

# EVALUATION OF BLOOD OXYGEN SATURATION OF HIGH JUMPERS BASED ON ISOKINETIC TEST



ORIGINAL ARTICLE  
ARTIGO ORIGINAL  
ARTÍCULO ORIGINAL

AVALIAÇÃO DA SATURAÇÃO DE OXIGÊNIO NO SANGUE DE SALTADORES DE ALTURA COM BASE NO TESTE ISOCINÉTICO

EVALUACIÓN DE LA SATURACIÓN DE OXÍGENO EN LA SANGRE DE SALTADORES DE ALTURA CON BASE EN EL TEST ISOCINÉTICO

Qiang Yao<sup>1</sup>   
(Physical Education Professional)

1. Department of Physical Education, Nanjing Institute of Tourism and Hospitality, Nanjing, China.

## Correspondence

Qiang Yao  
Nanjing, China, 211100.  
yaoqiangyh@163.com

## ABSTRACT

**Introduction:** An isokinetic test refers to the test of the force of a muscle or muscle group during centripetal and centrifugal movements at a constant speed in the whole range of joint motion by means of an isokinetic force tester. **Objective:** To explore the application of the knee centripetal flexor and extensor muscle groups in the blood oxygen saturation of high jumpers. **Methods:** Eighteen teenage female high jumper athletes above level 2 in a city sports school were selected. Their ages was 16.89±1.02 years old; height, 168.31±6.32cm; weight, 55.36±6.75kg. **Results:** At 60° S and 120° S test speed, the peak moment of the extensor muscle group on the same side of the knee was significantly greater than that of the flexor muscle group (P<0.05), while at 240° S test speed, it was the opposite. There was a significant difference in the peak moment of the flexor muscle group on the left and right side of the knee (P<0.01). **Conclusions:** The function of the dynamic muscle strength test system is one of the methods of studying the human muscle function, and can be used to test and evaluate the general strength of athletes. **Level of evidence II; Therapeutic studies - investigation of treatment results.**

**Keywords:** Athletes; Muscle strength; Exercise test.

## RESUMO

**Introdução:** Um teste isocinético se refere ao teste de força de um músculo ou grupo de músculos durante movimentos centrípetas e centrífugas a uma velocidade constante em toda a amplitude de movimento articular por meio de um verificador de força isocinética. **Objetivo:** Explorar a aplicação dos grupos musculares flexor e extensor centrípetos do joelho na saturação de oxigênio do sangue de saltadores de altura. **Métodos:** Dezoito saltadoras de altura adolescentes acima do nível 2 em uma escola esportiva urbana foram selecionadas. Suas idades em anos eram 16.89±1.02; altura, 168.31±6.32cm; peso, 55.36±6.75kg. **Resultados:** A 60° S e 120° S a velocidade de teste, o momento de pico do grupo muscular de extensão do mesmo lado do joelho era consideravelmente maior do que aquele do grupo muscular de flexão (P<0.05), enquanto a 240° S a velocidade de teste foi o contrário. Houve uma diferença importante no momento de pico do grupo muscular flexor nos lados esquerdo e direito do joelho (P<0.01). **Conclusões:** A função do sistema de testes de força muscular dinâmico é um dos métodos para o estudo da função muscular humana e pode ser usado para testar e avaliar a força geral de atletas. **Nível de evidência II; Estudos terapêuticos – investigação de resultados de tratamento.**

**Descritores:** Atletas; Força muscular; Teste de esforço.

## RESUMEN

**Introducción:** Un test isocinético se refiere al test de fuerza de un músculo o grupo de músculos durante movimientos centrípetos y centrífugos a una velocidad constante en toda la amplitud de movimiento articular por medio de un verificador de fuerza isocinética. **Objetivo:** Explorar la aplicación de los grupos musculares flexor y extensores centrípetos de la rodilla en la saturación de oxígeno de sangre de saltadores de altura. **Métodos:** Se seleccionó dieciocho saltadoras de altura adolescentes arriba del nivel 2 en una escuela deportiva. Sus edades eran 16.89±1.02; altura, 168.31±6.32cm; peso, 55.36±6.75kg. **Resultados:** A 60° S e 120° S la velocidad del test, el momento de pico del grupo muscular de extensión del mismo lado de la rodilla era considerablemente mayor que aquel del grupo muscular de flexión (P<0.05), mientras a 240° S la velocidad del test fue el contrario. Hubo una diferencia importante en el momento de pico del grupo muscular flexor en los lados izquierdo y derecho de la rodilla (P<0.01). **Conclusiones:** La función del sistema de test de fuerza muscular dinámico es uno de los métodos para el estudio de la función muscular humana y puede usarse para testar y evaluar la fuerza general de atletas. **Nivel de evidencia II; Estudios terapéuticos – investigación de resultados de tratamiento.**

**Descritores:** Atletas; Fuerza muscular; Prueba de estrés.



## INTRODUCTION

Isokinetic test refers to the test of the force of a muscle or muscle group during centripetal and centrifugal movement at a constant speed within the whole range of joint motion by means of an isokinetic force tester.<sup>1</sup> Compared with non-constant speed measurement system, constant speed measurement system can independently measure the force at one or more specific speed, which has the advantages of safety, effectiveness, high repeatability, direct feedback results and so on.<sup>2</sup> Therefore, isokinetic test has become an indispensable measurement method for the international study of human muscle strength, and is widely used in the assessment of muscle strength of athletes, training, prevention and rehabilitation of diseases of the motor system, etc.<sup>3</sup> At present, the more popular isokinetic testing systems in the world include Cybex, Biodex, mCRAL, Kin/Com, Lidoactive and Arid, among which Cybex and Biodex are the most widely used. In recent years, some scholars have introduced this technique into the field of sports, providing new means for athletes' muscle training, rehabilitation, diagnosis and material selection.<sup>4</sup> Among them, the research literature on knee joint is up to 41.2%, the accuracy of measurement is higher than that of other joints because the knee joint is relatively easy to be fixed in the isokinetic test and the range of motion is not very different.<sup>5</sup> In addition, the knee joint plays an important role in the competitive events that take walking, running and jumping as the basic movements. Especially for the high jump, the flexion and extension muscle characteristics of the knee joint are particularly important, however, most people's knee joint strength is relatively insufficient or the flexion and extension strength is unbalanced, which is easy to cause sports injury.<sup>6</sup>

## METHOD

### Test Objects

Eighteen teenage female high jumper athletes above level 2 in a city sports school were selected. Their age was  $16.89 \pm 1.02$  years old, height was  $168.31 \pm 6.32$  cm, weight was  $55.36 \pm 6.75$  kg.

### Research Methods

The dynamic muscle strength of knee joint was tested by Cybex isokinetic instrument produced by a company. The instrument has a unique dual power head design, which can alternatively flexion and extension swing of both knee joints at the same time, it's closer to sports practice. In this study, the knee joint of the test object was fixed in strict accordance with the method specified in the test manual, the test content was the isokinetic centripetal flexion and extension movement of both knee joints, test speed and sequence setting:  $60^\circ$  S flexion and extension 6 times at an interval of 30s,  $120^\circ$  S flexion and extension 10 times at an interval of 60s; 15 flexion and extension reps at  $240^\circ$  S. Before the beginning of the experimental test, the subjects were specially organized for a 10-minute preparation activity. Before the formal test, each person performed one sub-extreme flexion and extension exercise on the instrument at  $60^\circ$  S to adapt to the instrument.

### Data processing

SPSS11.0 statistical software and MicrosoftExcel were used for statistical and graphing processing of all experimental data, and the results were

expressed as  $\pm$ , T-test was performed on the flexion and extension muscle strength indexes of the subjects' bilateral knee joints, and the correlation analysis was conducted with the morphological indexes of the lower limbs.

## RESULTS

### Test results and analysis of flexor and extensor muscle peak torque and flexor and extensor force ratio of bilateral knee joints

Table 1 and Figure 1 show that the peak torque of the flexor and extensor muscles of both sides of the knee of teenage female high jumpers decreases with the increase of the given motion speed ( $60^\circ$  S and  $240^\circ$  S), at  $60^\circ$  S and  $120^\circ$  S test speed, the peak torque of the knee joint's ipsidium muscle group was significantly greater than that of the flexor muscle ( $P < 0.05$ ), while at  $240^\circ$  S test speed, it was vice versa, under the same test speed, the peak torque of left and right knee flexor group was significantly different ( $P < 0.01$ ), which was basically consistent with previous reports, the reason may be that the muscle strength is lost when the transverse bridge in the contractor is broken, and the muscle strength is lost when the transverse bridge is formed in the contraction process.

### Test results and analysis of the maximum power and maximum power flexor/extension ratio of flexor and extension muscle groups of bilateral knee joints

Table 2 and Figure 2 show that the maximum power of the flexor and extensor muscles of the bilateral knee joints of the teenage female high jumpers increases with the increase of the given motion speed ( $60^\circ$  S and  $240^\circ$  S), at the same test speed, there was no significant difference in the maximum power between flexor muscle group and extensor muscle group (except for extensor muscle at  $60^\circ$  S). Table 2 shows that the maximum power flexion/extension ratio of the knee joint is almost all greater than 1, indicating that the maximum power of the flexor group of the knee joint is greater than the maximum power of the extensor

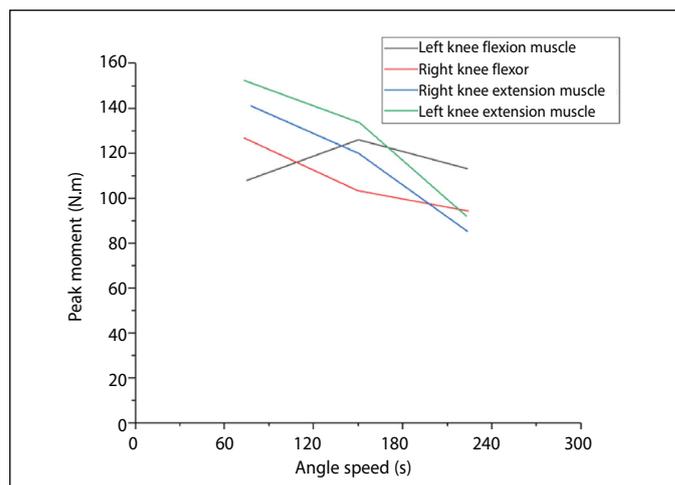


Figure 1. Relationship between isokinetic peak torque and angular velocity of flexor and extensor muscle groups of bilateral knee joints.

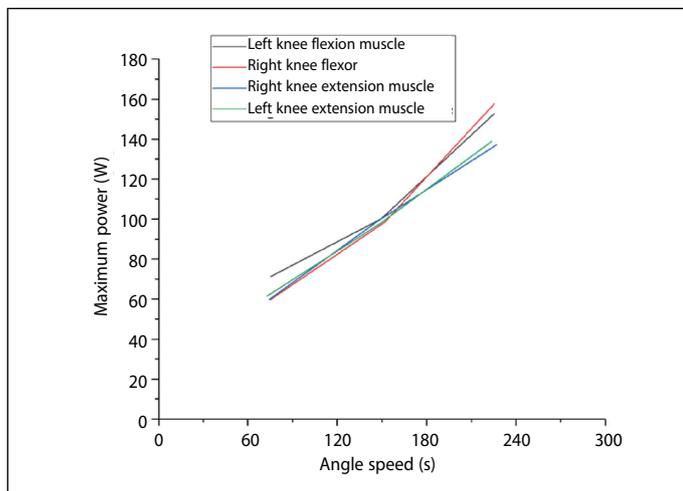
Table 1. List of isokinetic flexion and extension peak moments of knee joint of young female high jumpers.

The angular velocity( $^\circ$ s)	The left side			The right side		
	$60^\circ$	$120^\circ$	$240^\circ$	$60^\circ$	$120^\circ$	$240^\circ$
The flexor peak moment(N.m)	11.33 $\pm$ 30.74	126.67 $\pm$ 25.69	115.00 $\pm$ 37.15	125.44 $\pm$ 26.82**	105.44 $\pm$ 22.24**	95.22 $\pm$ 33.4**
Flexor versus peak moment(N.m kg)	2.00 $\pm$ 0.50	2.30 $\pm$ 0.42	2.09 $\pm$ 0.79	2.28 $\pm$ 0.76**	1.90 $\pm$ 0.34**	1.74 $\pm$ 0.70**
Extensor peak moment(N.m)	152.11 $\pm$ 28.56	134.11 $\pm$ 33.24	89.67 $\pm$ 25.61	143.33 $\pm$ 25.69	121.11 $\pm$ 23.99**	87.89 $\pm$ 27.29
Extensor to peak moment(N.m kg)	2.76 $\pm$ 0.86	2.42 $\pm$ 0.54	1.65 $\pm$ 0.65	2.60 $\pm$ 0.78	2.18 $\pm$ 0.35**	1.61 $\pm$ 0.73
Peak moment flexion and extension	0.72 $\pm$ 0.16	0.94 $\pm$ 0.23	1.28 $\pm$ 0.22	0.87 $\pm$ 0.21**	0.86 $\pm$ 0.18*	1.08 $\pm$ 0.17*

Note: Comparison of differences between left knee joint and right knee joint \*  $P < 0.05$ , \*\*  $P < 0.01$

**Table 2.** Table of maximum power of knee joint isokinetic flexion and extension of teenage female high jumpers.

The angular velocity(°s)	The left side			The right side		
	60°	120°	240°	60°	120°	240°
Maximum flexor power(W)	50.67±20.11	105.55±22.27	157.4±23.94	72.17±26.92**	99.61±23.30	154.44±21.04
Bend relative maximum power(W kg)	1.04±0.33	1.91±0.35	2.85±0.56	1.31±0.54*	1.08±0.36	2.79±0.53
Maximum power of extensor(W)	61.61±27.18	98.94±24.87	136.72±28.52	61.94±20.78	97.78±20.78	135.22±25.70
Extend relative maximum power(W kg)	1.11±0.51	1.79±0.52	2.48±0.72	1.12±0.31	1.76±0.60	2.46±0.62
Maximum power flexion and extension	0.93±0.48	1.16±0.35	1.22±0.36	1.43±0.46*	1.12±0.37	1.22±0.36

**Figure 2.** Relationship between angular velocity and maximum power of isokinetic contraction of flexor and extensor muscle groups of bilateral knee joints.

group. This result is quite different from the conclusion that the average power flexion/extension ratio of the knee joint in women should be maintained between 0.70 and 0.79, which needs to be further studied.

### Analysis of peak moment Angle and time characteristics of flexor and extensor muscles of bilateral knee joints

Table 3 shows that the Angle of flexor and extensor's peak moment of knee joint of young female high jumpers is significantly lower than that of flexor's peak moment, with the increase of the given movement speed, the angular flexor muscles of the left and right knee joints tended to increase while the extensor muscles tended to decrease. Under the same test speed, there was no significant difference in the Angle of peak moment of knee extensor group between left and right sides ( $P < 0.05$ ).

**Table 3.** Table of peak moment Angle and time of flexor and extensor of knee joint of young female high jumpers.

The angular velocity(°s)	The left side			The right side		
	60°	120°	240°	60°	120°	240°
Flexor peak torque Angle(°)	75.06±11.68	87.97±9.07	93.38±6.08	79.97±11.51	89.91±12.31	91.33±14.13
Peak torque time of flexor muscles(s)	0.65±0.36	0.30±0.16	0.21±0.06	0.79±0.45	0.30±0.11	0.23±0.05
Extensor peak torque Angle(°)	77.4±9.70	72.27±8.47	66.54±14.59	181.09±11.81	76.88±12.43	72.32±13.21
Extensor peak torque time(s)	1.23±0.32	0.62±0.16	0.33±0.11	1.13±0.40	0.56±0.13	0.31±0.09

**AUTHORS' CONTRIBUTIONS:** The author made significant contributions to this manuscript. Qiang Yao: writing and performing surgeries; data analysis and performing surgeries; article review and intellectual concept of the article

## REFERENCES

- Li LJ, Dong XM, Sun XC, Jia J. Treatment of 'suicidal jumper fractures' with lumbopelvic fixation: a report of nine cases. *Journal of Hard Tissue Biology*. 2021;30(2):205-10. doi: <https://doi.org/10.2485/jhtb.30.205>.
- Liu C, Yang S, Cui Y, Lv J, Chen B. Optimization method of switch jumper setting based on strategies for reducing conductive interference in railway. *Proceedings of the Institution of Mechanical Engineers Part F Journal of Rail and Rapid Transit*. 2020;235(5):095440972095130. doi: <https://doi.org/10.1177/0954409720951300>.
- Aksu N, Atansay V, Karalök I, Aksu T, Kara AN, Hamzaoglu A. Relationship of patellofemoral angles and tibiofemoral rotational angles with jumper's knee in professional dancers: an MRI analysis. *Orthop J Sports Med*. 2021;9(3):2325967120985229. doi: <https://doi.org/10.1177/2325967120985229>
- Lau D, Hervey-Jumper SL, Han SJ, Berger MS. Intraoperative perception and estimates on extent of resection during awake glioma surgery: overcoming the learning curve. *J Neurosurg*. 2018;128(5):1410-8. doi: <https://doi.org/10.3171/2017.1.JNS161811>.
- Riback JA, Bowman MA, Zmyslowski AM, Knoverek CR, Jumper JM, Hinshaw JR, et al. Innovative scattering analysis shows that hydrophobic disordered proteins are expanded in water. *Science*. 2017;358(6360):238-241. doi: <https://doi.org/10.1126/science.aan5774>.
- Morrida J, Gordeyev S, De Lucca N, Jumper EJ. Shock-related effects on aero-optical environment for hemisphere-on-cylinder turrets at transonic speeds. *Appl Opt*. 2017;56(16):4814-24. doi: <https://doi.org/10.1364/AO.56.004814>
- Jumper N, Hodgkinson T, Paus R, Bayat A. Site-specific gene expression profiling as a novel strategy for unravelling keloid disease pathobiology. *PLoS One*. 2017;12(3):e0172955. doi: <https://doi.org/10.1371/journal.pone.0172955>.
- Rennie RM, Nguyen M, Gordeyev S, Jumper EJ. Wave-front measurements of a supersonic boundary layer using laser induced breakdown. *AIAA Journal*. 2017;55(7):2349-57. <https://doi.org/10.2514/1.J055611>.
- Coconas NA. La didáctica de la lengua mediada por las TIC Storyjumper como propuesta innovadora en la creación de cuentos. *Revista Perspectivas*. 2021;6(1):101-13. doi: <https://orcid.org/0000-0002-9784-2073>.

## DISCUSSION

1. The peak torque of flexor and extensor of bilateral knee joint of adolescent female high jumpers decreases with the increase of movement speed (60° S \* 240° S). At the test speed of 60° S and 120° S, the peak torque of extensor was significantly greater than that of flexor ( $P < 0.05$ ), however, at the test speed of 240° S, it was the other way around. At the same test speed, there was a significant difference in the peak torque of the flexor muscle groups of the left and right knee joints ( $P < 0.01$ ).<sup>7</sup> The peak torque flexural extension ratio (FE) tends to increase with the increase of the given velocity.<sup>8</sup>

2. The Angle of flexor and extensor muscle to reach the peak moment of knee joint of young female high jumpers showed that the Angle of flexor and extensor muscle to reach the peak moment was significantly lower than that of flexor muscle to reach the peak moment, with the increase of the given movement speed, the angular flexor muscles of the left and right knee joints tended to increase, while the extensor muscles tended to decrease. Under the same test speed, there was no significant difference in the Angle of peak moment of knee extensor group between left and right sides ( $P < 0.05$ ).<sup>9</sup>

## CONCLUSION

As a more advanced means of muscle strength measurement, isokinetic test system has the advantages of safe test process, relatively stable and accurate test data. The isokinetic muscle strength testing system is still one of the few methods to quantitatively study the muscle function in the body so far and can be used to test and evaluate the general strength of athletes.

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