática para realizar la investigación empírica. Resultados: Los 10 segundos de salto de longitud, salto de pie, levantamiento, plancha y otros 10 segundos de rendimiento en los atletas de élite fueron significativamente más expresivos que los de los atletas ordinarios ($P < 0,01$). En la prueba de levantamiento, los atletas de élite fueron significativamente mejores que los ordinarios ($P < 0,01$). Hubo una diferencia significativa entre los atletas de élite y los atletas ordinarios en el soporte de la tabla ($P < 0,05$). No hubo diferencias significativas en el resto de las puntuaciones individuales. Conclusión: El periodo crítico del desarrollo de las extremidades superiores de las gimnastas rítmicas está significativamente retrasado en comparación con las extremidades inferiores. La disposición artística de la gimnasia rítmica resultó fundamental para su buena presentación. Las innovaciones y los cambios diversificados evidenciaron un avance en la gimnasia rítmica que debe ser absorbido por los atletas que aspiran a obtener mejores resultados competitivos. **Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.**

Descriptor: Gimnasia; Atletas; Entrenamiento de Fuerza; Aptitud Física.

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INTRODUCTION

Changes in the new rules will significantly impact the development of rhythmic gymnastics. It is of great significance and value to developing rhythmic gymnastics sports to understand the information conveyed by the sport's laws as early as possible and accurately. Choreography plays a pivotal role in rhythmic gymnastics. The innovation of its arrangement method is the key to obtaining excellent works. The four difficulties of the new rules lie in the integration of body, device, and body and device technology.¹ This paper measured the physical fitness of rhythmic gymnasts aged 8-14 years. In this paper, based on mastering the physical quality characteristics of athletes, we can know the distribution characteristics of the power of each part of their body. This paper studies the relationship between the strength of various parts of the athlete's body and the game's performance.² The research results of this paper help improve the physical fitness level of rhythmic gymnasts.

METHOD

Research objects

In this paper, 120 rhythmic gymnasts were measured accordingly. The athletes were divided into different groups according to their age. The age range of group A was 13-14 years old, the age range of group B was 11-12 years old, and the age range of group C was 8-10 years old. There are 40 members in each group.³ In this paper, body and leg muscle strength tests were performed on athletes of different ages.

Investigation method

This paper studies the physical fitness characteristics of rhythmic gymnasts aged 8-14, employing testing and statistical analysis. The main tests are upper body, trunk, and leg strength.⁴ This study set test indicators such as maximum grip strength, 10-second rope jump, vertical jump, standing long jump, single-leg forward control, sit-ups, trunk back flexion, and plank support. At the same time, this paper makes a comprehensive analysis and discussion of the characteristics of the movement arrangement of Chinese rhythmic gymnasts.

Finite element simulation of joints and muscles of rhythmic gymnasts e_j represents the quality of each force module of the joint muscles in the cushioning motion. s_j refers to the length of moment that each movement unit bears in rhythmic gymnastics. β_j is the distance between the articular muscle supports of each movement in the rhythmic gymnast's bone mass center. E is the vertical angle of the two thighs of a rhythmic gymnast in the same movement. λ_j represents the angle between the right foot and the most stressed hinge.⁵ Rhythmic gymnastics technical action joint mass center is the origin O of the coordinate system. This paper takes the motion direction vector H as the O_{x3} axis.

Rhythmic gymnastics technical action joint power kinetic energy can be described as:

$$W = \sum_{j=0}^n [T_j P_j^2 + e_j (\frac{x_j^2 - z_i^2}{x_j^2 + z_i^2})] \quad (1)$$

T_j is the force inertia of rhythmic gymnastics technical movements. The strength of each joint muscle of a rhythmic gymnast is:

$$Q = \sum_{j=0}^n \frac{h}{2} e_j z_j \quad (2)$$

The Lagrangian equation for the elastic torque supporting the leg is:

$$S = W - Q \quad (3)$$

In this paper, the homogeneous decomposition method of nonlinear dynamics is used to obtain the optimal solution for the technical action:

$$\frac{d}{dt} \frac{\partial S}{\partial P_j} - \frac{\partial S}{\partial P_j} = T_j \quad (4)$$

T_j is the acting moment of the joint muscles and joints of the technical movements of rhythmic gymnastics. M is the muscle strength matrix of body movement.⁶ The vector G represents the damping weighted least squares vector of the chain articulation torque:

$$M(P)\dot{P} + K(P, \dot{P}) + F(P) = T \quad (5)$$

λ_j ($j = 1, 2, \dots, 6$) is the transfer force inertia method of the articular muscles of rhythmic gymnastics technical movements. During the exercise program cycle, the athlete gets new positions to complete the movement and muscle strength modeling.

Ethical Compliance

Research experiments conducted in this article with animals or humans were approved by the Ethical Committee and responsible authorities of Guangdong Ocean University following all guidelines, regulations, legal, and ethical standards as required for humans or animals.

RESULTS

Grip strength analysis of different age groups

There was no significant difference in the right-hand grip ability of the athletes in the A and B groups.⁷ There was a significant difference in the left-hand strength values of the athletes in Group A and Group B. There was no significant difference in muscle strength between groups B and C. (Table 1)

Comparative analysis of the strength and quality of various parts of athletes at different levels

This article compares and analyzes elite and ordinary athletes' lower limbs and bodies.⁸ Table 2 shows that the elite athletes in group A performed significantly higher than ordinary athletes in 10 s of the 10-second small jump, standing long jump, sit-ups, and plank support ($P < 0.01$). There was a big difference between the elite and ordinary athletes in group B when doing sit-ups ($P < 0.01$). Athletes had significant differences in plank support ($P < 0.05$). Elite athletes in group C performed significantly higher than ordinary athletes in sit-ups, flat support, and other items ($P < 0.05$). The differences between the remaining two items were not significant.

Table 1. Comparison of Grip Index by Age Group.

Object of comparison	Saliency
Group A and Group B (right side)	0.067
Group A and Group B (left side)	0.006
Group B and Group C (right side)	0.231
Group B and Group C (left side)	0.089

Table 2. Comparison of the strength and quality of each part of the body of the elite and ordinary athletes in Group A.

Project	Group A	
	Excellent	Generally
10s rope jump (n)	38.95±1.38	30±4.76
Vertical jump (cm)	39.02±4.13	35.64±8.32
Standing long jump (cm)	196.05±15.51	166.32±22.39
Single leg forward left(s)	40.93±3.92	36.64±6.75
Single leg forward right(s)	47.63±6.08	41.91±10.24
Crunches (n)	11.58±1.86	7.89±1.76
Trunk back flexion (n)	10±1.68	8.42±2.03
Plank(s)	101.45±7.27	83.55±13.44
Project	Group B	
	Excellent	Generally
10s rope jump (n)	33.97±3.92	31.14±4.01
Vertical jump (cm)	31.96±3.92	32.49±4.71
Standing long jump (cm)	167.18±16.25	159.78±16.71
Single leg forward left(s)	37.13±5.52	35.08±5.24
Single leg forward right(s)	39.91±5.56	39.21±6.52
Crunches (n)	8.42±1.24	6.14±1.91
Trunk back flexion (n)	7.08±1.06	6.62±1.29
Plank(s)	75.02±18.63	60.71±14.85
Project	Group C	
	Excellent	Generally
10s rope jump (n)	29.91±1.93	29.43±3.55
Vertical jump (cm)	31.6±3.51	28.11±6.09
Standing long jump (cm)	155.35±16.46	143.82±16.53
Single leg forward left(s)	24.13±4.24	23.95±5.14
Single leg forward right(s)	31.4±6.19	30.26±4.88
Crunches (n)	6.4±1.52	5.35±1.45
Trunk back flexion (n)	5.79±1.05	5.35±1.12
Plank(s)	47.28±6.16	39.74±0.08

The physical fitness of elite athletes is significantly different from that of ordinary athletes. The main reason for this is the continuous improvement of the comprehensive ability of athletes in all aspects of their bodies.⁹ Due to the substantial improvement at a professional level, it becomes more challenging to participate in competitions. For older athletes to achieve excellent performance, it is necessary to improve their overall quality.

Comparative study of human lower extremity muscle strength in different age groups

Athletes in group A scored higher in standing long jump and vertical jump than in group B, but the scores in groups A and B were significantly higher (Table 3). In the lower limb static test, the left single-leg forward lift and the right single-leg forward lift in groups A and B were significantly better than those in group C. Leg muscle endurance in youth athletes increased with age, with a clear difference between groups C and B. Group A and Group B only had differences in vertical jump and standing long jump. There was no significant difference in the rest. (Table 4)

Comparison of physical strength of different age groups

The comparison of group A with groups B and C had great statistical significance. There was a big difference in the backbend between groups B and C. This indicates that the central performance of young rhythmic gymnasts is developing the rectus abdominis precuneus, muscle group. It showed a steady growth trend during the critical period.¹⁰ Athletes between the ages of 10 and 14 have the most sensitive muscles in the rear of the trunk, dominated by the erector spinae. Its strength increased the most. (Table 5)

This paper used the flat support method for static strength assessment. There were significant differences between groups A and groups B and C. There were significant differences between groups B and C. The physical stability of young rhythmic gymnasts aged 8-14 is a susceptible period. It has a gradually increasing trend. (Table 6)

DISCUSSION

Rhythmic gymnastics is a sport performed in space. Athletes use their bodies and equipment to present a variety of dynamics in space. Athletes change positions in space. Athletes create an invisible space through the tools of the body. Athletes use the flow of steps, the throwing of equipment, etc., to express different

Table 3. Comparison of lower limb dynamic strength in different age groups.

Project	Group A	Group B	Group C
10s rope jump (n)	32.98±5.82	32.03±4.15	29.53±3.06
Vertical jump (cm)	36.77±7.27	32.32±4.42	29.47±5.64
Standing long jump (cm)	176.23±24.6	162.11±16.69	147.49±16.97

Table 4. Comparative analysis of lower body static strength in different age groups.

Project	Group A	Group B	Group C
Left leg single leg forward raise(s)	38.07±6.21	35.73±5.34	24.09±4.77
Right leg single leg forward raise(s)	43.82±9.35	39.43±6.16	30.89±5.47

Table 5. Comparative analysis of rotodynamic strength quality in different age groups.

Project	Group A	Group B	Group C
Crunches (n)	9.13±2.49	6.91±2	5.69±1.54
Trunk back flexion (n)	8.95±2.03	6.76±1.22	5.49±1.11

Table 6. Comparative analysis of trunk static strength quality in different age groups.

Project	Group A	Group B	Group C
Plank (seconds)	89.52±14.43	2.17±17	42.25±7.2

spaces. Music is an art of expressing emotions. Athletes can make the whole set of sports vivid and colorful through the cooperation of music. Music can help bring out the atmosphere of the whole action. Music can increase the artistic charm and enhance the appeal of its movement. Athletes use the language of music to create musical material with strong emotions. Music has given a powerful impetus to the artistic movement. Combining the two can achieve a full effect. High-intensity physical exercise must have the good physical fitness to ensure. Graceful posture cannot be broken. Athletes should express their emotions vividly throughout the movement. The new round of "specs" refers to the precision of physical fitness and the standardization of equipment technology. Only in this way can you maximize your body language. This is something that most domestic athletes must do, and it is also an essential means to improve their overall strength.

CONCLUSION

The primary age stage of rhythmic gymnasts developing upper limb muscles lags behind the development of the main strength of lower limbs. At 8-14 years old, the static strength and dynamic performance of rhythmic gymnasts showed a steady upward trend. Rhythmic gymnasts aged 8-14 have gradually increased their lower limbs' static and dynamic capabilities with age. The new competition standards focus on the development of competition and art. In the choreography of rhythmic gymnastics, athletes should pay attention to the innovation of complicated movements. Under the guidance of the new regulations, the whole set of rhythmic gymnastics will gradually move towards the perfect integration of sports and art.

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REFERENCES

1. Riabchenko O. Determination of the correlation dependence of mastering the basic elements of rhythmic gymnastics on the use of the classical exercise by girls 5-6 years old. *Slobozhanskyi Her Sci Sport*. 2021;9(6):44-54.
2. Chirazi M. Expressiveness of gestural communication through body actions. *Învățământ, Cercetare, Creație*. 2021;7(1):53-9.
3. Akramovna AM, Kizi SDB. Methodology of teaching elements of rhythmic gymnastics in physical education in higher educational institutions. *ACADEMICIA: An International Multidisciplinary Research Journal*. 2022;12(6):57-9.
4. Tulanovich YT, Madaminovich DE, Baxodirovna XB. Rhythmic gymnastics in the system of physical education. *Innovative Technologica: Methodical Research Journal*. 2021;2(12):25-9.
5. Gantcheva G, Borysova Y, Kovalenko N. Evaluation and development of artistic abilities of 7-8-year-old rhythmic gymnasts. *Sci Gymnast J*. 2021;13(1):59-147.
6. Limanskaya OV, Yefimova OV, Kriventsova IV, Wnorowski K, Bensbaa A. The coordination abilities development in female students based on dance exercises. *Phys Educ Stud*. 2021;25(4):249-56.
7. Semyzorova A, Krasova I, Shevchenko K. Generalization of experience in the questions of improving the throwing elements with the hoop of young athletes in rhythmic gymnastics. *Slobozhanskyi Her Sci Sport*. 2021;9(4):42-55.
8. Moskovljević L. Rhythmic gymnastics in Serbia: From success to sustainable development strategy. *Fizička Kultura*. 2021;75(1):56-70.
9. Cherepov E, Kalugina G, Sevostianov D, Smirnova L. Development of coordination abilities in cheerleaders at the stage of initial preparation. *J Phys Educ Sport*. 2020;20(2):666-71.
10. Petrenko A. Classification of acrobatic movements of group p-"platforms" and their varieties in artistic swimming. *Slobozhanskyi Her Sci Sport*. 2021;9(6):66-76.