REPERCUSSIONS OF BALANCE TRAINING ON SOCCER PLAYERS' LOWER LIMB INJURIES

REPERCUSSÕES DO TREINO DE EQUILÍBRIO NAS LESÕES DE MEMBRO INFERIOR NOS JOGADORES DE FUTEBOL

REPERCUSIONES DEL ENTRENAMIENTO DE EQUILIBRIO EN LAS LESIONES DE LOS MIEMBROS INFERIORES EN LOS JUGADORES DE FÚTBOL

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ABSTRACT

Introduction: Soccer is a combative event that requires particular skills and physical fitness. The unique soccer characteristics determine the high incidence of joint injuries in the lower limbs. In this regard, balance training has proven to be particularly important, as research indicates a reduction in lower limb injuries justified by the gain in the athletes' muscle control capacity. Objective: This paper analyzes the repercussions of balance training on lower limb injuries in soccer players. Methods: 16 soccer players were randomly divided into experimental and control groups, without statistical difference. Both performed routine training first, with subsequent adherence to balance training by the experimental group. The experiment lasted eight weeks, and the balance training was based on an exercise protocol of approximately 30 minutes, three times a week, for eight weeks. Indexers on recovery from lower limb injury were statistically analyzed and compared. Results: After balance training, soccer players in the experimental group improved faster. At the same time, the lower limb injury was effectively improved. Conclusion: The balance training method can reduce the probability of lower limb injuries in soccer players. ***Evidence Level II; Therapeutic Studies - Investigating the result.***

Keywords: Resistance Training; Athletes; Lower limb; Postural Balance.

RESUMO

Introdução: O futebol é um evento combativo que requer habilidades e aptidão física altamente específicas. As características especiais do futebol determinam a alta incidência de lesões articulares nos membros inferiores dos seus esportistas. O treinamento de equilíbrio tem se mostrado particularmente importante nesse aspecto pois pesquisas indicam a redução das lesões nos membros inferiores justificada pelo ganho na capacidade de controle muscular dos atletas. Objetivo: Este artigo analisa as repercussões do treino de equilíbrio sobre as lesões nos membros inferiores dos jogadores de futebol. Métodos: 16 jogadores de futebol foram divididos aleatoriamente em grupos experimentais e de controle, sem diferença estatística. Ambos executaram primeiramente o treinamento de rotina, com adesão posterior ao treinamento de equilíbrio pelo grupo experimental. A duração do experimento foi de oito semanas, o treino de equilíbrio consistiu na execução de um protocolo de exercícios com duração aproximada de 30 minutos, três vezes por semana, durante 8 semanas. Foram analisados e comparados estatisticamente os indexadores na recuperação da lesão dos membros inferiores. Resultados: Após o treinamento de equilíbrio, os jogadores de futebol do grupo experimental melhoraram mais rapidamente. Ao mesmo tempo, a lesão dos membros inferiores foi efetivamente melhorada. Conclusão: O método de treinamento de equilíbrio pode reduzir a probabilidade de lesões nos membros inferiores dos jogadores de futebol. ***Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.***

Descritores: *Treinamento de Força; Atletas; Extremidade Inferior; Equilíbrio Postural.*

RESUMEN

Introducción: El fútbol es un evento combativo que requiere habilidades muy específicas y una buena forma física. Las características especiales del fútbol determinan la elevada incidencia de las lesiones articulares en los miembros inferiores de sus deportistas. El entrenamiento del equilibrio ha demostrado ser especialmente importante en este aspecto, ya que las investigaciones indican una reducción de las lesiones en los miembros inferiores, justificada por la ganancia en la capacidad de control muscular de los deportistas. Objetivo: Este trabajo analiza las repercusiones del entrenamiento del equilibrio en las lesiones de las extremidades inferiores en los jugadores de fútbol. Métodos: 16 jugadores de fútbol fueron divididos aleatoriamente en los grupos experimental y de control, sin diferencia estadística. Ambos realizaron un primer entrenamiento de rutina, con la posterior adhesión al entrenamiento de equilibrio por parte del grupo experimental. La duración del experimento fue de ocho semanas, el entrenamiento del equilibrio consistió en la ejecución de un protocolo de ejercicios con una duración aproximada de 30 minutos, tres veces por semana, durante 8 semanas. Se analizaron y compararon estadísticamente los índices de recuperación de las lesiones de las extremidades inferiores. Resultados: Tras el *entrenamiento del equilibrio, los futbolistas del grupo experimental mejoraron más rápidamente. Al mismo tiempo, la lesión de la extremidad inferior mejoró eficazmente. Conclusión: El método de entrenamiento del equilibrio puede reducir la probabilidad de lesiones en las extremidades inferiores en los jugadores de fútbol.* ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores: *Entrenamiento de Fuerza; Atletas; Extremidad Inferior; Equilibrio Postural.*

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INTRODUCTION

Football is an antagonistic event that requires highly specific physical stamina and specific skills. The special characteristics of football determine the high incidence of joint injuries of the lower limbs of football players.[1] The appearance of sports injuries will hinder athletes' performance and may even ruin the entire sports career. Maintaining balance requires a series of sensory inputs, including visual input, vestibular sensation, and proprioception. At present, balance includes static posture balance, dynamic posture balance, and dynamic stability.[2] Balance training is particularly important for young athletes. It can reduce the damage of lower limbs caused by athletes' muscle control ability. This article uses balance training to study the effects of prevention and intervention of juvenile football players' lower limb injuries. The article aims to provide a reference for football players' injury prevention.

METHOD

Research object

We selected 16 juvenile football players as the research objects. We randomly divided 16 subjects into two groups.[3] There are 8 people in the control group and 8 people in the experimental group. There was no statistical difference in the basic data of the subjects (P>0.05).

Research methods

The experiment time is from mid-April 2019 to mid-June 2019. The duration is 8 weeks. Training balance ability 3 times a week.[4] The time lasts for about 30 minutes. Except for the balance training three times a week, the experimental group performed routine training consistent with the control group for 8 weeks. The control group only performed routine training without other balance training.

Athletes do not perform any warm-up activities before performing the FMS functional test. We carried out two test screenings before and after the experiment on 16 athletes in turn and quantified their scores.

Human body inverse kinematics method

Inverse kinematics is to know the position of the end operating rod in Cartesian space and reversely determine the joint space's structural parameters.[5] Assume that the end position change is ΔX. The corresponding joint angle $\Delta\Theta$ changes as follows.

$$\Delta X = J\Delta\theta \qquad (1)$$

J is the Jacobian matrix of the system. Θ and X have different degrees of freedom, and J is irreversible. The usual solution is as follows.

$$\Delta_\theta = J^+\Delta X + \alpha(I - J^+J)\Delta Z \qquad (2)$$

Where J^+ represents the pseudo-inverse matrix of J. α is the penalty factor.[6] I is the identity matrix. ΔZ is the minimized constraint factor. Some scholars have given the relationship between speed and step length in normal walking motion:

$$Step\ length = 0.004 \times S \times body\ Height \qquad (3)$$

$$S = Step\ \ Length \times Step\ \ frequency \qquad (4)$$

Where S is the speed (unit: m/min). Step length is the distance between the landing of two successive feet. Step frequency is the number of steps in a given time. From the step length and speed, we can determine the movement period:

$$Step\ duration = Step\ Length / S \qquad (5)$$

Step duration is the movement time between successive landings of two feet. S is the movement speed.

The second layer determines the parameterized curves of the supporting feet, swinging feet, and the center of mass in Cartesian space.[7] The movement of the lower limbs mainly includes the movement of the supporting leg and the swinging leg. Empirical data can be obtained from the study of gait mechanisms. The angles Angle 1and Angle 2 between the supporting feet and the ground when they land and when they just leave the ground are determined by the speed of motion.

$$Angle1 = k_1 f_1(S) \qquad (6)$$

$$Angle2 = k_2 f_2(S) \qquad (7)$$

We use linear interpolation for each time interval to calculate the angle between the supporting feet and the ground. From this, the movement path of the supporting foot can be obtained:

$$Angle = f(Angle1, Angle2, t) \qquad (8)$$

f is the interpolation function. We use linear interpolation functions. We use a cubic Bezier curve to describe the path of the swinging foot in a straight walk. Its matrix expression is shown in equation (9).

$$Q(t) = [t^3\ t^3\ t\ 1]M_{Ber}[P_0\ P_1\ P_2\ P_3\ ]^T$$
$$M_{Ber} = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \qquad (9)$$

P_0 indicates the joint position when the swinging foot is just off the ground. P_1 represents the joint position when the swinging foot just hits the ground. P_2, P_3 represents the gait that controls the movement.[8] The movement of the pelvis on the YZ plane can be described by a sine curve as follows:

$$K\square RV + K\square RV \sin 2n(2t - \phi) \qquad (10)$$

In the formula, K is the adjustment coefficient. RV is the relative speed, which simply expresses the speed as a function of the height of the hip joint. t is the relative movement time. ϕ is the adjustment parameter.

During exercise, the pelvis rotates slightly around the Y axis γ_{pelvis}. There is a slight displacement d_{pelvis} on the transverse plane.[9] We obtain the equation of motion in Cartesian space through linear interpolation:

$$\gamma_{pelvis} = \gamma_0 + \alpha_t \quad (11)$$

$$d_{pelvis} = d_0 + \lambda_t \quad (12)$$

In the formula, γ_0, d_0 is the compensation factor. λ, α is the interpolation factor. t is the relative movement time. The third layer determines the posture of the human body in the joint space. When a person walks or runs, the upper limbs perform movements synchronized with the legs.[10] Usually, the rotation of the shoulder joint drives the swing of the upper arm, and the elbow joint's rotation drives the forearm's swing. The equation of motion is as follows:

$$\gamma_{shoulder} = k\alpha_{hip} + \beta_0 \quad (13)$$

$\gamma_{shoulder}$ is the anteroposterior swing angle of the shoulder joint. k is the scaling factor. α_{hip} is the swing angle of the reverse medullary joint. β_0 is the compensation factor. The movement pattern of the elbow joint is the same as $\gamma_{shoulder}$.

Mathematical Statistics

I did not let you use EXCEL2010, SPSS20.0 statistical software to analyze and process the test results. Independent sample T-test and paired sample T-test were used for analysis.

RESULTS

Analysis of the total item results of functional action screening (FMS)

It can be seen from Table 1 that there is no significant difference between the FMS scores of the experimental group and the control group before the intervention experiment (P>0.05). After the intervention experiment, the experimental and control groups' FMS scores were significantly different (P>0.05). It can be seen that the FMS score of the control group did not change much after 8 weeks of traditional training.[11] The scores both before and after are less than 14 points.

After passing the balance training, the average FMS score of the experimental group was greater than 14 points. This shows that balance training can reduce the risk of juvenile football players' lower limb injuries.

Analysis of the sub-items of functional action screening (FMS)

It can be seen from Table 2 that there was no significant difference in the 7 action test results between the experimental group and the control group before the intervention (P>0.05). After 8 weeks of intervention training, the experimental and control groups had significant differences in squats, hurdles, and lunges (P<0.05). There was no significant difference in the remaining 4 actions.

Table 1. Comparison of FMS score test results between the experimental and control groups.

	Test group	Control group	t	P
Before the experiment	9.38±4.47	9.63±4.37	-0.11	0.91
After the experiment	14.5±3.93	11.0±3.83	3.43	0.03
P	0.003	0.41		
t	-4.37	-0.88		

Analysis of static balance test results

Before intervention training, the experimental group and the control group had no significant difference in the movement track circumference of the feet with eyes open, the movement track circumference of the feet with the eyes closed, and the percentage of body stability limit (P>0.05). (Table 3) After 8 weeks of intervention training, the experimental and control groups had significant differences in the trajectory circumference of the feet with eyes open, the trajectory circumference of the feet with closed eyes, and the percentage of body stability limit (P<0.05).

Table 2. Comparison of FMS test results.

Index		Test group	Control group	t	P
High squat	Before the experiment	0.50±0.53	0.65±0.61	-0.8	0.44
	After the experiment	2.13±0.35	1.25±0.61	3.13	0.01
	P	0	0.16		
	t	-8.88	-1.53		
Hurdle step	Before the experiment	1.63±0.64	1.50±0.66	0.33	0.64
	After the experiment	2.25±0.46	1.63±0.52	2.55	0.02
	P	0.048	0.6		
	t	2.38	-0.55		
Lunge squat	Before the experiment	1.50±1.31	1.50±1.06	0	1
	After the experiment	2.38±0.52	1.00±0.83	3.66	0.04
	P	0.04	0.28		
	t	2.5	1.18		
Shoulder flexibility	Before the experiment	2.13±1.36	2.25±1.64	-0.2	0.85
	After the experiment	2.13±0.83	2.38±0.64	-0.63	0.54
	P	1	0.68		
	t	0	-4.24		
Active Straight Knee Lift	Before the experiment	2.16±1.25	2.16±1.25	0	1
	After the experiment	2.50±0.83	1.65±0.88	1.66	0.12
	P	0.35	0.55		
	t	1	0.63		
Trunk stability push-ups	Before the experiment	0.50±0.83	1.00±0.83	-1.08	0.3
	After the experiment	1.63±1.06	1.63±0.52	0	1
	P	0.06	0.22		
	t	2.18	-1.36		
Stable rotation on prone	Before the experiment	1.00±1.06	0.65±0.88	0.51	0.62
	After the experiment	1.65±0.61	1.38±0.64	1.03	0.38
	P	0.08	0.01		
	t	2.05	-3,42		

Table 3. Test results of static equilibrium and stability limit of experimental and control groups (s).

Index		Test group	Control group	t	P
Circumference of foot movement trajectory with eyes open	Before the experiment	287.02±71.92	267.15±109.65	0.33	0.68
	After the experiment	179.62±13.23	261.25±95.22	-2.3	0.036
	P	0	0.31		
	t	5.02	0.76		
Circumference of foot movement trajectory with eyes closed	Before the experiment	363.30±87.78	331.59±122.35	0.31	0.69
	After the experiment	213.68±32.67	303.60±98.02	-2.36	0.03
	P	0	0.02		
	t	6.28	3.12		
Percentage of stability limit	Before the experiment	81.37±6.93	83.03±6.36	-0.76	0.36
	After the experiment	91.36±3.18	85.63±6.07	2.3	0.03
	P	0	0.01		
	t	-5.59	-3.66		

DISCUSSION

The perimeter of the trajectory reflects the trajectory of the projection of the center of gravity. The longer the movement trajectory, the greater the shaking amplitude when the limb is standing. When the body maintains balance, it needs the input of vision, proprioception, and vestibular sensation. Because the visual input is lost when the eyes are closed, the body's balance ability will be weaker than when the eyes are opened. The stability limit test is the ability of the body to lean in multiple directions. Generally speaking, the ability to tilt the body to the left and right is stronger than tilt the body backward. From the perspective of biomechanics, when the horizontal projection of the heart just falls within the supporting surface, the body can remain upright without turning and other movements.

When the athlete completes the balancing exercise, the vision will continuously stimulate the momentary static and dynamic balance mechanism. In the advanced practice process, left and right head-turning and left and alternate right movements were also added. These actions help improve the function of the vestibular organs. These actions require athletes to maintain balance while strengthening the correct movement patterns. The balance training program can effectively develop athletes' vision, vestibular sensation, and proprioception. Continuously improve the central nervous system's ability to process and analyze sensory information comprehensively and coordinate with resistance to external interference, muscle strength and endurance, and joint flexibility, thereby improving the body's balance ability.

CONCLUSION

After 8 weeks of balance training, the total FMS score of the experimental group was higher than 14 points. This mainly reflects the significant improvement in the three test scores of high-lift squat, hurdle step, and lunge squat. After balance training, the experimental group's hip and ankle joint flexibility increased, knee joint stability, and trunk control ability increased. The athlete's static balance ability has been significantly improved. This shows that the balance training program effectively develops the athlete's vision, proprioception, and vestibular sensory abilities.

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