# IMPACTS OF RESISTANCE EXERCISE ON PERFORMANCE IN SWIMMERS

*IMPACTOS DO EXERCÍCIO DE RESISTÊNCIA SOBRE O DESEMPENHO EM NADADORES*

*IMPACTO DEL EJERCICIO DE RESISTENCIA EN EL RENDIMIENTO DE NADADORES*

**Original Article**
***Artigo Original***
***Artículo Original***

Yufeng Zhou[1]
(Physical Education Professional)

1. Public Foundation Department of Jiangsu College of Nursing, Huaian, Jiangsu, China.

**Correspondence:**
Yufeng Zhou
Huaian, Jiangsu, China. 223005.
zhouyufengsci@163.com

## ABSTRACT

Introduction: The need for strength of the lower limbs to provide absolute speed in competitive-level swimmers requires methodological and evidence-based training. Resistance training is an effective way to increase muscle strength and it is believed that it can be adapted to benefit swimmers. Objective: Study the impacts of lower-limb resistance exercise on the sport performance of swimming athletes. Methods: Twelve volunteer athletes were selected for the experiment, randomly divided between experimental and control groups. There was no significant difference between the two groups. The experimental group received intervention with lower limb resistance training, while the control continued with routine physical training. Results: The thigh circumference of the experimental group increased from 56.01±5.40 cm to 57.14±5.06 cm; the Dive angle decreased from 44.85±6.74 to 43.23±7.71; the Entry distance increased from 3.51±0.36 m to 3.69±0.39 m; flight time was reduced from 0.33±0.05 s to 0.31±0.07 s; freestyle performance was reduced from 28.90±2.40 s to 27.18±2.72 s. Conclusion: The training with resistance exercise in the lower limbs showed evident improvements in the swimmers' physical performance, besides the evident gain of muscle mass. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

**Keywords:** Training, Endurance; Lower Limbs; Swimming; Athletes; Evaluation of the Efficacy-Effectiveness of Interventions.

## *RESUMO*

*Introdução: A necessidade de força dos membros inferiores para proporcionar velocidade absoluta na natação dos esportistas de nível competitivo exige treinamentos metodológicos e embasados em evidências. O treinamento de resistência é uma maneira eficaz de aumentar a força muscular e acredita-se que ele possa ser adaptado para beneficiar os nadadores. Objetivo: Estudar os impactos do exercício de resistência de membros inferiores sobre o desempenho esportivo dos atletas de natação. Métodos: Foram selecionados 12 atletas voluntários para o experimento, divididos aleatoriamente entre grupo experimental e controle. Não houve diferença significativa entre os dois grupos. O grupo experimental recebeu intervenção com treinamento de resistência dos membros inferiores, enquanto o controle prosseguiu com o treinamento físico rotineiro. Resultados: A circunferência da coxa do grupo experimental aumentou de 56,01±5,40 cm para 57,14±5,06 cm; o ângulo de mergulho diminuiu de 44,85±6,74 para 43,23±7,71; a distância de entrada foi aumentada de 3,51±0,36 m para 3,69±0,39 m; o tempo de voo foi reduzido de 0,33±0,05 s para 0,31±0,07 s; o desempenho no estilo livre foi reduzido de 28,90±2,40 s para 27,18±2,72 s. Conclusão: O treinamento com exercício de resistência nos membros inferiores mostrou evidentes melhoras sobre o desempenho físico dos nadadores, além do evidente ganho de massa muscular.* ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

***Descritores:*** *Treinamento de Resistência; Membros Inferiores; Natação; Atletas; Avaliação de Eficácia-Efetividade de Intervenções.*

## *RESUMEN*

*Introducción: La necesidad de fuerza de los miembros inferiores para proporcionar velocidad absoluta en la natación de los atletas de nivel competitivo requiere un entrenamiento metodológico y basado en la evidencia. El entrenamiento de resistencia es una forma eficaz de aumentar la fuerza muscular y se cree que puede adaptarse para beneficiar a los nadadores. Objetivo: Estudiar el impacto del ejercicio de resistencia de las extremidades inferiores en el rendimiento deportivo de los atletas de natación. Métodos: Se seleccionaron 12 atletas voluntarios para el experimento, divididos aleatoriamente entre los grupos experimental y de control. No hubo diferencias significativas entre los dos grupos. El grupo experimental recibió intervención con entrenamiento de resistencia de miembros inferiores, mientras que el control continuó con entrenamiento físico rutinario. Resultados: La circunferencia del muslo del grupo experimental aumentó de 56,01±5,40 cm a 57,14±5,06 cm; el ángulo de inmersión disminuyó de 44,85±6,74 a 43,23±7,71; la distancia de entrada aumentó de 3,51±0,36 m a 3,69±0,39 m; el tiempo de vuelo se redujo de 0,33±0,05 s a 0,31±0,07 s; el rendimiento en estilo libre se redujo de 28,90±2,40 s a 27,18±2,72 s. Conclusión: El entrenamiento con ejercicios de resistencia*

CC BY

*en los miembros inferiores mostró mejoras indiscutibles en el rendimiento físico de los nadadores, además de la evidente ganancia de masa muscular.* ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

***Descriptores:*** *Entrenamiento de Resistencia; Extremidades Inferiores; Natación; Atletas; Evaluación de Eficacia-Efectividad de Intervenciones.*

DOI: http://dx.doi.org/10.1590/1517-8692202329012023_0083 Article received on 02/09/2023 accepted on 02/16/2023

## INTRODUCTION

Swimming mainly depends on the swing of the limbs, and the lower limbs are the main source of strength of the limbs in the water.[1] The balance and swimming in the water environment are realized through the action of the lower limbs beating and kicking on the water, while maintaining a high body position. And good kick is also an important factor to reduce resistance in water. Previous studies have shown that resistance training is an effective way to increase the physical muscle strength of athletes, and has a certain impact on improving the overall physical quality and sports performance.[2] Lower limb resistance training is a training method that focuses on the lower limb muscles of the body. It has a significant effect on transferring the core muscle group and enhancing the lower limb muscle strength and body balance ability.[3] In the process of lower limb resistance training, the tensile strength of muscles and ligaments can be effectively expanded by resisting the resistance brought by sports equipment. Resistance exercise with appropriate resistance and frequency can increase the cross-sectional area of muscle fibers, thus achieving the effect of shaping.[4] At the same time, the resistance training of the lower limbs will also exercise the muscles of the whole body except the muscles of the lower limbs, and also have a certain impact on the cardiopulmonary function.[5] According to the characteristics of swimming, combined with the professional needs of swimming, this study designed and conducted a control experiment with lower limb resistance training as a variable.[6] By studying the relevant effects of lower limb resistance training on athletes, some suggestions are provided to better improve the performance level of athletes.

## METHOD

### Research object

According to the purpose of the experiment and the research method, this paper chooses the method of control experiment to carry out the relevant research. The subjects were selected from a swimming club in a city, and the athletes aged between 16 and 20 were randomly selected for investigation. The study and all the participants were reviewed and approved by Ethics Committee of Jiangsu College of Nursing (JSCN2289SR). In order to ensure the accuracy of the final experimental results, after sorting out the basic information, 12 athletes were selected to carry out the experiment, excluding the athletes who could not participate in the experiment for various reasons. 12 athletes were randomly divided into experimental group and control group. See Table 1 for the basic information of the age, height, weight and training years of the two groups of subjects.

### Experimental ideas

The experiment lasted for 8 weeks. During the 8-week training period, all subjects were given the same swimming skill training and training warm-up and relaxation exercises. The difference was only when the experimental group received the intervention training of lower limb resistance movement, while the control group received the basic physical training according to the previous swimming training. The resistance movement of lower limbs mainly includes dumbbell squat, dumbbell step climbing and elastic lunge walking. Focus on training the gluteus, quadriceps and hamstring muscles of the athletes in the experimental group. The exercise frequency of the two groups of athletes remained the same. They trained once a day on Monday, Tuesday, Thursday and Friday, with a training duration of 2 hours, including warm-up exercise before training and stretching exercise after training.

**Table 1.** Sorting out the basic situation of swimmers in this paper.

| Experience group | Age | Height | Weight | Training duration |
|---|---|---|---|---|
| 1 | 18.525 | 188.13 | 80.806 | 5.44 |
| 2 | 19.535 | 193.221 | 76.21 | 6.041 |
| 3 | 17.584 | 188.442 | 71.473 | 5.708 |
| 4 | 18.827 | 194.325 | 68.9 | 6.574 |
| 5 | 16.962 | 181.663 | 77.47 | 6.357 |
| 6 | 16.998 | 181.819 | 82.235 | 5.857 |
| Summary | 18.10±1.505 | 185.64±10.006 | 74.94±10.734 | 5.78±0.851 |
| **Control group** | **Age** | **Height** | **Weight** | **Training duration** |
| 1 | 18.023 | 180.268 | 62.948 | 6.223 |
| 2 | 20.377 | 182.708 | 76.981 | 5.877 |
| 3 | 18.73 | 175.766 | 75.246 | 5.106 |
| 4 | 17.293 | 179.271 | 64.344 | 5.029 |
| 5 | 20.406 | 173.851 | 69.99 | 5.792 |
| 6 | 19.595 | 178.81 | 69.075 | 5.517 |
| Summary | 18.84±2.292 | 178.60±7.483 | 70.82±10.755 | 5.69±0.885 |

The experimental equipment used in this experiment mainly includes FMS test kit, electronic scale, tape measure, stopwatch, camera and tripod. The experimental equipment used in the exercise process mainly includes dumbbells, steps and yoga mats for lower limb resistance training in the experimental group. All tests and training are conducted in the swimming pool and gymnasium of the club.

## RESULTS

### Improvement of swimmers' physical quality through lower limb resistance exercise

First of all, by analyzing the changes of swimmers' lower limb circumference, the effect of lower limb resistance exercise on the improvement of swimmers' physical quality is explored. The results are shown in Table 2.

The data in Table 2 shows that after 8 weeks of lower limb resistance training, the thigh dimensions of the tested athletes in the experimental group changed significantly. The thigh circumference increased from 56.01 ± 5.406cm before training to 57.14 ± 5.060cm after training; The change of calf circumference was not obvious, only a small range was reduced, from 37.58 ± 3.700cm before the test to 37.21 ± 3.346cm after the training. The change in the control group was more obvious, and the trend was opposite to that in the experimental group. The thigh circumference decreased from 57.22 ± 6.340 cm before training to 56.20 ± 6.125 cm after training; The calf circumference increased from 37.74 ± 3.594cm before the test to 38.60 ± 3.510cm after training.

**Table 2.** Effect of lower limb resistance exercise on swimmers' lower limb circumference.

| Experience group | Thigh circumference before experiment cm | Thigh circumference after experiment cm | Calf circumference before experiment cm | Calf circumference after experiment cm |
|---|---|---|---|---|
| 1 | 50.645 | 61.062 | 38.54 | 34.264 |
| 2 | 51.693 | 61.474 | 37.044 | 36.319 |
| 3 | 51.462 | 56.956 | 34.877 | 40.013 |
| 4 | 52.257 | 58.596 | 34.69 | 34.195 |
| 5 | 59.157 | 53.422 | 34.997 | 35.087 |
| 6 | 60.992 | 62.174 | 41.193 | 35.772 |
| Summary | 56.01±5.406 | 57.14±5.060 | 37.58±3.700 | 37.21±3.346 |
| **Control group** | **Thigh circumference before experiment cm** | **Thigh circumference after experiment cm** | **Calf circumference before experiment cm** | **Calf circumference after experiment cm** |
| 1 | 54.162 | 56.391 | 38.575 | 39.731 |
| 2 | 50.97 | 61.619 | 39.864 | 40.813 |
| 3 | 55.476 | 53.761 | 36.976 | 40.859 |
| 4 | 54.462 | 61.15 | 36.974 | 39.203 |
| 5 | 59.139 | 59.814 | 40.117 | 40.381 |
| 6 | 63.302 | 61.817 | 39.061 | 35.358 |
| Summary | 57.22±6.340 | 56.20±6.125 | 37.74±3.594 | 38.60±3.510 |

## Improvement of swimmers' movement skills through lower limb resistance exercise

After testing the changes of swimmers' movement skills, the data of each index are shown in Table 3, Table 4 and Table 5.

The data in Table 3 shows the impact of lower limb resistance exercise on distance indicators of swimmers.

It can be seen from the data in Table 3 that the water entry distance of the experimental group shows an increasing trend after training, compared with the control group, there is no significant change. The water entry distance of the experimental group was increased from 3.51 ± 0.366m before training to 3.69 ± 0.398m after training, and the sliding distance was increased from 11.34 ± 1.316m before training to 11.60 ± 1.367m after training. Since the lower limb resistance training will improve the strength of the lower limb muscles, the water entry distance and sliding distance largely depend on the explosive force of the swimmer when kicking, the lower limb resistance training has obvious effect on the improvement of the water entry distance and sliding distance of the swimmer.

In addition, the angle indicators of swimmers are measured, and the results are shown in Table 4.

The take-off angle and entry angle of swimmers are the important factors that affect the glide speed of swimmers. The smaller the angle of taking off and entering the water, the easier it is for athletes to start swimming. It can be seen from Table 4 that after training, the takeoff angle of the experimental group changed slightly, only slightly, but the water entry angle changed greatly, from 44.85 ± 6.747 before training to 43.23 ± 7.717 after training. In contrast, the two indicators in the control group did not change significantly.

The measurement results of the time indicators of the tested athletes are shown in Table 5.

As can be seen from the data in Table 5, after 8 weeks of training, the flight time of the experimental group changed greatly, from 0.334 ± 0.0598s before training to 0.319 ± 0.0709s after training. The departure time changed little, only the mean value decreased slightly, from 0.587 ± 0.0407s before training to 0.579 ± 0.0497s after training. The departure time of the control group did not change significantly, but the flight time increased to a certain extent, from 0.328 ± 0.0304s before training to 0.346 ± 0.0298s after training.

**Table 3.** The Effect of Resistance Exercise of Lower Extremities on Distance Index of Swimmers.

| Experience group | Water inlet distance before test m | Water entry distance after test m | Sliding distance before test m | Sliding distance after test m |
|---|---|---|---|---|
| 1 | 3.853 | 3.78 | 12.548 | 12.667 |
| 2 | 3.595 | 3.722 | 11.425 | 11.038 |
| 3 | 3.602 | 3.982 | 10.642 | 11.579 |
| 4 | 3.563 | 4.001 | 10.447 | 11.744 |
| 5 | 3.305 | 3.788 | 11.8 | 10.612 |
| 6 | 3.395 | 3.92 | 10.762 | 10.453 |
| Summary | 3.51±0.366 | 3.69±0.398 | 11.34±1.316 | 11.60±1.367 |
| **Control group** | **Water inlet distance before test m** | **Water entry distance after test m** | **Sliding distance before test m** | **Sliding distance after test m** |
| 1 | 3.838 | 3.798 | 12.175 | 11.884 |
| 2 | 3.838 | 3.446 | 12.281 | 11.209 |
| 3 | 3.516 | 3.067 | 11.68 | 12.375 |
| 4 | 3.778 | 3.814 | 13.109 | 13.362 |
| 5 | 3.659 | 3.717 | 12.742 | 11.612 |
| 6 | 3.489 | 3.85 | 12.614 | 11.469 |
| Summary | 3.56±0.409 | 3.50±0.457 | 12.02±1.570 | 12.08±1.641 |

**Table 4.** Influence of lower limb resistance exercise on swimmers' angle index.

| Experience group | Take-off angle before experiment | Post-test take-off angle | Water inlet angle before experiment | Water inlet angle after test |
|---|---|---|---|---|
| 1 | 31.644 | 29.828 | 40.239 | 44.848 |
| 2 | 34.193 | 33.619 | 39.963 | 49.505 |
| 3 | 30.548 | 29.334 | 48.074 | 35.8 |
| 4 | 35.435 | 36.609 | 39.248 | 41.838 |
| 5 | 32.32 | 35.319 | 42.59 | 43.433 |
| 6 | 32.369 | 35.361 | 46.805 | 38.621 |
| Summary | 33.36±4.361 | 33.34±4.297 | 44.85±6.747 | 43.23±7.717 |
| **Control group** | **Take-off angle before experiment** | **Post-test take-off angle** | **Water inlet angle before experiment** | **Water inlet angle after test** |
| 1 | 37.516 | 34.64 | 50.054 | 47.604 |
| 2 | 34.867 | 35.913 | 41.82 | 43.063 |
| 3 | 42.804 | 40.014 | 46.38 | 50.765 |
| 4 | 39.599 | 34.485 | 46.048 | 40.019 |
| 5 | 41.34 | 33.434 | 41.906 | 49.06 |
| 6 | 38.44 | 41.607 | 49.978 | 42.05 |
| Summary | 37.68±6.020 | 37.40±4.646 | 44.72±5.742 | 44.99±5.859 |

## Improvement of swimmers' performance level by lower limb resistance exercise

In addition to testing the movement skills of the tested athletes, a comparative analysis of the performance level of the tested athletes was carried out, and the results are shown in Table 6.

The data in Table 6 shows that resistance training and general physical training can improve athletes' performance to a certain extent. However, there will be certain differences according to the athletes themselves and the different sports. Therefore, the two can be organically combined during training to maximize the overall performance of athletes.

## DISCUSSION

The change of body composition is mainly reflected in the change of skeletal muscle mass. Resistance training usually has a positive effect on the enhancement of muscle strength and circumference, which is mainly reflected in the increase of the cross section volume of single muscle cell and whole muscle due to the increase of the number and

**Table 5.** Influence of lower limb resistance exercise on swimmers' time index.

| Experience group | Departure time before experiment s | Departure time after experiment s | Flight time before experiment s | Flight time after experiment s |
|---|---|---|---|---|
| 1 | 0.5964 | 0.6244 | 0.3566 | 0.2779 |
| 2 | 0.5718 | 0.5336 | 0.2932 | 0.2489 |
| 3 | 0.576 | 0.5633 | 0.3792 | 0.2959 |
| 4 | 0.5894 | 0.5956 | 0.3261 | 0.2611 |
| 5 | 0.5698 | 0.5332 | 0.3557 | 0.3209 |
| 6 | 0.5562 | 0.5827 | 0.3273 | 0.2737 |
| Summary | 0.587±0.0407 | 0.579±0.0497 | 0.334±0.0598 | 0.319±0.0709 |
| **Control group** | **Departure time before experiment s** | **Departure time after experiment s** | **Flight time before experiment s** | **Flight time after experiment s** |
| 1 | 0.5583 | 0.5458 | 0.3219 | 0.3664 |
| 2 | 0.5476 | 0.5902 | 0.3263 | 0.375 |
| 3 | 0.5701 | 0.5708 | 0.3384 | 0.3285 |
| 4 | 0.5825 | 0.5279 | 0.3005 | 0.3221 |
| 5 | 0.5687 | 0.5744 | 0.3334 | 0.3228 |
| 6 | 0.5633 | 0.5838 | 0.3265 | 0.3588 |
| Summary | 0.567±0.0299 | 0.568±0.0407 | 0.328±0.0304 | 0.346±0.0298 |

**Table 6.** Influence of lower limb resistance exercise on the 50m performance level of swimmers.

| Experience group | Pre-experiment breaststroke s | Post-experiment breaststroke s | Pre-experiment freestyle s | After experiment freestyle s |
|---|---|---|---|---|
| 1 | 36.4455 | 34.5562 | 29.1774 | 28.5498 |
| 2 | 35.8255 | 36.1025 | 29.4683 | 29.3168 |
| 3 | 34.3643 | 35.1104 | 28.6887 | 24.4808 |
| 4 | 36.9192 | 34.7137 | 30.3757 | 26.0671 |
| 5 | 34.7533 | 34.5059 | 27.1722 | 28.7422 |
| 6 | 36.1673 | 35.1041 | 30.0114 | 29.0862 |
| Summary | 35.798±1.6389 | 35.456±1.0484 | 28.905±2.4050 | 27.189±2.7200 |
| **Control group** | **Pre-experiment breaststroke s** | **Post-experiment breaststroke s** | **Pre-experiment freestyle s** | **After experiment freestyle s** |
| 1 | 35.9835 | 35.11 | 28.0072 | 29.3515 |
| 2 | 36.0333 | 35.2448 | 28.0773 | 27.8149 |
| 3 | 35.8799 | 35.2489 | 28.2988 | 27.8871 |
| 4 | 36.1791 | 35.0248 | 28.1457 | 29.0709 |
| 5 | 36.0744 | 35.1683 | 28.3467 | 28.944 |
| 6 | 36.23 | 35.1647 | 28.2129 | 28.3277 |
| Summary | 36.081±0.2123 | 35.142±0.1230 | 28.265±0.2603 | 28.464±0.9071 |

dimension of myofibrils. In this study, the changes of swimming related indexes after 8-week lower limb resistance training intervention were proved and compared. Previous studies have shown that compared with single-mode resistance training, muscles are more adaptable to multi-mode resistance training combined with high resistance and low resistance training. At the same time, the intervention time, training intensity and method will have different effects on the body muscles. At the same time, the benefits of aerobic training are less than those of pressure resistance training, but pressure aerobic training can actually increase cell swelling, metabolic stress and energy consumption. It can be seen that both resistance training and aerobic training are beneficial to the growth of muscles and athletes. The above two methods can be combined in actual sports training.

## CONCLUSION

This paper mainly discusses the effect of lower limb resistance training on the performance of young swimmers. In the process, expert interviews, literature review, experimental methods and mathematical statistics were used to summarize and analyze the results of the impact of lower limb resistance training on the useful performance of young athletes, explore the impact and differences of traditional training methods and lower limb resistance training on the performance of swimmers, and provide new ideas for the improvement of scientific training of swimmers. According to the results of 8-week training, it can be concluded that lower limb resistance training can improve the thigh circumference of swimmers, improve the angle of takeoff and entry, reduce flight time, and improve freestyle performance. However, there are differences in the degree of influence of different swimming styles, and even in some cases, there are deficiencies compared with traditional training methods. Therefore, lower limb resistance training and traditional physical training should not exist separately, but should complement each other and play a role together. Lower limb resistance training exists as a new element in the training content and plan formulation of swimmers. The unique training actions and the use of new training equipment in the process can better cultivate athletes' special skills and ultimately improve sports performance.

The author declare no potential conflict of interest related to this article

**AUTHORS' CONTRIBUTIONS:** The author has completed the writing of the article or the critical review of its knowledge content. This paper can be used as the final draft of the manuscript. Every author has made an important contribution to this manuscript. Yufeng Zhou: writing and execution.

## REFERENCES

1. Hemelrijk CK, Reid DAP, Hildenbrandt H, Padding JT. The increased efficiency of fish swimming in a school. Fish Fish (Oxf). 2015;16(3):511-21.
2. Westcott WL. Resistance training is medicine: effects of strength training on health. Curr Sports Med Rep. 2012;11(4):209-16.
3. Chen Y, Niu M, Zhang X, Qian H, Xie A, Wang X. Effects of home-based lower limb resistance training on muscle strength and functional status in stable Chronic obstructive pulmonary disease patients. J Clin Nurs. 2018;27(5-6):e1022-37.
4. Valtonen A, Pöyhönen T, Sipilä S, Heinonen A. Effects of aquatic resistance training on mobility limitation and lower-limb impairments after knee replacement. Arch Phys Med Rehabil. 2010;91(6):833-9.
5. Motalebi SA, Cheong LS, Iranagh JA, Mohammadi F. Effect of low-cost resistance training on lower-limb strength and balance in institutionalized seniors. Exp Aging Res. 2018;44(1):48-61.
6. Whiteford J, Ackland TR, Dhaliwal SS, James AP, Woodhouse JJ, Price R, et al. Effects of a 1-year randomized controlled trial of resistance training on lower limb bone and muscle structure and function in older men. Osteoporos Int. 2010;21(9):1529-36.