Unilateral and bilateral isokinetic knee strength indices in professional soccer players

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Received: 01.08.2018
Accepted: 21.02.2019

Summary

Introduction: The maximum isokinetic torque is one of the most commonly applied methods to assess the muscle strength of the lower extremities in soccer. Knee force indices have been used extensively to identify possible risk factors for injuries such as torn hamstring muscles or rupture of the anterior cruciate ligament.
There are previous studies that describe the isokinetic profile in different populations and there are few in Latin American population. The objective of this study is to describe the isokinetic profile and strength indices in a population of soccer players from a professional Mexican team.
Methodology: This is an observational, retrospective, analytical study. The maximum torque was measured with an angular velocity of 60°/s in 375 professional soccer players from 1st, 2nd and 3rd division from 2010 to 2015 in the Department of Sports Medicine and Rehabilitation of the "Dr. José Eleuterio González" University Hospital, Monterrey Nuevo León, Mexico.
Results: The results obtained were general, clinimetry and isokinetic parameters. The maximum torque was cataloged by group in injured and non-injured players according to the division: 1st (n = 142), 2nd (n = 86) and 3rd (n = 147). From these, the isokinetic strength indices of each of the players were obtained, observing anthropometric differences, in the unilateral and bilateral knee indices, between each category, and even more so in players with injuries.
It is important to have isokinetic parameters and identify at-risk players according to their category as this will provide reference data for future assessments of professional soccer players and they can be used to categorize muscle function as normal or at risk of injury.

Key words:
Dynamometry. Soccer. Sports injury. Torque. knee.

Índices de fuerza isocinética unilateral y bilateral de rodilla en jugadores profesionales de futbol

Resumen

Introducción: El torque máximo isocinético es uno de los métodos más comúnmente aplicados para evaluar la fuerza muscular de las extremidades inferiores en el futbol. Se han empleado índices de fuerza de la rodilla extensivamente para identificar posibles factores de riesgo para lesiones como desgarros de la musculatura isquiotibial o la ruptura del ligamento cruzado anterior.
Hay estudios previos que describen el perfil isocinético en distintas poblaciones y hay pocas en población latinoamericana. El objetivo de este estudio es describir el perfil isocinético y los índices de fuerza en una población de jugadores de soccer de un equipo profesional mexicano.
Metodología: Es un estudio observacional, retrospectivo y analítico. Se midió el torque máximo con una velocidad angular de 60°/s en 375 futbolistas profesionales de 1°, 2° y 3° división del 2010 al 2015 en el Departamento de Medicina del Deporte y Rehabilitación del Hospital Universitario "Dr. José Eleuterio González", Monterrey Nuevo León, México.
Resultados: Los resultados recabados fueron generales, clinimetria y parámetros isocinéticos. Los torques máximos fueron catalogados por grupo en jugadores lesionados y no lesionados de acuerdo a la división: 1°(n=142), 2° (n=86) y 3° (n=147). A partir de estos se obtuvieron los índices de fuerza isocinética de cada uno de los jugadores existiendo diferencias antropométricas, en los índices unilateral y bilateral de rodilla, entre cada categoría, y más aún en jugadores con lesiones.
Es importante tener parámetros isocinéticos e identificar jugadores en riesgo según su categoría ya que esto aportar datos de referencia para futuras valoraciones en los jugadores profesionales de soccer y pueden ser utilizados para categorizar la función muscular como normal o con riesgo de lesión.

Palabras clave:
Dinamometría. Futbol. Lesión deportiva. Torque. Rodilla.

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Introduction

Soccer is considered the most popular sport in the world with 270 million people actively involved in the sport[1]. Physiologically, soccer is characterized by a high intensity and intermittent exercise[2–4] where basic motor skills and specific technical abilities of the players must be constantly adapted to the internal and external variables that are modified during the game period[5]. This is why it is essential to identify the aspects that comprise general physical performance and then examine these individually in each game position as well as establish injury prevention measures[6].

Isokinetic strength assessment tests are probably the most frequently used tools for estimating muscle function in the physical-sports field[7]. Assessment of maximum isokinetic torque is a method that is commonly applied to assess lower limb muscle strength in soccer[8,9].

From this, knee force indices have been extensively used in sports medicine to identify possible risk factors for injuries such as hamstring muscle tears[10] or rupture of the anterior cruciate ligament (ACL)[11], as well as to monitor the effectiveness of rehabilitation programs in soccer players and determine if an athlete can safely return to the game[7,12].

Bilateral strength indices have been used more often because of the relationship between maximum strength of the dominant and nondominant leg[13]. It has been found that the bilateral strength index of concentric knee flexion is able to distinguish people with hamstring and/or ACL[14] pathology and healthy individuals[15]. An asymmetry of less than 10% in the bilateral index at an angular velocity of 60°/s was able to identify non-injured players with a probability of 90.1%[16].

The unilateral strength index is calculated as the quotient of the moment or peak maximum force of the flexor muscle and the extensor muscle of the knee measured during concentric contractions.[16] An index less than 0.50-0.60 has been associated with a significant increase of 17-times the probability of suffering lesions of the ACL and hamstring tears[13,17].

There are previous studies that describe the isokinetic profile in different populations and few studies that describe this in Latin American populations. The objective of this study is to describe the isokinetic profile and strength indices in a population of professional Mexican soccer players.

Material and method

Design

The studied population includes a retrospective analysis of 375 isokinetic tests of professional soccer players recognized by the Mexican Football Federation and evaluated annually by a protocol of the Department of Medicine, Sports and Rehabilitation of the UANL University Hospital in Monterrey, Mexico from 2010 to 2015. The study was previously approved by the Ethics in Research Committee of the institution with registration number MD16-00001. Medical files of first, second and third division players, regardless of age, were included. Files that did not have the collected data or studies with a variation coefficient greater than 12% were excluded[18,19].

Test

Isokinetic tests were performed on a Biodex Multijoint System 4 (Shirley NY, Biodex Medical Systems, Inc.) with a maximal concentric stress isokinetic test. The patient was in a sitting position and movement arcs were established individually according to the anatomical characteristics of each player with five repetitions of extension and knee flexion executed at an angular velocity of 60°/s. The players were instructed to work with as much force as possible in both directions of movement, performed bilaterally, to compare the difference in strength between the two legs, starting with the dominant leg, after at least five minutes of warm-up on the static bicycle and some movements on the dynamometer to get used to the dynamics of the test. Trunk flexibility was assessed with the "Sit and Reach" test. The equipment automatically analyzed the torque peaks of the 5 repetitions in both flexion and extension of both knees; gravity corrections were made for the results obtained in the isokinetic tests.

Data collection

The data collected from each record were general (category, age), clinical (weight, height, flexibility) and isokinetic (peak torque of knee flexors and extensors of both legs) at an angular velocity of 60°/s.

The bilateral strength index was calculated as the difference between the peak torque of the knee flexors for both extremities, expressed as a percentage deficit, using the dominant leg or the uninjured leg as a reference.

The unilateral strength index was calculated as the quotient between the peak torque of the flexor muscles and the peak torque of the extensor muscles, expressed as the quotient of each one of the legs.

Players with a prior injury of the ACL or a lesion of the hamstring muscles were included in this work.

Statistical Analysis

Descriptive statistics were performed for all variables. The distribution of the numerical variables was verified with the Kolmogorov-Smirnov normality test finding that all variables followed a parametric distribution, which is why they were reported as means and standard deviation.

Results

A total of 375 medical records were included and classified according to the participant´s clinical characteristics as injured and non-injured. Players with injuries were older in the first and third division. All injured players had a lower weight and height in all three divisions. Flexibility was greater according to division; the higher the division, the greater the flexibility (Table 1).

Regarding isokinetic tests, players without injuries had greater flexor and extensor strength. Flexor strength, which is related to hamstring injuries, was close to 100 N.m for injured players. Second division players had a better flexor and extensor strength profile than first and third division players (Table 2).

Table 1. General, clinical y flexibility characteristics.

Players	Age, years	Weight, kg	Height, cm	Trunk flexibility, cm
1st division				
Non injured, n=114	25.1 ± 3.8	75.5 ± 8.4	178.4 ± 7.4	11.53 ± 6.3
Injured, n=28	28 ± 4.1	70.2 ± 6.9	174.4 ± 6.9	9.8 ± 5.6
2nd division				
Non injured, n=67	18 ± 1.1	69.5 ± 7.0	176.5 ± 6.1	11.26 ± 4.9
Injured, n=19	17.7 ± 1.1	66.3 ± 6.9	174.1 ± 5.0	10.6 ± 5.2
3rd division				
Non injured, n=133	15.7 ± 1.0	66 ± 6.6	176 ± 6.6	9.68 ± 5.8
Injured, n=14	16.3 ± 1.3	62.8 ± 6.6	174 ± 4.5	6.7 ± 7.0

Values are means ± standard deviation.

Table 2. Bilateral peak torque strength of knee flexors and extensors.

Variable	PRET, N•m	PLET, N	PRFT, N•m	PLFT, N•m
1st division				
Non injured, n=114	208.93 ± 40.5	207.9 ± 35.9	123.67 ± 29.6	120.84 ± 26.2
Injured, n=28	196.1 ± 43.2	185.25 ± 39.3	110.22 ± 30	100.17 ± 29.6
2nd division				
Non injured, n=67	219.57 ± 40.2	212.46 ± 34.8	124.91 ± 26.7	119.77 ± 20.6
Injured, n=19	196.3 ± 40.3	201.87 ± 40.7	115.99 ± 30.1	109 ± 25.7
3rd division				
Non injured, n=133	191.15 ± 37.5	190.55 ± 34.3	105.61 ± 22.2	102.54 ± 23.4
Injured, n=14	166.8 ± 27.1	163.48 ± 24.7	98.51 ± 18.9	89.45 ± 17.5

Values are means ± SD (standard deviation).
PRET: Peak right extensor torque; PLET: Peak left extensor torque; PRFT: Peak right flexor torque; PLFT: Peak left flexor torque; N•m: Newton meter.

Table 3. Isokinetic strength indices according to category.

Variable	Bilateral index	Unilateral index right	Unilateral index left
1st division			
Non-injured	11.14 ± 9.89	0.598 ± 0.12	0.585 ± 0.10
Injured	15.65 ± 13.12	0.564 ± 0.10	0.536 ± 0.08
2nd division			
Non-injured	11.46 ± 9.86	0.577 ± 0.11	0.569 ± 0.08
Injured	14.27 ± 10.66	0.538 ± 0.11	0.544 ± 0.10
3rd division			
Non-injured	11.54 ± 8.37	0.558 ± 0.09	0.541 ± 0.09
Injured	12.12 ± 8.14	0.50 ± 0.08	0.541 ± 0.12

Values are means ± SD (standard deviation).

Results of the bilateral isokinetic strength index were less than 12% in non-injured players in the three divisions. In contrast, the bilateral index was increased in first and second division and only slightly above 12% in third division. The best results regarding the left and right unilateral indices (<0.6) were found in the first division (Table 3).

Discussion

General and clinical

The age of the population is similar to the age of other professional soccer team players. The mean height found in both groups was lower than in another Latin population studied, Brazil[20,21], and European populations, such as England[22], Spain[23] and Poland[24]; however, it is similar to population from the Middle East, such as Qatar[25], Saudi Arabia[26], and the United Arab Emirates[27].

The mean weight in both groups was lower than that reported in populations such as Brazil, Poland, and England[9,21,23]. This variation seems to be in agreement with ethnic variants. Mean flexibility was lower than in other populations also measured by the sit and reach test, such as Irish[28] and Chinese population[29].

Isokinetics

In this study, the isokinetic strength of knee extension and flexion was greater in elite players with a more variable pattern in the category of second division. Although there is literature available to compare the differences in strength in the different soccer categories, this is limited, and methodological differences make it difficult to analyze this when they are compared by position[9,30].

The results of this study indicate that in general, the isokinetic profiles of knee extension and flexion strength of the players of the three categories are lower than in other elite football populations and the junior elite of the Belgian league[31]. French elite soccer players and amateurs[32] showed higher absolute maximum torque peak values at 60°/s. There are studies that have reported values that may explain the apparent reduction in absolute strength due to a lower body mass[25].

In the unilateral isokinetic index, significantly lower values were observed when comparing the first against the second and third division. This could be explained by greater experience with better muscle strength parameters. These proportional differences have been demonstrated with age and in the knee flexor-extensor muscle strength in young and adult soccer players with isokinetic torque peaks increased with age and professional level[15,33]. Imbalances of muscle strength in the knee joint, measured by the quadriceps/hamstring ratio, are a predisposing factor for hamstring strain injuries and are related to joint stability[34,35].

The index between the flexor and extensor muscles is an indicator of the functionality of the knee joint. This means that values below 0.50 at an angular velocity of 60°/s indicate a discrepancy between muscle capacity and risk of injury. When the extensor muscles exert a disproportionate force on the flexor muscles, this will cause excessive work of the tibia on the femur during dynamic activities, and the ACL will have excessive tension[21]. Therefore, if the flexor muscles are weak, to neutralize the excessive force, the ACL will have a greater chance of rupture[36–38]. The results show a difference in the unilateral index, the best results, close to 0.60, decrease by soccer category and even more in players with a history of injury, thus, it is a good marker of discrimination.

The imbalance found in the bilateral index shows a pattern consistent with the literature where the highest value of this imbalance in players without an injury does not exceed 12%[39,40]. When the muscle forces of the flexors of the dominant leg against the non-dominant

leg are compared, this same index is increased almost 0.4% more in those players with apparent injuries. Compared with other studies, the results showed that the normality point or reference value of 12.5% of bilateral imbalance expressed by the FR/FRCON60 index[41] (sensitivity and specificity, 0.73 and 0.80, respectively), is more important for the detection of a previous injury in the hamstring musculature in soccer players, with this being consistent with the results obtained. Naturally, muscle strength disorders cannot explain all hamstring injuries; persistent disorders in various players do not significantly correlate with the presence of bilateral index imbalances[42].

Intrinsic and extrinsic factors have been described that contribute to the risk of lesions of the ACL and the hamstring muscles. Importance has been given to those that are related to muscular force imbalances. A significant difference between the agonist and antagonist groups of the knee joint entails risk and rapid identification for injury prevention. The most difficult task will be that the agonist and antagonist muscles should be trained correctly because it is complicated to make an accurate assessment of each muscle group. This ironically leads strength training to a muscular imbalance, and this in turn, to sports injuries.

Conflict of interest

The authors do not declare a conflict of interest.

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