INTRODUCTION

Soccer as it is played today is a physical activity that requires a high level of conditioning in addition to proficient technical and tactical skills. The game can be characterized as a predominant aerobic exercise combined with frequent intermittent short intense actions with a high rate of the anaerobic energy turnover. Reports of match analyses revealed that elite soccer players generally cover 9,500–12,000 m during a 90-minute game (4,8,14,18,24). Approximately 40% of this distance consists of high-intensity running (>14.0 km·h⁻¹) with or without the ball (18) and 1–11% of sprinting (>19 km·h⁻¹) (14). These sprinting exercises of short duration lead to a high rate of creatine phosphate breakdown, which is resynthesized afterward during the following lower intensity periods (3). The speed of this recovery depends on the power of the aerobic metabolism (V̇O₂max) (20,21). The average work intensity of a soccer game is close to the anaerobic threshold (i.e., the highest exercise intensity at which the removal of lactate equals its production) at a heart rate (HR) of approximately 85% HRpeak (3,12). Based on the linear relationship between the HR and oxygen uptake obtained during an incremental treadmill exercise test, this HR corresponds to an average oxygen uptake of 75% V̇O₂max (23).

Despite the soccer game being dependent predominantly on the aerobic metabolism, it should be argued that the most decisive actions are covered by means of the anaerobic metabolism (i.e., sprinting, jumping, etc.). The intermittent character of a soccer game results in a subsequence of high-intensity activities with an accumulation of lactate and periods of low intensity during which the removal of lactate can take place. During a soccer game, the blood lactate concentration generally varies between 2 and 10 mmol·L⁻¹ (1,8,13). This indicates that the overall intensity of the game is rather high stimulating the energy turnover through the anaerobic glycolysis and also that the measured lactate concentration depends highly on the actions preceding the blood sampling. These game characteristics (and the technical and tactical requirements) impose that the physical performance of elite soccer players is based on the combination of endurance, speed, agility, and strength. Soccer players therefore are bound to have both a high power and capacity of the aerobic and anaerobic metabolism.
to be able to perform at the highest level. The combined importance of these physical determinants is specific to soccer, and in this way, soccer training needs to be well balanced and structured to optimize the player performance without inducing overreaching and overtraining.

It should be noted, however, that the physiologic and metabolic demands of a soccer game have to be seen in view of the player’s position. It has been reported that midfielders cover 5–15% more total distance compared with the fullbacks, forwards, and center backs and even 20–40% more distance at high intensity compared with the forwards and center backs. Forwards and fullbacks spent 20–40% more time sprinting compared with the midfielders and center backs (4,6,7,14,17). The results of these studies show that the different positions on the field are characterized by specific physical activities and demands. Next to motion analysis to obtain information on the physiological demands of a soccer game, laboratory and field measurements might be useful to evaluate the physiological characteristics of the players in reflection to the specific demands of the different positions on the field. The aim of this study was to test whether a laboratory test battery could distinguish these specific characteristics between players from various positions on the field. In this way, this study could contribute to identify the physical profile (i.e., strengths and weaknesses) of the players conform their position on the field and facilitate the individualization of training. It should be noted that the physical profile, next to technical and tactical skills, is an important determinant for the level of a player. Several motion analysis studies have shown that the level of player influences the activity pattern on the field. High-level players not only cover a higher total distance but they also perform a higher amount of high-intensity activities (12,14) during a soccer game compared with players of a lower level. Therefore, the individualization of training, based on the position on the field and the individual weaknesses, is important for enhancing performance during a soccer game. In line with the content of this study Sporis et al. (22) determined the fitness profile of elite Croatian soccer players. It was observed that the anthropometric features and the aerobic and anaerobic performance differed among the different playing positions. In this study, the physical profile of Belgian elite soccer players incorporating the anthropometric characteristics and aerobic and anaerobic performance was examined. Furthermore, we wanted to acquire an insight into whether the physical profile of the players varied according to the different positions on the field. Based on the abovementioned motion analysis studies (e.g., [4,6]), we hypothesized that the aerobic characteristics would be more dominant in the midfielders and the fullbacks compared with the forwards, whereas the forwards and the defenders would display a higher anaerobic power and capacity inherent to the specific characteristics and demands of the different positions on the field.

METHODS

Experimental Approach to the Problem

To allow the extrapolation of the results in this study (i.e., physical and physiological profile) into the training practice of elite soccer players and teams throughout the world, one of the main conditions is that a representative group of players is used. Therefore, a large (n = 289) subject group was tested consisting of elite soccer players in the Belgian first division (championship level). Among this test group, 41 players had also been selected to play in the National Team of their country. Respectively, 11 and 9 players were active in the World Championship of 2006 in Germany and 2010 in South Africa. To obtain an insight into the physical and physiological profile, the subjects completed a battery of both laboratory-based anaerobic and aerobic tests. The anaerobic tests incorporated both sprint and jump tests in line with the anaerobic movements inherent to the soccer game. To examine reactivity and speed, a 10-m sprint was performed, whereas the agility was tested by means of a 5 × 10-m shuttle run (SR). The jump test consisted of a squat jump (SJ) and a countermovement jump (CMJ) to obtain information on specific jump strength (explosive power). In addition to the anaerobic tests, the subject performed an incremental running test to examine the aerobic performance and running speed at the anaerobic threshold. A large subject group was used to obtain a sufficient number of players for each position on the field so that a reliable representation of the physical and physiological profile of the elite Belgian soccer player could be made.

Subjects

The test group consisted of 289 professional soccer players (age: 25.4 ± 4.9 years) active in the Belgian first division between 2003 and 2010. The subjects played in 1 of the 6 teams, which attended the Laboratory of Exercise Physiology of the Centre of Sports Medicine of the Ghent University Hospital (Ghent, Belgium) for the physical tests in the preseason phase. Three of the 6 teams finished in the 8 seasons between 2003 and 2010 at least 6 times among the 5 best teams in the first division and were, therefore, also active in the Champions League or Europa League/Union of European Football Associations (UEFA) Cup. The subjects were divided into 5 groups according to their self-reported best position on the field: center backs (n = 60), full backs (n = 82), midfielders (n = 68), strikers (n = 62), and goalkeepers (n = 17). This study had the approval of the Ethical Committee of the Ghent University Hospital, Ghent, Belgium. All the participants were fully informed about the nature and demands of the study, and the known health risks. They completed a health history questionnaire, signed an informed consent document, and were informed that they could withdraw from the study at any time.

Experimental Protocol

The physical tests were performed 2–4 weeks before the start of the season. In this period, the club training consisted mainly
of specific soccer training sessions with occasionally a basic running training. The subjects were asked to abstain from strenuous exercise 24 hours before the tests. The tests were performed between 8.30 AM and 5 PM. The experimental protocol consisted of 4 parts: anthropometric measurements, sprint tests, jump tests, and an incremental running test on a treadmill. It took approximately 90 minutes for 1 subject to complete the entire test battery. Throughout the tests, the subjects were clearly instructed about the procedures, and they were verbally encouraged to give their maximal effort. During the whole testing battery, the laboratory was air conditioned at a temperature of 21°C. It took approximately 90 minutes for the subjects to complete the entire testing battery. The subjects were wearing a standard soccer kit.

**Anthropometry.** Before the physical tests, body height (±0.1 cm), body weight (±0.1 kg) (Seca balance), and body fat percentage of the subjects were determined. The fat percentage was calculated by means of measurements of skinfold thickness using a Harpenden skinfold caliper. The skinfolds were measured at 10 locations (15). Two experienced test leaders assessed the anthropometric measurements throughout the entire study.

**Sprint Exercise.** The sprint exercise consisted of 2 different exercises. First, the subjects had to sprint for 10 m with the time recorded electronically by light sensors at both 5 and 10 m (Ergo Tester, Globus, Italy). An auditory cue was used as a starting signal for the subjects. This exercise was performed twice, and the best result was retained for data analysis. In the second test, the subjects performed an SR in which the subjects had to run 5 times 10 m as fast as possible. The same auditory cue was used for the 10-m sprint. The subjects had to cross the 10-m marks with 1 foot while turning. The first test was used both to obtain information about both the reaction time and the starting speed (explosiveness) of the players, whereas the second test was used to evaluate their agility in combination with speed.

**Jump Exercise.** After the sprint tests, the subjects performed the SJ and the CMJ. They performed both jumps without arm movement (i.e., with the hands in the hips). For the SJ, the subjects took a deep position with a knee angle of 90°. The flexion of the hips could be chosen freely. The subjects remained in this position for 3 seconds. In the CMJ, the subjects were instructed to jump as high as possible without further guidelines concerning knee and hip angles. Each jump test was performed twice. The best result was recorded for data analysis. The jumping height was calculated from the flight height from the jumping mat measured with the Ergo Tester (Globus).

**Incremental Running Test.** The incremental exercise consisted of steps of 3 minutes starting from a speed of 8 km h⁻¹, and the speed was increased with 2 km h⁻¹ after each step. During the test, the slope of the treadmill was set at 1.5% (11). At the end of each step, a blood sample was taken from the fingertip to determine the concentration of lactate in the blood by means of a lactate analyzer (1500 Sport, YSI, Yellow Springs, OH, USA). When the blood lactate concentration had passed the threshold of 4 mmol L⁻¹, the subjects had to perform a final step to exhaustion in which the speed was increased by 1 km h⁻¹, but the slope of the treadmill was increased 0.5% each 30 seconds until volitional fatigue. The subjects were encouraged verbally to obtain the individual’s maximal effort. During the test, the oxygen uptake was registered by means of a metabolic measurement system (Jaeger Oxycon Pro, Hohenhausen, Germany). The Jaeger Oxycon Pro and the Lactate analyzer were calibrated before each exercise test.

**Statistical Analyses**

**Sprint Exercise.** The time at 5 m was used as a parameter of reaction time and explosiveness, whereas the difference between the time at 5 and 10 m was considered as a measure of speed. The time for the SR was used as a measure for speed and agility.

**Jump Exercise.** The jumping heights for the squat and CMJs were used as a measure of anaerobic power.

**Incremental Running Test.** The peak performance was determined as the maximal speed (V max) and slope (S max) that could be maintained for the full 30 seconds in the final step. The maximal oxygen uptake (V O₂ max) was determined as the highest 30-second average of the breath-by-breath values obtained from the metabolic measurement system. The anaerobic threshold was determined at a lactate concentration of 4 mmol L⁻¹ (9) and was expressed as a speed in kilometers per hour (V Lact).

The Statistical Package for Social Sciences SPSS 15.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. For the 5 positions, descriptive statistics (mean values ± SD) were calculated for height, weight, fat percentage, V O₂ max, V Lact, and 5-m- and 10-m times, SR, SJ, and CMJ. These parameters were compared between the 5 positions by means of a Repeated Measures analysis of variance (5 × 1). If the analysis of variance (ANOVA) was significant, Tukey post hoc tests were performed. The reliability of the anaerobic sprint and jump tests was determined by means of the test-retest method. The reliability analysis (Cronbach alpha) and intraclass correlation coefficients showed that these anaerobic tests were highly reliable. The reliability coefficients (alpha) were respectively 0.91, 0.92, 0.88, 0.90, 0.89 for the 5-m times, 10-m times, SR, SJ, and CMJ, respectively. Also, the ICCs for the 5-m times (0.88), 10-m times (0.90), SR (0.81), SJ (0.87), and CMJ (0.84) confirm the reliability of the tests. Before setting the significance level, a power analysis was performed. This analysis revealed a statistical power of 0.94, and therefore, a significance level of p < 0.05 could be used.
Physical Profile of Elite Belgian Soccer Players

RESULTS

Anthropometry
The overall mean height and weight of the subjects were 182.4 ± 6.0 cm and 77.4 ± 7.1 kg, respectively, with a mean body fat percentage of 11.0 ± 2.5% (Table 1). The ANOVA revealed that the goalkeepers and center backs were taller and heavier compared with the full backs and midfielders (p < 0.05). The height of the strikers did not differ significantly from the goalkeepers (p = 0.67) and defenders (p = 0.54), but on average, the former had a lower weight (p < 0.05). The body fat percentage was significantly higher in the goalkeepers compared with the 4 other positions (p < 0.05).

Aerobic Performance
The parameters of the aerobic performance are presented in Table 3. The mean peak performance for the incremental exercise test was 15.6 km·h⁻¹ with a slope of 4.4%. The mean VO₂max for the total subject group was 57.7 ± 4.7 ml·min⁻¹·kg⁻¹, and the mean running speed at the level of the anaerobic threshold (4 mmol·L⁻¹) was 13.7 ± 1.1 km·h⁻¹. The full backs and the midfielders had a higher jumping height compared with the full backs (p < 0.001) and the midfielders (p < 0.01). Also the forwards had a higher CMJ height compared with the full backs (p =0.03) and the midfielders (p = 0.03).

Table 1. Mean ± SD height, weight, and body fat ± SD for the 5 different positions on the field.

<table>
<thead>
<tr>
<th></th>
<th>Goalkeepers</th>
<th>Center backs</th>
<th>Full backs</th>
<th>Midfielders</th>
<th>Strikers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>188.2 ± 4.5†</td>
<td>186.4 ± 4.3*</td>
<td>179.3 ± 4.8†</td>
<td>181.3 ± 4.1††</td>
<td>183.5 ± 6.7‡‡</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.2 ± 5.2*</td>
<td>82.5 ± 5.0*</td>
<td>73.4 ± 6.4†</td>
<td>76.7 ± 5.1††</td>
<td>78.6 ± 4.8‡‡</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>15.5 ± 4.1*</td>
<td>10.9 ± 1.7††</td>
<td>10.4 ± 1.6†</td>
<td>11.0 ± 1.7††</td>
<td>10.1 ± 1.9††</td>
</tr>
</tbody>
</table>

The labels, *, †, ‡, ††, ‡‡, are used to show significant differences between the 5 positions. The same label indicates that the parameter did not differ between the positions. Positions with a different label differ significantly. p < 0.05 was used as the level of significance.

Table 2. Mean ± SD 5-m time, 10- to 5-m time, SR, SJ, and CMJ ± SD for the 5 different positions on the field.*

<table>
<thead>
<tr>
<th></th>
<th>Goalkeepers</th>
<th>Center backs</th>
<th>Full backs</th>
<th>Midfielders</th>
<th>Strikers</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 m (s)</td>
<td>1.46 ± 0.07††</td>
<td>1.48 ± 0.06†</td>
<td>1.45 ± 0.04§</td>
<td>1.46 ± 0.06††</td>
<td>1.43 ± 0.04§</td>
</tr>
<tr>
<td>10–5 m (s)</td>
<td>0.76 ± 0.08††</td>
<td>0.77 ± 0.04†</td>
<td>0.74 ± 0.05§</td>
<td>0.75 ± 0.05§</td>
<td>0.72 ± 0.04§</td>
</tr>
<tr>
<td>SR (s)</td>
<td>12.32 ± 0.44‖</td>
<td>12.53 ± 0.41†</td>
<td>12.22 ± 0.37§</td>
<td>12.09 ± 0.30§</td>
<td>12.01 ± 0.25‖</td>
</tr>
<tr>
<td>SJ (cm)</td>
<td>42.2 ± 2.9†§</td>
<td>42.4 ± 4.2†§</td>
<td>38.6 ± 2.6‡</td>
<td>39.4 ± 3.0‖§</td>
<td>41.2 ± 4.2‖§</td>
</tr>
<tr>
<td>CMJ (cm)</td>
<td>45.6 ± 2.6††</td>
<td>46.0 ± 4.1†</td>
<td>41.0 ± 3.8‡</td>
<td>41.4 ± 3.7‡</td>
<td>44.2 ± 4.2†</td>
</tr>
</tbody>
</table>

*SR = shuttle run; SJ = squat jump; CMJ = countermovement jump.
The labels, †, ‡, ††, ‡‡, ‖, ||, are used to show significant differences between the 5 positions. The same label indicates that the parameter did not differ between the positions. Positions with a different label differ significantly. p < 0.05 was used as the level of significance.


### Table 3. Mean ± SD \( \dot{V}O_2 \max \) speed at the anaerobic threshold \( (V_{\text{A}T}) \), and lactate concentration at the end of the incremental running test ± SD for the 5 different positions on the field.

<table>
<thead>
<tr>
<th>Position</th>
<th>Goalkeepers</th>
<th>Center backs</th>
<th>Full backs</th>
<th>Midfielders</th>
<th>Strikers</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \dot{V}O_2 \max ) (ml·min(^{-1})·kg(^{-1}))</td>
<td>52.1 ± 5.0*</td>
<td>55.6 ± 3.5\†</td>
<td>61.2 ± 2.7\‡</td>
<td>60.4 ± 2.8\‡</td>
<td>56.8 ± 3.1\†</td>
</tr>
<tr>
<td>( V_{\text{A}T} ) (km·h(^{-1}))</td>
<td>12.7 ± 1.4*</td>
<td>13.4 ± 0.6\†</td>
<td>14.4 ± 0.7\‡</td>
<td>14.2 ± 0.6\‡</td>
<td>13.8 ± 0.7\‡</td>
</tr>
<tr>
<td>[Lactate] (mmol·L(^{-1}))</td>
<td>9.3 ± 2.2*</td>
<td>9.8 ± 2.7*</td>
<td>9.1 ± 3.0*</td>
<td>9.6 ± 1.7*</td>
<td>9.8 ± 2.3*</td>
</tr>
</tbody>
</table>

The labels, *, †, ‡, were used to point significant differences between the 5 positions. The same label indicates that the parameter did not differ between the positions. Positions with a different label differ significantly. \( p < 0.05 \) was used as the level of significance.

### Discussion

The purpose of this study was to gain an insight into the general fitness level of elite soccer players active in the Belgian first division. A large subject population was tested for anthropometric characteristics and for anaerobic and anaerobic performance. Furthermore, we wanted to test whether these different aspects of the general fitness level would vary according to the position of the player of the field. As hypothesized, the results of this study clearly show that the anthropometric, physical and physiological characteristics differ according to the specific demands inherent to the position on the field.

The \( \dot{V}O_2 \max \) that is reported in the literature varies in general between 55 and 65 ml·min\(^{-1}\)·kg\(^{-1}\) for elite soccer players (8,10,16,22). The mean \( \dot{V}O_2 \max \) of the elite soccer players in this study (52.7 ± 4.7 ml·min\(^{-1}\)·kg\(^{-1}\)) was in line with these studies. The differences between the studies can be attributed to the experimental protocol (i.e., protocol of the incremental exercise, metabolic measurement system, etc.), the testing period with respect to the phase in the season or the level of the players. In this context, it should be noted that the Belgian competition is not among the strongest in Europe. However, considering the performances in the Champions League and Champions League and Europa League (formerly known as UEFA Cup), the level of the Belgian competition (ranked 14th in the UEFA country ranking) is very comparable (or even stronger compared to Croatia (22nd) (22), Norway (27th) (10), and Sweden (24th) (8). Compared with the aforementioned studies, the performance in the squat and CMJ was slightly lower (on average 3 cm) in this study. It should be noted, however, that the mean age of the subject group in this study was lower (25.4 ± 4.9 years) in comparison with most other studies in which the mean age is approximately 28 years. This might explain the lower anaerobic performance (SJ and CMJ) compared with other studies. Soccer players are generally at their peak performance at the age of 27–30 years, and therefore, the subjects in our test group have a few more years to develop their explosiveness and strength.

The position of the goalkeeper on the soccer pitch requires relatively low demands from the aerobic energy metabolism. The goalkeeper generally covers about 4 km during a soccer game (19), and most of his actions are determined predominantly by the anaerobic power, that is, jumping and sprinting. In this study, the goalkeepers had a significantly lower \( \dot{V}O_2 \max \) and performance at the anaerobic threshold compared with the other positions. On the other hand, they exert a high anaerobic power, especially during the jumping test. In combination with their body size, goalkeepers are on average the tallest players in the team, and they have a high reach and they can cover a large part of the goal, which is necessary to efficiently avoid the opponent to score. In this study, the goalkeepers also had a higher body fat percentage compared with that of the other positions. This can probably be attributed to the lower amount of aerobic training. The average sprinting performance might also be in part related to the higher body fat percentage. Also, the proportional contribution of strength and sprint training in the training regime of goalkeeper, with an important role for strength training with an increase in muscle mass as a consequence, might attribute to the average speed and agility.

With regard to the field players, the center backs generally cover the shortest distance (14,17). The center backs need strong positional play with a good headplay. They perform a smaller number of explosive sprint movements during soccer games. Generally, they play only a minor role in the support of the attack, and they only move to the front for the corner kicks or the free kicks. According to the present data, their physiological profile is in line with these specific positional demands. Apart from the goalkeeper, they not only have the lowest \( \dot{V}O_2 \max \) and running speed at the anaerobic threshold, but their anaerobic sprint performance and agility are also rather low. This is in line with the findings of other studies with elite soccer players (2,22). The lower sprint and agility performance is probably because of the large body size, which hinders the sudden changes in direction during the SR and in extension on the pitch. Their anaerobic power for jumping is higher compared with the other positions, and in combination with their body size, this benefits their headplay, which is an important part of the defensive skills.

The midfielders and full backs generally cover the largest distance during a soccer game, on average 10.5–11.5 km...
A full back is characterized by different physical demands compared with a center back. Therefore, in our opinion, the position of the full back should be considered as a separate position on the field beside the center backs, especially because it was observed in this study that the fitness profile of a full back more closely resembles that of a midfielder. The information of this study, reporting the physiological profile of elite soccer players, can be useful for the training staff into the optimization of the training process to maximize the performance level specific for the role of the player in the team. Furthermore, in team sports, where there is a tendency for early specialization concerning the position on the field, these physiological profiles can be used in the selection of a player for a position and for the development of specific training programs based on the important characteristics of the position of the field. It should be noted that motion analysis of soccer games was not included in our study. This motion analysis provides important information on the physical characteristics of a soccer game especially with regard to the different positions on the field. However, the disadvantage of these match data is that these measures are performed in a situation that strongly depends on the strength of the own team and of the opponent, tactical gameplay, and weather conditions. The measures performed in this on the other hand are conducted in a standard situation following strict guidelines, and therefore, these measures provide valuable insights into the physical characteristics of the players. The combination of both laboratory measures and motion analysis on the field could provide important additional information on the physical demands of the positions on the field and on the main factors that determine the individual performance.

From this study, it could be concluded that the physical profile of the elite soccer players in the Belgian competition is specific inherent to the specific demands of the position on the field. It is not clear, however, whether the process of obtaining a specific position on the field is a matter of natural selection, based not only on the physical profile but also on technical-tactical skills, team cohesiveness and even match performance, or whether the specific physical profile is a consequence of the specific demands of the position itself which the player has grown into. In the modern game of soccer, however, it is clear that adult players need to be trained specifically according to their position on the field to optimize the performance of the team. The physical profile provided in this study can help the coaches in identifying the physical characteristics, which are important for the different positions to optimize the training and performance of each individual player. On the other hand, the physical profile can also help the coaches to direct younger players to the position that corresponds best to their physical profile.

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