REPERCUSSIONS OF CORE STRENGTH TRAINING ON SOCCER PLAYERS' PERFORMANCE

REPERCURSSÕES DO TREINO DE RESISTÊNCIA DO CORE SOBRE O DESEMPENHO DOS JOGADORES DE FUTEBOL

REPERCUSIONES DEL ENTRENAMIENTO DE LA RESISTENCIA DEL CORE EN EL RENDIMIENTO DE LOS FUTBOLISTAS

Original Article
Artigo Original
Artículo Original

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ABSTRACT

Introduction: Soccer players are athletes who need to develop advanced characteristics of strength and speed. The resistance training of the muscles involved in the core is a new training theory applicable to modern sports that is gaining prominence due to its amazing results. It is of great value for researchers to integrate the strengths of core strengthening into soccer training, improve their protocols, and compensate for their limitations. Objective: This study aimed to analyze the relationship between core strength training and physical conditioning in soccer players. At the same time, this article discusses the influence of core muscle strength characteristics on athletes' physical performance. Methods: This article selects advanced soccer players as research subjects. Volunteers were randomly divided into two groups (control and experimental groups). The experimental group received core muscle strength training, while the control group received daily training. This paper analyzed the muscle strength characteristics of the two groups of volunteers. Then, this paper conducts a statistical and mathematical analysis of the muscle strength level data in two groups of athletes. Results: The experimental group showed significant differences in bilateral hip and ankle joint flexors after core muscle strength training (P<0.01). The relative peak moment of flexion and extension of the left hip was lower than that of the right hip, a factor justified by the predominant motor laterality principle on the players. The muscle strength of the left knee and ankle joints was greater than that of the right. Both experimental and control groups showed that the strength of the ankle flexors was better than the ankle extensors (knee toe flexors). The data were very significantly different (P<0.01). Conclusion: Muscular endurance training can help improve the physical conditioning of soccer players. Athletes can reinforce core strength training in their daily training. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Endurance Training; Soccer; Athletes; Sports; Muscle Strength.

RESUMO

Introdução: Jogadores de futebol são atletas que necessitam desenvolver características avançadas de força e velocidade. O treinamento de resistência da musculatura envolvida no core é uma nova teoria de treinamento aplicável aos esportes modernos que vem ganhando destaque devido aos surpreendentes resultados. É de grande valor para os pesquisadores integrar os pontos fortes do fortalecimento do core no treinamento de futebol, aprimorar seus protocolos e compensar as suas limitações. Objetivo: O objetivo deste estudo foi analisar a relação entre o treinamento de resistência do core e o condicionamento físico em jogadores de futebol. Ao mesmo tempo, este artigo discute a influência das características de força muscular do core no desempenho físico dos atletas. Métodos: Este artigo seleciona jogadores avançados de futebol como objetos de pesquisa. Os voluntários foram divididos aleatoriamente em dois grupos (grupos de controle e experimental). O grupo experimental recebeu treinamento de força muscular principal, enquanto o grupo controle recebeu treinamento diário. Este artigo analisou as características de força muscular dos dois grupos de voluntários. Em seguida, este artigo conduz uma análise estatística e matemática dos dados do nível de força muscular em dois grupos de atletas. Resultados: O grupo experimental apresentou diferenças significativas nos flexores bilaterais da articulação do quadril e tornozelo após o treinamento de resistência muscular do core (P<0,01). O momento de pico relativo de flexão e extensão do quadril esquerdo mostrou-se menor do que o do quadril direito, fator justificado pelo princípio de lateralidade motora predominante sobre os jogadores. A força muscular das articulações do joelho esquerdo e tornozelo foi maior que a da direita. Ambos os grupos experimentais e de controle mostraram que a resistência dos flexores do tornozelo era melhor do que os extensores do tornozelo (flexores do dedo do dedo do joelho). Os dados foram muito significativamente diferentes (P<0,01). Conclusão: O treinamento de resistência muscular pode ajudar a melhorar o condicionamento físico dos jogadores de futebol. Os atletas podem reforçar o treinamento de resistência do core em seus treinamentos diários. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

***Descritores**: Treino de Resistência; Futebol; Atletas; Esportes; Força muscular.*

RESUMEN

Introducción: Los jugadores de fútbol son atletas que necesitan desarrollar características avanzadas de fuerza y velocidad. El entrenamiento de resistencia de la musculatura implicada en el *core* es una nueva teoría de entrenamiento aplicable a los deportes modernos que ha ido ganando protagonismo por sus sorprendentes resultados. Es de gran valor para los investigadores integrar los puntos fuertes del fortalecimiento del *core* en el entrenamiento del fútbol, mejorar sus protocolos y compensar sus limitaciones. **Objetivo:** El objetivo de este estudio fue analizar la relación entre el entrenamiento de la fuerza del *core* y la condición física en jugadores de fútbol. Al mismo tiempo, este artículo analiza la influencia de las características de la fuerza muscular del *core* en el rendimiento físico de los atletas. **Métodos:** Este trabajo selecciona como sujetos de investigación a jugadores de fútbol de nivel avanzado. Los voluntarios fueron divididos aleatoriamente en dos grupos (grupo de control y grupo experimental). El grupo experimental recibió un entrenamiento de fuerza de los músculos principales, mientras que el grupo de control recibió un entrenamiento diario. Este trabajo analizó las características de la fuerza muscular de los dos grupos de voluntarios. A continuación, este trabajo realiza un análisis estadístico y matemático de los datos del nivel de fuerza muscular en dos grupos de atletas. **Resultados:** El grupo experimental mostró diferencias significativas en los flexores bilaterales de las articulaciones de la cadera y el tobillo tras el entrenamiento de la fuerza muscular del *core* (P<0,01). El momento máximo relativo de flexión y extensión de la cadera izquierda fue menor que el de la cadera derecha, factor que se justifica por el principio de lateralidad motora que predomina en los jugadores. La fuerza muscular de las articulaciones de la rodilla y el tobillo izquierdos era mayor que la del derecho. Tanto el grupo experimental como el de control mostraron que la fuerza de los flexores del tobillo era mejor que la de los extensores del tobillo (flexores de los dedos de la rodilla). Los datos fueron significativamente diferentes (P<0,01). **Conclusión:** El entrenamiento de la resistencia muscular puede ayudar a mejorar la condición física de los futbolistas. Los atletas pueden reforzar el entrenamiento de la fuerza del *core* en su entrenamiento diario. **Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.**

***Descriptores*:** Entrenamiento Aeróbico; Fútbol; Atletas; Deportes; Fuerza Muscular.

DOI: http://dx.doi.org/10.1590/1517-8692202329012022_0297 Article received on 06/05/2022 accepted on 07/15/2022

INTRODUCTION

Football is a power and speed sport. In football, players must change the line of defense in time, control the ball and solve emergencies. These movements require athletes to have muscular waist and abdomen strength. Football players generally experience hypoxia when performing technical movements in sprints and rapid running.[1] At this time, they need to use muscle anaerobic metabolism to provide a lot of energy. The core muscles of the legs Whether group strength training has a direct and positive effect on improving the exceptional quality of amateur athletes in colleges and universities needs further research. This article analyzes football players' left and right hip, knee, and ankle joints for testing and diagnosis. This article explores the characteristics of lower limb joint muscle strength in football players. This allows for more targeted muscle strength training for athletes.

METHOD

Research objects

This paper selects 16 football players as the research object. (Table 1) We divided them into an experimental group and a control group. There was no significant difference in height and weight between groups.[2] Before the experiment, there was no apparent damage to the lower limb joints. All the athletes volunteered to participate in this experiment.

Research methods

We arranged for the control group to adopt the traditional primary and basic training methods.[3] In this paper, the left and right hip, knee, and ankle joints of 16 subjects were tested in slow 60°/S and fast 240°/S flexion and extension modes using isokinetic muscle strength testing equipment. We asked subjects to perform a 15-minute warm-up before the formal test.

Table 1. Research subjects.

Group	N	Age	Height (cm)	Weight (kg)	Years of exercise
Test group	8	21.47±3.36	187.31±3.17	77.11±4.74	7.71±2.16
Control group	8	21.71±2.42	186.41±4.31	78.46±4.81	6.41±3.81

Simulation of the force on the leg muscles of football players

In this paper, according to the height of swinging legs, the mechanical planning parameters of the joint coordination planning of the mechanical characteristics of the football player's leg muscles are obtained as t_k. This paper analyzes the moment of inertia of a football player's leg muscles at the moment of landing based on the energy lost by the system in the current cycle.[4] At the same time, we take the upper bound of variance $R^i_v(k)$ as the adjustment coefficient. In this way, the force characteristics of the legs at the time of landing are:

$$F_s = Et_k \pi D_0 \left(\frac{(1-\varepsilon^2)}{\tan\theta + \cot\theta} \left(1 - \frac{R^i_v(k)}{\sin\theta} \right) \right) \tag{1}$$

In this paper, the parametric simulation of the force on the leg muscles of football players is carried out by employing end pose analysis and the mechanical constraint method. In this paper, the inertia parameters are adjusted according to the output torque of the knee joint.[5] At the same time, according to the combined detection results of the inertia moment coefficient of the muscle, the feedback control adjustment polarization equation is obtained:

$$f_l = F_s - \sqrt{1-(1-\varepsilon)^2 \cos^2\theta} \tag{2}$$

In this paper, the stability posture adjustment is carried out according to the output torque of the leg muscles of football players.[6] Then this paper obtains the state equation of the athlete's leg and hips joint control:

$$P_f = \frac{(P-P_e)LD}{f_l} \tag{3}$$

In this paper, the joint control of the athlete's leg and the hip joint is realized by actively adjusting the mechanical parameters of the leg muscles.

Mathematical Statistics

In this paper, the relative peak torque (PT/W), antagonist/active muscle ratio (PTR), and muscular endurance (ER) of the left and right hip, knee, and ankle joints of the two groups of subjects were measured by SPSS17.0 statistical software.[7] Do statistics. In this paper, independent samples were conducted for the relative peak torque (PT/W), antagonist/active muscle ratio (PTR), and flexion and extension muscle endurance (ER) of the hip, knee, and ankle joints in the same group and on the same side between groups. T-test. Significant differences were expressed as $P < 0.05$, and very significant differences were expressed as $P < 0.01$.

There is no need for a code of ethics for this type of study.

RESULTS

Relative peak torque (PT/W) analysis of hip, knee, and ankle joints

The data in Table 2 reflect that the relative peak moments of flexion and extension of the hip, knee, and ankle joints in the experimental and control groups decreased sequentially.[8] This is in line with the principle that the strength of the human body, from large joints to small joints, decreases in turn. The flexors of bilateral hips and ankles in the experimental group had very significant differences (P<0.01). The relative peak moments of left hip flexion and extension were smaller than that of the right hip, while the knee and ankle joints showed that the left side was more significant than the right side. This is related to the subject's left leg being the takeoff leg. Only the ankle flexors had the same results in the control group.

In the 60°/S test, there was a significant difference between the experimental and control groups in bilateral ankle flexors (P<0.01). Greater ankle flexor absolute strength enhances ankle stability. In the 240°/S test, the bilateral hip extensors, left knee (takeoff leg), and bilateral ankle flexors were more prominent in the experimental group.[9] The data were very significantly different (P<0.01). It shows that the advantage of the experimental group is the explosive ability of the lower limbs when doing rapid flexion and extension.

Antagonist/active ratio (PTR) analysis of hip, knee, and ankle joints

The data in Table 3 shows that in the test at 60°/S, there are significant differences between the experimental group's left and right hip joints and the control group (P<0.05). The left and right ankles of the experimental group had very significant differences (P<0.01). The left and right PTR values of the hip and ankle joints of the two groups showed a downward trend with the increase in speed.[10] The knee joint of the experimental group showed an upward trend. No similar characteristics were found in the control group.

Table 2. Relative Peak Torque (PT/W) Values of Subjects' Hip, Knee, and Ankle.

Speed (/S)		60			
Group		Test group		Control group	
Limb	Side	Left	Right	Left	Right
Hip	Qu	2.54±0.10	3.33±0.07	2.75±0.07	3.45±0.13
	Stretch	3.90±0.24	4.12±0.35	4.02±0.32	4.21±0.22
Knee	Qu	2.12±0.05	2.20±0.15	2.21±0.14	2.15±0.09
	Stretch	3.71±0.22	3.44±0.30	3.95±0.27	3.52±0.25
Ankle	Qu	2.40±0.15	1.79±0.22	1.50±0.07	1.37±0.12
	Stretch	0.47±0.24	0.49±0.17	0.43±0.17	0.45±0.20
Speed (/S)		**240**			
Group		**Test group**		**Control group**	
Limb	Side	Left	Right	Left	Right
Hip	Qu	2.51±0.17	3.07±0.15	2.52±0.10	2.70±0.09
	Stretch	4.17±0.25	4.44±0.32	3.59±0.21	3.71±0.15
Knee	Qu	2.27±0.12	2.24±0.15	2.00±0.12	1.79±0.07
	Stretch	3.71±0.17	3.57±0.12	3.31±0.25	3.25±0.17
Ankle	Qu	2.21±0.25	1.75±0.17	1.57±0.10	1.05±0.15
	Stretch	0.40±0.25	0.37±0.13	0.53±0.14	0.39±0.11

Muscular endurance (ER) analysis of hip, knee, and ankle joints

Muscular endurance (ER) refers to the ability of a muscle to withstand fatigue during repetitive contractions. The number of repetitions for measuring endurance is generally 20 or 25. Usually, the ratio of the work done in the last five times to the work done in the first five times is used as the endurance index. Better muscular endurance is critical to the impact of athletic performance.[11] Few data are available to illustrate the range of muscular endurance ratios in elite athletes. This study compared the differences between the experimental group and the control group. This provides a basis for guiding athletes' regular strength training.

In this paper, the lower limb muscular endurance statistics of the takeoff leg found that the endurance of the ankle flexors in the experimental group and the control group was better than that of the ankle extensors. (Table 4) The data has a very significant difference (P<0.01), in which the swing legs of the experimental group also showed a similar law. After 25 tests, the work of the ankle flexors was not significantly reduced.[12] The statistics of swinging legs in this paper found that the experimental group's hip (flexion, extension) and knee (flexion) endurance were better than those of the control group. But the data had no significant difference (P>0.05). This shows that the experimental and control groups' hip flexion and extension endurance are relatively good. In contrast, the endurance of the knee and ankle extensor muscles needs to be improved.

Table 3. Antagonist/Actor Ratio (PTR) Values of Subjects' Hip, Knee, and Ankle.

Speed (/S)	Group	Limb	Hip	Knee	Ankle
60	Test group	Left	0.72±0.10	0.52±0.09	5.00±1.55
		Right	0.91±0.09	0.59±0.12	3.95±1.12
	Control group	Left	0.59±0.07	0.55±0.11	5.53±1.70
		Right	0.92±0.09	0.51±0.05	4.75±1.52
240	Test group	Left	0.53±0.04	0.54±0.05	3.72±1.07
		Right	0.5±0.07	0.52±0.09	3.04±0.99
	Control group	Left	0.57±0.09	0.59±0.05	2.95±0.97
		Right	0.73±0.09	0.55±0.10	2.59±0.92

Table 4. Analysis of Muscular Endurance (ER) Values of Subjects' Hip, Knee, and Ankle.

Limb	Group	Model	Hip	Knee	Ankle
Left	Test group	Qu	0.90±0.05	0.62±0.04	0.92±0.09
		Sstretch	0.91±0.03	0.65±0.13	0.40±0.19
	Control group	Qu	0.95±0.06	0.60±0.05	0.99±0.02
		Stretch	0.90±0.06	0.65±0.09	0.42±0.12
Right	Test group	Qu	0.93±0.09	0.69±0.10	0.65±0.22
		Stretch	0.95±0.10	0.65±0.09	0.43±0.11
	Control group	Qu	0.69±0.09	0.62±0.11	0.90±0.06
		Stretch	0.96±0.12	0.66±0.12	0.42±0.99

DISCUSSION

The antagonist/agonist ratio (PTR) refers to the peak torque ratio of the two muscle groups. It reflects the balance of muscle strength between the two groups of antagonistic muscle groups in joint activities. This has a particular significance for judging the stability of the joint. A reasonable PTR value can prevent agonist or antagonist muscle strain. At the same time, it also has a positive impact on the completion of sports technology.

Some scholars have found that the PTR ratio of the knee joint changes with the change of the test speed. The range is 50-70%, and the ratio of athletes in different sports varies. If the coach requires the athlete to have a solid explosive force when kicking off the ground, then a strong hamstring muscle group is needed to support. Football events require athletes to have a strong enough takeoff ability in their takeoff legs. The test results of the experimental group are consistent with this view. Some scholars studied 30 sprinting, hurdling, and football players with hip joint (60°, 120°, 240°/S) flexion-extension ratios ranging from 0.70 to 0.79.

CONCLUSION

There was no significant difference in the ratio range of the lower limb joint flexor and extensor groups between the experiment and the contgroupsroup. The hip joint is between 0.63 and 0.82, the knee joint is between 0.56 and 0.64, and the ankle joint is between 2.69 and 5.53. The ankle flexors of the experimental group and control groups' ankle flexors had better endurance than the ankle extensors (P<0.01). The swing legs of the experimental group also showed a similar pattern. The endurance of the knee and ankle extensor muscles of the experimental group and the control group needs to be strengthened.

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

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

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