Physical Fitness, Injuries, and Team Performance in Soccer

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ABSTRACT

ARNASON, A., S. B. SIGURDSSON, A. GUDMUNDSSON, I. HOLME, L. ENGEBRETSEN, and R. BAHR. Physical Fitness, Injuries, and Team Performance in Soccer. *Med. Sci. Sports Exerc.*, Vol. 36, No. 2, pp. 278–285, 2004. **Purpose:** To investigate the relationship between physical fitness and team success in soccer, and to test for differences in physical fitness between different player positions. **Methods:** Participants were 306 male soccer players from 17 teams in the two highest divisions in Iceland. Just before the start of the 1999 soccer season, the following variables were tested: height and weight, body composition, flexibility, leg extension power, jump height, and peak O_2 uptake. Injuries and player participation in matches and training were recorded through the 4-month competitive season. Team average physical fitness was compared with team success (final league standing) using a linear regression model. Physical fitness was also compared between players in different playing positions. **Results:** A significant relationship was found between team average jump height (countermovement jump and standing jump) and team success ($P = 0.009$ and $P = 0.012$, respectively). The same trend was also found for leg extension power ($P = 0.097$), body composition (% body fat, $P = 0.07$), and the total number of injury days per team ($P = 0.09$). Goalkeepers demonstrated different fitness characteristics from outfield players. They were taller and heavier, more flexible in hip extension and knee flexion, and had higher leg extension power and a lower peak O_2 uptake. However, only minor differences were observed between defenders, midfield players, and attackers. **Conclusion:** Coaches and medical support teams should pay more attention to jump and power training, as well as preventive measures and adequate rehabilitation of previous injuries to increase team success. **Key Words:** PHYSICAL PERFORMANCE, MAXIMAL O_2 UPTAKE, JUMPING ABILITY, LEG POWER, FLEXIBILITY, BODY COMPOSITION

Soccer is one of the most widely played sports in the world (15,29) and is a sport characterized by short sprints, rapid acceleration or deceleration, turning, jumping, kicking, and tackling (4,30). It is generally assumed that through the years, the game has developed to become faster, with more intensity and aggressive play than seen previously (29). Elite soccer is a complex sport, and performance depends on a number of factors, such as physical fitness, psychological factors, player technique, and team tactics. Injuries and sequelae from previous injuries can also affect the players' ability to perform.

During a 90-min soccer match an elite player covers on the average between 10 and 11 km per game (4,6,11,20,29). Although the distance covered by different players in the same position varies, studies have shown that midfielders travel farther than defenders or attackers, probably because of their linking role in the team (6,11,29). Among the defensive players, the fullbacks usually cover more distance than centerbacks, since they are usually more involved during the attacking phase. Although most of the movement for all players is at low or submaximal intensity (6,21,29), it has been estimated that the mean work rate is about 70–75% of maximum oxygen uptake and close to the anaerobic threshold (6,20,21). Midfield players cover a greater percentage of their distance at lower intensity, whereas attackers cover a greater proportion at a sprint (11,29). This indicates that there may be a difference in the requirements between different playing positions, but whether this is reflected by differences in fitness is not clear (6,10,30).

Studies on the physical performance of elite soccer players indicate that the average maximal O_2 uptake ranges between 56.8 and 67.6 $mL \cdot kg^{-1} \cdot min^{-1}$ (1,5,6,8,10,22,27,30), whereas mean body fat (%) is between 8.6 and 11.2% (8,10,22,27). Muscular power has mainly been reported as jump height, using different tests. Some studies have found a vertical jump of 55.6–63.4 cm (27,28), whereas other studies reported a countermovement jump height of 41.4–41.6 cm and a standing

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jump height of 38.5–39.0 cm (8,9). Flexibility, muscle strength and hamstring to quadriceps strength ratios among soccer players have also been reported in several studies, but methodological differences (test type, speed, joint angle, etc.) make direct comparisons difficult (9,10,18,19).

Although one might expect team success to be strongly correlated to physical fitness, there is limited evidence for such a relationship. One study found a correlation between the amount of training and the training to match ratio on one side and team success on the other (12). Wisloff et al. (30) compared the fitness of one team at the top and another at the bottom of the Norwegian elite division and found that the best team had significantly higher test values for maximal O_2 uptake and 1-RM squat. However, an obvious limitation of this study was that only two teams were compared, and we therefore wanted to expand their approach by including the teams of two divisions in Icelandic soccer. The aim was to study the relationship between physical fitness and team performance by comparing various indices of physical fitness between and within divisions with final league standing. We also wanted to test for differences in physical fitness between different player positions.

MATERIALS AND METHODS

Of 20 soccer teams that participated in the Icelandic elite and first division during the 1999 season, 17 accepted an invitation to participate in this study (nine from the elite and eight from the first division). At the end of the season, the three teams that declined to participate finished third in the elite division, and 9th and 10th in the first division. The Icelandic soccer season lasts from mid-May until mid-September. The teams played a double round-robin competition format, home and away, and the final league standing was determined based on the total number of points won. For each game, a team was awarded 3 points for a win, 1 point for a draw, and 0 points for a loss. Each coach selected the 18 best players from his team to participate ($N = 306$). Just before the start of the season, players were tested to estimate peak O_2 uptake (226 of the players completed this test), body composition ($N = 228$), leg extensor power ($N = 215$), jumping ability ($N = 217$), and flexibility ($N = 249$). Endurance tests and power/jump tests were conducted on separate days. A total of 153 players (50%) participated in all of the tests, and 301 (98%) took part in at least one of the tests (mean age 24, range 16–38). These 301 players were included in the analyses. The project was reviewed and approved by the National Bioethics Committee and Data Protection Authority in Iceland, and written informed consent was obtained.

During the soccer season, the team physical therapists recorded injuries on a special form. This form included information about the type and location of the injury, prior similar injuries, injury mechanism, duration of the injury, and the exact diagnosis. A player was defined as injured if he was unable to participate in a match or a training session because of an injury that occurred in a soccer match or during training, and classified as injured until he was able to comply fully with all instructions given by the coach (3). During the same time period, the coaches recorded individual match and training exposure, that is, player participation for every training session (including the duration of each session). Detailed information on injury incidence, injury types, and risk factors for injury is reported separately (2).

Peak O_2 uptake. The test session started with a warm-up period of about 6-min running on a treadmill (h/p/Cosmos Quasar med, H-P-Cosmos Sports & Medical GmbH, Nussdorf-Traunstein, Germany). The inclination was 0°, and the speed was gradually increased during the first 3 min until 70–75% of maximal heart rate was obtained, and this speed was maintained for the final 3 min. Then the player was allowed to stop and stretch for about 3 min. He was connected to a mouth/nose piece (model 7940, Hans Rudolph, Kansas City, MO), and O_2 uptake and CO_2 production were measured while he ran for about 2 min at the same speed as previously. Then the speed was increased by 0.5 $m \cdot s^{-1}$ every minute until a speed of 4 $m \cdot s^{-1}$ was reached. After that, the inclination of the treadmill was increased by 1.5° every minute until volitional exhaustion. O_2 uptake and CO_2 production was measured continuously using test instruments from VacuMed (models 17620 and 17630, Ventura, CA) connected to Macintosh Quadra 650 computer using a Super Scope II 2.17 program. The meters were calibrated using gases with known O_2 and CO_2 concentrations determined by Scholander technique (25). Heart rate was measured using a Polar Sport Tester PE 4000 pulse meter (Polar Electro oy, Kempele, Finland). The total exercise session usually took 16–20 min, 10–12 min for warm-up and stretching, and 6–8 min for the test itself.

Body composition. Skinfold measurements were taken from six different areas: triceps brachii, subscapular, pectoralis major, iliac crest, abdomen and, anterior thigh (Lange Skinfold Caliper, Cambridge Scientific Industries Inc., Cambridge, MD). The results were calculated using four different formulas, and the average was used as the final result for body composition (% body fat) (14,16,17,26). Body mass index (BMI, $kg \cdot m^{-2}$) was calculated as the mass (kg) divided by the squared height (m).

Leg extensor power testing. Maximal average power was measured in the extension phase of a squat. The player warmed up on Monark cycle ergometer for 6 min at 100 W, and then a squat test was performed in a Smith machine (MultiPower, TechnoGim, Torreveccia Teatinge, Italy), which is a slide machine with a guided horizontal barbell. A MuscleLab unit (Ergotest Technology a.s., Langesund, Norway) was connected to the Smith machine with a linear encoder (ET-Enc-01, Ergotest Technology a.s.), which measures vertical movement of the bar as a function of time. The linear encoder is connected to the bar with a cord that rotates a measuring wheel that generates 512 pulses per each round, measuring distance with a resolution of <0.1 mm. The MuscleLab unit counts the pulses with 10-ms interval. The calculation of velocity, force, and power has been described in detail by Bosco et al. (7).

After receiving instructions, the player put on a weightlifting belt and practiced the technique with light loads:

hands on the bar, grip a little wider than shoulder width, hips and feet under the bar, and shoulder width between the feet. After a few practice trials, when his technique was accepted, the player rested the bar on his trapezius, and lifted it from the locked position. He took a deep breath and bent his hips and knees to 90° as measured with a goniometer, stopped observably for 1–2 s, then extended his hips and knees as fast as possible. Tests were performed with external weight of 20, 40, 60, and 80 kg, with two attempts at each weight. The better outcome was used as the final result. The players were accustomed to regular weight training as part of their training program. The reliability of this method in our lab ranges between 4% (light load) and 6% (heavy load) (CV) (J. I. Gaasvaer, personal communication, March 1999).

Jump testing. Jump tests were performed right after the power test on a contact mat (PE, TapeSwitch Corp., Farmingdale, NY) connected to the MuscleLab unit, which measures the height of rise of the center of gravity above the ground (h, cm) based on the flight time (t_f, s) with the formula: $h = t_f^2 \cdot g \cdot 8^{-1}$ (7). The players were instructed to jump and land in exactly the same place with the body in an erect position during the jump until landing. The better of two outcomes was used as the final result.

Three types of jumps were tested (7). A standing jump (SJ) was performed with the player holding his hands on the iliac crest, bending his knees to 90°, stopping there observably for 1–2 s, and then extending his knees and hips and jumping as high as he could. No countermovement of the trunk or knees was allowed. A countermovement jump (CMJ) was done on both legs in the same way, but without stopping in the lowest position. Single leg countermovement jumps were also performed on both the right and left legs. No arm swing was allowed in any of the jumps. The reliability (CV%) of these methods in our lab is 4.3% for SJ and 5.3% for CMJ (J. I. Gaasvaer, personal communication, March 1999).

Flexibility tests. Flexibility was measured as static range of motion (ROM) for the hamstrings, adductors, rectus femoris, and hip flexors. The procedure for each of the muscle groups has been described in detail in a separate report (2). All of the flexibility tests were performed by the same physical therapist and assistant, and the reliability (CV%) of these test ranges between 0.8% and 3.5%. Before the flexibility tests, the players warmed up on a Monark cycle ergometer as for the power tests. The tests were performed on an examination table with a wooden surface. For each test, the player was fixed on the bench with belts to avoid accessory movements. Three reflex markers were used on the player for each test, one marker in the movement axis for the involved joint and two other markers in the center line of the proximal and distal limbs. The predetermined movement was carried out with the same load for each player, measured with a tension meter (MIE Medical Research Ltd., Leeds, UK) or a Myometer (Penny & Giles Transducers, Christchurch, UK). ROM was measured based on photos taken with a JVC digital camera and analyzed using the KineView movement analysis system (Kine, Reykjavik, Iceland), except for hip abduction, which was measured with a double-armed goniometer.

Statistical methods. SPSS (version 10.0; SPSS Inc., Chicago, IL) was used for the statistical analysis. Independent samples t-tests were used to compare test results between all players in the elite and first divisions. However, in order to compare the teams, the team average was also calculated for each test variable, and independent samples t-tests were used to compare team averages between divisions. To test for a possible relationship within divisions between team averages (independent variable) and the final league standing of the teams (dependent variable), the common slope for both divisions corrected for division was calculated using linear regression. Unstandardized regression coefficients (B) were used to describe the slope.

Players in the study were classified as attackers, midfielders, defenders, and goalkeepers. The most common playing formation was 4-4-2 (four defenders, four midfielders, and two attackers), although 4-5-1 and 3-5-2 were also seen. A one-way ANOVA was used to test for possible differences in test variables between different player positions (goalkeepers, defenders, midfielders, and strikers). The same method was also used to test for differences between goalkeepers and field players, and between the three different positions of field players using Bonferroni correction for multiple comparisons. P values ≤ 0.05 were considered as statistically significant.

RESULTS

When comparing the team averages between the elite league and first division, the only difference observed was

TABLE 1. Comparison between team averages between the teams in the elite division and first division; at least 10 players per team had to have participated in each test for the team to be included in the analysis.

	Elite Division		Division I		
	N	**Mean ± SEM**	***N***	**Mean ± SEM**	***P***
Age (yr)	9	24.2 ± 0.2	8	23.6 ± 0.4	0.22
Height (cm)	9	181.7 ± 0.5	8	179.6 ± 0.5	0.007
Body mass (kg)	9	77.0 ± 0.7	8	75.7 ± 0.7	0.22
Body composition (% fat)	8	9.9 ± 0.5	7	11.2 ± 0.5	0.10
BMI ($kg \cdot m^{-2}$)	8	23.5 ± 0.2	7	23.6 ± 0.1	0.72
Flexibility (sum, °)	9	468.7 ± 2.2	8	468.2 ± 2.8	0.88
Maximal average power (W)	8	1351 ± 21	7	1339 ± 25	0.71
Counter movement jump (cm)	8	39.4 ± 0.4	7	38.8 ± 0.7	0.40
Standing jump (cm)	8	37.8 ± 0.4	7	37.0 ± 0.5	0.27
Peak O_2 uptake ($mL \cdot kg^{-1} \cdot min^{-1}$)	8	63.2 ± 0.4	7	61.9 ± 0.7	0.14

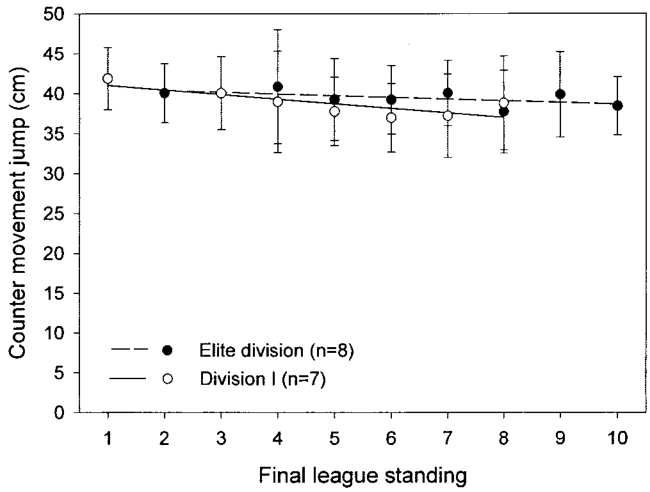

FIGURE 1—Relationship between team average for the countermovement jump height (cm) and the final league standing of the teams. When corrected for division, the common slope was significant (B = −0.36 ± 0.12, *P* = 0.009) with CMJ as independent and final league standing as dependent variables. Error bars are also shown to show the variation within each team (SD).

that the elite league teams were taller than the first division teams (Table 1). However, if the individual player values were compared between divisions, significant differences were also observed for peak O_2 uptake (63.2 ± 4.5 vs 61.7 ± 5.1 $mL \cdot kg^{-1} \cdot min^{-1}$, $P = 0.02$, $N = 226$) and body composition (10.0 ± 4.2% fat vs 11.2 ± 4.3%, $P = 0.03$, $N = 228$).

A significant relationship was observed between the team average for jump height (countermovement jump and standing jump) and team success (defined as final league standing) (Figs. 1 and 2). Trends were observed when examining the relationship between team success and the team averages for leg extensor power (Fig. 3) and body composition (% body fat, Fig. 4). Finally, there was also a trend toward a better final league standing at the end of the season for teams that incurred less injuries during the season (total

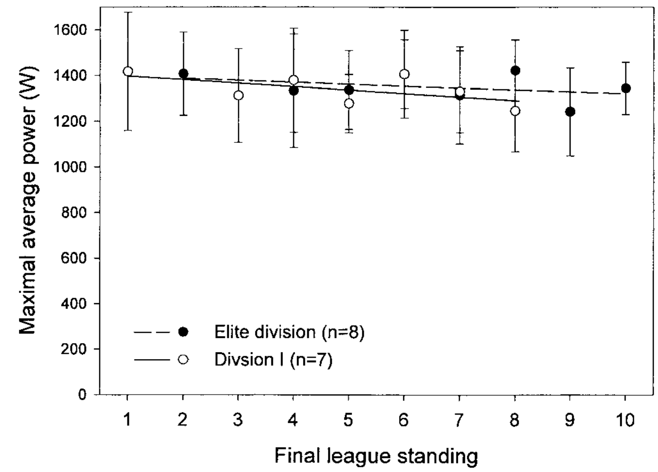

FIGURE 3—Relationship between team average for the maximal average leg extension power (W) and the final league standing of the teams (B = −11.30 ± 6.28, *P* = 0.097). Error bars are also given to show the variation within each team (SD).

number of injury days) (Fig. 5). However, no relationship was observed between team success and team averages for other test values: peak O_2 uptake (Fig. 6), height, weight, BMI, and flexibility.

Goalkeepers were significantly taller ($P < 0.001$) and heavier ($P = 0.002$) than outfield players (Table 2). They also had greater ROM in hip extension (hip flexor flexibility) ($P = 0.04$) and knee flexion (rectus femoris flexibility) ($P = 0.02$), but their peak O_2 uptake was lower ($P < 0.001$) than outfield players. Goalkeepers also displayed greater leg extensor power than midfielders ($P = 0.008$) and defenders ($P = 0.03$). The time loss due to injury (number of injury days) was also lower among goalkeepers ($P = 0.05$). Because goalkeepers were so different from other players, the groups of outfield players were also compared separately from goalkeepers with few differences observed. Midfielders were older than strikers ($P = 0.02$), defenders taller than midfielders ($P = 0.02$), and strikers more powerful than

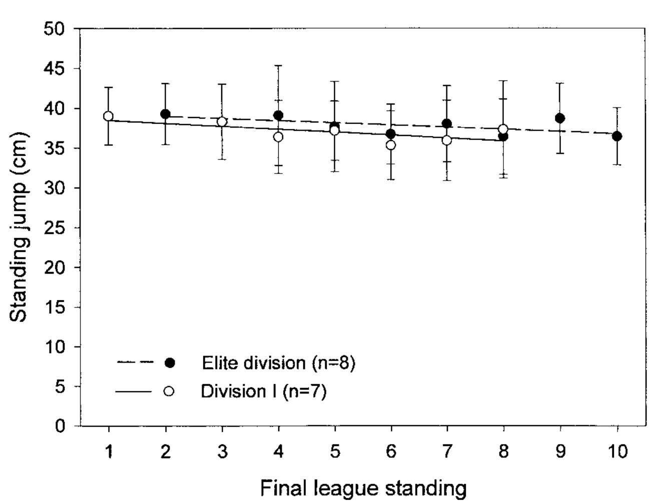

FIGURE 2—Relationship between team average for the standing jump height (cm) and the final league standing of the teams (B = −0.31 ± 0.12, *P* = 0.012). Error bars are also given to show the variation within each team (SD).

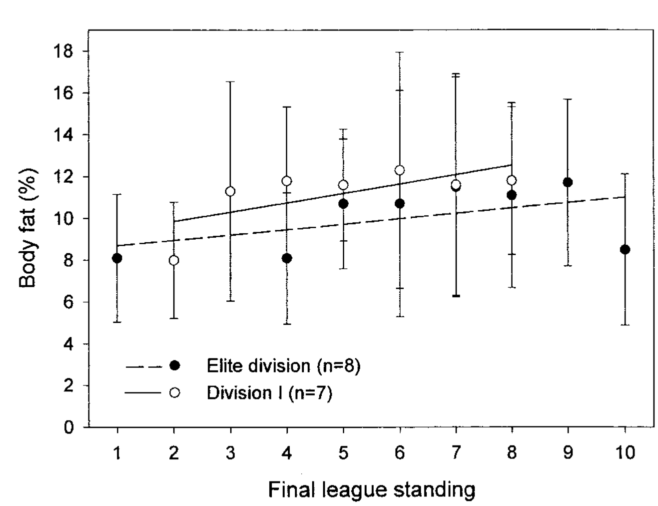

FIGURE 4—Relationship between team average for the body fat (%) and the final league standing of the teams (B = 0.27 ± 0.14, *P* = 0.07). Error bars are also given to show the variation within each team (SD).

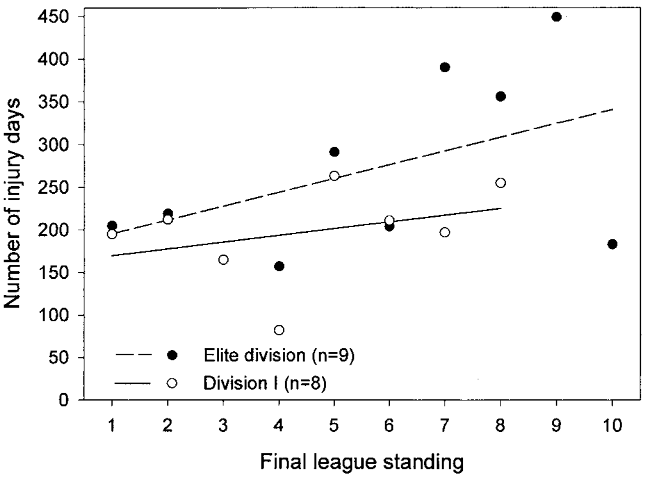

FIGURE 5—Relationship between number of injury days per team and the final league standing of the teams (B = 13.2 ± 7.30, *P* = 0.092).

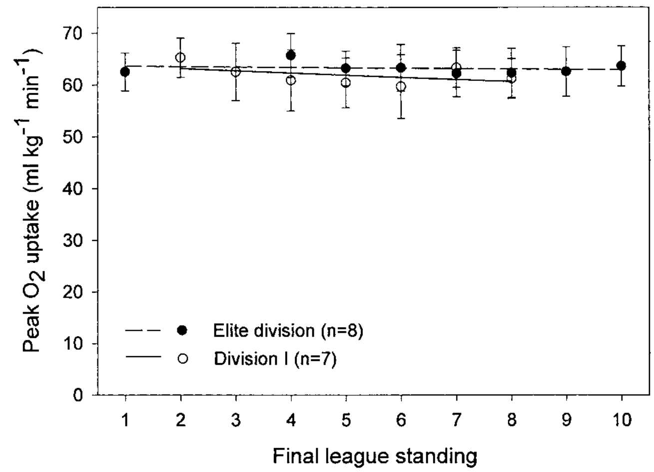

FIGURE 6—Relationship between team average for the peak O_2 uptake ($mL \cdot kg^{-1} \cdot min^{-1}$) and the final league standing of the teams (B = −0.19 ± 0.16, *P* = 0.27). Error bars are also given to show the variation within each team (SD).

midfielders ($P = 0.01$). No difference was found between central midfielders and wing midfielders in any of the tests.

DISCUSSION

The main finding of the present study was that surprisingly few differences were observed in the team average test values between or within the two highest male soccer divisions in Iceland. Moreover, the relationship between team average performance on the various tests and team success expressed as final league standing was generally weak. Finally, goalkeepers appeared to have a different fitness profile than the other player positions, whereas the three groups of outfield players were similar in their performance on the tests.

Methodological considerations. Although this is the largest study of its kind to date, an obvious limitation is that we were not able to perform all the tests on all the players. Of 306 players, between 215 and 257 players participated in each of the tests. This limits the number of players per team available to estimate the team average for each of the tests. Therefore, teams where we had tested fewer than 10 players in any particular test were excluded from the analyses. The reason why players did not participate in testing is in most cases unknown: some declined the invitation to be tested, and others did not show up for their appointment. Although a few could not perform certain tests because of off-season injuries, we do not know of any other bias in the recruitment for testing. No differences were found in age, height, weight, level of play, or injury rate between players that participated in different tests and those who did not. However, the players that participated had significantly higher exposure during matches than the players that we were unable to test. This indicates that the players that saw more playing time were tested, which increases the validity of the study. Physiological variables were measured using established methods with acceptable precision, and it is our impression that the players that were tested were well motivated.

The injury registration was performed prospectively by the team physical therapists, but although the quality of

TABLE 2. Means and standard deviations (SD) of descriptive characteristics by player position.

Test Variables	Strikers		Midfielders		Defenders		Goalkeepers		All Players	
	N	Mean ± SD	*N*	Mean ± SD	*N*	Mean ± SD	*N*	Mean ± SD	*N*	Mean ± SD
Age (yr)	64	23.1 ± 3.4	96	24.7 ± 4.6[b]	113	24.2 ± 4.3	24	23.5 ± 3.3	297	24.0 ± 4.2
Height (cm)	53	180.2 ± 5.3	75	179.3 ± 5.2	90	181.1 ± 5.4[a]	18	185.2 ± 4.7[c]	236	180.6 ± 5.4
Body mass (kg)	53	75.3 ± 5.9	74	75.9 ± 7.0	90	76.9 ± 6.1	17	81.4 ± 7.7[c]	234	76.5 ± 6.6
Body fat (% fat)	47	9.6 ± 5.1	76	10.7 ± 4.2	89	10.6 ± 3.6	15	12.3 ± 5.3	227	10.5 ± 4.3
BMI ($kg \cdot m^{-2}$)	47	23.3 ± 2.1	76	23.6 ± 1.7	89	23.6 ± 1.4	15	23.6 ± 1.5	227	23.5 ± 1.7
Hamstring flexibility (°)	57	113.3 ± 11.1	78	113.4 ± 13.7	95	113.7 ± 13.3	19	111.4 ± 14.2	249	113.3 ± 13.0
Hip flexor flexibility (°)	57	179.0 ± 5.1	78	178.7 ± 5.7	95	178.5 ± 5.8	19	181.4 ± 6.5[c]	249	178.9 ± 5.7
Rectus femoris flexibility (°)	57	134.1 ± 7.3	78	134.0 ± 7.1	95	134.7 ± 7.3	19	138.5 ± 8.0[c]	249	134.6 ± 7.3
Adductor flexibility (°)	57	43.5 ± 4.1	78	43.3 ± 4.7	95	43.1 ± 5.0	19	43.4 ± 5.2	249	43.3 ± 4.7
Flexibility (sum ROM, °)	57	470.0 ± 19.9	78	469.4 ± 22.0	95	470.0 ± 19.0	19	474.8 ± 26.4	249	470.2 ± 20.7
Leg extensor power (W)	46	1400 ± 212[a]	68	1309 ± 185	84	1335 ± 179	16	1451 ± 233[c]	214	1349 ± 196
CMJ (cm)	49	39.4 ± 4.2	70	39.3 ± 4.9	79	39.3 ± 5.5	16	38.0 ± 5.6	214	39.2 ± 5.0
SJ (cm)	49	37.8 ± 4.4	70	37.6 ± 4.8	79	37.7 ± 4.9	16	35.8 ± 5.3	214	37.6 ± 4.8
Peak $\dot{V}O_2$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	47	62.9 ± 5.5	76	63.0 ± 4.3	87	62.8 ± 4.4	15	57.3 ± 4.7[c]	225	62.5 ± 4.8
Injury days per player (d)	64	10.1 ± 19.6	96	11.9 ± 20.7	114	10.0 ± 19.0	24	2.8 ± 5.5[c]	298	10.1 ± 19.1

[a] Significantly different from midfielders ($P < 0.05$).
[b] Significantly different from strikers ($P < 0.05$).
[c] Significantly different from other player groups pooled ($P < 0.05$).

Icelandic soccer is high, the clubs have limited resources for medical support. Physical therapists were usually present before, during, and after matches but not routinely during training sessions. Although players were instructed to contact their physical therapist if injured, limited attendance of physical therapists during training may have lead to an underestimation of minor injuries, causing players to miss one or two training sessions only. The injury registration period was limited to the competitive season, which means that injuries occurring before the start of the season were not registered, even if the players could not participate fully from the start of the season. This means that the total absence because of injury (injury days) may have been underestimated somewhat. In the present study, we have compared the number of injury days per team with team performance or final league standing. A player who suffers from five minor injuries and a player with one major injury can be out for the same number of days, but it is possible that the longer period out of play might affect a team more. Because the possibility to replace injured players is limited and the player groups of most of the teams in Iceland are smaller than in many other countries, the absence of key players from matches can affect the team results more. A major injury can also affect physical, tactical, technical, and psychological skills of the player when he returns to play. Unfortunately, it was not possible to test these hypotheses with the data available in the present study.

Fitness and soccer performance. Elite soccer is a complex sport, and performance is assumed to depend on a number of factors, including psychological factors, player technique, team tactics, and physical fitness. We therefore expected to find substantial differences in the results from the various fitness tests between and within divisions, with the best results in the elite division, and with a gradient from better to lower performance from the top to the bottom teams in each league. In accordance with this, Wisloff et al. (30) found a significant difference in endurance (maximal O_2 uptake, 13% difference) and leg extensor strength (1-RM squat, 22% difference) between the best and the worst teams of the Norwegian elite division. However, the only difference we found when comparing the team averages between divisions was that the teams in the elite division were taller than in the first division. If we compared the individual test results of the players instead of the team averages, peak O_2 uptake was also found to be 2.4% higher among elite players than in the first division, in accordance with the study by Wisloff et al. (30). However, when examining the relationship between the team average fitness indices and team success within divisions, the only significant correlation observed was for jump height (CMJ and SJ), although trends were seen for leg extensor power and body composition, as well.

Few other studies have been found that compare physical fitness between different levels of soccer players (9,23,24). Some indicate that soccer players playing at a higher level have a significantly higher vertical jump than players at a lower level (13,23), but not all studies have confirmed this finding (9,30). We were not able to measure sprint speed, but studies have shown that there is a close correlation between jump height and running speed (13), as well as leg extensor strength (11,30). In accordance with our findings, it has been reported that the main physical difference between elite and nonelite soccer players is their sprinting speed (10,11).

One potential explanation for the apparently low correlation between fitness and team performance could be that the differences in physical fitness between the teams in our sample were too small to be able to detect a relationship. However, the range in the team averages for peak O_2 uptake (Fig. 6) and leg extensor power (Fig. 3) was 10% and 15%, respectively. In other sports, such as long-distance running, sprint running, or high/long jump, such a range in physical fitness tests would be highly predictive of performance. A subsidiary explanation could be that the best teams were more homogenous than the lesser teams in their physical fitness level. However, as shown in Figures 1 through 6, where we have included error bars to show the variation within each team, there was no trend toward a greater variance among the lower placed teams.

It could be hypothesized that the Icelandic players had not reached their peak physical fitness when they were tested just before the season started, and that this is the reason for the apparent lack of relationship between league standing and the team fitness profile. Compared with most of the European countries, the 4-month Icelandic soccer season is relatively short, but consequently the preseason preparation period in the two highest divisions is long (lasting 6–7 months). This means that the precompetition fitness tests should be represent measures of their fitness level during the short season. We were not able to test fitness during or after the season, but one study indicates that changes in physical fitness factors occur during the first half of the season, such as a decrease in body fat (%) and an increase of the anaerobic threshold (8). It could be argued that because of the long preparation period, Icelandic teams are more likely to have reached a higher fitness level than in other countries, where teams have less time to prepare. The preparation period includes a hard fitness program, training camps, and numerous matches in preseason tournaments and friendly games, especially during the final 2 months before the season starts. In addition, there is no reason to believe that this factor would systematically differ between teams.

Thus, our limited ability to predict team performance from physical fitness tests suggests that other factors may be more important, for example, player technique, team tactics, psychological factors, or injuries. However, this does not mean that a team with superior fitness would not have a definite advantage when playing an opponent with less physically fit players. If one team were to have a 10% higher maximal O_2 than the other, it would nearly amount to having one player more on the pitch. Nevertheless, the ability to transform this fitness advantage to a real performance advantage would depend on a number of other factors, such as motivation, and technical and tactical skills.

Injuries and performance. Injuries on key players would be expected to affect team performance. In individual sports, this relationship is simple; if you are unable to compete because of an injury, you cannot win. In team sports, the effects of injury on team performance are perhaps less obvious, because injured players can be replaced by substitutes or even by acquiring new players from other clubs. In the present study, we observed a trend toward a significant relationship between the total number of injury days per team and team success. In fact, if one outlier team from the elite league (number 10 in final league standing) is excluded, the result was clearly significant corrected for division ($B = 20.3 \pm 6.8$, $P = 0.01$). This is not surprising, as in Iceland soccer teams have limited resources to replace injured players. In the major leagues in Europe, where teams are in a position to buy new quality players when needed, it is possible that injuries can be seen to be more as a financial issue and be less directly related to team performance on the pitch. We have not been able to find any previous studies where the relationship between injuries and performance has been studied systematically.

Fitness and playing position. The present results on player age, height, weight, body composition, standing jump, and peak O_2 uptake are in accordance with previous studies on elite soccer players, whereas the countermovement jump height results were in the lower range reported before (1,3,5,6,8–10,22,24,27,28,30). Other test variables such as flexibility, strength, and power tests are more difficult to compare between studies because of differences in the test methods used.

Our comparison between different playing positions showed that the goalkeepers had different characteristics from the outfield players, a reflection of the difference in requirements between these player groups. In accordance with Davis et al. (10), they have a lower peak O_2 uptake, indicating that running ability is less important. They were taller and heavier (10) than outfield players, and displayed a greater leg extension power. Because the important tasks of a goalkeeper are to react and move quickly, to jump or dive to save or deflect shots, and to cover a large perimeter, we would also have expected to find a difference for jumping ability.

We observed very few differences between the three groups of outfield players, defenders, midfielders, and strikers. Defenders were significantly taller than midfield players, which can be taken as an indication that size is an advantage in this position—to be able to reach high balls in their defensive role and perhaps to increase their reach in tackling duels, as well. We did not find a difference in peak O_2 uptake between midfield players and strikers or defenders, as has been suggested by others (10,29,30). The small differences observed in physical fitness between players in different player positions is perhaps not surprising, because in modern soccer each outfield player assumes a larger role in the overall play of the team, so the positional differences are less than previously seen.

Practical implications. Elite soccer is a complicated sport with large demands on the players. However, the present study suggests that other factors may be as important for performance as physical fitness. Nevertheless, we did find a correlation with jumping ability and leg extension power, indicating that speed and acceleration of movement are important qualities, which should be given priority in training. It should be noted that, at least in this group of relatively fit soccer players, maximal O_2 uptake appears to be a less important factor than expected.

Injuries are another concern. The present study showed a trend between a high number of days lost to injury and lack of team success. This indicates that injury prevention should be a priority. We have recently shown that previous injury is the most important risk factor for injury, which suggests that adequate rehabilitation and follow-up of injuries may be a key factor to prevent recurrent injuries (2).

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