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Isokinetic muscle testing of Algerian professional football players

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ABSTRACT

The objective of this research is to identify the isokinetic profile of soccer players using technological equipment (CYBEX 6000) at different angular speeds; then to verify the relationship between peak strength and speed and jump performance. The isokinetic parameters selected were peak force and H/Q ratio with 15 professional footballers. The recorded extensor and flexor strength is comparable to the values of French professional footballers, the H/Q ratios (concentric and mixed) showed an agonist/antagonist muscular balance, our data were higher than the standard values, the vertical jump and sprint performances were significantly related to the quadriceps and hamstring maximal strength evaluated at 30, 60 and 240°/s.

Keywords: Isokinetic, football, quadriceps, hamstring; ratio H/Q

RESUME:

L'objectif de cette recherche d'identifier le profil isocinétique des footballeurs en utilisant un matériel technologique (CYBEX 6000) à différentes vitesses angulaires; ensuite vérifier la relation entre le pic de force et les performances de vitesse et de détente. Les paramètres isocinétiques retenus sont le pic de force et le ratio IJ/Q avec 15 footballeurs professionnels. La force des extenseurs et des fléchisseurs enregistrés est proche des valeurs de footballeurs professionnels français, les ratios IJ/Q (concentrique et mixte) témoignent d'un équilibre musculaire agoniste/antagoniste, nos données sont supérieures aux valeurs standards, les performances de détente et de vitesse sont liées significativement avec les pics de force des extenseurs et fléchisseurs évalués à 30, 60 et 240°/s.

Keywords: Isocinétique, football, quadriceps, ischio-jambier, ratio IJ/Q

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1- Introduction:

Since Hilsopp and Perrine's original publication in 1967 (Rochcongar, 2004). Since Hilsopp and Perrine's original publication in 1967, a great deal of work has been published on isokinetic exploration. Most of them concern the knee joint. The knee is a joint that allows good reproducibility of measurements of extensor and flexor force moments during a simple flexion-extension movement (Croisier et al 1999, Dauty et al 2001, Drouin et al 2004). The isokinetic method enables objective quantification of peak forces developed at a joint. It also makes it possible to monitor the evolution of muscle strength developed through sports training (Rochcongar et al 2004). Interpreting results in terms of strength can therefore help the trainer to plan and optimize training according to the sporting discipline. It can highlight right/left or flexor/extensor imbalances and, if necessary, suggest appropriate muscle reinforcement. Certain abnormalities may be the cause or consequence of sports-related pathologies (Oberg et al 1986, Jidovtseff 2005). In addition, isokinetic measurement can be used to establish reference values for an athlete's muscular strength in order to better understand individual variations over the course of a season, or to compare him to a group of athletes (Risberg 2018).

Quadriceps and hamstring strength are particularly important, as they contribute mechanically to knee function and performance during sports movements. The quadriceps play a role in jumping, ball-striking and sprinting, and the hamstrings in protecting the knee, and more specifically the anterior cruciate ligament, during changes of direction. Indeed, correlations have been established between isokinetic quadriceps muscle strength and sprint speed or jumps (Dauty 2001, Fischer 2017, Sliwowski 2017). When playing soccer, jumping, sprinting and kicking the ball involve the lower limbs, particularly the knees, because of their mobility. These joint stresses could be the cause of traumatic and micro-traumatic muscular and tendinous pathologies that are sources of recurrence.

Playing soccer at the highest level demands a wide range of physical, technical, strategic and psychological qualities. These requirements become even more pressing as the level of play increases. Among the physical qualities required, sprinting and jumping are essential for recovering the ball and taking part in the game. A footballer needs a highly developed anaerobic alactic metabolism (strength, speed and relaxation). The main aim of training a soccer team is to help improve the qualities involved in individual and collective motor performance. The different physical qualities represent one of the elements of

this performance, hence the importance of an evaluation according to energy channels in order to identify physical profiles and propose suitable training protocols. This approach is based on two hypotheses: firstly, the practice of top-level sport could be at the origin of the development of a specific isokinetic muscle profile, a consequence of the repetition of sporting gestures performed in training and in competition, depending on the sport practised (Barthélémy and al 1995, Jidovtseff 2005). On the other hand, sprinting and jumping are linked to the external force developed by the lower limbs in the knee extensors and flexors.

The objective of our study, firstly, is to identify an isokinetic muscular profile for members of our sample, compared with the profiles of other populations of footballers, and thus to recommend a type of training and, in particular, avoid certain non-contact injuries, which account for 28 to 76% of all soccer injuries (Dupont 2010). Secondly, to verify the nature of the relationship between peak strength and the two qualities of speed and vertical jump. Isokinetic testing has been chosen as far as possible, as the equipment and technique chosen to assess muscular strength must be adapted to sporting gestures. For example, isokinetic testing is more appropriate when resistance is encountered at the end of the movement, when the limb reaches a high speed.

2- Materials and methods :

2-1- Population: Fifteen male volunteers aged 26.33 ± 3 (years); weight: 74.5 ± 5.41 (Kg) and height: 178.5 ± 8.32 (Cm) participated in this study. They were MCA senior footballers playing in professional league 1. Isokinetic tests were carried out at the National Sports Medicine Centre (NSMC) in Algiers. The subjects had no muscular or articular lesions that could prevent the tests from being carried out or bias the results.

2-2- Isokinetic protocol:

All isokinetic tests were performed using a Cybex 6000 isokinetic dynamometer. The installation of the subject followed the manufacturer's recommendations to ensure better reproducibility of measurements. Effective strapping was applied to the trunk and thigh to limit compensation. The axis of the dynamometer was aligned with the mean joint center of flexion-extension of the knee. The resistive counterweight was placed on the leg segment two fingers distal to the lateral malleolus of the ankle. The contralateral knee and ankle were left free so as not to influence the force developed. Concentric isokinetic tests were defined according to the consensus of the European Group for Development and Research in Isokinetics (EGDRI). The isokinetic dynamometer was calibrated monthly in accordance with the manufacturer's

recommendations. Force moment and hamstring-to-quadriceps ratio were collected for all three angular speed.

2-2-1- Dynamic isokinetic test:

Muscle function in concentric mode was measured in the quadriceps and hamstrings on a Cybex 6000 isokinetic machine for footballers. In order to use the ergometer in the safest possible conditions, a light ten (10) minute warm-up on an ergo-cycle with no-load followed by hamstring and quadriceps stretching was carried out before the dynamic tests, and a minimum of three voluntary sub-maximal isometric contractions were performed to check joint alignment. This phase enabled the choice of the best lever arm configuration according to each subject's leg length. In addition, subjects were able to familiarize themselves with the device and cooperate more effectively with the test.

We measured the peak developed by the subject during a contraction with shortening of the muscle insertions. To do this, the subject operated a lever arm moving at a constant angular velocity of 30°/s, 60°/s and 240°/sec. Initially, the subject performed a series of 5 extension-flexion movements at an angular speed of 240°/sec, in order to feel the movement and adapt to the ergometer. The subject then performed three extension-flexion exercises at respective angular speeds: 240°/s and 60°/s concentrically, followed by 3 eccentric flexions at 30°/s. Each series was interspersed with a one-minute recovery phase. The number of repetitions completed was given regularly, and the subject was encouraged to obtain the best performance, i.e. to complete all three series, always respecting the instruction to complete the movement in either flexion or extension. The ergometer followed the joint movement generated by the muscles.

2-3- Vertical jump test:

The aim of the vertical jump test is to measure anaerobic alactic power with its strength and speed components, using the Opto-Jump system, an optical system for measuring contact time (ct) and take-off time (tot). These values are used to calculate jump height. The exercises performed are: the squat-jump (SJ) to measure "dry" vertical jump, without stretching, the subject starts the test in a flexed position at 90° (knee joint), the hands are fixed on the hips to avoid arm involvement. The counter movement jump (CMJ), the subject in a standing position executes a vertical jump after a downward countermovement bringing knee flexion to 90° "stretch-relax cycle". Each jump was repeated three times. The best trial was retained for analysis. The CMJ-SJ difference reflects the player's muscular elasticity.

2-4- Speed test 10 and 20m:

The literature shows that 96% of sprints during a football match are under 30m. This field test has been validated for measuring speed and muscular power. A proper warm-up that respects the physiological laws of phosphagen resynthesis is essential before performing this test. Neuromuscular exercises, which do not induce fatigue while maintaining a high level of nerve impulse stimulation, are essential for high performance. The start was from a standing position behind a materialized line. Photoelectric cells (Microgate, race time 2, Bolzano, Italy) were placed at the start and at 10 and 20 m. They were combined with an electronic control system. These were combined with an infrared instantaneous speed measurement system (Stalker ATS, USA). The profile of instantaneous speed, maximum speed and initial acceleration was then determined.

2-5- Statistical analysis:

Means and standard deviations were calculated for isokinetic tests. The agonist-antagonist ratio (H/Q) was calculated for 60°/s concentric speed, then the mixed H/Q ratio 30°/s ecc/240°/s con was measured. All these data were related to pre-established references. Correlations were then calculated between force peaks on the one hand, and speed and vertical relaxation results on the other.

3- Results:

3-1- Quadriceps results:

Table 1: Peak force values (Nm) of the quadriceps at 60 and 240°/s:

Angular speed	Peak force	Standard deviation	Maximum	Minimum
60°/s	252	13.5	270	235
240°/s	149	9.34	161	138

Table 1 shows peak quadriceps force values at 60 and 240°/s. Our population showed peak forces of 252 ± 13.5 and 149 ± 9.34 (Nm) respectively for angular velocities of 60 and 240°/s.

3-2- Hamstring results :

Table 2: Hamstring peak force values at 30°, 60° and 240°/s:

Angular speed	Peak force	Standard deviation	Maximum	Minimum
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30°/s exc	203	18	222	177
60°/s con	143	18.6	170	120
240°/s con	123	7.72	133	112

Our population showed hamstring force peaks of 203 ± 18 (Nm) at 30°/s in eccentricity, with a maximum value of 222 and a minimum value of 177. Concentric values of 143 ± 18.6 and 123 ± 7.72 (Nm) were also recorded for angular velocities of 60 and 240°/s respectively.

3-3- Hamstring / quadriceps ratio results (H/Q):

Table 3: H/Q ratio values (concentric and mixed).

Ratio	Mean	Standard deviation	Maximum	Minimum	Standards
Conc R	0.55	0.04	0.62	0.49	< 0,47
Mixed R	1.35	0.05	1.40	1.28	< 0,8

Table 3 shows the values of the concentric and mixed (H/Q) ratios. Our population shows a concentric ratio of 0.55 ± 0.04 , which is higher than the standard value of 0.47. We also observe a mixed ratio of 1.35 ± 0.05 , which is higher than the standard value of 0.87.

Speed and vertical jump test results:

3-4- Table 4: Speed and vertical jump performance:

Test	Mean	Standard deviation	Maximum	Minimum
10m (s)	1.79	0.028	1.85	1.75
20m (s)	2.84	0.031	2.89	2.81
SJ (cm)	50.5	3.87	55	45
CMJ (cm)	54.8	4.39	60	48

Our population recorded performances of 1.79 ± 0.028 and 2.84 ± 0.031 for the 10m and 20m tests respectively. We also noted vertical jump performances of 50.5 ± 3.87 (Cm) for the squat jump (SJ).

3-5- Correlation of force peaks with speed and vertical jump.

Table 5: Correlation of force peaks with speed and vertical jump.

Test	Q 60°/s	Q 240°/s	H30°/s exc	H 60°/s	H 240°/s
10m (s)	-0.913***	-0.912***	-0.919***	-0.915***	-0.945***

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20m (s)	-0.959***	-0.936***	-0.938***	-0.873***	-0.926***
SJ (cm)	0.975***	0.982***	0.975***	0.935***	0.982***
CMJ (cm)	0.963***	0.961***	0.953***	0.910***	0.966***

*** *p*-value < .001 . Q : Quadriceps. H : Hamstring

The results recorded in Table 5 show a significant correlation between vertical jump performance and peak quadriceps and hamstring strength, irrespective of angular speed and muscle contraction mode. The correlation index (r) varied between 0.91 and 0.98. There was also a negative correlation between recorded time and peak quadriceps and hamstring strength, irrespective of angular speed and muscle contraction mode. This means a positive correlation between peak force and speed. The correlation index (r) varies between -0.95 and -0.87.

4- Discussion:

For many years now, isokinetic testing has been a benchmark technique for assessing muscular performance (Rochcongar, 2014). Isokinetic testing has an indisputable place in the evaluation of healthy subjects (establishment of reference standards) and patients in the post-operative rehabilitation phase in particular. Isokinetic exploration is an excellent means of assessing knee extensor and flexor strength. This technique is a very useful complement to conventional assessment methods, and has enabled us to establish benchmarks according to age, sex and sporting specialty (Herlant, 1993).

Since the 2000s, isokinetic muscle strength testing of the quadriceps and hamstrings has been systematically carried out at the start of the season in top-level athletes, particularly professional footballers (Svensson 2005). In isokinetic training, the speed of movement remains constant thanks to the intervention of a variable resistance that is permanently controlled by the subject's exertion capacity. This principle allows maximum force to be applied over the entire range of motion. It offers encouraging prospects for the individual and longitudinal monitoring of athletes (Zouita Ben-moussa, 2005).

We note that the peak torque values recorded respectively at 60 and 240°/s for the quadriceps (Q) and hamstring (H) are close to those recorded by Le Gall et al (1999) on French professional footballers (264 ± 37 Nm at 60°/s Q, 186 ± 26 Nm at 60°/s H, 152 ± 20 Nm at 240°/s Q and 133 ± 24 Nm at 240°/s H). Other studies confirm our results (Amato et al 2001, Croisier et al 2014). Specific training, repetition of stereotyped, high-intensity and sometimes asymmetrical gestures, can lead to particular adaptations of the muscular profile. Professional players undergo intense physical preparation at the start of each season. The aim is to develop each player's aerobic and anaerobic qualities in preparation for competition (Davis et al. 1992). A strength training program

is often included to develop muscular strength and improve performance. In football, the lower limbs are directly involved in performance (Chatard 1998, Tumilty 1993). The quantitative and qualitative combination of training and competition workloads favours muscular-articular adaptation in favour of the lower limbs (Amato et al.2001).

According to Le Gall et al.1999, although the purely physical aspect is only one of the elements of performance, along with technique, mental and tactical skills, top-level football requires, among other things, significant power in the lower limbs. Quadriceps muscle power and explosiveness appear to correlate very well with the level of competition. It's easy to see why muscle strengthening is so important.

In terms of hamstring/quadriceps ratios, the subjects showed a concentric ratio of 0.55 ± 0.04 , which is above the standard limit (<0.47) (H/Q). A mixed H/Q ratio of 1.35 ± 0.05 was also observed, above the standard limit (<0.8). Various studies confirm that footballers have high hamstring/quadriceps ratios. The frequency with which female footballers use their hamstrings explains these values. During training sessions and especially competitions, footballers perform an mean of 100 short sprints (Chatard 1998, Tumilty 1993, Mambaerts 1992 and Dellal 2006). This type of movement intensely loads the hamstrings concentrically during ground contact and eccentrically during knee extension and ball striking (Amato et al. 2001). This contraction controls the concentric activity of the quadriceps and protects the ligamentous structures of the knee joint (Solomonov et al.1987, Barratta et al.1988). This balance between hamstrings and quadriceps is important to achieve, as it seems to be the guarantor of good active protection in the various instability situations that the knee may encounter during soccer practice. Ekstrand J (2011), moreover, considers it to be a protective factor against muscular accidents, so frequent in the thigh in this sport. These values testify to the important dynamic role played by the hamstrings, which is confirmed by the fact that, at fast speeds, the share taken by the hamstrings is greater, with ratios close to 1 (Kerkour et al.1987).

A prospective study (Croisier et al 2008) of professional football players (Croisier et al 2008) found that players with a strength imbalance identified by isokinetic testing at the start of the season (in particular a reduction in the mixed ratio of H ecc30°/s/Qconc 240°/s) and not specifically treated were characterized by a 4-fold increase in the risk of hamstring injury, compared with players who were muscularly balanced; correction of the anomalies identified at the start of the season significantly reduced the risk of injury;

however, this reduction in the risk of tearing only appeared to be effective in players whose normalization had been proven in control tests; in this series, players whose mixed ratio was greater than 1.40 had not suffered any hamstring injuries during longitudinal follow-up.

These observations confirm the predictive value of isokinetic tests performed at the start of the season to identify players at increased risk of hamstring injury. Correcting imbalances reduces the risk of injury. However, other authors have failed to find this link, so this ratio remains contested (Bennel et al 1998). One of the limitations of this standard value is that it could be obtained either by a weakness in the strength of the knee flexors, or because the knee extensors develop a relatively high level of strength, as is the case with footballers.

Sprinting correlated significantly with peak extensor and flexor strength evaluated at 30, 60 and 240°/s (table 5). Cometti (2001) found no correlation between the rolling start sprint (timed test between 10 and 30 m) and the concentric and eccentric peak force of the knee flexors and extensors. However, the study does not specify whether a correlation was sought by isolating the 29 national first division soccer players from the 95 other footballers studied on the basis of their sporting level. This could explain the absence of correlation in amateur footballers, who sprint more slowly. Sprinting from a standing start is also inversely related to the eccentric force developed by the knee flexors.

This relationship can be explained by the role of the hamstrings, which act as a brake on knee extension to prevent joint damage. On the other hand, (Dowson, 1998) found a significant correlation between 10 and 20 m standing start sprinting and peak knee extensor concentric force (240°/s) in 11 sprinters. Due to the limited number of subjects, these results are in favor of population specificity. The higher the sprint performance, the greater the link between peak knee extensor force and peak concentric force. The results of our study show that jumping is also significantly correlated with peak knee extensor and flexor forces evaluated at 30, 60 and 240°/s.

Cometti (2001) and Ostenberg (1998) had not described any correlation in footballers of different sporting level and gender. Augustsson (1998), on the other hand, found a significant correlation between vertical relaxation and peak knee extensor strength. Petchnig uses the vertical relaxation test to assess knee function at a distance from anterolateral cruciate ligament surgery, due to a significant correlation with peak extensor strength. Professional football players undergo intense physical preparation at the start of each season. The

aim is to develop each player's aerobic and anaerobic qualities in preparation for competition. These footballers show sprinting and jumping performances in line with their level of play. These performances are significantly linked to peak concentric extensor strength (Dauty et al 2002).

5- Conclusion:

Isokinetic testing of the adult knee has provided important additional information to complement clinical and imaging findings. This functional test provides information not only on muscular capacity, but also on joint function in general. This latter aspect must never be forgotten when reporting results, whether the test is performed concentrically or eccentrically. Caution must be exercised when interpreting results, particularly in the field of prevention. The demands of soccer activity, combined with the phenomenon of growth, lead to an adaptation of isokinetic muscular characteristics.

This study determined the isokinetic profile of professional footballers. Their muscular strength is greater. These results can no doubt be explained by the specific nature of this sport. The size of the pitch requires numerous long runs. Changes of direction and kicking the ball have also undoubtedly contributed to this result, especially when these movements have been repeated for many years. Hamstring/quadiceps ratios (concentric and mixed) show a balance of agonist/antagonist muscle strength, with values well above standard norms. Vertical rebound and speed performances are significantly linked with extensor and flexor force peaks evaluated at 30, 60 and 240°/s. To improve jumping and sprinting, concentric strengthening of the extensors and eccentric strengthening of the flexors can therefore be proposed.

Isokinetic testing provides the athlete and trainer with an objective indication of muscular efficiency. This provides objective criteria for optimizing training follow-up. Systematic testing can highlight right/left or flexor/extensor imbalances and, if necessary, suggest appropriate rehabilitation or muscle strengthening to correct these injury-prone imbalances. The results obtained in the present study can serve as a reference for muscle strengthening for these footballers. From a purely medical point of view, the value of annual testing of footballers lies in the detection of possible muscular deficits, which need to be interpreted and treated. This type of test should also be used as a reference for re-training after injury.

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