

KINEMATIC ANALYSIS OF LOWER EXTREMITY MOVEMENT TECHNIQUES IN SOCCER TRAINING

ANÁLISE CINEMÁTICA DAS TÉCNICAS DE MOVIMENTO DOS MEMBROS INFERIORES NO TREINAMENTO DE FUTEBOL

ANÁLISIS CINEMÁTICO DE LAS TÉCNICAS DE MOVIMIENTO DE LOS MIEMBROS INFERIORES EN EL ENTRENAMIENTO DE FÚTBOL



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ABSTRACT

Introduction: The improvement of soccer sports skills depends on many training efforts and is closely related to intrinsic scientific methods. Attention to the integral quality of the lower limb muscles and the performance of specific exercises of technical movements is essential to reach the optimal state of physical performance in players. **Objective:** Analyze the kinematic effect of lower limb movement techniques in soccer training. **Methods:** 10 athletes were marked with reflective spheres and submitted to the kinematic training method of the lower limbs designed by the coaches in 60 minutes, three times a week, for six weeks. Before and after the experiment, data captured by reflective spheres were captured, compared, classified, and analyzed. **Results:** Kinematic training can effectively optimize movement time, swing amplitude, swing angle, and other aspects of lower limb mechanical structure, thus improving energy expenditure and making the movement concise, conveying strength and precision. **Conclusion:** Trainers should seriously study the principles of applied kinematic analysis and optimize the training program from a scientific point of view because the athletic level of athletes is significantly improved with this real-time feedback. **Level of evidence II; Therapeutic studies - investigation of treatment outcomes.**

Keywords: Soccer; Lower Extremity; Kinematics.

RESUMO

Introdução: O aprimoramento das habilidades esportivas do futebol depende de muitos esforços de treinamento e está intimamente relacionado com métodos científicos intrínsecos. Atenção na qualidade integral dos músculos dos membros inferiores e a realização de exercícios específicos de movimentos técnicos é essencial para atingir o estado ótimo da performance física nos jogadores. **Objetivo:** Analisar o efeito cinemático das técnicas de movimento dos membros inferiores no treinamento de futebol. **Métodos:** 10 atletas foram marcados com esferas reflexivas e submetidos ao método de treinamento cinemático dos membros inferiores desenhado pelos treinadores num período de 60 minutos, três vezes por semana, durante 6 semanas. Antes e depois do experimento, os dados capturados por esferas reflexivas foram capturados, comparados, classificados e analisados. **Resultados:** O treinamento cinemático pode otimizar efetivamente o tempo de movimento, amplitude de balanço, ângulo de balanço e outros aspectos da estrutura mecânica dos membros inferiores, melhorando assim o dispêndio energético e tornando o movimento conciso, transmitindo força e precisão. **Conclusão:** Os treinadores devem estudar seriamente os princípios da análise cinemática aplicada, otimizar o programa de treinamento do ponto de vista científico, pois o nível esportivo dos atletas é melhorado significativamente com a adição desse feedback em tempo real. **Nível de evidência II; Estudos terapêuticos - investigação dos desfechos do tratamento.**

Descritores: Futebol; Membros Inferiores; Cinemática.

RESUMEN

Introducción: La mejora de las capacidades deportivas en el fútbol depende de muchos esfuerzos de entrenamiento y está estrechamente relacionada con métodos científicos intrínsecos. La atención sobre la calidad integral de los músculos de los miembros inferiores y la realización de ejercicios específicos de movimientos técnicos es esencial para alcanzar el estado óptimo del rendimiento físico en los jugadores. **Objetivo:** Analizar el efecto cinemático de las técnicas de movimiento del miembro inferior en el entrenamiento de fútbol. **Métodos:** 10 atletas fueron marcados con esferas reflectantes y sometidos al método de entrenamiento cinemático de los miembros inferiores diseñado por los entrenadores en un período de 60 minutos, tres veces por semana, durante 6 semanas. Antes y después del experimento, se capturaron, compararon, clasificaron y analizaron los datos captados por las esferas reflectantes. **Resultados:** El entrenamiento cinemático puede optimizar eficazmente el tiempo de movimiento, la amplitud del balanceo, el ángulo de balanceo y otros aspectos de la estructura mecánica de las extremidades inferiores, mejorando así el gasto de energía y haciendo que el movimiento sea conciso, transmitiendo fuerza y precisión. **Conclusión:** Los



entrenadores deberían estudiar seriamente los principios del análisis cinemático aplicado, optimizar el programa de entrenamiento desde un punto de vista científico, ya que el nivel atlético de los deportistas mejora significativamente con la incorporación de esta información en tiempo real. **Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.**

Descriptor: Fútbol; Extremidades Inferiores; Cinemática.

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INTRODUCTION

As a team sport with high competitiveness and strong appreciation, football has developed rapidly in China in recent years and has a large number of fans. With the development of professionalization and specialization of Chinese football projects, football training has also changed from the previous basic training to professional and systematic training.¹ However, due to the special status of football in China and the special requirements of professional football training for venues, the number of professional training venues is far less than that of basketball courts, badminton courts and other sports with low requirements for venues, which requires coaches to continuously optimize the training system, improve the efficiency of training and maximize the benefits of training in limited venues and time.²

Due to the particularity of the sports rules of football and the characteristics of high confrontation, in training and competition, whether it is dribbling, passing, shooting and defense, it has particularly high requirements for the technical movements of legs and feet.³ In training, we should pay attention to the practice of athletes' leg movements and improve the training efficiency with the help of mechanical analysis.⁴ In the process of training, whether it is aerobic exercise, anaerobic exercise and the ability of combination of man and ball, We should pay attention to improving the comprehensive quality of athletes' leg body, and also carry out targeted leg technical movements in combination with different positions and roles of athletes on the field.⁵ In this way, athletes can make use of their good leg technical movements and body quality to improve their competitive level and achieve good competition results in training or competition.⁶

METHOD

Because it is difficult to extract and analyze the mechanics of leg movements, excellent football players with relatively standard movements are selected in the selection of research objects. In order to ensure the richness of samples as much as possible and prevent data extraction errors caused by too few numbers and athletes' personal preferences, 10 athletes were selected. The study and all the participants were reviewed and approved by Ethics Committee of Hunan Normal University (NO. 20HNUD-089). According to the principle of complete voluntariness, athletes can carefully and effectively complete the relevant leg mechanics training, and have good physical quality in the whole experimental process without sports injury, so as to eliminate the interference of irrelevant factors as far as possible.

The experiment adopts the form of maker reflective ball positioning, and the part bound with maker reflective ball is modeled and extracted by motion capture equipment.

Before the experiment, the staff and relevant volunteers will improve the equipment, bind the maker reflective ball at the joint position of 10 athletes respectively, use the photographic equipment to record the athletes during the exercise, and extract and model the athletes' leg action through the position of maker reflective ball, so as to obtain the relevant mechanical model, including leg action time, leg swing amplitude, leg swing angle and angular velocity Extraction of ankle three-dimensional coordinates and other aspects.

After completing the preliminary data acquisition, 10 athletes were trained according to the leg mechanics training method designed by the coach. The frequency is 60 minutes three times a week and the cycle is 6 weeks. Within 6 weeks, 10 athletes shall keep the work and rest of all sports as consistent as possible to prevent experimental errors caused by human factors.

After 6 weeks of training, bind the maker reflective ball again according to the way before the experiment for data extraction, and compare, sort out and analyze with the data before the experiment.

RESULTS

This paper arranges and analyzes the leg movement time before and after football training. As shown in Table 1, the analysis of the thigh movement of football players shows that the forward swing time decreases from (0.1620 ± 0.0099) s before training to (0.1498 ± 0.0205) s after training, and the backward swing time decreases from (0.1534 ± 0.0205) s before training to (0.1390 ± 0.0203) s after training, $P > 0.05$, indicating that there is no significant difference. Through the analysis of mechanics, it can be seen that the thigh swings back and forth with the hip joint as the center. The shorter the swing time, the more accurate the dynamic potential energy provided by the hip joint will be transmitted to the lower leg. Therefore, the relevant football training can reduce the thigh swing time, which is beneficial to improve the football performance.

The analysis of the lower leg movement of football players shows that the forward swing time decreases from (0.0924 ± 0.0103) s before training to (0.0799 ± 0.0100) s after training, and the backward swing time of the lower leg decreases from (0.1643 ± 0.0200) s before training to (0.1394 ± 0.0102) s after training, $P > 0.05$, indicating that there is no significant difference. Through the model analysis, it can be seen that the shorter the leg swing time, the more effective it is to reduce the kinetic energy consumption in the swing process, so that more kinetic energy can be transmitted to the football, so as to provide better strength for the football and improve its speed. Therefore, football mechanics training can effectively shorten the swing time of large and small legs, so as to reduce the consumption of energy provided by hip joint in the transmission process as much as possible, so as to achieve better hitting effect.

This paper arranges and analyzes the leg swing amplitude before and after football training. As shown in Table 2, the thigh movement of football players is analyzed. The front swing amplitude decreases from (39.4912 ± 1.9943) ° before training to (37.8617 ± 1.9368) ° after training, and the back swing amplitude increases from (17.1491 ± 1.8256) ° before training to (18.5935 ± 1.4288) ° after training, $P > 0.05$, indicating that there is no significant difference. By analyzing the calf movement of

Table 1. Analysis of leg movement time before and after football training (s).

Option	Before training	After training	P
Placing in front of the thigh	0.1620±0.0099	0.1498±0.0205	P>0.05
Backing of the thigh	0.1534±0.0205	0.1390±0.0203	P>0.05
Time to swing the calf	0.0924±0.0103	0.0799±0.0100	P>0.05
Time to swing on the calf	0.1643±0.0200	0.1394±0.0102	P>0.05

football players, the front swing amplitude decreased from $(123.5428 \pm 5.4302)^\circ$ before training to $(118.3199 \pm 6.0524)^\circ$ after training, and the back swing amplitude increased from $(100.4603 \pm 2.7824)^\circ$ before training to $(106.9360 \pm 3.0904)^\circ$ after training, $P > 0.05$, indicating that there was no significant difference. Combined with the relevant mechanical movement principles, it can be seen that through the back swing of large and small legs, the muscle strength can be brought into full play, so as to provide better power guarantee for kicking. Therefore, relevant mechanical football training can optimize the mechanical model of leg movement to a certain extent, so as to obtain better kinetic energy transmission effect.

In the process of playing football, the force starts from the hip joint, combined with the traction of the thigh muscle group to produce a large amount of kinetic energy, which is provided to the ankle through the transmission of the lower leg, and then applied to the football. In this process, the optimization of leg swing angle and angular velocity model is very important to the optimization of football skills. Through the analysis of Table 3, it can be seen that through football training, the angle and angular speed of thigh and calf swing back and forth are optimized, so as to enhance the accumulation of strength, reduce consumption as much as possible, make the movement more coherent and the transmission of force smoother.

The mechanical characteristics of the ankle joint are closely related to the strength and angle of kicking. The vertical axis refers to the central axis from the human foot to the head, with little difference. The coronal axis is opposite to the direction of the ball, and the sagittal axis is the same as the direction of the ball. The three-dimensional coordinates of the ankle on the coronal axis and sagittal axis are related to the domination of kinetic energy. Through the analysis of Table 4, it can be seen that football mechanics training can effectively optimize the angle and angular velocity of the three-dimensional coordinates of the ankle, so as to optimize the relevant mechanical models and obtain a better sports experience.

DISCUSSION

Mechanical analysis of leg movement technology in football training

In football training and competition, whether it is long-range shooting or long pass, we need to kick the ball further. According to the mechanical

Table 2. Analysis of leg swing amplitude before and after football training ($^\circ$).

Option	Before training	After training	P
Ahead of the thigh	39.4912 \pm 1.9943	37.8617 \pm 1.9368	P>0.05
Activity of the thigh	17.1491 \pm 1.8256	18.5935 \pm 1.4288	P>0.05
The front of the calf	123.5428 \pm 5.4302	118.3199 \pm 6.0524	P>0.05
The beam of the calf	100.4603 \pm 2.7824	106.9360 \pm 3.0904	P>0.05

Table 3. Analysis of leg swing angle and angular velocity characteristics before and after football training.

Option	Before training	After training	P
Angle angle of the thigh ($^\circ$)	69.8914 \pm 3.0913	66.6900 \pm 4.1088	P>0.05
The angle speed of the front of the thigh (rad/s)	210.9758 \pm 15.5698	219.4563 \pm 17.0518	P>0.05
Angle angle of the calf ($^\circ$)	47.9975 \pm 2.1539	54.0078 \pm 2.9936	P>0.05
The angle speed of the calf (rad/s)	686.8217 \pm 46.0128	716.4483 \pm 14.9608	P>0.05
Angle angle of the thigh ($^\circ$)	97.5696 \pm 2.0840	106.7181 \pm 2.9173	P>0.05
The angle speed of the back of the thigh (rad/s)	9.9953 \pm 1.9172	10.4306 \pm 1.6576	P>0.05
Angle angle of the calf ($^\circ$)	130.3033 \pm 3.0106	141.5332 \pm 3.2025	P>0.05
The angle speed of the calf rear (rad/s)	458.1793 \pm 3.4393	478.5085 \pm 4.1577	P>0.05

Table 4. Analysis of three-dimensional coordinate characteristics of ankle joint before and after football training.

Option	Before training	After training	P
Vertical axis angle ($^\circ$)	6.0160 \pm 0.4091	6.2504 \pm 0.4169	P>0.05
Vertical axis angle speed (rad/s)	77.2976 \pm 4.4696	82.6837 \pm 6.0171	P>0.05
Sagittal axis angle ($^\circ$)	7.9216 \pm 0.3734	8.1436 \pm 0.3538	P>0.05
Saga shaft angle speed (rad/s)	86.6887 \pm 9.0916	97.9932 \pm 10.9890	P>0.05
Coronary shaft angle ($^\circ$)	0.7483 \pm 0.3152	0.7625 \pm 0.3852	P>0.05
Coronal axis angle speed (rad/s)	7.9514 \pm 1.7452	8.3914 \pm 1.3568	P>0.05

analysis, in order to give the ball a strong impact and shorten the time for the lower limbs to collide with the football as much as possible, so as to improve the speed of passing and shooting, before the feet touch the football, our legs need to swing to the rear of our body, while the knee joint drives the lower legs to bend 90 degrees. Before our lower limbs touch the ball, we can fully swing back through the lower limb muscles to prolong the length of the lower limb muscles. At the same time, by fully stretching the lower limb muscles, drive the lower limb muscles, and fully increase the muscle strength through exercise. Through the bending of the body trunk, the angle of contact between the body and football is changed, the speed of contact is increased, and finally the speed of linear motion of football is improved. This set of movements ensures that the athlete can increase the flying distance of the football with the minimum force under the condition of driving the whole body movement muscle group. At the same time, under the condition of more labor-saving, it reduces the fatigue degree of the muscle, so as to save physical strength.

To improve the comprehensive quality of athletes' lower limb muscles, we can use aerobic and anaerobic sports to effectively improve athletes' lower limb muscles. First, we can use sprint to improve the excitement of athletes' lower limb muscles, so as to improve athletes' short-term explosive power, and then through endurance uniform running, improve athletes' lower limb muscles' Sports endurance and maintain athletes' muscle endurance in the competition. After running training, you can use relevant equipment, such as weight-bearing equipment such as dumbbells and sandbags. Relevant anaerobic exercises such as squatting or flat support are used to improve the explosive power of athletes' core muscles and leg muscles.

CONCLUSION

Through the research of this paper, we can see that the improvement of football skills not only depends on many times of hard training, but also is closely related to the scientific way of training. Through the mechanical modeling of athletes' actions, analyze their mechanical characteristics, and purposefully optimize them to reduce the kinetic energy consumption as much as possible, so as to obtain better ball strength and angle and improve athletes' football skills. Therefore, coaches should carefully study the relevant mechanical principles and optimize the training scheme from a scientific perspective. Athletes should actively feed back according to their own actual situation and seriously cooperate with the guidance of coaches, so as to improve the sports level.

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