Original Paper DOI: 10.5604/942736 Biol. Sport 2011;28:89-94

ISOKINETIC STRENGTH AND SPRINT TIMES IN ENGLISH PREMIER LEAGUE FOOTBALL PLAYERS

Accepted for publication 23.03.2011

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ABSTRACT: This study assessed the relationship between isokinetic leg strength and 10 to 30-m sprint times in 14 professional English Premier League football players: 6 international and 8 non-international. Isokinetic measurements were performed at 60, 180, 240 and 300°·s^{-1} on knee extensors and flexors. International players were shorter (179 ± 7 cm versus 185 ± 2.5 cm, $P < 0.01$), lighter (78.6 ± 4.8 kg versus 88.8 ± 6 kg, $P < 0.01$) and leaner (11.4 ± 1% versus 14.3 ± 2.2%, $P < 0.02$) than the non-international players. In absolute values, extensor peak torques (PT) were significantly lower for the international players than for the non-international players at 60, 180, 240 and 300°·s^{-1} while flexor PT were significantly lower only at 180, 240 and 300°·s^{-1}. These differences were explained by body weight variations. Indeed, when expressed per kg of body weight no differences for both extensor and flexor PT were found between national and international football players. There were no differences in the sprint times either. In the whole population, extensor peak torques were related to the 20-30-m sprint performance at 180, 240 and 300°·s^{-1} ($r = 0.77$, $r = 0.74$, and $r = 0.80$, $P < 0.01$, respectively). High muscle strength was needed for 30-m sprint times. However, international football players were not stronger than national players, highlighting the major importance of both well-developed tactical sense and high technical standard.

KEY WORDS: exercise, knee extensors, knee flexors, performance, running

INTRODUCTION

During a soccer match, elite soccer players perform 150-250 brief intense actions lasting 1.9 to 2.7 s each [14], 49% being shorter than 10 m and 96% shorter than 30 m. Overall, a professional soccer player runs at high speed every 70 to 90 s [19,20]. Tackling, turning and jumping are also high energy activities. They number up to 50 according to individual playing style and position in the team [14,20]. Professional players are faster than amateurs [4,20]. However, there is no data in the literature comparing international with non-international soccer player sprint times. Thus, it is unknown if sprint times may differentiate elite football players from others.

High muscle strength is needed in jumps, kicks, tackles, turns, running backwards and changing pace [1,19,21]. For studying muscle strength at different angular velocities, isokinetic devices are considered a good means [1,2,15-17]. International soccer players are stronger than others [16].

The relationship between isokinetic measurements and sprint times in soccer players is a subject of controversy. Özçakar et al., [17] and Newman et al., [15] found a strong relationship between knee extensor and flexor peak torques and 10 to 20-m sprint times. In contrast, Cometti et al. [2] did not find any relationship.

The main purpose of the present study was to assess isokinetic strength and 10 to 30-m sprint times in a group of professional English Premier League soccer players. As, on one hand, there is no study available comparing international and non-international players' sprint times, and as, on the other hand, the group of players could be arbitrarily divided into 2 sub-groups, international versus non-international, a secondary purpose was to assess the hypothesis that muscle strength and sprint times are of major importance in the playing performance and level of soccer players.

MATERIALS AND METHODS

Subjects. A group of 14 professional soccer players playing in an English Premier League team participated in the study on a voluntary basis and signed an informed consent form. Nine were British, 2 Scottish, 1 Irish, 1 Welsh and 1 Italian. During the season, the team was ranked 5th to 7th in the Premier League. They all trained on a daily basis on average 10 to 14 hours a week, and during the 2 previous years had played 1 to 2 matches per week. Six were international players: 2 in under-21 teams and 4 in A teams. Two were central defenders, 1 a fullback, 1 a midfielder, and 2 attackers. The other 8 players were 1 goalkeeper, 1 central defender, 2 fullbacks, 2 midfielders, and 2 attackers. The 2 groups were thus almost equivalent in their playing positions. Ten were right-handed and 4 were left-handed.

Measurements

All the tests were performed in July during a pre-season camp. Before testing, players had 2 weeks of vacation and 3 weeks of individual training. All the subjects performed the same test on the same day and were previously accustomed to the testing procedure. Body mass and height were determined by using standard physician's scales. Subcutaneous skin-fold thickness was measured on biceps, triceps, sub-scapula, and supra-iliac areas measured with Holtain callipers [11].

Isokinetic test

Muscle strength was measured with an isokinetic dynamometer Cybex Norm (Lumex Bay Shore Inc., Ronkonkoma, New York, USA). The peak torque of the knee extensors and flexors, expressed in newton metres, was measured on both sides after a 15-min standardized warm-up to become familiar with the apparatus. The range of knee motion was fixed at 100° from the active maximum extension, 0° corresponding to complete extension. The subjects performed the tests in the sitting position, arms folded over the chest and the pelvis firmly strapped to a backrest. Straps over the upper and lower parts of the thigh firmly held the hip joint in 90° flexion. The longitudinal axis of the dynamometer was aligned with the longitudinal axis of the lever arm. The length adjustment of the input accessory was standardized to 25 cm. Peak torques were automatically gravity corrected. Measurements were made at $60°·s^{-1}$, $180°·s^{-1}$, $240°·s^{-1}$ and $300°·s^{-1}$. The tests began on the right side and finished on the left. The subjects were asked to execute 2 submaximal trials before performing 3 maximal efforts at each angular velocity. A 2-min rest period separated each test. The peak torque retained was the highest torque value registered during the measurements. Peak torques were also expressed per kg body weight ($N·m·kg^{-1}$) and as a percentage of the $60°·s^{-1}$ peak torque. The intra-individual variation of the strength measurements, assessed in the 14 players using the coefficient of variation of the difference between 2 measurements, was 4.2%.

30-m sprint test

After the isokinetic test, on another day, the 30-m sprint test was performed after a 30-min standardized warm-up. The test was performed on an indoor soccer field with an artificial playing surface. The subjects ran in their own football boots. Run times over 10, 20 and 30 m were measured with 4 photoelectric cells (Brower Timing, USA) placed at the start and at 10, 20 and 30 m. Cells were placed at an elevation of 1.05 m. Once ready, the subjects decided themselves when to start. They started from a static position, the front foot immediately behind the start line. Subjects were explained not to break the line with their arm or upper body before starting. The subjects were asked to repeat the 30-m sprint twice with a 10-min rest period between each test. Only the best 30-m time was retained. Average velocity was calculated for 0 to 10 m, 10 to 20 m and 20 to 30 m. The intra-individual variations in 10, 20 and 30 m performance were 5.21, 4.75 and 4.50%, respectively.

Statistical analysis

Means and standard deviations were calculated for all variables. Analysis of variance followed by post-hoc Tukey tests was used to search for differences in anthropometric data, peak torques and sprint times between international and non-international soccer players. The relationships between variables were evaluated using linear regression analyses. $P < 0.05$ was considered statistically significant.

RESULTS

Anthropometric characteristics. The mean ± SD anthropometric characteristics of the 14 players were for age, height, weight, and

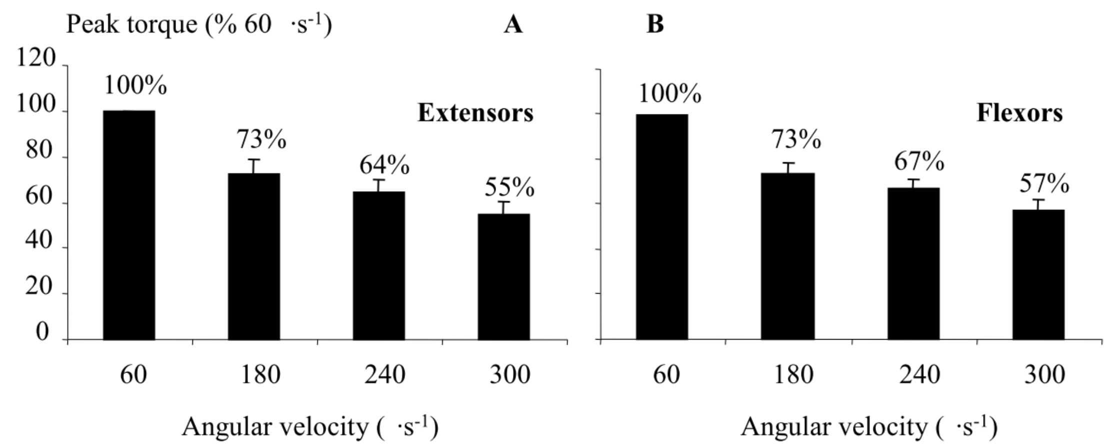

FIG. 1. MEAN PEAK TORQUES OF THE 2 KNEE EXTENSORS (A) AND 2 KNEE FLEXORS EXPRESSED AS A PERCENTAGE OF THE RESULTS AT $60°·s^{-1}$ (B).

TABLE 1. RESULTS FROM THE ISOKINETIC TEST AT 60°·s^{-1}, 180°·s^{-1}, 240°·s^{-1}, AND 300°·s^{-1}. PEAK TORQUES (PT) OF THE LEG EXTENSORS AND FLEXORS OF BOTH SIDES ARE EXPRESSED IN ABSOLUTE VALUE (NM), RELATIVE TO BODY WEIGHT VALUE (N·m·kg^{-1}) AND RELATIVE TO THE 60°·s^{-1} PEAK TORQUE (MEAN ± SD).

	Right side				Left side			
	60°·s-1	180°·s-1	240°·s-1	300°·s-1	60°·s-1	180°·s-1	240°·s-1	300°·s-1
Extensors								
PT (Nm)	246 ± 42	174 ± 26	153 ± 24	130 ± 22	240 ± 41	176 ± 24	156 ± 20	134 ± 17
PT (Nm·kg-1)	2.90 ± 0.34	2.06 ± 0.22	1.81 ± 0.20	1.53 ± 0.20	2.82 ± 0.31	2.09 ± 0.18	1.85 ± 0.16	1.59 ± 0.15
PT (%60°·s-1)	100 ± 0	71 ± 6	63 ± 5	53 ± 4	100 ± 0	74 ± 8	66 ± 8	57 ± 9
Flexors								
PT (Nm)	153 ± 30	113 ± 20	102 ± 20	87 ± 18	151 ± 31	109 ± 19	100 ± 16	86 ± 13
PT (Nm·kg-1)	1.80 ± 0.27	1.33 ± 0.20	1.20 ± 0.20	1.03 ± 0.19	1.79 ± 0.31	1.28 ± 0.17	1.18 ± 0.15	1.01 ± 0.12
PT (%60°·s-1)	100 ± 0	74 ± 6	67 ± 4	57 ± 5	100 ± 0	73 ± 7	67 ± 7	58 ± 7

Note: There was no statistical difference ($P > 0.05$) between the two legs.

TABLE 2. COMPARISONS BETWEEN THE INTERNATIONAL (INTER) AND NON INTERNATIONAL (NON INTER) SOCCER PLAYERS OF THE PEAK TORQUE AT 60°·s^{-1}, 180°·s^{-1}, 240°·s^{-1}, AND 300°·s^{-1}. PEAK TORQUES (PT) OF THE LEG EXTENSORS AND FLEXORS OF BOTH SIDES ARE EXPRESSED IN ABSOLUTE VALUE (Nm), RELATIVE TO BODY WEIGHT (N·m·kg^{-1}) AND RELATIVE TO THE 60°·s^{-1} PEAK TORQUE (MEAN ± SD).

	60°·s-1		180°·s-1		240°·s-1		300°·s-1	
	Inter (n=6)	Non Inter (n=8)	Inter (n=6)	Non Inter (n=8)	Inter (n=6)	Non Inter (n=8)	Inter (n=6)	Non Inter (n=8)
Extensors								
PT (Nm)	220 ± 30	260 ± 39*	158 ± 16	189 ± 20*	140 ± 15	165 ± 19*	120 ± 11	141 ± 18*
PT (Nm·kg-1)	2.79 ± 0.25	2.92 ± 0.34	2.01 ± 0.15	2.12 ± 0.19	1.79 ± 0.16	1.86 ± 0.18	1.53 ± 0.13	1.59 ± 0.18
PT (%60°·s-1)	100 ± 0	100 ± 0	72 ± 8	73 ± 6	64 ± 7	64 ± 5	55 ± 7	55 ± 5
Flexors								
PT (Nm)	136 ± 14	164 ± 31	98 ± 7	120 ± 20*	90 ± 8	109 ± 19*	78 ± 10	93 ± 15*
PT (Nm·kg-1)	1.73 ± 0.18	1.85 ± 0.30	1.25 ± 0.09	1.35 ± 0.21	1.15 ± 0.12	1.22 ± 0.19	0.99 ± 0.15	1.04 ± 0.16
PT (%60°·s-1)	100 ± 0	100 ± 0	73 ± 6	73 ± 5	67 ± 7	66 ± 3	58 ± 7	57 ± 3

Note: * indicates significant difference ($P < 0.05$) between inter and non inter.

TABLE 3. MEAN RUNNING TIMES AND VELOCITIES OVER 10 m, 20 m AND 30 m OF THE 30-m SPRINT TEST FOR THE TOTAL GROUP, INTERNATIONAL SOCCER PLAYERS (INTER) AND NON INTERNATIONAL PLAYERS (NON INTER) : NO STATISTICAL DIFFERENCE BETWEEN INTER AND NON INTER.

	0-10 m (s)	0-20 m (s)	0-30 m (s)	0-10 m (m·s-1)	10-20 m (m·s-1)	20-30 m (m·s-1)
Total group	1.69 ± 0.08	2.94 ± 0.11	4.10 ± 0.14	5.92 ± 0.28	8.06 ± 0.29	8.57 ± 0.36
Inter	1.68 ± 0.06	2.92 ± 0.09	4.08 ± 0.13	5.96 ± 0.20	8.06 ± 0.33	8.63 ± 0.49
Non inter	1.70 ± 0.10	2.95 ± 0.12	4.12 ± 0.14	5.89 ± 0.34	8.07 ± 0.28	8.53 ± 0.25

Note: no statistical difference between Inter and Non Inter.

fat percentage 25.5 ± 5.0 yr, 183 ± 6 cm, 84.5 ± 7.4 kg, and 13 ± 2.3%, respectively.

The international players were shorter (179 ± 7 cm versus 185 ± 2.5 cm, $P < 0.01$), lighter (78.6 ± 4.8 kg versus 88.8 ± 6 kg, $P < 0.01$) and leaner (11.4 ± 1% versus 14.3 ± 2.2%, $P < 0.02$) than the non-international players. There was no statistical difference for age (24.2 ± 6.1 yrs versus 26.5 ± 5.9).

Isokinetic and sprint performances

Results of the isokinetic tests are presented in Table 1. There was no statistical difference ($P > 0.05$) between the 2 legs for the peak torques at any angular velocity. The results were thus grouped and analysed together. Mean peak torques expressed in percentage of results at 60°·s^{-1} are presented in Figure 1.

Comparison of the peak torques between national and international football players is presented in Table 2. In absolute value, extensor peak torques were significantly lower for the international players than for the non-international players at 60, 180, 240 and 300°·s^{-1}. Flexor peak torques were significantly lower for the international players than for the non-international players at 180, 240 and 300°·s^{-1}. However, these differences were explained by body weight variations. Indeed, when expressed per kg of body weight no differences for both extensor and flexor peak torques were found between national and international football players.

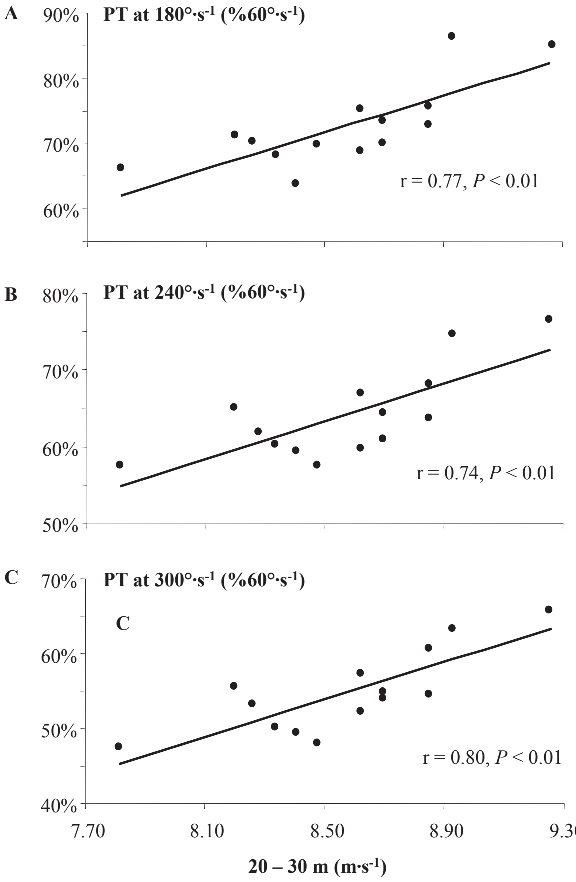

FIG. 2. RELATIONSHIP BETWEEN 20 AND 30-M VELOCITY AND PEAK TORQUE (PT) EXPRESSED IN PERCENTAGE OF THE RESULTS AT 60°·s^{-1} OF THE KNEE EXTENSORS AT 180°·s^{-1} (A), 240°·s^{-1} (B), AND 300°·s^{-1} (C).

For the sprint times, there were no statistical differences between the international and the non-international players (Table 3).

Relationships between anthropometric characteristics and isokinetic and sprint performances

Body mass was related to the peak torque when expressed in absolute value. On average, at the 4 measured isokinetic velocities, 60, 180, 240 and 300°·s^{-1}, r = 0.76± 0.04, P < 0.01 and r=0.59 ± 0.04, P < 0.01 for quadriceps and hamstring respectively. Body mass was also related to the sprint time but only for the last part of the 30-m sprint, between 20 and 30 m (r = -0.63, P < 0.01). Body mass was not significantly related to the shorter sprint distances 10 and 20 m.

Extensor peak torques, in absolute values, were related to the 20-30-m sprint times at 60°·s^{-1} (r = -0.60; P = 0.02). As a percentage of the 60°·s^{-1} value, this relationship was significant at 180, 240 and 300°·s^{-1} (r = 0.77, P < 0.01, Figure 2A, r = 0.74, P < 0.01, Figure 2B and r = 0.80, P < 0.01, Figure 2C, respectively). For flexor peak torque, the relationship was significant only at 240°·s^{-1} (r = 0.56, P < 0.04). When peak torque was expressed as a percentage of body weight, there were no significant relationships with sprint times from 60 to 300°·s^{-1}.

DISCUSSION

The main finding of this study was that a significant relationship was found between peak torques and sprint times in Premier League professional soccer players. This relationship was mainly found at high angular velocities with the knee extensors. A secondary finding was that international soccer players were found to be anthropometrically different when compared with non-international players. However, their peak torques per kg of body weight were not different, nor were their sprint times.

Anthropometric characteristics

As a group, international soccer players were anthropometrically different from the non-international ones: smaller in stature, lighter in body mass, and leaner in fat percentage. Although the peak torques of the international soccer players were lower in terms of absolute value, they were not different when reported per kg of body weight. Additionally, no significant difference was found between the sprint times of the 2 groups.

The morphological differences between international and national players could have been expected. Indeed, Wong et al., [22] comparing 1464 international players of the 32 nations participating at the 2002 and 2006 World Cup, found an average weight and height of 76.1 kg and 181 cm respectively, close to the 78.6 kg and 179 cm of the present study. These authors did not find any anthropometric differences for the teams qualified in the quarter finals when compared to the non-qualified teams.

This indicates that success in football can be achieved despite rather moderate anthropometric characteristics. The reasons for these anthropometric differences are unknown. However, it highlights the major importance of both well-developed tactical sense and high technical standard [19]. These data were confirmed by Malina et al. [9], studying specific technical performances such as shooting accuracy, dribbling speed and passing accuracy in 13-15-year-old players. They did not find that age and morphological stage of maturity were significant predictors of performance.

In the present study, the relationship between body mass and sprint time was found significant only between 20 and 30 m when the body mass inertia is minimal. These data were confirmed by Wong et al. [23], in young players. They found that body mass was of major importance for 30-m sprint time in football. In shorter distances, 10 and 20 m, where body mass inertia is maximal, as in the present study, a relationship was not found.

In conclusion, the findings of the present study suggest that there is an optimal weight to play at an international level, between 73 and 78 kg. Being heavier than 80 kg is not an advantage although it improves muscle peak torques.

High peak torques and sprint times

Peak torques measured in the present study and sprint times from 10 to 30 m are close to the best values reported in the literature for elite soccer players [20]. For extensors at 180°·s^{-1}, peak torques were, for example, 175 ± 24 N·m versus 131 to 179 N·m in other studies [1,2,16,20]. Ten-metre sprint times were 1.69 ± 0.08 s while some studies [2,6,7,20] reported values ranging from 1.79 to 1.87 s, i.e. 8 to 9% slower. These studies also reported values ranging from 3.02 to 3.13 s for 20-m sprint times. The present times (2.94 ± 0.11 s) were thus 2 to 6% faster. Özçakar et al. [17] registered faster 20-m sprint times at 2.86 ± 0.12 s. The difference might be related to the methodology. In Özçakar's study, the runners started the sprint test 1 m behind the starting line. This rolling start shortens sprint time by more than 0.18 s. For the 30-m sprint times, the best values reported in the literature for elite male soccer players [2,21] range from 4.00 to 4.22 s and were similar to the present study: 4.10 ± 0.14 s.

Cometti et al. [2] found that 10-m sprint times were better in French professional soccer players than in amateur soccer players. These data were confirmed by other studies comparing 10 to 40-m sprint times in professional and non-professional players [20]. In the present study, the international level soccer players were compared to non-international players. As a group, they were not better sprinters than their non-international counterparts. Unfortunately, comparisons with other international players were not available in the literature. In young players, between 13 and 15 years old, muscle strength and body mass were found to be the most significant predictors of 30-m sprint performance [10,11,21,22]. Players who mature earlier have a direct anthropometric advantage. However, their proportions may decrease with age [11]. During childhood, body mass is a strong bias that disappears when football specific skills become more important, like for example in national or international players [18].

Relationship between peak torque and sprint times

A significant relationship between peak torques and sprint running times was mainly found with the knee extensors rather than with the knee flexors at high angular velocities. In many activities in soccer, the generation of force occurs at high angular velocities [19]. Jonhagen et al., [8] using EMG recordings to study the roles of knee extensors and flexors during a 100-m sprint, observed that extensors were of major importance in the first part of the 100 m to create propulsive energy, a finding confirmed by Mann et al. [12]. The role of the flexors is mainly to protect the knee joint. Flexors are activated eccentrically to avoid flexion of the hip and extension of the knee just before the ground impact, and at the beginning of the support phase. During that last phase, they co-contract with the extensors and stabilize the knee joint. These different biomechanical roles could explain the stronger relationship found with the extensors than with the flexors.

The relationship between knee peak torque and the sprint running times was mainly found when peak torques were expressed as a percentage of the 60°·s^{-1} value. In isokinetics, 60°·s^{-1} is considered a slow movement while 180, 240 and 300°·s^{-1} are fast. The ratio between the peak torques at fast speed and the peak torque at 60°·s^{-1} gives valuable information on the relative fast-low speed capacity of the players. As this ratio was related to the best sprint performances, it indicates that strength measured at a relatively fast speed is an important determinant in professional soccer players, confirming previous data [16].

The relationship between knee peak torques and the sprint running times was mainly found between 20 and 30 m. The lack of a relationship between peak torques and 10-m sprint times was unexpected. Indeed, during the first strides of a sprint run, the contact phase is longer than after [13], allowing high propulsive forces. Ozçakar et al. [17] reported a significant relationship between knee extensor peak torque and 10-m sprint times. Hoff and Helgerud [7] found a significant effect of knee strength training on the 10-m sprint times in 8 professional Norwegian soccer players. In football, complex series of synergic muscle actions involve the antagonistic muscles as well as the agonists [19] and isokinetic tests may not necessarily reflect the movement of the limbs involved during sprinting.

Wisloff et al. [21] found a significant relationship between 10, 20 and 30-m sprint times and the maximum voluntary contraction of a half squat in professional soccer players. Half squat could be a closer movement to sprint running than knee extension or flexion in a sitting position. EMG recording [8,13] during sprint running showed important activation of the gluteus maximus (hip extensor) to generate propulsive forces. Because the half squat movement is a combination of ankle, knee and hip extensions, the gluteus maximus and other hip extensor muscles play a significant role in total force production. This total force production has a determinant effect in the 10-m sprint times of soccer players [21]. Another possible explanation is the lack of a stretch shortening cycle in isokinetic conditions [3].

CONCLUSIONS

A significant relationship between peak torques and sprint times was found mainly with knee extensors. International soccer players were morphologically different when compared with the non-international players but their peak torques per kg of body weight were not different, and nor were their sprint times. It was concluded that high muscle strength is needed for 30-m sprint times. However, international football players are not stronger than national players. This highlights the major importance of both well-developed tactical sense and high technical standard.

Acknowledgements

The authors thank Everton's coaches David Moyes and Alan Irvine for their technical assistance, and James Pryce and Kelly Knez for reading and correcting the English manuscript.

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