Study on physical strength of 8-14-year-old rhythmic gymnasts in Sichuan

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Abstract: This study conducted relevant physical strength tests on 101 young rhythmic gymnasts aged 8-14 in Sichuan Province, covering upper limb strength, trunk strength, and lower limb strength. The collected data were integrated using mathematical statistics and analyzed logically to reveal the characteristics of strength training for rhythmic gymnasts aged 8-14, as well as the development features of static and dynamic strength at different age stages. The findings provide suggestions for improving the physical strength training of young rhythmic gymnasts in Sichuan Province.

Keywords: Rhythmic Gymnastic, Athletes, Physical Strength Characteristics

1. Introduction

Rhythmic gymnastics is a skill-dominated sport characterized by its aesthetic difficulty. The stable execution of various action combinations and precise coordination between the human body and apparatus are the main forms of expression in rhythmic gymnastics. Athletes are required to perform complex dynamic and static movements in three-dimensional space, with high frequency and large amplitude, all set to music. The accurate and smooth handling of apparatus is also essential. As a sport based on flexibility and technique, rhythmic gymnastics inevitably prioritizes strength as a key factor for success. Strength is fundamental for mastering sports techniques and improving action stability, especially for completing high-difficulty movements. Therefore, strength training, as a core element determining sports performance, has long been a focal point in the field of rhythmic gymnastics worldwide. Although rhythmic gymnastics in China achieved a breakthrough with a silver medal in the team event at the 2008 Beijing Olympics, challenges such as generational turnover, athlete injuries, and insufficient backup talent, combined with a significant gap in training compared to international standards, indicate that the development path for rhythmic gymnastics in China remains long and arduous.

By testing the physical strength of 8-14-year-old rhythmic gymnasts in Sichuan Province, this study aims to understand the characteristics of physical strength at this age stage, the differences in strength among different body parts, and the correlation between strength and sports performance. This understanding is conducive to the refined strength training of rhythmic gymnasts and provides a reference for improving the technical level of rhythmic gymnasts in Sichuan Province.

2. Related concept review

2.1. Strength

Strength is the ability of the human body to overcome resistance and serves as the foundation for other physical abilities such as speed, endurance, and agility. Maintaining body posture, moving limbs, and performing work against resistance all require a certain level of muscle strength. Absolute muscle strength, relative muscle strength, muscle explosive power, and muscle endurance are the main forms of muscle strength expression. In his book "Sports Training Science," Tian Maijiu classified physical strength into general strength and specific strength based on the relationship between physical strength and sports specialization.

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2.2. Specialized strength characteristics of rhythmic gymnastics

Rhythmic gymnastics is a type of skill-based sport with diverse and expressive action structures. Athletes use apparatus such as ropes, hoops, balls, clubs, and ribbons, combined with various balancing, jumping, rotating, and flexibility movements, all performed to music. Given the characteristics of rhythmic gymnastics, athletes must possess excellent jumping ability, flexibility, stable balance, rotational control, extraordinary endurance, speed strength, explosive power, and coordination. In the field of rhythmic gymnastics, strength is defined in three different types: static strength, dynamic strength, and explosive strength. In the training process, high-level rhythmic gymnasts should combine traditional training methods with modern technological training methods, focusing on the balanced development of individual and overall physical strength.

3. Research objects and methods

3.1. Research objects

This study selected 101 rhythmic gymnasts aged 8-14 who participated in the 12th Sichuan Provincial Games in 2014 as test subjects. The athletes were divided into three age groups: Group A (13-14 years old), Group B (11-12 years old), and Group C (8-10 years old). Tests were conducted on the trunk and lower limb strength of the athletes in each group.

3.2. Research methods

This study employed research methods such as literature review, expert interviews, questionnaires, testing, and statistical analysis to investigate the physical strength characteristics of 8-14-year-old rhythmic gymnasts in Sichuan Province. Based on the results of the questionnaire survey of rhythmic gymnastics coaches, considering the feasibility and relevance of the tests, and referring to relevant literature, the following test items were set: maximum grip strength, 10-second rope skipping, vertical jump, standing long jump, single-leg front lift control, sit-ups, trunk hyperextension, and plank support.

4. Research content

4.1. Analysis of physical strength characteristics of different age groups

Table 1: Basic Information of Tested Athletes

Item	Group	Mean (x_)	Standard Deviation (s)	Maximum (max)	Minimum (min)
Height(cm)	Group A(n=29)	157	6.4	168	143
	Group B(n=37)	150	6.2	162	136
	Group C(n=35)	138	7.3	158	127
Weight (kg)	Group A(n=29)	37	5.1	47	26
	Group B(n=37)	33	6.	46	22
	Group C(n=35)	27	3.8	38	21
Training Years	Group A(n=29)	5.7	1.7	9	2
	Group B(n=37)	4.7	1.1	7	2
	Group C(n=35)	3.3	1.5	6	1
Weekly Training Sessions	Group A(n=29)	4.6	2.2	7	1
	Group B(n=37)	3.8	1.9	7	2
	Group C(n=35)	4.4	1.9	7	2

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4.1.1. Analysis of basic information of tested athletes

From Table 1, it can be observed that as the age of the athletes increases from Group C to Group B and then to Group A, the average values of training years, height, and weight also increase correspondingly, which is consistent with the age growth of the athletes. However, the trend of weekly training sessions does not follow this pattern. Group A has the highest average value, followed by Group C, while Group B has the lowest, indicating that the training volume of Group B is relatively insufficient. When considering the standard deviation of this indicator, Group A has the highest value, which suggests that the distribution of weekly training sessions among Group A athletes is the most dispersed. In terms of training years, Group A also has the highest standard deviation, indicating the greatest dispersion of training years within this group. During the developmental stage of athletes, height and weight generally grow proportionally and synchronously. However, the height indicator shows the highest degree of unevenness in Group C, while the weight indicator shows the highest degree of unevenness in Group B. This indicates that the physical development of athletes at this age stage is highly uneven.

4.1.2. Analysis of grip strength in different age groups

As shown in Table 2, there is no significant difference in right-hand grip strength between Group A and Group B athletes. However, a highly significant difference is observed in left-hand grip strength between these two groups. No significant differences are found in bilateral grip strength between Group B and Group C athletes. This suggests that the critical age interval for the development of upper limb strength in adolescents begins around 13-14 years old on the left side, while it occurs later on the right side. Compared to lower limb strength, the critical age interval for upper limb strength development is relatively delayed.

Table 2: Comparison of Grip Strength Indicators in Different Age Groups (Group A n=29, Group B n=37, Group C n=35)

Comparison Groups	Significance (Two-sided)
Group A vs. Group B (Right)	0.064
Group A vs. Group B (Left)	0.006**
Group B vs. Group C (Right)	0.219
Group B vs. Group C (Left)	0.085

4.1.3. Comparison of strength qualities between elite and average athletes in each group

This study compared the lower limb and trunk strength between elite and average athletes in each group. The results are as follows:

As shown in Table 3, elite athletes in Group A significantly outperformed average athletes in the 10-second rope skipping, standing long jump, sit-ups, and plank support tests ($P<0.01$).

Elite athletes in Group B significantly outperformed average athletes in the sit-up test ($P<0.01$) and the plank support test ($P<0.05$) (see Table 4).

Elite athletes in Group C significantly outperformed average athletes in the sit-up and plank support tests ($P<0.05$), with no significant differences in other tests (see Table 5).

The analysis of these results indicates that as the athletes' age increases, the differences in strength quality indicators between elite and average athletes become more pronounced. This is mainly because as the athletes grow older, their strength qualities improve steadily. The significant enhancement of specialized abilities increases the difficulty of competition. Therefore, for older athletes to achieve excellent results, they must build on a foundation of comprehensive development.

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Table 3: Comparison of Strength Qualities in Different Body Parts Between Elite and Average Athletes in Group A (n=29)

Item	Excellent Athletes	Average Athletes
10-second rope skipping (times)	37.00±1.31	28.50±4.52▲▲
Vertical jump (cm)	37.07±3.92	33.86±7.90
Standing long jump (cm)	186.25±14.73	158.00±21.27▲▲
Single-leg forward lift (left) (s)	38.88±3.72	34.81±6.41
Single-leg forward lift (right) (s)	45.25±5.78	39.81±9.73
Sit-ups (times)	11.00±1.77	7.5±1.67▲▲
Trunk backward flexion (times)	9.50±1.60	8.00±1.93
Plank (s)	96.38±6.91	79.37±12.77▲▲

Table 4 Comparison of Strength Qualities in Different Body Parts Between Excellent Athletes and Average Athletes in Group B (n=37)

Item	Excellent Athletes	Average Athletes
10-second rope skipping (times)	32.27±3.72	29.58±3.81
Vertical jump (cm)	30.36±3.72	30.87±4.47
Standing long jump (cm)	158.82±15.44	151.79±15.87
Single-leg forward lift (left) (s)	35.27±5.24	33.33±4.98
Single-leg forward lift (right) (s)	37.91±5.28	37.25±6.19
Sit-ups (times)	8.00±1.18	5.83±1.81▲▲
Trunk backward flexion (times)	6.73±1.01	6.29±1.23
Plank (s)	71.27±17.70	57.67±14.11▲

Table 5 Comparison of Strength Qualities in Different Body Parts Between Excellent Athletes and Average Athletes in Group C (n=35)

Item	Excellent Athletes	Average Athletes
10-second rope skipping (times)	28.41±1.83	27.96±3.37
Vertical jump (cm)	30.02±3.33	26.70±5.79
Standing long jump (cm)	147.58±15.64	136.63±15.70
Single-leg forward lift (left) (s)	22.92±4.03	22.75±4.88
Single-leg forward lift (right) (s)	29.83±5.88	28.75±4.64
Sit-ups (times)	6.08±1.44	5.08±1.38▲
Trunk backward flexion (times)	5.50±1.00	5.08±1.06
Plank (s)	44.92±5.85	37.75±.08▲

4.1.4. Analysis of lower limb strength comparison among different age groups

In this study, the lower limb and trunk strength of athletes from various cities and prefectures who participated in the 12th Sichuan Provincial Games artistic gymnastics competition in 2014 were tested. The test results showed that in the dynamic lower limb tests, Group A athletes had significantly higher scores in the vertical jump and standing long jump compared to Group B. Moreover, the test results of the 10-second rope skipping, standing long jump, and vertical jump for both Group A and Group B athletes were significantly higher than those of Group C athletes (see Table 6).

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In the static lower limb tests, both Group A and Group B athletes performed significantly better in the single-leg forward lift (left and right) compared to Group C. However, there was no significant difference between Group A and Group B in the single-leg forward lift (left).

The dynamic lower limb exercises selected in this study reflect the explosive power of the lower limb muscles, while the static single-leg forward lift exercise reflects lower limb muscle endurance. These results indicate that the explosive power and muscle endurance of the lower limbs of young athletes in Sichuan Province increase with age. There is a significant difference between Group C and Group B athletes. However, compared to Group B, Group A athletes only showed significant differences in the vertical jump and standing long jump, with no significant differences in other aspects. This suggests that the critical period for the development of static lower limb strength in young artistic gymnasts in Sichuan Province is between 8 and 10 years old, and it tends to grow steadily between 11 and 14 years old (see Table 7).

Table 6 Comparison of Dynamic Lower Limb Strength Qualities Among Different Age Groups

Item	Group A (n=29)	Group B (n=37)	Group C (n=35)
10-second rope skipping (times)	31.33±5.53	30.43±3.94	28.05±2.91▲▲★
Vertical jump (cm)	34.93±6.91	30.70±4.20▲▲	28.00±5.36▲▲★
Standing long jump (cm)	167.42±23.37	154.00±15.86▲▲	140.12±16.12▲▲★★

Table 7 Comparison of Static Lower Limb Strength Qualities Among Different Age Groups

Item	Group A (n=29)	Group B (n=37)	Group C (n=35)
Single-leg forward lift (left leg) (s)	36.17±5.90	33.94±5.07	22.89±4.53▲▲★★
Single-leg forward lift (right leg) (s)	41.63±8.88	37.46±5.85	29.35±5.20▲▲★★

4.1.5. Comparative analysis of trunk strength among different age groups

In terms of trunk strength test results, this study selected sit-ups and trunk backward flexion as evaluation indicators. The results showed that Group A athletes had very significant differences in both indicators compared to Groups B and C. In comparison between Group B and Group C, there was a very significant difference in trunk backward flexion and a significant difference in sit-ups. This indicates that among young artistic gymnasts in Sichuan Province, the development of the trunk anterior muscle group, represented by the rectus abdominis, is in a critical period and shows a steady upward trend during the ages of 8 to 14. The strength of the trunk posterior muscle group, represented by the erector spinae, is more sensitive and shows the greatest increase in strength during the ages of 10 to 14 (see Table 8).

Regarding static strength, this study selected the plank as an evaluation indicator. The results showed that Group A athletes had very significant differences compared to Groups B and C, and Group B athletes also had very significant differences compared to Group C. This indicates that among young artistic gymnasts in Sichuan Province, the trunk stability strength is in a sensitive period and shows a gradual upward trend during the ages of 8 to 14 (see Table 9).

Table 8 Comparison of Dynamic Trunk Strength Qualities Among Different Age Groups

Item	Group A (n=29)	Group B (n=37)	Group C (n=35)
Sit-ups (times)	8.67±2.37	6.56±1.90▲▲	5.41±1.46▲▲★
Trunk backward flexion (times)	8.50±1.93	6.42±1.16▲▲	5.22±1.05▲▲★★

Table 9 Comparison of Static Trunk Strength Qualities Among Different Age Groups

Item	Group A (n=29)	Group B (n=37)	Group C (n=35)
Plank (seconds)	85.04±13.71	62.06±16.15▲▲	40.14±6.84▲▲★★

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In summary, it can be concluded that the optimal age range for developing static trunk strength in adolescents is 8 to 14 years old, while the optimal age range for developing dynamic trunk strength is 10 to 14 years old for the lateral and front sides, and 8 to 14 years old for the back side. Overall, these findings are consistent with the general trend of strength development in children and adolescents.

5. Recommendations

Based on the current level of development, the overall direction for the training of rhythmic gymnasts aged 8 to 14 in Sichuan Province should be determined. On this basis, a careful analysis of the required degree of strength qualities should be conducted. Prior to developing training plans, targeted strength quality tests should be carried out for different groups and age stages to identify key areas of strength training (dynamic strength or static strength) and reinforce these areas in phases. Sichuan Province needs to conduct real-time testing and monitoring of the critical age ranges for the development of different strength qualities in rhythmic gymnasts across various age stages, and implement scientifically targeted training.

It is recommended that coaches focus on trunk strength training during the adolescent phase of athletes. Once athletes reach the senior level, the emphasis should shift to comprehensive development with a particular focus on lower limb strength training.

6. Conclusion

This study comprehensively tested and analyzed the strength qualities of rhythmic gymnasts aged 8 to 14 in Sichuan Province, exploring the characteristics and development patterns of strength qualities in the upper limbs, trunk, and lower limbs across different age stages. The results indicate that the development of strength qualities in these gymnasts shows distinct stage-specific features within this age range: The critical period for the development of static lower limb strength occurs earlier, focusing on ages 8 to 10, while dynamic strength develops more stably between ages 11 and 14. Trunk strength (especially static strength) remains in a sensitive development phase throughout the entire 8- to 14-year-old period, with dynamic strength development lagging behind that of the lower limbs. Upper limb strength development is relatively delayed, particularly on the right side, where the critical age range for development is even later.

These findings provide important scientific evidence for the strength training of young rhythmic gymnasts in Sichuan Province. It is recommended that training programs focus on the refined development of strength qualities, especially by implementing targeted intensive training during critical age periods. Coaches should also flexibly adjust training content and intensity based on the specific circumstances of each athlete, emphasizing the integration of comprehensive development and specialized abilities. Moreover, real-time monitoring of athletes' strength development and timely adjustments to training strategies are essential means to enhance training effectiveness.

As a sport highly dependent on strength qualities, the level of training in rhythmic gymnastics is crucial for athletes' competitive performance. Through the in-depth analysis and scientific recommendations of this study, it is believed that strong support can be provided for the development of rhythmic gymnastics in Sichuan Province, promoting the progress of this sport in China. Future research can further explore additional influencing factors to provide more comprehensive theoretical support for the all-around development of rhythmic gymnasts.

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