

LOWER LIMB BALANCE CHARACTERISTICS DURING TAI CHI CHUAN

CARACTERÍSTICAS DE EQUILÍBRIO DOS MEMBROS INFERIORES DURANTE O TAI CHI CHUAN

CARACTERÍSTICAS DEL EQUILIBRIO DE LOS MIEMBROS INFERIORES DURANTE EL TAI CHI CHUAN



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ABSTRACT

Introduction: Tai chi chuan training claims to not only promote the circulation of internal energy in the body to achieve a preventive and healing effect of diseases, but also to improve static and dynamic body balance. While the former claims are not validable, the question about the effectiveness of improving balance remains valid. **Objective:** Verify the characteristics of lower limb balance during tai chi chuan practice. **Methods:** Selected volunteers underwent a bioelectricity testing system via noninvasive surface electromyography to evaluate muscle activity during the exercises. The results were collected, cataloged and statistically work on corresponding graphs according to different content of literature research for objective analysis. **Results:** The variation of the displacement of the center of gravity was controlled within 0.1M, the most unstable time of the center of gravity was about 0.65s before the start of balance. In temporal terms, it is found that the order of discharge of each muscle tested in the vertical balance and unilateral support was as follows: the tibialis anterior muscle discharges first, the rectus femoris and biceps femoris second, finally gastrocnemius, gluteus medius and gluteus maximus joint discharge almost at the same time. **Conclusion:** Some benefit is perceived in the validity of improving lateral balance velocity, shortening the action completion time, and improving balance stability, improving the quality of action in practitioners of this exercise modality. **Level of evidence II; Therapeutic studies - investigation of treatment outcomes.**

Keywords: Tai Ji; Lower Extremity; Postural Balance.

RESUMO

Introdução: O treinamento do tai chi chuan alega não só promover a circulação de energia interna no corpo para alcançar um efeito preventivo e curador de doenças, mas também aprimorar o equilíbrio estático e dinâmico corporal. Enquanto as primeiras afirmações não são validáveis, o questionamento sobre a eficácia no aprimoramento do equilíbrio permanece válido. **Objetivo:** Verificar as características do equilíbrio nos membros inferiores durante a prática do tai chi chuan. **Métodos:** Voluntários selecionados passaram por um sistema de testes com bioeletricidade via eletromiografia superficial não invasiva para avaliar a atividade muscular durante os exercícios. Os resultados foram coletados, catalogados e estatisticamente trabalhos sobre gráficos correspondentes, de acordo com diferentes conteúdos de pesquisa literária, para análise objetiva. **Resultados:** A variação do deslocamento do centro gravitacional foi controlada dentro de 0,1M, o tempo mais instável do centro de gravidade foi cerca de 0,65s antes do início do equilíbrio. Em termos temporais, constata-se que a ordem de descarga de cada músculo testado no equilíbrio vertical e apoio unilateral foi a seguinte: o músculo tibial anterior descarrega primeiro, o reto femoral e bíceps femoral em segundo lugar, finalmente conjunto gastrocnêmico, glúteos médios e glúteo máximo descarregam quase ao mesmo tempo. **Conclusão:** Percebe-se algum benefício na validade de aprimorar a velocidade de balanço lateral, encurtar o tempo de conclusão da ação e melhorar a estabilidade do equilíbrio, melhorando a qualidade da ação em praticantes dessa modalidade de exercício. **Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.**

Descritores: Tai Chi Chuan; Extremidade Inferior; Equilíbrio Postural.

RESUMEN

Introducción: El entrenamiento de Tai chi chuan pretende no sólo promover la circulación de la energía interna en el cuerpo para lograr un efecto preventivo y curativo contra las enfermedades, sino también mejorar el equilibrio corporal estático y dinámico. Mientras que las primeras afirmaciones no son válidas, la pregunta sobre la eficacia de la mejora del equilibrio sigue siendo válida. **Objetivo:** Verificar las características del equilibrio de los miembros inferiores durante la práctica del tai chi chuan. **Métodos:** Los voluntarios seleccionados se sometieron a un sistema de pruebas de bioelectricidad mediante electromiografía de superficie no invasiva para evaluar la actividad muscular durante los ejercicios. Los resultados fueron recogidos, catalogados y trabajados estadísticamente en los gráficos correspondientes según los diferentes contenidos de la investigación literaria para su análisis objetivo. **Resultados:** La variación del desplazamiento del centro de gravedad se controló dentro de 0,1M, el tiempo más inestable del centro de gravedad fue de unos 0,65s antes del inicio del equilibrio. En términos temporales, se encontró que el orden de descarga de cada músculo probado en el equilibrio vertical y el apoyo unilateral fue el siguiente: el músculo tibial anterior descarga primero, el recto femoral y el bíceps femoral segundo, finalmente el gastrocnemio, el glúteo medio



y el glúteo mayor descargan casi al mismo tiempo. Conclusión: Se percibe algún beneficio en la validez de mejorar la velocidad de equilibrio lateral, acortar el tiempo de finalización de la acción y mejorar la estabilidad del equilibrio, mejorando la calidad de la acción en los practicantes de esta modalidad de ejercicio. **Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.**

Descriptor: Taichi Chuan; Extremidad Inferior; Equilibrio Postural.

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INTRODUCTION

Taijiquan training can not only promote the circulation of internal energy in the body and achieve the effect of disease prevention and treatment, but also learn the static and dynamic balance.¹ Taijiquan is a complete set of movements composed of many single movements. Each movement has its different efficacy and value in practice. There is relatively little research on the kinematics and dynamics of Taijiquan, especially in the aspect of single movement. From the technical point of view, Taijiquan kicking is one of the difficult movements, which involves the working ability of lower limb muscles, the balance and stability of human single leg upright, kicking and the movement of lower limb joints.²

In view of this research problem, Wang X and others measured and analyzed the plantar pressure in 9 areas of the sole of the foot in 5 typical movements of 16 excellent Taijiquan practitioners, and concluded that: in Taijiquan, the pressure of the first metatarsal and the first toe is significantly greater than that of other parts;³ Pjc A and others compared and analyzed the plantar pressure of Taijiquan exercise and normal walking of 16 Taijiquan athletes, and believed that the total duration of single foot support posture in Taijiquan exercise was less than that of normal walking, and the trajectory of pressure center in the left and right directions was larger;⁴ Kotoshiba S and others studied and analyzed the plantar pressure and human spine of the typical movements of Taijiquan of two young male athletes, and pointed out that the subjects had good similarities in Ding step, bow step, up step and the deviation of pressure center point, while there were great differences in virtual step and backward step.⁵

Based on the current research, this paper puts forward the lower limb balance control characteristics of Taijiquan starting leg movement. It is found that the discharge sequence of each test muscle in the vertical balance of side kick and holding feet is as follows: the anterior tibial muscle discharges first, the rectus femoris and biceps femoris secondly, and finally the three muscles of gastrocnemius, middle gluteus and gluteus maximus discharge almost at the same time. Conclusion: The stability of the movement is closely related to the swing speed and swing order of the unsupported leg and the opposite arm.

METHOD

Research object

This study selected six elite female routine athletes from a sports team as the research object, including two Wu Ying level, two national first-class athletes and two national second-class athletes. They have achieved excellent results in Wushu routine competitions in recent years.

Introduction to experimental instruments.

The multi-channel exercise bioelectricity test system produced by German biovision company is used to measure the muscle without damage, so as to collect the athlete's EMG signal, and the sampling frequency is set to 1024Hz. The electrode piece is a disposable ECG electrode produced by Shanghai Yunkang Medical Equipment Co., Ltd.⁶

Muscle selection

The selection of the measured muscles is mainly based on the main muscle groups that can reflect the characteristic movements. In this

study, six muscles including rectus femoris, gluteus maximus, biceps femoris, gluteus medius, gastrocnemius and tibialis anterior muscle were selected to measure during exercise.⁷

Mathematical statistics

The original EMG signal data obtained from the experiment were imported into Excel for sorting, and the corresponding charts were drawn according to different research contents for objective analysis. Spss18.0 system software is used to input, sort out and statistically process the required original data.⁸

RESULTS AND ANALYSIS

Side kick and hold feet upright

According to the principle of balance mechanics, the side kick and holding foot belonging to the supporting balance action stand upright, and the external closing torque is zero.⁹ By analyzing its action, it is found that the side swing of the unsupported leg is bound to cause the body to rotate counterclockwise around the y-axis. According to the principle of balance mechanics and the conservation theorem of momentum moment, in order to maintain the balance, a force is necessary to compete with it to make the momentum moment of the body rotating clockwise around the y-axis, and the opposite arm of the unsupported leg swings clockwise on the y-axis.¹⁰

It can be seen from Figure 1 that the shaking range of the center of gravity of the vertical balance action of side kick and holding feet is controlled within 0.1M, and the most unstable time of the center of gravity is about 0.65s before the beginning of balance. Combined with the moving image, it can be seen that this time is the time when the hands and feet hug in the side kick and holding feet, and the athletes adjust and stabilize the balance for a short time in this stage, and then complete the subsequent action. It can be seen that in the vertical balance of side kicking and holding feet, the most unstable stage of balance is the moment when hands and feet hug. In the practice process of this action, we need to pay attention to the technical focus of arm and leg coordination and active cooperation.

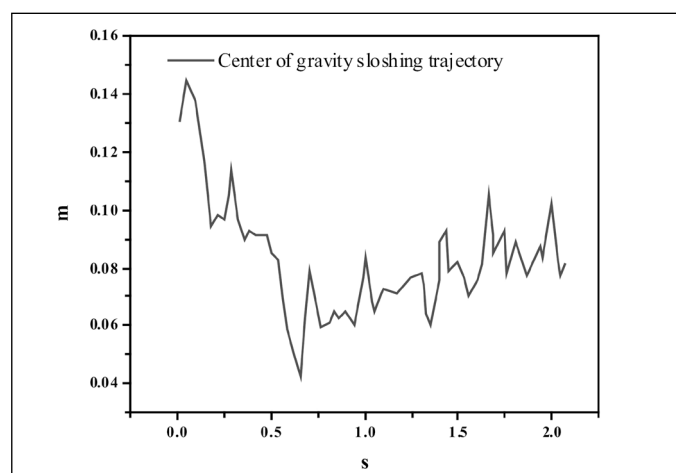


Figure 1. Track of Y-axis change of gravity center of side kick, holding feet and standing balance body.

Lift the feet and stand upright

The upright balance of moving feet towards the sky is also known as “pedaling towards the sky”, which requires athletes to hold the non supporting legs on the side of the body with their hands when the supporting legs stand upright and steady, while the toes are lifted, the soles of the feet are upward, and the height is kept level with the head.

It can be seen from Figure 2 that the movement of the foot towards the sky and the upright balance, and the change trend of each joint angle of the unsupported leg in the process of completing the action. Among them, the knee angle shows a trend of decreasing first and then increasing, with a minimum of about 74°. The emergence of this minimum value is the stage of knee lifting and foot moving in the balance movement. Then, the knee angle gradually increases with the lifting of the unsupported leg, reaches the maximum value of about 174.6° when the action is completed, and starts to maintain the stability of the action. The hip angle of the unsupported leg gradually decreases with the lifting action of the leg, which is in line with the kinematic law of the action. When the unsupported leg is lifted to the highest point, the hip angle reaches the minimum value of about 20°. The smaller the angle, the better the flexibility of the athlete. In order to control the stability of the center of gravity, the ankle angle of the supporting leg gradually decreases with the lifting of the non supporting leg. However, in the stage of maintaining balance, the ankle angle always changes in the range of about 10°.

EMG data analysis of two balance movements

By observing the electromyography of the two balance movements, it can be found that the discharge order of each test muscle in the vertical balance of side kicking and holding feet is as follows: the anterior tibial muscle discharges first, the rectus femoris and biceps femoris secondly, and the gastrocnemius, middle gluteus and gluteus maximus discharge almost at the same time. In the upright movement of holding feet and pedaling towards the sky, the discharge order of muscles is: anterior tibialis, gastrocnemius, rectus femoris, biceps femoris, middle gluteus and gluteus maximus. The electromyography of the test muscles of the two movements of side kick, holding feet upright balance and holding feet upright pedaling towards the sky are shown in Figures 3 and 4.

It can be seen from Figure 5 that in the upright balance of side kick and holding feet, the discharge amount of each test muscle is in the order of tibialis anterior muscle > gluteus medius muscle > gluteus maximus muscle > gastrocnemius muscle > rectus femoris muscle > biceps femoris muscle. The order of the discharge of each test muscle is: tibialis anterior muscle > gluteus maximus muscle > gluteus medius

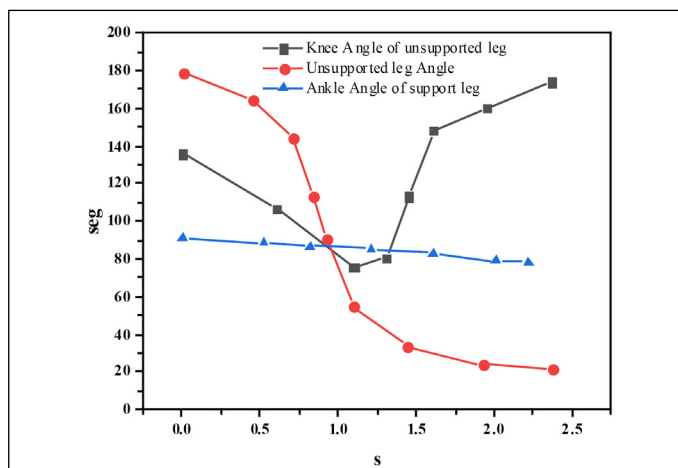


Figure 2. Change of link angle of non supporting leg when lifting the foot upward and standing upright.

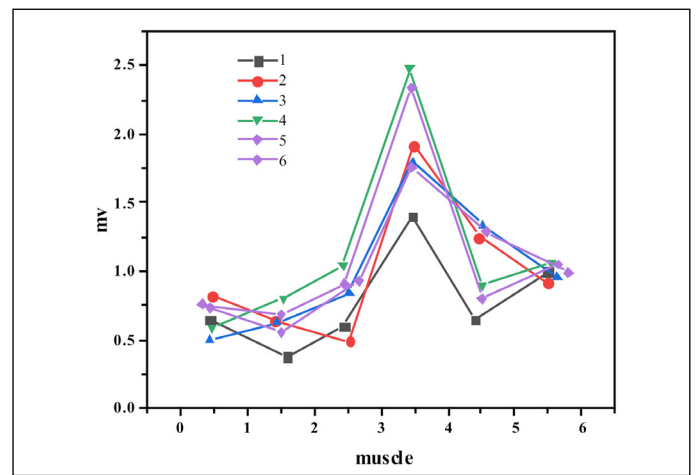


Figure 3. IEMG trend of vertical balance with side kick and holding feet.

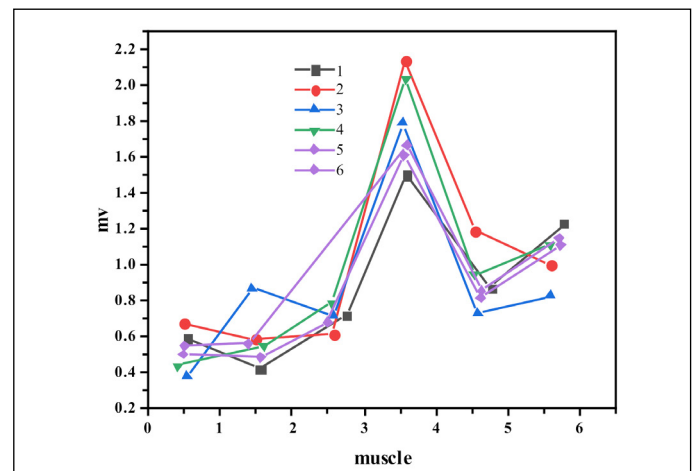


Figure 4. IEMG trend of lifting feet, pedaling upright and balancing.

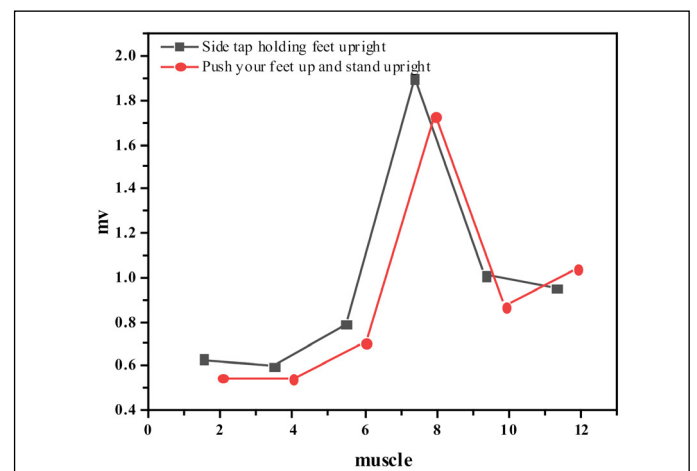


Figure 5. IEMG of each test muscle in two balance movements in upright state.

muscle > gastrocnemius muscle > biceps femoris muscle > rectus femoris muscle. The magnitude of muscle discharge reflects the magnitude of muscle strength.

The center of gravity is closer to the center of the human body than the vertical balance of side kicking and holding feet. The muscle force arm of rectus femoris and biceps femoris is smaller than that of side kicking and holding feet. Therefore, the discharge of rectus femoris and biceps femoris is smaller than that of side kicking and holding feet. Therefore, the discharge of tibialis anterior muscle and gastrocnemius muscle is less than that of side kick and holding foot upright balance. The gluteus maximus and gluteus medius muscle rotate the pelvis to

the opposite side due to the centripetal contraction of the hip joint in the process of moving the unsupported leg, which is convenient for lifting the leg. However, the muscle force arm of the gluteus maximus muscle is shorter than that of the gluteus medius muscle due to the rotation, so the discharge of the gluteus maximus muscle in the upright balance of moving the foot towards the sky is greater than that of the gluteus medius muscle.

CONCLUSION

This paper puts forward the lower limb balance control characteristics of Taijiquan staring leg movement, objectively and accurately tests the six muscles supporting the balance leg, and analyzes the influence of muscle discharge and movement sequence on the balance movement

under different balance states. Through the EMG test, it is found that the discharge of the tibialis anterior muscle supporting the leg in the stage of maintaining balance and stability is the largest among the six muscles tested. We should pay more attention to the strength exercise of the tibialis anterior muscle. In the upright state, the swing speed and swing order of the unsupported leg and the opposite arm are closely related to the stability of the action. The swing of the opposite arm shall precede the swing of the unsupported leg. This is beneficial to improve the side swing speed, shorten the time of action completion, and enhance the stability of balance while improving the quality of action.

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AUTHORS' CONTRIBUTIONS: The author made significant contributions to this manuscript. NL: writing, data analysis, article review and intellectual concept of the article.

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