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ORIGINAL INVESTIGATION

Anaerobic Performance Testing of Professional Soccer Players 1995–2010

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Purpose: To compare sprint and countermovement-jump (CMJ) performance among competitive soccer players as a function of performance level, field position, and age. In addition, the authors wanted to quantify the evolution of these physical characteristics among professional players over a 15-y period. ***Methods:*** 939 athletes (22.1 ± 4.3 y), including national-team players, tested 40-m sprint with electronic timing and CMJ on a force platform at the Norwegian Olympic Training Center between 1995 and 2010. ***Results:*** National-team and 1st-division players were faster ($P < .05$) than 2nd-division (1.0–1.4%), 3rd- to 5th-division (3.0–3.8%), junior national-team (1.7–2.2%), and junior players (2.8–3.7%). Forwards were faster than defenders (1.4%), midfielders (2.5%), and goalkeepers (3.2%) over 0–20 m ($P < .001$). Midfielders jumped ~2.0 cm lower than the other playing positions ($P < .05$). Sprinting velocity peaked in the age range 20–28 y and declined significantly thereafter ($P < .05$). Players from 2006–2010 had 1–2% faster 0–20 m and peak velocity than players from the 1995–1999 and 2000–2005 epochs, whereas no differences in CMJ performance were observed. ***Conclusions:*** This study provides effect-magnitude estimates for the influence of performance level, position, and age on sprint and CMJ performance in soccer. While CMJ performance has remained stable over the time, there has been a small but positive development in sprinting velocity among professional players.

Keywords: sprint, vertical jump, anaerobic characteristics

Speed and power are critical performance factors in soccer. Male soccer players conduct high-intensity actions every 60 to 90 seconds during games, each lasting 2 to 3 seconds on average.[1–3] Although sprinting and high-intensity actions represent only 8% to 12% of covered running distance, these capabilities are considered critical.[3–6] In this decisive portion of match play, it is likely that maximal-sprint situations represent particularly critical moments. Both horizontal acceleration (sprinting) and vertical acceleration (jumping power) are involved in ball possession, repossession, defense play, corner kicks, and attack on goal.

Arnason et al[7] reported that players at high competition level jumped higher than players at lower performance levels. However, Cometti et al[8] and Rösch et al[9] observed no differences in speed or jump height as a function of performance level. A few studies have investigated speed and power characteristics according to playing position.[10–15] Davis et al[10] concluded that forwards were the fastest players, ahead of defenders, midfielders, and goalkeepers. Boone et al[11] reported differences in speed and countermovement jump (CMJ) according to playing position. Sporis et al[12] found differences in speed but not for CMJ, while Taskin[13] found no speed differences as a function of position. The literature also remains unclear regarding potential sprint-performance differences across age among elite players.[9,16] Most previously published studies were performed on semiprofessional soccer players and did not include a broad range of player performance level. Many coaches claim that international soccer players are faster now than 10 years ago, but objective data supporting this claim are not available.

The Norwegian Olympic training center is a standard testing facility for a large number of teams at different performance levels, including national squads. A database of sprint and CMJ results that has been collected over 15 years provides the potential to address several different questions related to the role of sprint and vertical-jump performance in soccer. Therefore, the aim of this study was to quantify possible differences in sprinting velocity and jump height as a function of athlete performance level, field position, and age. In addition, we evaluated the evolution of sprinting velocity and CMJ height among elite performers in Norwegian soccer over a 15-year period. We hypothesized that both sprinting performance and CMJ height would distinguish the highest performance divisions from lower divisions. We also hypothesized that sprinting performance has improved over time due to increased training focus.

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Methods

Subjects

In total, 939 soccer players 16 to 37 years old (22.1 ± 4.3 y), body mass 77.2 ± 8.0 kg, representing a broad range of performance levels participated in this study. Of those, 98 players had foreign citizenship. All players were tested between 1995 and 2010. In total, 1723 sprint tests and 1003 CMJ tests formed the basis for this investigation (Table 1). For the 40-m sprint and CMJ tests, 531 of 418 players tested once, 231 of 130 tested twice, and 177 of 85 tested 3 times or more. The difference in sample size between sprint and CMJ is due to different priorities among team coaches. All tests were performed in the afternoon (between 2 and 8 PM) at the Olympic training center in Oslo. These were preexisting data from the semiannual or annual testing that these teams perform for training purposes, so no informed consent was obtained. The Norwegian Olympic Committee and Confederation of Sports approved the use of these data, provided that individual test results remained confidential. This study was approved by the ethics committee of the Faculty for Health and Sport, University of Agder.

Senior national team athletes were defined as players who represented Norway in senior World Cup, Euro Cup, qualifying matches, or training matches. Since 1995, the Norwegian squad has been ranked among the top 10 several times in the official FIFA ranking (www.fifa.com/worldfootball/ranking). The international ranking at the time this article was written (2011) was 11. The first-division athletes represented clubs from the highest division level in the Norwegian soccer league system. Considering the performance level of first-division teams, Norway has been ranked between 10th and 20th place in UEFA's country ranking (http://www.uefa.com/member associations/uefarankings/country/index.html) during the time period 1995–2010. The second-division athletes were playing in the second highest division. Junior national-team players in the database had represented Norway in the U20 and/or U23 age group. The junior athletes in the database were playing in the highest division level in the Norwegian junior league system. National-team and first- and second-division players were fulltime professional performers, while the third- to fifth-division and junior players were semiprofessionals or amateurs with part or full-time jobs or educational programs in addition to their sports career.

Table 1 Sample Size, Age, Body Mass, and Height for Analyzed Categories in the Current Study

Category	Sprint, CMJ (n)	Age (y)	Body mass (kg)	Height (cm)	Body-mass index
National team	49, 21	26.8 ± 3.4[a]	83.0 ± 7.8[b]	184.0 ± 5.6	24.8 ± 1.8
1st division	315, 244	23.4 ± 4.3	79.0 ± 7.1[b]	182.9 ± 6.2	23.6 ± 1.6
2nd division	158, 90	23.4 ± 3.7	80.1 ± 7.9[b]	181.7 ± 6.0	24.3 ± 1.7
3rd–5th division	175, 93	23.0 ± 3.7	77.1 ± 8.3	—	—
Junior national team	106, 56	18.5 ± 1.8	74.9 ± 6.8	181.9 ± 6.5	22.6 ± 1.7[f]
Juniors	136, 129	17.6 ± 0.9	72.8 ± 7.8	—	—
Forwards	150, 100	22.2 ± 3.9	78.7 ± 6.9	182.4 ± 5.9	23.7 ± 1.6
Defenders	210, 132	23.4 ± 4.6	80.3 ± 6.8	183.8 ± 5.5	23.8 ± 1.6
Midfielders	210, 134	22.5 ± 4.4	75.0 ± 5.8[c]	179.5 ± 5.4 [c]	23.3 ± 1.5
Goalkeepers	58, 45	23.5 ± 4.1	86.7 ± 7.1[d]	189.5 ± 4.0 [d]	24.2 ± 1.9
<18 y	67, 51	16.8 ± 0.4	74.3 ± 6.4[e]	181.0 ± 4.7	22.6 ± 1.7[g]
18–19 y	112, 62	18.5 ± 0.5	75.4 ± 7.1[e]	181.8 ± 7.2	22.8 ± 1.6
20–22 y	140, 74	21.1 ± 0.8	78.2 ± 6.4	182.4 ± 6.0	23.5 ± 1.8
23–25 y	141, 99	24.0 ± 0.8	80.7 ± 7.3	182.8 ± 6.8	24.2 ± 1.7
26–28 y	92, 63	27.0 ± 0.8	81.5 ± 7.8	183.6 ± 5.2	24.2 ± 1.8
>28 y	76, 62	30.6 ± 1.6	81.5 ± 6.6	183.6 ± 5.4	24.2 ± 1.8
1995–1999	312, 113	23.0 ± 4.1	79.3 ± 7.2	182.1 ± 6.2	23.9 ± 1.6
2000–2005	155, 148	22.1 ± 4.6	78.2 ± 7.5	183.1 ± 6.3	23.3 ± 1.6
2006–2010	161, 150	23.2 ± 4.5	79.5 ± 7.5	183.3 ± 5.8	23.7 ± 1.7

Abbreviations: CMJ indicates countermovement jump.

[a] National team > other performance-level categories ($P < .001$). [b] National-team and 1st- and 2nd-division players > junior national-team and junior players. [c] Midfielders were shorter and had less body mass than the other playing positions ($P < .001$). [d] Goalkeepers were taller and had more body mass than the other playing positions ($P < .001$). [e] <20-y-old players < the other age categories ($P < .001$). [f] Junior national team < national team and 2nd division ($P < .05$). [g] <18-y-old players < 23- to 25-y-old players ($P < .05$).

Instruments and Procedures

All sprint tests were monitored by electronic timing equipment (Biorun, Norway). The clock was initiated when the front foot stepped off a start pad placed under the track at the start line. CMJ tests were performed on an AMTI force platform (AMTI model OR6-5-1). The data were amplified (AMTI Model SGA6-3), digitized (DT 2801), and saved to dedicated computer software (Biojump, Norway). Each athlete was weighed on the force platform before testing. Body height was registered by self-report. All jumps were performed with hands placed on the hips. Sprint-timing equipment, force platform, and testing procedures were identical to those in the study performed by Haugen et al.[17] Our procedures have remained consistent over 15 years and have recently been proven valid and reliable.[18]

Data Analysis and Statistics

SPSS 18 was used for all analyses. Means and SDs of each 10-m split are presented for all analyzed categories. The analyses of sprint velocity as a function of performance level, position, age, and time epoch were based on best individual 40-m-sprint test results with associated split times. Several studies show that sprint bouts during games last 2 to 4 seconds on average.[2,6,19] For these reasons, 0- to 20-m times were chosen to represent acceleration capability in the current study. Buchheit et al[20] reported maximal sprinting speed as the main determinant of the distance associated with best split among young soccer players. Expressing the data in terms of peak velocity provides a reference for game-activity analysis. Thus, we chose to use best 10-m split time as the basis for calculating peak sprint velocity.

CMJ analyses were based on best individual CMJ test results. In some cases, best sprint and CMJ test results occurred on different testing days. Data from a single athlete were only included in 1 category for each analysis. That category was the athlete's affiliation on the day of his best result. All athletes (N = 939) were included in the performance-level analysis. The playing position, age, and time-epoch analyses were restricted to players playing professionally at the time of testing. Player positions were identified for each athlete by their coaches or by self-report as goalkeepers, defense players, midfielders, or forwards. Athlete age was calculated from date of birth and testing date and categorized as under 18, 18 to 19, 20 to 22, 23 to 25, 26 to 28, and 28 plus. To quantify the development of sprinting velocity and CMJ ability over time, the database was divided into 3 time epochs: 1995–1999, 2000–2005, and 2006–2010.

Mean and 95% confidence intervals were calculated for each group or category. Pearson R was used to examine the relationship between CMJ and sprint ability. Best individual sprint tests formed the basis for split-time correlations. Best individual CMJ test with corresponding sprint test during the same testing day formed the basis for correlation analyses between sprint and vertical-jump ability. One-way ANOVA followed by Tukey post hoc test where necessary was used to identify differences among groups or categories. Effect size (Cohen d) was calculated to evaluate the meaningfulness of the difference between category means. Effect magnitude was interpreted categorically as small (d 0.2–0.6), moderate (d 0.6–1.2), or large (d 1.2–2.0) using the scale presented by Hopkins et al.[21]

Results

Table 2 presents 10-m split times for the analyzed categories. Our data showed that 64% of the players increased their velocity from 30 to 40 m compared with 20- to 30-m times, 12% remained stable, while 24% of the athletes reduced their speed during the final 10 m. However, the difference between the last two 10-m splits was never more than 0.02 second for any of the categories.

Figure 1 (panel A) shows that national-team players were 1.4% faster than second-division players ($P = .046$, $d = 0.5$), 3.8% faster than third- to fifth-division players ($P < .001$, $d = 1.2$), 2.1% faster than junior national-team players ($P = .002$, $d = 0.7$), and 3.2% faster than juniors ($P < .001$, $d = 1.1$) over 0 to 20 m. First-division players were 1% faster than second-division players ($P = .038$, $d = 0.3$), 3.5% faster than third- to fifth-division players ($P < .001$, $d = 1.1$), 1.8% faster than junior national-team players ($P = .001$, $d = 0.6$), and 2.8% faster than junior players ($P < .001$, $d = 0.9$). Similar trends were observed for peak velocity (Figure 1, panel B). Figure 1 (panel C) shows that national-team players jumped 11.3% higher than juniors ($P < .001$, $d = 0.8$). First- and second-division and junior national-team players jumped 5% to11% higher than third- to fifth-division and junior players ($P < .05$, d 0.5–0.8).

Figure 2 (panel A) shows that forwards were 1.4% faster than defenders ($P < .001$, $d = 0.5$), 2.5% faster than midfielders ($P < .001$, $d = 0.8$), and 3.2% faster than goalkeepers ($P < .001$, $d = 1.0$) over 0 to 20 m. Defenders were 1.1% faster than midfielders ($P = .002$, $d = 0.4$) and 1.8% faster than goalkeepers ($P < .001$, $d = 0.6$). Similar trends were observed for peak velocity (Figure 2, panel B). Figure 2 (panel C) shows that midfielders demonstrated 5% to 6% poorer jumping performance than forwards ($P < .001$, $d = 0.6$), defenders ($P = .003$, $d = 0.5$), and goalkeepers ($P = .016$, $d = 0.6$).

Figure 3 (panel A) shows that players under 18 years of age ran 1.8% slower than the 20- to 22-year group ($P = .007$, $d = 0.6$) and 1.4% slower than the 23- to 25-year-old players ($P = .015$, $d = 0.4$). Peak velocity among players under 18 (Figure 3 panel B) was 2.0% slower than in the 20- to 22-year group ($P = .013$, $d = 0.6$), 1.9% slower than 23- to 25-year-old players ($P = .018$, $d = 0.6$), and 2% slower than the 26- to 28-year-old group ($P = .026$, $d = 0.5$). Players in the 18- to 19-year-

Table 2 Countermovement-Jump (CMJ) Height and 10-m-Split Times for Analyzed Categories, Mean ± SD

Category	CMJ (cm)	0–10 m (s)	10–20 m (s)	20–30 m (s)	30–40 m (s)
National team	39.4 ± 5.2	1.51 ± 0.05	1.24 ± 0.04	1.14 ± 0.04	1.13 ± 0.04
1st division	39.0 ± 4.6	1.52 ± 0.06	1.24 ± 0.05	1.15 ± 0.07	1.14 ± 0.07
2nd division	38.8 ± 4.6	1.53 ± 0.05	1.26 ± 0.05	1.15 ± 0.05	1.15 ± 0.05
3rd–5th division	36.7 ± 4.4	1.58 ± 0.09	1.28 ± 0.09	1.18 ± 0.05	1.17 ± 0.05
Junior national team	39.0 ± 4.6	1.54 ± 0.06	1.26 ± 0.04	1.16 ± 0.04	1.15 ± 0.04
Juniors	35.4 ± 4.2	1.55 ± 0.06	1.28 ± 0.05	1.19 ± 0.05	1.17 ± 0.06
Forwards	40.0 ± 4.9	1.50 ± 0.06	1.23 ± 0.05	1.13 ± 0.04	1.12 ± 0.05
Defenders	39.5 ± 5.0	1.53 ± 0.05	1.25 ± 0.04	1.15 ± 0.04	1.13 ± 0.04
Midfielders	37.5 ± 3.7	1.54 ± 0.06	1.26 ± 0.04	1.16 ± 0.04	1.15 ± 0.04
Goalkeepers	39.8 ± 4.2	1.55 ± 0.06	1.27 ± 0.05	1.18 ± 0.04	1.17 ± 0.05
<18 y	38.6 ± 5.1	1.54 ± 0.07	1.27 ± 0.04	1.16 ± 0.05	1.15 ± 0.05
18–19 y	38.8 ± 4.6	1.52 ± 0.07	1.25± 0.05	1.16 ± 0.05	1.15 ± 0.05
20–22 y	38.6 ± 4.8	1.52 ± 0.05	1.24 ± 0.04	1.14 ± 0.03	1.14 ± 0.04
23–25 y	40.2 ± 4.6	1.53 ± 0.06	1.24 ± 0.05	1.15 ± 0.04	1.13 ± 0.05
26–28 y	38.5 ± 4.2	1.52 ± 0.06	1.24 ± 0.05	1.15 ± 0.04	1.13 ± 0.05
>28 y	38.6 ± 4.1	1.54 ± 0.05	1.26 ± 0.04	1.16 ± 0.05	1.15 ± 0.04
1995–1999	38.4 ± 4.5	1.53 ± 0.05	1.25 ± 0.05	1.15 ± 0.04	1.14 ± 0.04
2000–2005	39.3 ± 4.3	1.52 ± 0.05	1.26 ± 0.04	1.15 ± 0.04	1.15 ± 0.05
2006–2010	39.2 ± 4.9	1.51 ± 0.07	1.24 ± 0.05	1.14 ± 0.04	1.13 ± 0.05

old group were 1.6% slower than 20- to 22-year-old players (P = .031, d = 0.5) and 1.5% slower than the 23- to 25-year-old group (P = .043, d = 0.4). Players older than 28 years were 2% slower than 20- to 22-year-old players (P = .007, d = 0.6), 1.9% slower than 23- to 25-year-old players (P = .010, d = 0.5), and 2.0% slower than those in the 26- to 28-year age category (P = .015, d = 0.6). No differences in CMJ were observed across the age categories (Figure 3, panel C).

Overall, the 95% CIs demonstrate a slight trend toward faster elite players over time (Figure 4, panels A and B). Elite soccer players from the time epoch 2006–2010 had 1.4% and 1.1% higher velocity over 0 to 20 m than in the 1995–1999 (P < .001, d = 0.4) and 2000–2005 (P = .014, d=0.3) epochs, respectively. Players from 2006–2010 had 1.4% higher peak velocity (Figure 4, panel B) than 1995–1999 players (P = .001, d = 0.4) and were 2% faster than 2000–2005 players (P < .001, d = 0.5). No significant differences in CMJ were observed across the epochs (Figure 4, panel C).

Table 3 shows correlation values between sprint and CMJ performance among analyzed categories in the current study. Overall, there was a strong correlation between CMJ height and 0- to 20-m velocity (r = .63, P < .001, n = 633) and between CMJ height and peak velocity (r = .60, P < .001, n = 633). The correlation between 0- to 20 m and peak velocity was very high (r = .81, P < .001, n = 939).

Discussion

In the current study, data from a large sample of athletes tested under identical conditions demonstrate moderate to large differences in sprinting velocity and moderate differences in CMJ height as a function of soccer performance level and playing position. Small to moderate differences in sprinting velocity as a function of age were observed. We also observed a small but significant positive development in 0- to 20-m sprint performance and peak velocity among professional soccer players over a 15-year period of testing, but no significant changes in CMJ ability.

Split-Time Analysis

About 64% of the players ran faster between 30 and 40 m than in the 20- to 30-m interval. Buchheit et al[20] reported that faster players reach peak velocity in a later stage of a sprint than slower performers. Since we have no data beyond 40 m, we might have missed peak velocity for some of the fastest players. However, the difference between the last two 10-m splits was never more than 0.02 second for any of the categories. Thus, it is reasonable to claim that sprinting velocity among the majority of male elite soccer players peaks between 20 and 40 m at 8.8 to 9.0 m/s. The apparently fast 0- to 10-m times compared with the other splits in Table 2 are explained by the time initiation with a foot-pressure-release system.[17]

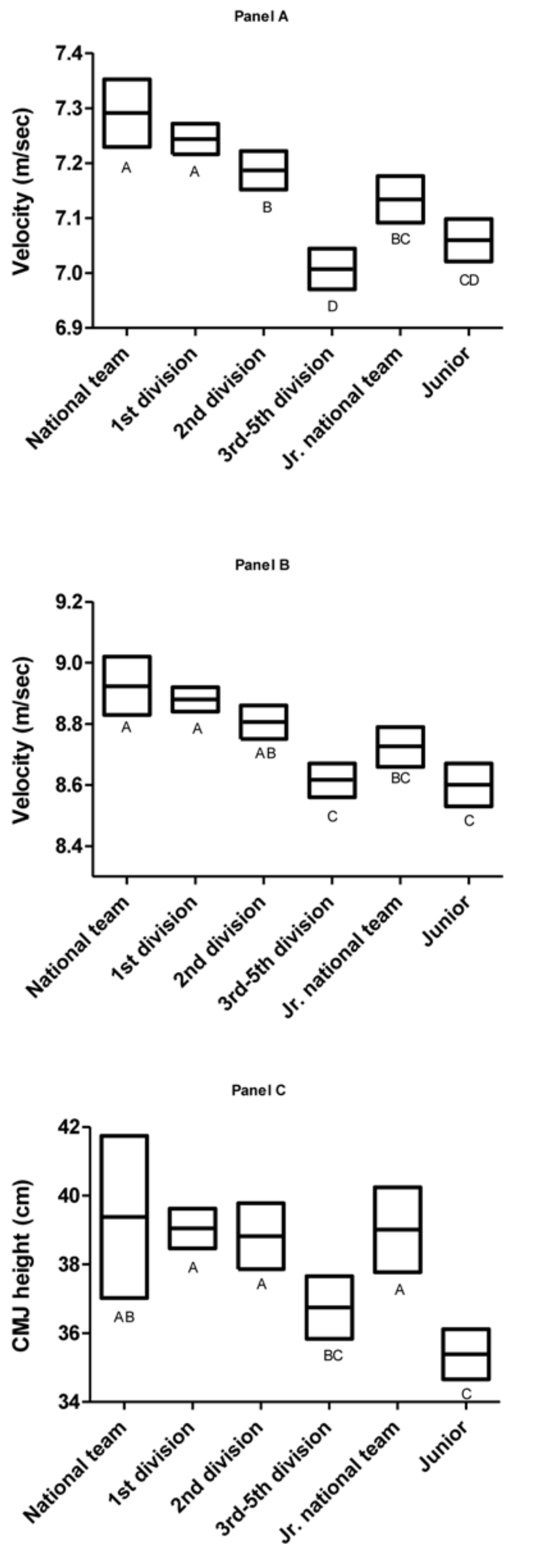

Figure 1 — 95% confidence intervals for (A) 0- to 20-m velocity, (B) peak velocity, and (C) countermovement-jump (CMJ) height as a function of performance level. Differing letters (A–D) indicate significant differences among groups.

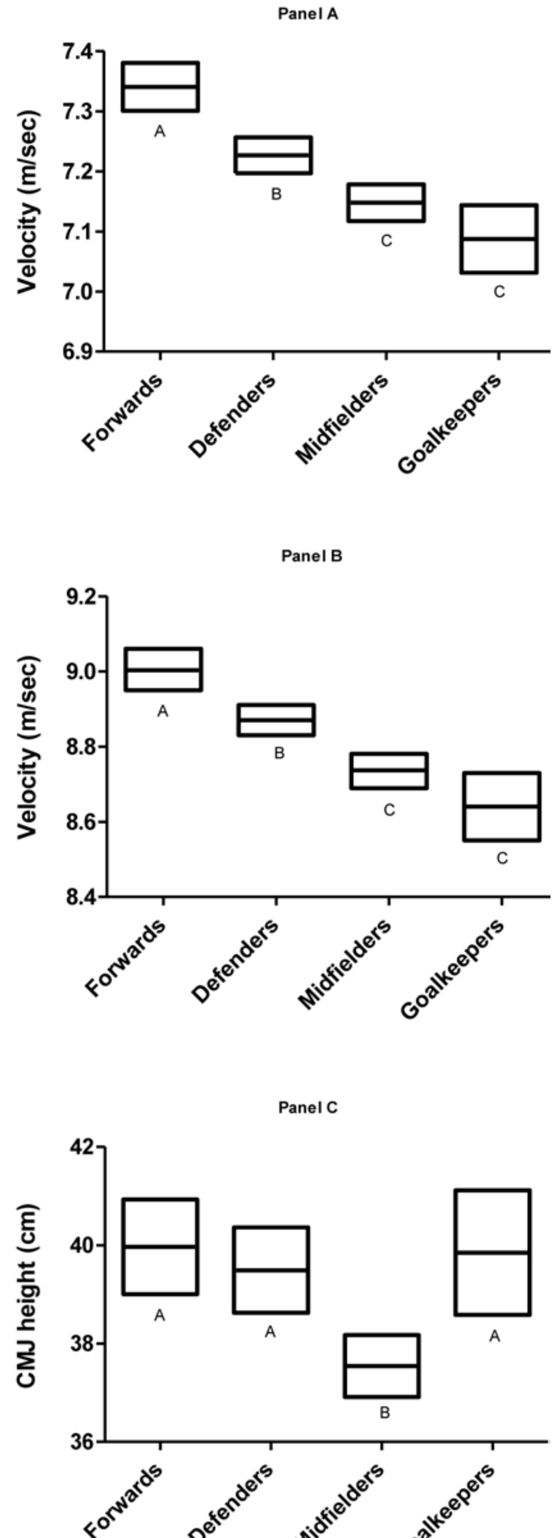

Figure 2 — 95% confidence intervals for (A) 0- to 20-m velocity, (B) peak velocity, and (C) countermovement-jump (CMJ) height as a function of playing position. Differing letters (A–C) indicate significant differences among groups.

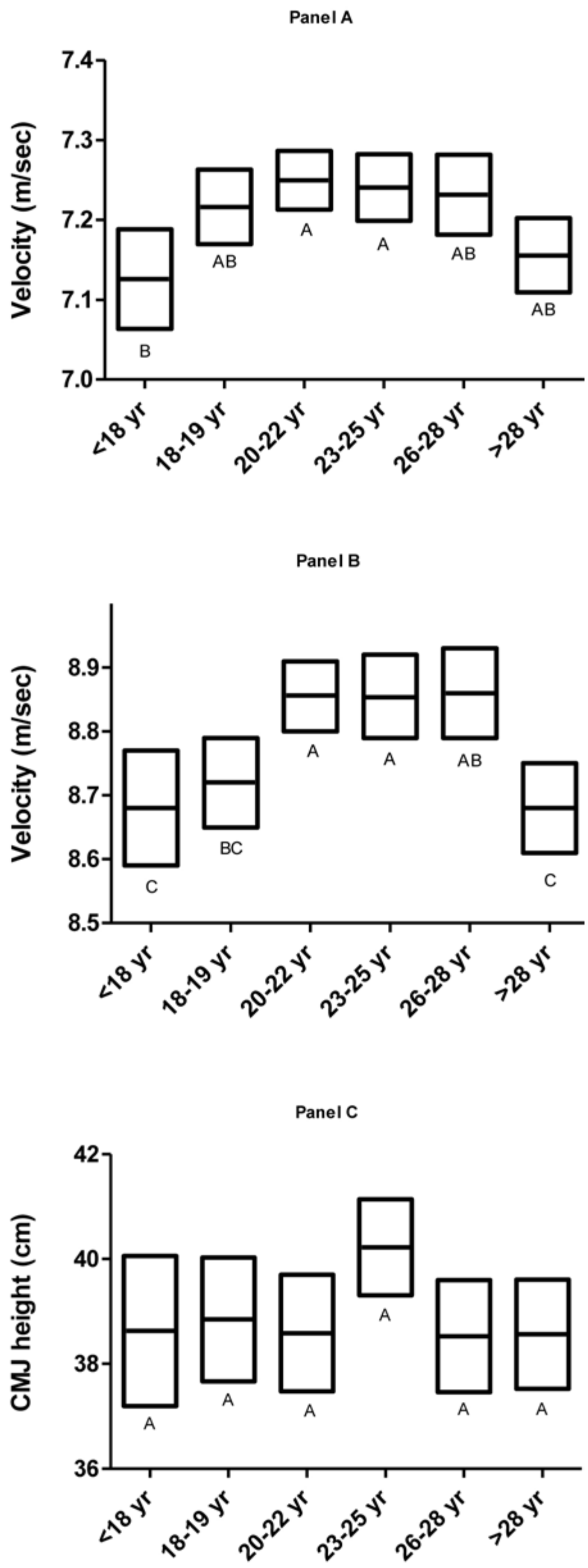

Figure 3 — 95% confidence intervals for (A) 0- to 20-m velocity, (B) peak velocity, and (C) countermovement-jump (CMJ) height as a function of age. Differing letters (A–C) indicate significant differences among groups.

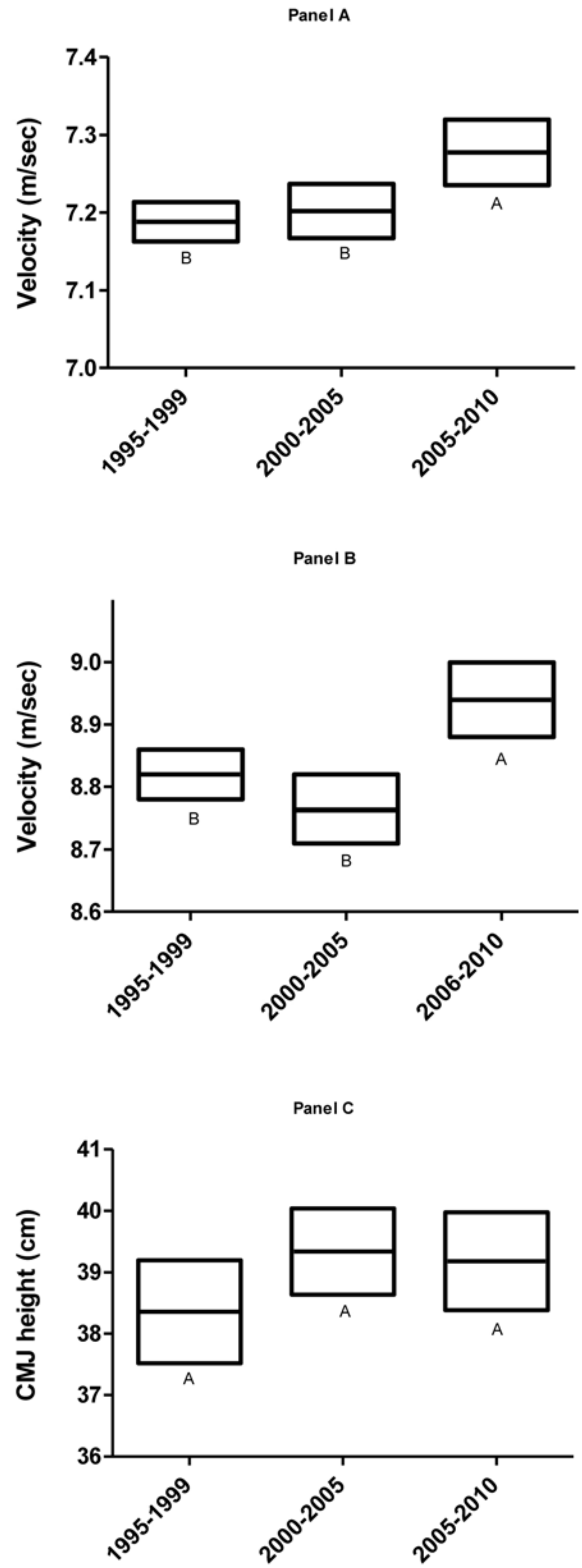

Figure 4 — 95% confidence intervals for (A) 0- to 20-m velocity, (B) peak velocity, and (C) countermovement-jump (CMJ) height as a function of time epoch. Differing letters (A–B) indicate significant differences among groups.

Table 3 Correlation Values (95% Confidence Intervals of *r*) for Sprint and Countermovement-Jump (CMJ) Performance Among Analyzed Categories

	CMJ vs 0- to 20-m Velocity			CMJ vs 30- to 40-m Velocity		
Category	Lower bound	*r*	Upper bound	Lower bound	*r*	Upper bound
National team	.18	.57	.80	.45	.74	1.00
1st division	.47	.56	.64	.46	.55	.63
2nd division	.47	.62	.73	.40	.56	.69
3rd–5th division	.39	.55	.68	.29	.47	.62
Junior national team	.51	.68	.80	.30	.52	.69
Juniors	.46	.59	.69	.36	.50	.62
Forwards	.50	.63	.74	.42	.57	.69
Defenders	.54	.65	.74	.44	.57	.68
Midfielders	.50	.62	.71	.36	.50	.62
Goalkeepers	.31	.55	.73	.39	.61	.77
<18 y	.21	.46	.65	.26	.50	.68
18–19 y	.48	.65	.77	.29	.50	.67
20–22 y	.44	.61	.74	.36	.54	.68
23–25 y	.56	.68	.77	.47	.61	.72
26–28 y	.51	.67	.79	.36	.56	.71
>28 y	.20	.43	.61	.34	.54	.70
1995–1999	.44	.58	.69	.43	.57	.68
2000–2005	.49	.60	.69	.33	.47	.59
2006–2010	.52	.63	.72	.50	.61	.70

Note: All correlations were significant ($P < .001$).

Performance Level

The 95% CIs in Figure 1 show that sprinting velocity trends predictably across performance level. To our knowledge, this is the first study to demonstrate that linear sprinting ability is a performance-distinguishing factor in male soccer. All differences observed were larger than test–retest reliability (CV ~1%) for the same timing system and starting procedures as reported by Haugen et al.[18] Cometti et al[8] reported no speed differences over 30 m between French elite players and amateurs. However, the elite players in that study ran faster over 10 m.

This study did not demonstrate a clear relationship between jumping height and soccer performance level. No differences among the professional players and junior national-team players were observed, despite lower body-mass index among the junior national-team players (Table 1). All these performance-level categories jumped ~3 to 5 cm higher than third- to fifth-division players and juniors. Our data support the statement by Rampinini et al,[22] who claim that vertical-jump performance is not able to discriminate players of different match performance. Furthermore, Rösch et al[9] did not report CMJ differences among French, German, and Czech senior players at different performance levels. In contrast, Arnason et al[7] found a significant relationship between average jump height and success among 17 teams in the 2 highest divisions in Iceland. Taking all the studies together, there is not enough evidence to claim that CMJ ability is a performance-distinguishing factor among professional soccer players.

Playing Position

Velocity differences across playing positions ranged from small to large in the current investigation. All differences observed were larger than test–retest reliability.[18] The internal ranking by player position is in accordance with the findings by Davis et al,[10] Boone et al,[11] and Sporis et al.[12] Buchheit et al[14] and Mendez-Villanueva et al[15] claim that the impact of physical capacities on game physical performance is position dependent. Taskin[13] did not find differences in 30-m-sprint times as a function of playing position among 243 Turkish professional soccer players. Physical characteristics may vary across clubs and nations, depending on tactical dispositions and differences in athlete-selection process over time. Sprinting ability must also be seen in relationship to the physical demands of the different positions on the field. Our playing-position categorization is somewhat limited, but forward and defenders are probably the fastest players because they are involved in most decisive duels during match play.[5] Midfielders cover the longest distance during games,[6] indicating physical qualities other than sprinting velocity as more important.

Our data showed that midfielders had less vertical-jump capacity than the other positions. This is in contrast to Sporis et al,[12] who reported no CMJ-height differences across positions among 270 Croatian elite soccer players. Goalkeepers performed better in CMJ than sprinting relative to the other position groups in our study, which is in accordance with Boone et al.[11] They were also the tallest players (Table 1), supporting the logical expectation that explosive range is an important performance factor for goalkeepers.

Age

No studies have so far examined velocity and power characteristics through different age stages among male soccer players. Overall, the 95% CIs show that sprint velocity peaked in the age range 20 to 28 years, with small but significant decreases in velocity thereafter. Mujika et al[16] reported no significant differences in 15-m-sprint times between juniors and seniors representing a Spanish soccer club. Athletic statistics show that world top-50 sprinters have achieved their best performances at a mean age of 25 ± 3.1 years (http://www.iaaf.org/statistics/ toplists/index.html). No further improvement in sprint velocity was observed after the age of 20 to 22 years in our study. Thus, peak sprinting performance within the larger skill set of soccer peaks 3 to 4 years earlier than when sprint optimization is the only training goal. This stagnation may be considered in the context of match program and specific training. Extensive soccer training including 1 to 3 hours running with varying intensity 5 to 6 d/wk can possibly inhibit sprinting skills.

No differences in CMJ ability were observed across the age categories. This finding reinforces the notion that vertical-jump performance is less important than sprinting ability in soccer.

Time Epoch

This study demonstrates a small but positive development in sprinting velocity for the professional players over time. No studies have so far monitored a large number of male soccer players' physical characteristics in a long-term perspective. The time-epoch analysis was restricted to professionals, and all of these players were tested as part of routine testing procedures. Therefore, the difference observed cannot be explained by selection bias. Instead, we hypothesize that this provides some evidence for the contention that professional performers have become faster over time. Our data showed no development in CMJ height during the corresponding time epochs. We are not aware of studies reporting development in short sprinting distances without development in CMJ ability. Our results remained consistent even when only players who performed both sprint and CMJ testing were considered. These findings indicate that sprint and vertical jump are specific and independent qualities.

Sprint and CMJ Relationship

Overall, most sprint and CMJ correlation values reported were in the range of moderate to very large. Our findings are in accordance with similar soccer investigations.[17,23] The coefficients of determination between our sprint and CMJ data were mainly.25 to .5. Variables should be considered specific and independent of each other when the coefficient of determination is less than .50.[24] Equally performing players on the sprint test in this study differed by as much as 10 to 15 cm on the CMJ test. Salaj and Markovic[25] suggest that vertical and horizontal acceleration characteristics should be tested separately.

Practical Applications

In the current study there were moderate to large velocity differences across performance level, supporting the notion that linear sprinting velocity is an important skill in modern soccer. Small to large performance differences among playing-position groups indicate that individual physical capacity is an important part of tactical dispositions within the team. Sprinting velocity peaks in the age range of 20 to 28 years, with small but significant decreases in velocity thereafter. Based on the smaller between-groups differences in CMJ height in this investigation, it is tempting to claim that speed is more important than vertical-jump ability in soccer, except for goalkeepers. Soccer athletes have many qualities to develop, and coaches should take sprinting velocity into account within the larger skill set of soccer. Selection of players, testing, and physical conditioning of the athletes should reflect the importance of speed. Future research should focus more on the relationship between physical demands of the game, capacity profiles among players, and consequences for long-term planning of individual fitness programs in soccer.

Conclusion

This study provides effect-magnitude estimates for the influence of performance level, player position, and age on sprint and CMJ performance in soccer. There was a small but positive difference in sprinting velocity among professional players over time, whereas CMJ performance has remained stable.

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