IMPACTS OF CORE TRAINING ON PHYSICAL TRAINING IN SYNCHRONIZED SWIMMING

IMPACTOS DO TREINO DO CORE SOBRE O TREINAMENTO FÍSICO DE FORMAÇÃO NO NADO SINCRONIZADO

IMPACTO DEL ENTRENAMIENTO DEL CORE EN LA PREPARACIÓN FÍSICA DE FORMACIÓN EN LA NATACIÓN SINCRONIZADA

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ABSTRACT

Introduction: Synchronized swimming is a sport of artistic expression, skill, and physical fitness. Explosive, high-intensity movements rely mainly on the athlete's good basal strength. Although China attaches great importance to the physical training of synchronized swimming athletes, there is no theoretical achievement in consolidating specific training. Objective: To analyze the impact of CORE strengthening on the physical training of synchronized swimming athletes. Methods: This article selects 30 synchronized swimmers as volunteers for the research. A basal metabolism test was used to verify the maximal oxygen consumption (VO2max), ventilatory anaerobic threshold (VT), and other indicators. The isokinetic force measurement system measured the athletes' maximum lumbar-abdominal muscle flexion/extension torque, explosive strength, fast muscle strength capacity, total work, and anti-fatigue capacity. Results: The synchronized limb training results of the swimming team were positively correlated with the stability of the CORE muscles. There is a positive relationship between 30 years old and maximal strength training and performance in athletes. Abdominal muscular endurance showed the highest correlation coefficient with synchronized swimming performance. Conclusion: Coaches should organize adequate strength training according to the growth and development characteristics of athletes and the characteristics of synchronized swimming movements. In this way, an excellent physical training effect can be achieved by CORE training. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Resistance Training; Swimming; Physical Conditioning, Human; Athletes; Sports.

RESUMO

Introdução: O nado sincronizado é um esporte de expressão artística, habilidade e aptidão física. Movimentos explosivos, de alta intensidade, dependem principalmente da boa força basal do atleta. Embora a China atribua grande importância ao treinamento físico de atletas do nado sincronizado, não há conquista teórica na consolidação de um treinamento específico. Objetivo: Analisar o impacto da aplicação do fortalecimento do core sobre o treinamento físico de atletas do nado sincronizado. Métodos: Este artigo seleciona 30 nadadores sincronizados como voluntários para a pesquisa. Um teste de metabolismo basal foi utilizado para verificar o consumo máximo de oxigênio (VO2max), o limiar anaeróbico ventilatório (VT) e outros indicadores. Utilizou-se o sistema de medição de força isocinética para medir o torque máximo de flexão/extensão muscular lombar-abdominal dos atletas, força explosiva, capacidade de força rápida muscular, trabalho total e capacidade anti-fadiga. Resultados: Os resultados de treinamento dos membros sincronizados da equipe de natação foram positivamente correlacionados com a estabilidade dos músculos do core. Há uma relação positiva entre os 30 anos de idade e o melhor desempenho no treinamento de força máxima em atletas. A resistência muscular abdominal apresentou o maior coeficiente de correlação com desempenho sincronizado de natação. Conclusão: Os treinadores devem organizar o treinamento de força adequado de acordo com as características de crescimento e desenvolvimento dos atletas e as características dos movimentos sincronizados de natação. Desta forma, um excelente efeito de treinamento físico pode ser alcançado pelo treino do core. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

***Descritores*:** *Treinamento de Força; Natação; Condicionamento Físico Humano; Atletas; Esportes.*

RESUMEN

Introducción: La natación sincronizada es un deporte de expresión artística, de habilidad y de condición física. Los movimientos explosivos y de alta intensidad dependen principalmente de la buena fuerza basal del deportista. Aunque China atribuye una gran importancia a la preparación física de las atletas de natación sincronizada, no existe ningún logro teórico en la consolidación de un entrenamiento específico. Objetivo: Analizar el impacto de la aplicación del fortalecimiento del core en la preparación física de las atletas de natación sincronizada. Métodos: En este artículo se seleccionan 30 nadadores de sincronizados como voluntarios para la investigación. Se utilizó una prueba de metabolismo basal para verificar el consumo máximo de oxígeno (VO2max), el umbral anaeróbico ventilatorio (VT) y otros indicadores. Fue aplicado el sistema de medición de la fuerza isocinética para medir el par máximo de flexión/extensión de los músculos lumbares-abdominales de los atletas, la fuerza explosiva, la capacidad

de fuerza muscular rápida, el trabajo total y la capacidad antifatiga. Resultados: Los resultados del entrenamiento de las extremidades sincronizadas del equipo de natación se correlacionaron positivamente con la estabilidad de los músculos del core. Existe una relación positiva entre los 30 años de edad y la fuerza máxima de entrenamiento y el rendimiento en los atletas. La resistencia muscular abdominal mostró el mayor coeficiente de correlación con el rendimiento de la natación sincronizada. Conclusión: Los entrenadores deben organizar un entrenamiento de fuerza adecuado en función de las características de crecimiento y desarrollo de los deportistas y de las características de los movimientos de la natación sincronizada. De este modo, se puede conseguir un excelente efecto de entrenamiento físico entrenando el core. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Entrenamiento de Fuerza; Natación; Acondicionamiento Físico Humano; Atletas; Deportes.*

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INTRODUCTION

Synchronized swimming requires athletes to master a full range of skills. Athletes bring visual enjoyment to the audience by showing the strength and beauty of their limbs and the voluptuous beauty of their postures. China's synchronized swimming skills are more than enough, but not enough ornamental. Although China attaches great importance to the physical training of synchronized swimmers, there is no theoretical achievement in consolidating training.[1] This has led to the rapid development of practical training in China but the slower development of theoretical research. Synchronized swimming techniques are constantly being updated. Coaches only use the previous single training method and can not meet the needs of the competition. We need to promote the progress of synchronized swimming in China by updating physical training methods.

METHOD

Test objects

We selected 30 synchronized swimming team athletes as research subjects. During the winter training period from November 2020 to February 2021, we used the energy metabolism tester to test the athletes' maximal oxygen consumption (VO2max), ventilation anaerobic threshold (VT), and other indicators.[2] We use the isokinetic force measurement system to measure the athletes' lumbar and abdominal muscle flexion/extension maximum torque, explosive force, quick start ability, total work, anti-fatigue ability, and other indicators.

Swimming water resistance and posture dynamic modeling optimization simulation

This paper takes the athlete's arm stroke as an example to analyze the athlete's force in the water.[3] The athlete swims forward in direction V. Its resistance to water is R. We decompose the water resistance into the lift L perpendicular to the forward direction and the backward water resistance D. The sum of the lift and water resistance projections in the forward direction. F is the driving force for swimming. Its formula is as follows

$$D = \frac{1}{2} C_D \rho A V^2 \quad (1)$$

$$L = \frac{1}{2} C_L \rho A V^2 \quad (2)$$

C_D is the coefficient of water resistance. C_L is the coefficient of water lift. A is the frontal projected area opposite to the water. It is related to the swimming posture of the athlete. V is the stroke speed of the athlete. ρ is the density of water.

There is no need for a code of ethics for this type of study.

RESULTS

Speed quality

Only a few of China's 30 synchronized swimmers can reach the standard in 50m freestyle, 50m breaststroke, 50m butterfly, or 50m backstroke training. (Table 1) There is a big gap between China's synchronized swimming speed and the world team.[4] There is a big gap between the national synchronized swimmers in 50m freestyle, 400m freestyle, 200m medley, and other sports and the top 30 national swimmers. (Table 2)

Endurance quality

The average performance of Chinese synchronized swimmers in the 400m freestyle is 5min5.37s. The average result of the 200m medley is 2min30.5s. Only 42.8% of Chinese synchronized swimmers reached this

Table 1. National synchronized swimmers' results on land, water, and special tests.

Land test results	Standing forward flexion (cm)	19.402±3.47
	Rib Leg Raise (n/15s)	13.902±2.952
	High Leg Raise (n/30s)	125.55±9.75
	Pull-ups (n)	9.510±4.354
	Alternate legs for the single bar (n/15s)	47.293±5.359
	Handstand(s)	3.32±2.573
	Round trip (10m×0)	29.507±1.233
Water test score(s)	25m self-elevating	19.52±0.953
	50m butterfly	32.995±1.434
	50m backstroke	35.109±1.549
	50m breaststroke	40.445±1.72
	50m freestyle	30.52±1.159
	200m mix	150.502±5.099
	400m freestyle	305.373±11.099
Special test score(s)	25m breaststroke leg	23.215±1.133
	25m torpedo	23.295±1.40
	15m Crane March	27.293±2.959
	25m treading water	44.522±5.445
	15m head to ballet	24.254±2.907
	100m special	124.923±4.799
	300m special	515.19±22.254

Table 2. Comparison of the average swimming performance of national synchronized swimmers and swimmers (s).

	50m freestyle	200m Medley	400m freestyle
National synchronized swimmer	30.52	150.502	305.373
2020 National Top 30 Swimmers	26.873	130.738	261.728
Top 8 in 2021 National Swimming Championships	28.868	160.808	318.038

standard in the post-winter training test at the end of 2021. This shows a more significant gap between China's synchronized swimming's middle and long-distance endurance events and the world's top teams.

Strength and quality

Push-ups reflect the strength of the human body's upper limbs, shoulders, and back muscles and the ability to work continuously. This is also one of the essential contents of strength training. This paper shows that the strength of the back muscles and abdominal muscles of Chinese synchronized swimmers is equivalent to the value of the maximum slow torque of the waist measurement by the isokinetic force measurement system.[5] Athletes are at a moderately weak level. Two of the 30 athletes tested had extremely unbalanced development of the low back muscles. Eight people develop unevenly. The strength and control of the lower back muscles in synchronized swimmers are essential indicators of ability. Unbalanced development of the back muscles can easily lead to low back injuries. This adversely affects training.

Synchronized swimming performance is closely related to muscle strength. The strength of elbow and knee joints is significant for synchronized swimmers. Muscle strength has a decisive impact on their water height.[6] Abdominal strength is also an essential requirement for maintaining various vertical postures when out of the water. Among the correlation coefficients between elbow, knee, waist, abdominal muscle strength, and performance, the correlation coefficient between abdominal muscle endurance and synchronized swimming performance is the highest. Improving abdominal muscle endurance is beneficial for improving performance and preventing low back pain and other injuries. (Table 3)

Aerobic capacity

The maximum oxygen uptake of the Chinese synchronized swimmer youth team was 41.49ml/min·kg. We measured the maximal oxygen uptake, anaerobic threshold, and respiratory quotient of 30 athletes to analyze their cardiorespiratory function of the athletes. The study found that 8 out of 14 athletes in the group under 18 years old had a better comprehensive evaluation.[7] Their relative VO2max values exceeded 45ml/min·kg. Six athletes performed poorly. Their relative VO2 max was lower than 35ml/min·kg. None of the 16 athletes in the senior group was in the excellent range. (Table 4)

Lactic acid tolerance

The blood lactate level is still high immediately after the synchronized swimming double or team event. The athlete's lactate tolerance is essential to the synchronized swimming event itself. We improve the athlete's lactate tolerance while maintaining aerobic capacity—correlation between peak lactate and performance in athletes' 30s maximal strength treadmill. We consider the synchronized swimming set to be an intermittent exercise. The maximal-intensity exercise lasted only a few seconds before transitioning to low-intensity exercise. (Table 5) Previous studies have found that intermittent exercise only accounts for a smaller fraction of the energy from the lactic acid system. Synchronized swimmers mainly use the ATP-CP system for energy when they complete high-intensity explosive sports in technical or free choice. The anaerobic capacity of the ATP-CP system contributes more to success than the lactate system. Some scholars pointed out that the regeneration of ATP mainly comes from CP's degradation and oxidative metabolism. The peak blood lactate of Russian synchronized swimmers was 8.5±1.6mmol/L. These results suggest that the Russian elite synchronized swimmers have strong aerobic metabolism and lactic acid scavenging ability.[8] A high level of aerobic capacity in synchronized swimmers is beneficial for delaying fatigue and maintaining technical precision.

Table 3. Abdominal endurance improves exercise-preventive lowback pain injury test results during major competitions.

Slow maximum torque (NM/kg)		Slow Max Power (W/kg)	
Bend	Stretch	Bend	Stretch
2.888±0.44	2.841±0.624	1.678±0.856	1.871±0.704

Table 4. Waist isokinetic test results of national synchronized swimmers.

Average endurance torque (Nm/kg)		Output power (W/kg)		Fast and slow torque ratio	
Bend	Stretch	Bend	Stretch	Bend	Stretch
1.940±1.099	2.994±0.522	0.176±0.694	3.095±0.544	2.623±2.165	1.014±0.179

Table 5. Peak blood lactate levels in synchronized swimmers after different forms of exercise.

Content	Blood lactate value (mmol/L)
5min treading water	8.21
Double	8.66
Collective free choice	10.33
Collective technology optional	12.14
200m Medley	14.17
100m special	14.54

DISCUSSION

Synchronized swimming is a diversified sports competition. Project techniques include paddling, stepping, propulsion, lifting, and flexibility. Changes in the rules of synchronized swimming have higher requirements on athletes' physical fitness. According to the length of the optional competition, synchronized swimming is an aerobic energy-supplying sport. Many movements require instant bursts of power to complete the complete set of optional movements.[9] The underwater running formation and leg movements need to be completed by holding your breath in the water. It also requires anaerobic energy.

Strength and quality

The longest time required for a set of synchronized swimmers is nearly 4 minutes. Many of the movements in this series require instantaneous power and explosiveness. It can be seen from these actions that synchronized swimming is a sport that requires overall athletic qualities. The strength required by synchronized swimmers is mainly manifested in five body parts: upper limbs, waist, abdomen, buttocks, and legs.[10] Athletes especially need core strength in the lower back and abdomen. There are many basic movements and postures performed in water that are inverted. This requires the athlete to have a strong core. Athletes also need a strong core for treading, spinning, and leg movements. Muscular core stabilization ensures accurate movement and smooth high water. Swimmers with a strong core can often perform a variety of high-quality leg movements in the water. When designing a physical training plan, coaches must pay attention to the intensity load of upper body strength. This ensures that the athlete has muscular upper body strength in the water.

Coordination and agility

Difficult-to-beauty sports groups have relatively high requirements for visual effects. Coordinated and smooth movements can give a visual aesthetic. Athletes must be able to combine optional movements with music and perform the entire optional movement with good coordination. Athletes need to have balance. Synchronized swimmers need to have a strong sense of balance. Balance is the essential ability to coordinate quality. We have to develop athlete coordination. The development of coordination quality in synchronized swimming is not

limited to improving the coordination of athletes' physical movements but also includes the development of the coordination of athletes' nerves and muscles.

CONCLUSION

Coaches should carry out targeted training according to the fundamental strength of outstanding synchronized swimmers. We need to educate athletes about the basics of physical training. Athletes need to dare to train hard. Coaches need to strengthen psychological counseling and ideological guidance for athletes to improve training results. Athletes need training that strengthens core stability. This can improve the balance of athletes. Based on basic training and load training, coaches improve core stability strength training difficulty. Athletes need to use sports equipment such as balance discs to improve stability and power. Coaches need to build professional test profiles of athletes. The coach conducts regular inspections according to the physical fitness of the athletes and carefully and objectively records the particular physical fitness test data.

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