



Original article

Effects of power training in mechanical stiffness of the lower limbs in soccer players



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ABSTRACT

Objective: The aim of this study was evaluate whether leg stiffness (*Kleg*) changes after power training. **Methods:** Forty professional soccer players were divided into 2 groups (20 were assigned to the trained group and 20 to the control group). A quasi-experimental study with pre-post intervention was conducted to estimate *Kleg* before (period 1) and after a six-week period of power training (period 2). Leg stiffness was measured using a three-dimensional filming method while soccer players ran on a treadmill at 13 km/h. The heights of squat jumps (SJ) and countermovement jumps (CMJ) were measured and the pre-stretch augmentation (PSA) was calculated before and after the training period in both groups. **Results:** We found a significant increase in *Kleg* after the power training program. Significant positive linear relationships between *Kleg* and SJ height were found in both periods and groups, while CMJ height was not correlated with *Kleg* in the trained group during period 2. No significant relationships were found between *Kleg* and PSA in either case.

Conclusions: We concluded that *Kleg* can change significantly after a short power training program. Based on our results and previous studies, we suggest that these changes could be mainly associated with adaptations at muscle control level.

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Efectos del entrenamiento de potencia sobre la rigidez mecánica de miembros inferiores en jugadores de fútbol

RESUMEN

Objetivo: El objetivo de este estudio fue evaluar si la rigidez de la pierna (*Kleg*) cambia después de un período de entrenamiento de potencia.

Métodos: Cuarenta jugadores profesionales de fútbol se dividieron en 2 grupos (20 se asignaron al grupo entrenado y 20 al grupo control). Se realizó un estudio cuasi-experimental con pre-post intervención para estimar *Kleg* antes (período 1) y después de 6 semanas de entrenamiento de potencia (período 2). Se cuantificó *Kleg* mediante la reconstrucción de imágenes en 3 dimensiones mientras los sujetos corrían en una cinta a 13 km/h. Se midieron las alturas de *squat jumps* (SJ) y *countermovement jumps* (CMJ) y se calculó el *pre-stretch augmentation* (PSA) antes y después del período de entrenamiento para ambos grupos.

Resultados: Se encontró un aumento significativo en *Kleg* después del programa de entrenamiento. Se encontraron correlaciones lineales positivas entre *Kleg* y la altura de los SJ en ambos períodos para los 2 grupos, mientras que la altura CMJ no se correlacionó con *Kleg* únicamente en el grupo entrenado durante el período 2. No se encontraron relaciones significativas entre *Kleg* y PSA.

Palabras clave:

Biomecánica
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Conclusiones: Llegamos a la conclusión de que Kleg puede cambiar significativamente como producto del entrenamiento de potencia. Basados en nuestros resultados y considerando estudios previos sugerimos que estos cambios podrían estar asociados principalmente con adaptaciones a nivel del control muscular.

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Efeitos do treinamento de potência sobre rigidez mecânica dos membros inferiores em atletas de futebol

R E S U M O

Palavras-chave:

Biomecânica
Fisiologia
Esporte
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Objetivo: O objetivo deste estudo foi avaliar mudanças na rigidez da perna (Kleg) após um período de treinamento de potência.

Método: Quarenta jogadores de futebol profissionais foram divididos em 2 grupos (foram designados 20 ao grupo treinado e 20 ao grupo controle). Se realizou um estudo quase experimental com uma intervenção pré/pós teste para estimar a Kleg antes (período 1) e após 6 semanas de treinamento de potência (período 2). A Kleg foi quantificada através de um método de filmagem tridimensional enquanto os sujeitos corriam em uma esteira a 13 km/h. Foram medidas as alturas nos testes *squat jumps* (SJ) e *countermovement jumps* (CMJ), e foi medido e calculado o *aumento pré-estiramento* (PSA), antes e depois do período de treinamento para ambos os grupos.

Resultados: Foi encontrado um aumento significativo em Kleg após o programa de treinamento. Foi encontrado uma correlação linear positiva entre a Kleg e a altura do SJ em ambos os períodos para os dois grupos, enquanto a altura do CMJ somente não se correlacionou com a Kleg no grupo treinado durante o período 2. Não foram encontradas relações significativas entre a Kleg e o PSA.

Conclusão: Chegamos à conclusão que a Kleg pode mudar significativamente como resultado ao treinamento de potencia de curta duração. Com base em nossos resultados e considerando estudos anteriores, sugerimos que estas alterações podem estar associadas, principalmente, com adaptações a nível de controle muscular.

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Introduction

When people run, the musculoskeletal structure of the lower limbs can be modelled as a spring-mass system consisting of a linear spring which represents the stance limb, and a point mass equivalent to the body mass.¹⁻³ With this assumption, the spring stiffness would represent the overall mechanical stiffness of lower limbs during the stance phase.^{1,3-5} Mechanical stiffness of lower limbs has been evaluated through different experimental approaches, but Kleg is one of the most used ones.⁶ This is a global parameter that represents the stiffness of the muscle-tendon units in the legs during the effective ground contact phase.^{4,6}

Kleg is an important variable that can influence the performance of athletes.^{6,7} Furthermore, it has been established that power training programs could generate important changes in the structural and mechanical properties of the locomotor system, enabling changes in strength and speed rates.⁸ Considering that the rate of force development and sprint kinematics are included among the athletic variables that have been associated with Kleg,⁶ the evaluation of possible changes in Kleg after power training could be of great interest to the sport community. Specifically in sports like soccer, in which performances include high intensity intermittent activities,⁹ explosive strength or power is one of the most important capacities to work in physical training.

Regarding the factors that determine Kleg, Hobara et al.⁸ suggested that this variable is partly dependent on the muscle activation pattern and probably in short-latency stretch reflex response of the triceps surae. In a subsequent study, Hobara et al.¹⁰ found that Kleg of power-trained athletes is significantly higher than Kleg of distance runners. Furthermore, cross-sectional studies indicate that physical power training enhances Kleg.^{11,12} However, optimal Kleg required for running remains a topic of debate^{6,13-15} and few

studies are available that discuss the effect of power training on Kleg levels during human running.

Based on the literature that has been considered so far, a better understanding of changes in Kleg after a power training program contributes to the development of more effective training methods in soccer.

The goal of this study is to evaluate if Kleg changes after a short power training program. We hypothesized that after this training program an increase in the value of Kleg would be observed. Moreover, through the relationship between Kleg, SJ and CMJ heights, performed to evaluate the training program, and considering results of previous studies, we suggest possible explanations for Kleg values found before and after the training period.

Methods

Sample

Forty professional soccer players (24.7 ± 3.1 years, 73.3 ± 2.5 kg), without any recent injury, voluntarily participated in this study. They were selected by convenience (we worked with a full professional team) and divided randomly into two groups. One group underwent power training (group 1) and the other was the control group (group 2). The sample size in each group was estimated by the model for comparison of two means:

$$n = \frac{2(Z_{\alpha} + Z_{\beta})^2 \times S^2}{d^2}$$

where n is the number of subjects in each sample, Z_{α} and Z_{β} are the values corresponding to desired risk, S^2 is the variance of Kleg in the control group (taken from the literature⁶), and d is the minimum difference value to be detected (taken from literature).⁶

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