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AEROBIC AND ANAEROBIC TEST PERFORMANCE AMONG ELITE MALE FOOTBALL PLAYERS IN DIFFERENT TEAM POSITIONS

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Abstract

The purpose was to determine the magnitude of aerobic and anaerobic performance factors among elite male football players in different team positions. Thirty-nine players from the highest Swedish division classified as defenders (n=18), midfield players (n=12) or attackers (n=9) participated. Their mean (± sd) age, height and body mass (bm) were 24.4 (±4.7) years, 1.80 (±5.9)m and 79 (±7.6)kg, respectively. Running economy (RE) and anaerobic threshold (AT) was determined at 10, 12, 14, and 16km/h followed by tests of maximal oxygen uptake (VO_{2max}). Maximal strength (1RM) and average power output (AP) was performed in squat lifting. Squat jump (SJ), counter-movement jump with free arm swing (CMJ_a), 45m maximal sprint and the Wingate test was performed. Average VO_{2max} for the whole population (WP) was 57.0mL $O_2 \cdot kg^{-1} min^{-1}$. The average AT occurred at about 84% of VO_{2max}. 1RM per kg $bm^{0.67}$ was 11.9±1.3kg. Average squat power in the whole population at 40% 1RM was 70±9.5W per kg $bm^{0.67}$. SJ and CMJ_a were 38.6±3.8cm and 48.9±4.4cm, respectively. The average sprint time (45m) was 5.78± 0.16s. The AP in the Wingate test was $10.6 \pm 0.9 W \cdot kg^{-1}$. The average maximal oxygen uptake among players in the highest Swedish division was lower compared to international elite players but the Swedish players were better off concerning the anaerobic threshold and in the anaerobic tests. No significant differences were revealed between defenders, midfielders or attackers concerning the tested parameters presented above.

Key words: *football, physical performance, plays position*

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Introduction

Played at a relatively high mean work intensity interspersed with short periods of very-high- intensity sprint and jump performance, football may be regarded as a sport with both aerobic and anaerobic demands. The average work intensity during a typical football game between male elite teams at senior level is approximately 85% of maximal heart rate (HR_{max}), which corresponds to about 75% of maximal oxygen uptake (VO_{2max}) (Stølen et al., 2005). The match duration in combination with the load on the aerobic system indicates that the main energy contribution comes from aerobic processes. Typical for football is also the continuous variation in work intensity related to action on the football field, involving standing (0 – 0.6km h^{-1}), walking (0.7 – 7.1km h^{-1}), jogging (7.2 – 14.3km h^{-1}), running (14.4 – 19.7km h^{-1}), high-speed running (19.8 – 25.1km h^{-1}), and sprinting (>25.1km h^{-1}). Thus, oxygen uptake constantly fluctuates between levels above and below average. Fast running and sprinting will cause an oxygen debt, which will be paid for during periods of low work intensity. High intensity running and sprint distance have increased of about 30-50% across the last few years in the English Premier League matches (Bush et al., 2015) and a similar increment has been measured over a 44 years period in FIFA World Cup Final Matches (Wallace & Norton, 2014). The relatively high average intensity level and the long work duration during a typical football match indicate that high aerobic power is relevant in a football capacity profile. VO_{2max}, among senior elite male football players, varies between 50 and $75mLO_2 \cdot kg^{-1} \cdot min^{-1}$ (Stølen et al., 2005), the average being about 61mL $O_2 \cdot kg^{-1} \cdot minute^{-1}$. Fatigue-related decline in technical proficiency for a given intensity has been negatively associated with the fitness level of the players (Rampinini et al., 2008). In line with this, Apor (1988) showed that the winning team in the Hungarian elite league had a higher average maximum oxygen uptake than lower-ranked teams. Also, Wislöff and co-workers (1998) showed that the winning team in the Norwegian elite league had higher mean aerobic power than the team that finished last.

Running economy (RE) is defined as oxygen consumption during running at a given speed. The football player who can keep a given speed at a lower oxygen cost per kg body mass may theoretically have a smaller oxygen debt and will therefore be less susceptible to fatigue. RE may differ by about 20% among elite runners (Sjödin and Svedenhag, 1985). In terms of quantitative optimization of the aerobic processes during a football game, running economy may be a relevant factor.

The anaerobic threshold (AT), also called the lactate threshold (LT), is defined as the work intensities at which the lactate can no longer be metabolized at the rate it is produced. The AT among football players varies between approximately 80 – 90% of HR_{max} (Brewer, 1992; Ströyer et al., 2004). Theoretically it may be advantageous if the AT occurs close to VO_{2max} i.e. the higher the relative use of VO_{2max} can be without crossing the AT, the better. It has been argued that football players with a high VO_{2max} have a higher anaerobic threshold i.e. can use a larger fraction of VO_{2max} before crossing AT (MacRae et al., 1992). The reason for the latter possible relationship is unknown at present.

Anaerobic power may play an important role during a typical soccer game. Several studies have shown a significant positive correlation between maximal squats leg muscle strength (1RM) and acceleration and speed in running (Buhrle & Schmidtbleicher, 1977; Hoff and Almåsbakk, 1995; Wislöff et al., 2004). An example of short-time explosive strength (anaerobic power) is also jump ability. Mean values between 44 – 60cm have been recorded in male football players in counter-movement jumps (CMJ) (Adhikari and Kumar Das, 1993; Wislöff et al., 1998). The majority of short anaerobic performance events in a football match are sprints 96% shorter than 30m and 49% shorter than 10m (Valquer et al., 1998). In line with this, sprints between about 2 and 5 seconds are frequent in football (Reilly and Thomas, 1976; Rienzi et al., 2000). Although the longest sprints, up to about 6 seconds, can be regarded as an alactacidic work period, the lactacidic anaerobic system is also activated, further the sprints are performed in a work situation where the mean intensity is about 85% of HR_{max} (Stölen et al., 2005). This indicates that the lactacidic anaerobic system may also play a role during certain periods in a typical football match. The above indicates that it may be important to study both aerobic and anaerobic performance factors with respect to football players' capacity profile.

The team positions in football differ by denomination and defined general function. Few studies have investigated the physiological capacity profile representative of each. In most research studies, the players are classified into four groups: forwards/attackers, midfielders, defenders, and goalkeepers (Bush et al. 2015). Sometimes, defenders are divided into two sub-groups (Davis et al., 1992). Players in different team positions have a different workload during a game: midfielders run the longest distances (up to 11 – 11.5km) followed by forwards and defenders (Bansgbo et al., 1991). The highest oxygen consumption values have been found in midfielders, the lowest values in goalkeepers (Stølen et al., 2005). However, it was not clear whether the midfield players were chosen as midfielders for their higher aerobic endurance capacity, or whether their higher oxygen uptake was related to the midfield play position or any other factor (Bansgbo and Michalsik, 2002). In elite football, forwards are the fastest players and time observations show that they sprint the most during a match (Rienzi et al., 2000).

It is rare that a study like the present one addresses such a comprehensive set of aerobic and anaerobic performance factors simultaneously in relation to team play position among elite football players. In line with this and the information presented above, the purpose was to determine aerobic factors (VO_{2max}, running economy and lactate threshold) and anaerobic factors (maximal and explosive leg muscle strength, jump and sprint ability, and maximal anaerobic power) for elite male football players in different play positions.

Materials and Methods

Thirty-nine elite male football players from the highest Swedish division took part in the study. Their mean (± sd) age, height and body mass were 24.4 (±4.7) years, 1.80 (±0.59) m and 79 (±7.6)kg, respectively (see also Table 1 in the Result section). The players represented three clubs in the middle of the result list at the end of the season. The tests were performed during the end of or directly after the season. The participants were classified by their team coaches as defenders; D (n=18), midfield players; MF (n=12) or attackers; A (n=9). During all tests the players wore light clothing and sport shoes with rubber soles. The experimental procedures were in accordance with the Helsinki Declaration and all participants were informed that they could leave the study without giving any reason for doing so (signed informed consent).

Apparatus and test setup

Anaerobic threshold (determined as lactate threshold; LT), running economy (RE) and maximum oxygen uptake (VO_{2max}) were determined during running on a motor-driven treadmill (Cybex Stable flex, Cybex International Inc., US). RE was defined as oxygen consumption (mL $O_2 \bullet kg^{-1} \bullet minute^{-1}$) during running at given speeds. LT was defined as onset of blood lactate accumulation (OBLA) at 4 $mM \bullet L^{-1}$ (Heck et al., 1985).

To allow reproduction of the present study design and comparison of RE and anaerobic threshold, which are dependent on treadmill speed fluctuations and running surface stiffness, treadmill speed was calibrated and the stiffness characteristics of the treadmill were determined. Speed was calibrated by video-filming a reference point on the moving treadmill belt (film rate: 50Hz). The preset speed and the calculated speed from the video recording were compared with a subject (71.3kg body mass) running on the treadmill from 10 to 20 km•h^{-1}. The deviation from the preset speed was less than 1.5 percent in all cases. The stiffness of the running surface, defined as surface deflection per kilo load (per N vertical force), was tested. A 2.5cm thick iron plate (area: 30.5 • 10.3cm) was placed in the middle of the treadmill belt approximately at the touchdown surface during running on the treadmill. The plate was cumulatively loaded with weights (50kg) up to 250kg corresponding to a vertical force of 2453N, i.e. higher than the vertical reaction force at the highest speed used in the present investigation according to Nilsson and Thorstensson (1989). The deflection of the treadmill was measured with a micrometer at the level of the load position. Surface deflection for every added 50kg weight was registered (Figure 1). The relationship between deflection (Y) per added mass (X) was best expressed by a polynomial equation ($Y=0.025876 + 0.04065X + (- 1.48756 E^{-5} X^{2})$.

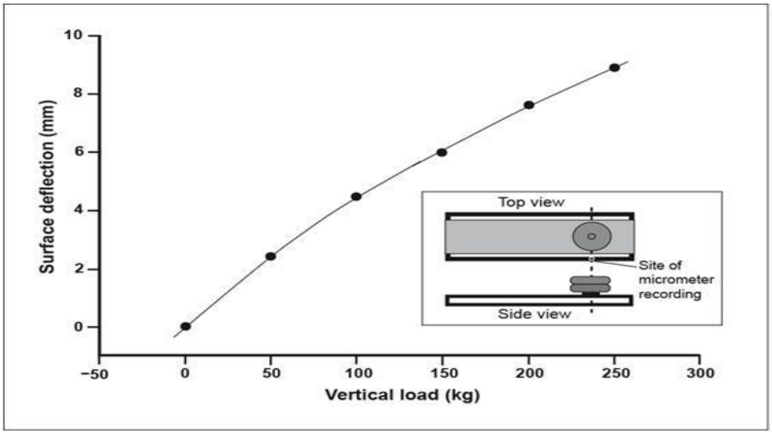

Figure 1. The relationship between vertical load (kg) and the treadmill surface deflection (mm). The inset figure shows a top and side view of the arrangement on the treadmill with the load weight on top of the iron plate at the location of touch down in running. Note the site of the micrometer recording.

Oxygen uptake at submaximal and maximal workloads during running on the treadmill was determined using an automatic measuring system for oxygen uptake with a mixing chamber (OxygenPro, Jaeger GmbH, Germany). This system was validated before the test with comparative in-series measurements using OxyconPro and Douglas bags analyzed separately. The OxyconPro was also validated by means of a metabolic simulator (oxygen uptake simulator) (Vacu-Med Inc. US). No significant deviation in results was seen when the results from these comparisons were analyzed.

The blood lactate concentrations when running at submaximal and maximal intensities were determined from blood from a punctured fingertip. The blood sample (20 µL) was analyzed electro-enzymatically (Biosen C-line, EKFdiagnostic GmbH, Germany). The instrument was calibrated using standard lactate solutions at concentrations of 2, 7 and 18mM•L^{-1}.

One repetition maximum (1RM) in concentric squat (from a 90-degree knee angle was performed using a Smith machine. Power output was tested with a loaded squat jump. The external load defined was set as a percentage of the 1RM squat value. During the lifts, security locks were used in the deep position. A vertical displacement linear encoder (Muscle Lab., Ergotest Technology AS, Norway) enabled calculation of power output in each lift. A body mass fraction of 90 % was included in the power calculation.

A squat-jump (SJ) and counter-movement jump test with arm swing (CMJ$_a$) was used to determine maximal explosive jump performance. An optoelectronic measuring system (IVAR Measuring Systems, Estonia) was used to measure flight time during SJ and CMJ$_a$. The jump height was calculated from the flight time. The system uses infrared light beams and these were set at 11mm distance above the jump surface, creating an optoelectronic circuit between an emitter and a reflector. Start and termination of flight time were triggered when the optoelectronic circuit was electrically opened and closed.

Maximal sprint ability 0 – 45m was also measured with an optoelectronic system (IVAR Measuring System, Estonia). Pairs of photocells and reflectors were placed at the start line (0 m) and at 10, 15, 20, 30, 40 and 45m. Each photocell contained two measuring cells which both had to be interrupted to trigger the timing device. The sprints were performed on a 2mm thick, 1.2m wide and 45m long rubber mat placed on a wooden gym floor. In the sprint test, the players chose their own starting posture with the front foot at a line 0.5m from the first photocell pair. The players made standing starts on their own command. They were allowed three attempts and the rest period between each was 5 – 10minutes.

Maximal anaerobic power was tested in a 30second Wingate test on a bicycle ergometer (Peak Bike, Monark AB, Sweden). After a preparatory procedure, the test was controlled by means of a computer and software (Monark Anaerobic Test Software, version 2.0). The breaking weight was set to 10% of body mass. The test started at zero flywheel speed with the pedal crank arms at 45 degrees to the horizontal plane. The breaking load was programmed to be released "momentarily" when the pedals started to rotate.

Test procedures. The total set of tests was performed during two consecutive days. All participating players were accustomed to treadmill running before testing. In the test of running economy and anaerobic threshold the participants ran four minutes each at 10, 12, 14, and 16km•h^{-1} on the horizontal treadmill. Between the run at each speed level the participants got one minute of rest while a blood sample was collected for determination of blood lactate concentration. After the last submaximal speed level the players got two minutes of rest before the test of maximal oxygen uptake (VO_{2max}). This started with running horizontal at 14km•h^{-1}. After one minute the speed was increased to 15km•h^{-1} and this speed was kept for one minute. Subsequently the speed was increased by 0.5km•h^{-1} each minute to 20km•h^{-1}. Most players were physically exhausted and had terminated the test before this speed level. Physiological parameters were constantly checked during this test. Criteria for reaching VO_{2max} were: "leveling off" in oxygen uptake and/or respiratory exchange ratio (RER)>1.1, perceived exertion according to the RPE scale (Borg et al., 1985) higher than or equal to "very hard" and rate of increase in pulmonary ventilation. The rated perceived exertion was registered immediately after the maximal oxygen uptake test, and after three minutes a blood sample was collected for determining blood lactate concentration.

The players performed the squat test during two days, the first day being used for familiarization with the test procedure and progressively reaching 1RM. This allowed the second day to be limited to a few serious attempts to reach 1RM.

In the loaded squat jump test, the players lifted external loads equal to 20, 40 and 60% of the squat 1RM value. Three attempts for each load were performed with 1-3minutes recovery between lifts. The players were instructed to perform an explosive concentric movement from the start position at 90° knee angle. The power output was calculated during the concentric phase and the best of three trials at each power level was selected.

In both the SJ and the CMJ_a tests, the players were allowed preparatory jumps in which they were instructed concerning the test procedure. In the SJ the players started from a stationary squatting position (about 90° knee joint angle) to jump as high as possible, i.e. to reach the highest vertical displacement. In SJ the hands were kept on the hips during the whole jump. The players were not allowed to employ any downward movement (i.e., a counter-movement). This instruction was given to reduce the effect of the stretch-shortening cycle before the concentric jump phase. In CMJ_a a free arm swing was allowed. No instruction was given on the depth of the downward movement, and so knee angle in the eccentric preparatory jump phase was a matter of choice. In both jumps, the players were instructed to land on the spot of release with extended ankle joints and straight knees. The best of three SJ and CMJ_a attempts was selected.

In the Wingate test, the players were instructed to pedal at maximal intensity for 30seconds from the start to the end of the test. They were informed when 10seconds remained and when the 30seconds had elapsed. They had to remain seated during the whole test.

Statistics

For statistical calculations the StatView statistical package for Windows (version 5.0, SAS Institute Inc., USA) was used. All data are reported as mean ± standard deviation (sd). Differences between team play positions were assessed with repeated measures ANOVA followed by a Scheffé post hoc test. Statistical significance was set at the 0.05 level.

Results

Mean age, height and body mass of the whole population of tested football players were 24.4 years, 1.80m and 79kg, respectively. There was no significant difference between the team play positions concerning age, height or body mass except for a significant difference in body mass between defenders and midfielders (Tab. 1).

Table 1

Average (±sd) age, height and body mass of players at different team play positions.

Subjects characteristics			
	Age (years)	Height (m)	Body mass (kg)
Whole population	24.4±4.7	1.80±5.9	79±7.6
Defenders n= 18	25±4.7	1.82±4.2	80.7±7.4
Midfielders n= 12	23.9±4.8	1.78±5.3	76.3±5.1
Attackers n= 9	24.4±5.1	1.81±8.7	79±10.1

The average maximal oxygen uptake (VO_{2max}), all players included (WP), was 57.0mL O_2•kg^{-1}•$minute^{-1}$. The midfielders showed somewhat higher values but not significantly different from those of defenders and attackers (fig. 2).

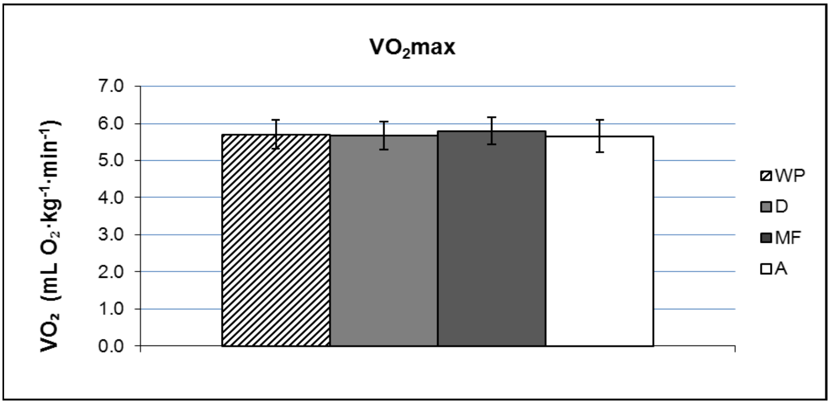

Figure 2. Mean (±sd) maximal oxygen uptake (VO_{2max}) for all players in the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A)

There was no significant difference in oxygen consumption at 10, 12, 14 and 16km•h^{-1} for players in different team positions in the running economy test (fig. 3).

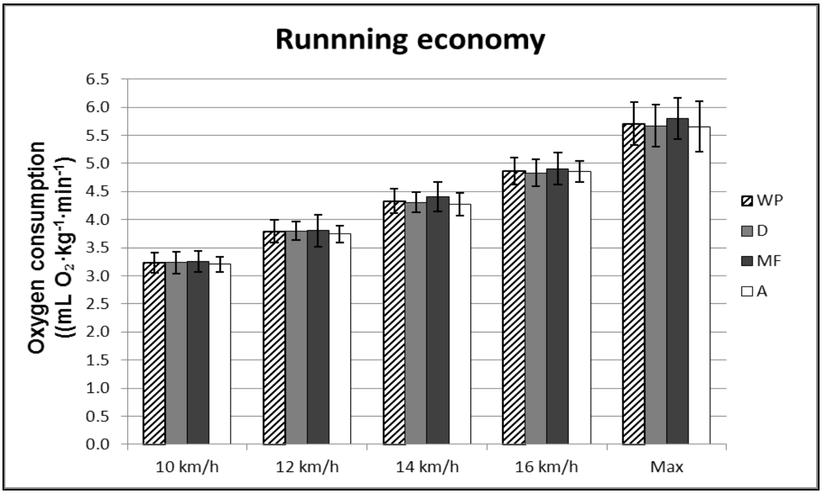

Figure 3. Mean (±sd) oxygen consumption (mL O_2•kg^{-1}•min^{-1}) for players at different team positions (whole population; WP, defenders; D, mid-fielders; MF and attackers; A) at 10, 12, 14 and 16km•h^{-1} and maximal oxygen consumption

Blood lactate concentration was approximately 2mM•L^{-1} at 10 and 12km/h, increasing to about 2.5mM•L^{-1} at 14km/h and approximately 4 mM•L^{-1} at 16 km•h^{-1} but not significantly different between team positions. The average blood lactate accumulation for the WP after VO_2max test was approximately 11 mM•L^{-1} (fig. 4).

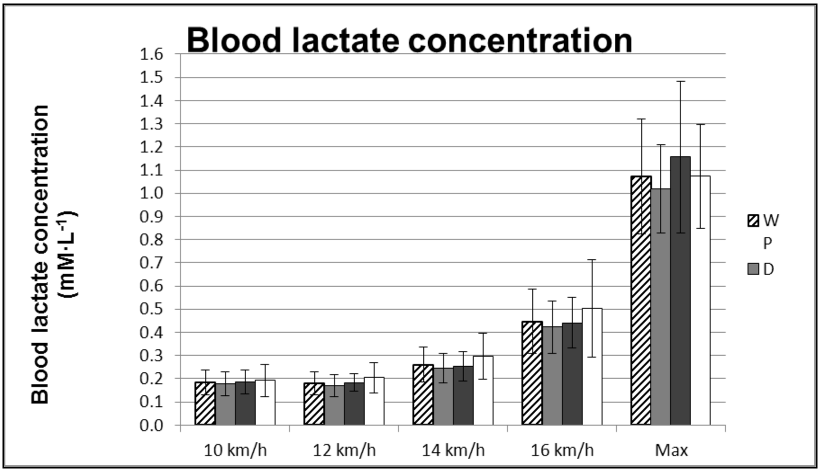

Figure 4 Mean (±sd) blood lactate accumulation (mM•L^{-1}) at 10, 12, 14, 16km•h^{-1} at horizontal level and after test of maximum oxygen uptake for players at different team positions (whole population; WP, defenders; D, mid-fielders; MF, and attackers; A)

The average mean relative oxygen uptake as a percentage of maximum oxygen uptakes at lactate threshold was 84.5% for the whole population. There was no significant difference between team positions (fig. 5).

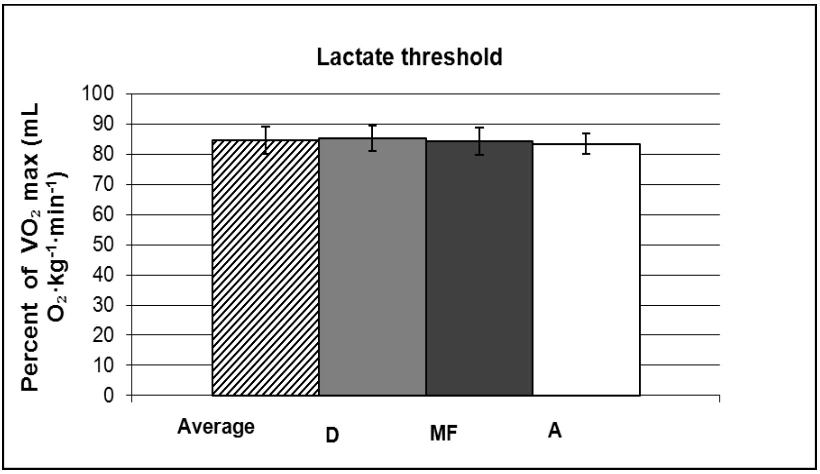

Figure 5. Mean (±sd) relative oxygen consumption in percent of VO$_{2max}$ at lactate threshold for players at different team positions (whole population; WP, defenders; D, mid-fielders; MF and attackers; A)

Squat 1RM was about 12kg per kg $bm^{0.67}$, with no significant difference between the different team play positions.

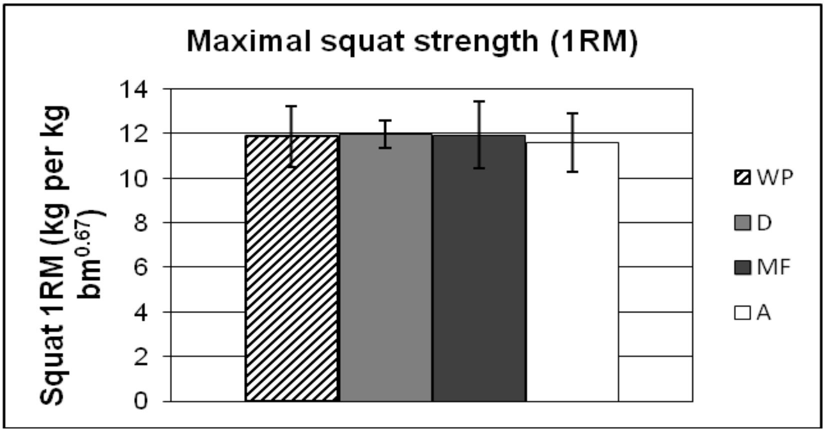

Figure 6. Mean (±sd) 1RM per kg $bm^{0.67}$ squat strength for the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A)

Loaded squat jump average power output at 40% of 1RM was 70±9.5W per kg $bm^{0.67}$ for the whole population, 72±8.9W per kg $bm^{0.67}$ for the defenders, 68±8W per kg $bm^{0.67}$ for the midfielders and 68±13.1W per kg $bm^{0.67}$ for the attackers.

The highest average power tended to be obtained at 40% of 1RM, except for attackers who reached it at 20% of 1RM. There was no significant difference between team positions in power output (fig. 7).

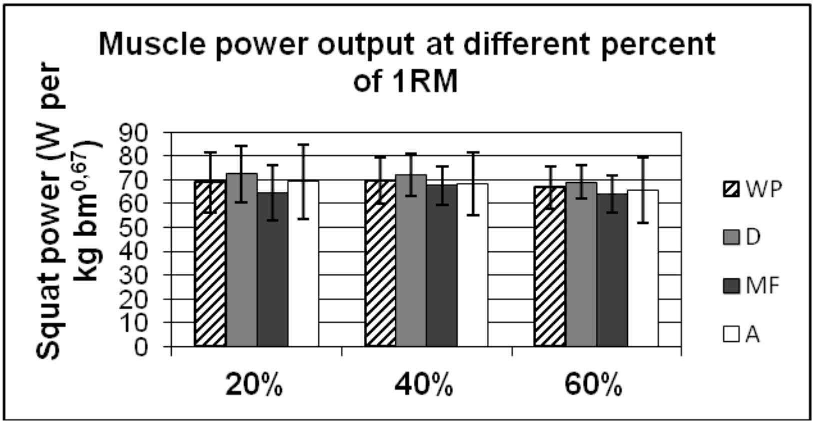

Figure 7. Average squat power output (±sd) (W per kg $bm^{0.67}$) at 20, 40 and 60 % of 1RM for the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A)

The mean jump height in the SJ was 38.5±4.0, 39.5±3.9, 37.7±4.1 and 37.2±3.9cm, for the whole population, defenders, midfielders and attackers, respectively. The defenders performed the highest average jump height, but there was no significant difference between the different team positions (fig.8).

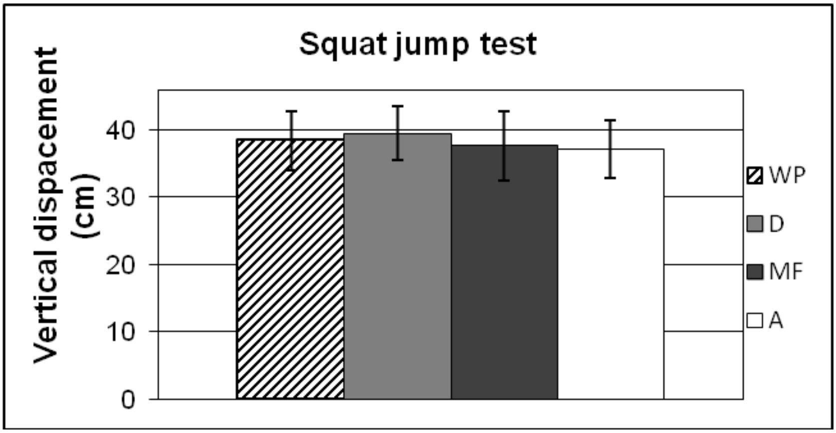

Figure 8. Mean (±sd) jump height in squat jump (SJ) for the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A).

The mean jump heights in the CMJ$_a$ were 48.9±4.4, 49.5±3.9, 48.7±5.2, and 48.1±4.1cm, respectively, for the whole population, defenders, midfielders and attackers. The defenders achieved the highest average jump height, but there was no significant difference between the different team positions (fig.9).

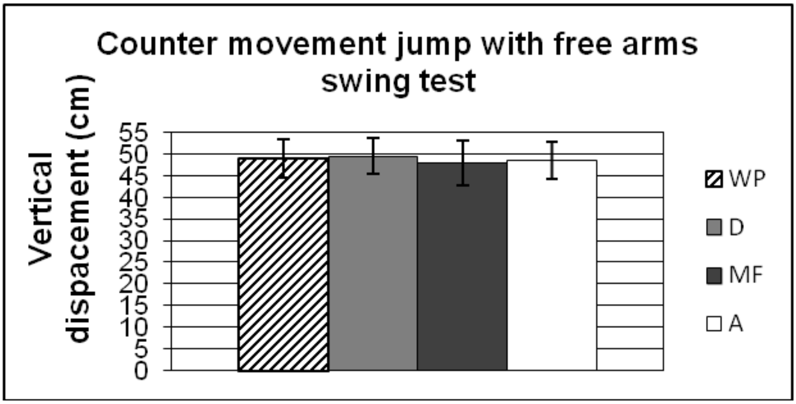

Figure 9. Mean (±sd) jump height in the counter movement jump with arm swing (CMJ$_a$) for the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A)

There were no significant differences in the sprint results between team positions in any of the recorded distances (fig. 10).

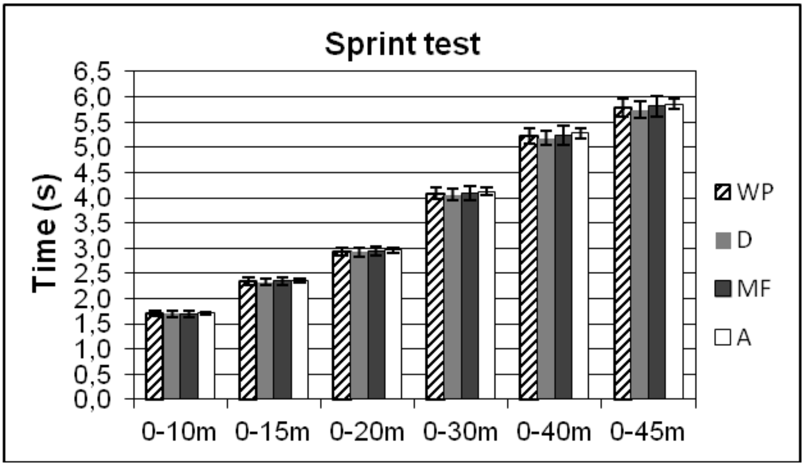

Figure 10. Mean (±sd) sprint duration at different distances between 0-45 m average for the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A)

The average power in the 30-second Wingate test was about 10W per kg body mass. There was no significant difference between team positions in mean power (fig. 11).

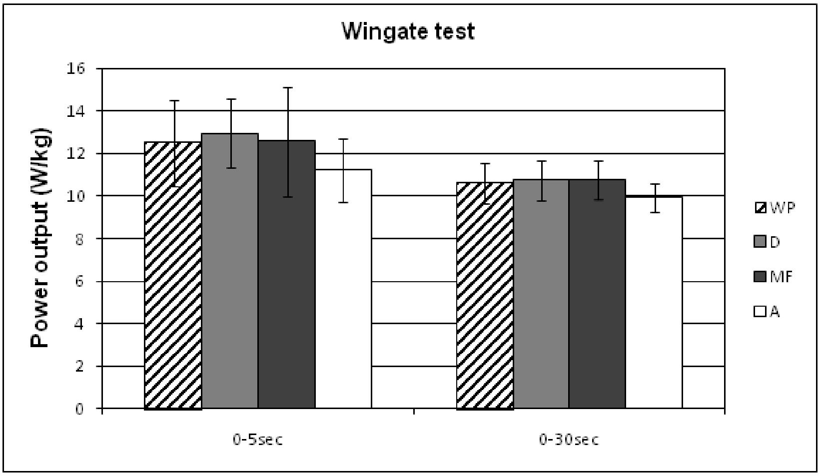

Figure 11. Mean (±sd) power output in the Wingate test during the first five seconds and during the whole test. Average value for the whole population; WP, D; defenders, M; midfielders and A; attackers

Discussion

International team comparison. Average team maximum oxygen uptake obtained among male elite football players in the highest Swedish division in this study was 57.0mL O_2•kg^{-1}•minute^{-1}. This is lower than reported from tests on elite male teams in an international comparison (teams in the highest division or national teams) which average approximately 61mL O_2•kg^{-1}•minute^{-1} (Stølen et al., 2005).

To our knowledge, no article has appeared concerning running economy in professional football players which also describes speed consistency and treadmill running-surface stiffness. The stiffness of the treadmill construction is one important factor that might influence oxygen uptake and blood lactate concentration at given speeds. In our study, attempts were made to describe the stiffness and speed characteristics of the treadmill used in order to allow comparisons with results of future studies.

The anaerobic threshold investigated in our study occurred at about 84% of VO_{2max}. This is a somewhat higher value than those obtained by elite teams in an international comparison, which shows an average value of approximately 82 % of the ventilator anaerobic threshold (Vanfraechem and Tomas, 1993; Al-Hazzaa et al., 2001; Casajus, 2001). The relative use of maximum oxygen uptake in an average male elite football match is approximately 75% of VO_{2max} (Stølen et al., 2005). This, together with the fact that a football match of 90 minutes should be regarded as a long performance, indicates that aerobic power is relevant for performance in football. Other things being equal, a high VO_{2max} and lactate threshold and good running economy could be regarded as performance factors in football because they may, at least theoretically, allow a higher mean speed without excessive use of anaerobic energy metabolism. Scientific indications have been reported that support this assumption (Ziogas et al., 2011). It is also reasonable to assume that recovery between high-intensity runs may benefit from high aerobic power (Bishop et al., 2011). Thus, the parameters presented above can be regarded as factors important for average aerobic work intensity in football. However, additional future studies are needed to evaluate how tests with incremental constant load correlate with the variation in load typical for a football match (Buchheit et al., 2011).

In contrast to the results in maximal oxygen uptake, the Swedish elite players were better off concerning anaerobic performance factors. International male elite football players have been tested concerning sprint ability (0 – 40m) (Brewer, 1992; Kollath and Quade, 1993; Cometti et al., 2001; Helgerud et al., 2001; Dupont et al., 2004; Wislöff et al., 2004). Compared to the results of the international elite players the Swedes averaged about 4% shorter time on the tested sprint distances. The distance from the first photocell pair (0.5 m) and excellent running surface friction may have contributed to the Swedish results.

In the comparison of jumping ability between international elite players (Casajus, 2001; Wislöff et al., 2004) and Swedish players, squat jump height was similar whereas CMJ_a was somewhat higher (4%) among international elite players.

In the test of anaerobic power (the Wingate test) results for international elite football players (Brewer, 1992; Davis et al., 1992; Al-Hazzaa et al., 2001) were considerably lower (18%) than the power obtained by Swedish elite players. This lower value can partly be the effect of the methodology used during the Wingate test. Starting the test with zero speed on the flywheel in our study instead of accelerating it before starting the power calculation and risking excessive use of the phosphate energy store may be an advantage.

Team position comparison. One might expect that players in different play positions may differ in aerobic and anaerobic power due to different work demands related to their position. This is the rationale behind the present comparison of play positions. However, we made no further sub-division into each play position in the comparison below. This was justified after testing for significant differences in all aerobic and anaerobic parameters between central defenders versus right- and left-wing midfielders. The only significant difference occurred between central defenders and right and left wing midfielders in running economy. Football is a complex sport and numerous performance components have to be trained. This may reduce the time available for training physical performance factors such as VO_{2max}, RE, anaerobic threshold and anaerobic power. The time conflict with other important components of the game such as team tactics might be a problem. The present investigation compares the physical performance of elite football players in different team play positions. The results of this comparison can be used in the ongoing debate about the need for differentiation in physical capacity between team play positions. The comparison of average values concerning VO_{2max}, running economy, lactate threshold and anaerobic performance factors such as loaded squat jump power output, sprinting speed and jump height showed no significant differences between team positions (defenders, midfielders and attackers). The absence of physical profiles concerning the above parameters among players in the different team positions may have several causes. One may be the absence of a physiological strategy concerning aerobic endurance and anaerobic power when the team is put together.

Another may be related to deficits in resources for individually training and testing different capacities in the team-developing process. Coaches may also believe that aerobic and anaerobic performance factors are of less importance in the total perspective, so that it is not worth the time and resources to emphasize these for the different team positions. Above, a few examples of explanations concerning the situation in Swedish male elite football are presented. Physical equality between players in different positions might be optimal for total team performance. But it can also be argued that well-developed physical capacity for certain play-position-related performance demands is better for team performance. In an international comparison a slightly different picture emerge especially related to aerobic endurance. The typical pattern concerning distance covered during the game according to playing position in numerous studies of elite football players is that midfielders always show the highest mean values in comparison with those in other playing positions (see e.g. Reilly & Thomas, 1976; Bansgbo et al., 1991; Mohr et al., 2003). It was also shown by Reilly and Thomas (1976) that signs of fatigue during the game were most prominent in center-backs and attackers but less apparent in midfield players and full-backs, who also tended to have a higher maximal oxygen uptake. The midfield players covered the greatest distances and managed to maintain high work intensity throughout the game. The tendency of the midfielders and full-backs to have somewhat higher aerobic power than players in other positions is supported by other studies on elite players (Puga et al., 1993; Al-Hazzaa et al., 2001; Bansgbo and Michalsik, 2002). However, brief information on jump ability among outfield players showed no difference (Arnason et al., 2004). On the other hand, Davis and co-workers (1992) found that central defenders showed the highest mean anaerobic power in a Wingate test, followed by attackers, full-backs and midfielders. All team play positions also require movement in other than the forward directions. Defenders show the highest percentage of backwards and sideways locomotion (Reilly, 1996). Thus players in given team play positions need to be able to locomote in certain ways due to the structure of the game, the behavior of the opponent team and so forth. The energy cost to move sideways and backwards is higher than in forward running (Reilly and Bowen 1984). Thus, players in certain team positions, such as defenders, are forced to use more energy. This indicates that the demand profile concerning movement repertoire, and thereby the energy cost, may differ between team play positions in certain parts of the game.

Conclusion

The average maximal oxygen uptake among players in the highest Swedish division was lower compared to international elite players. In contrast the Swedish players were better off concerning the anaerobic threshold and in the anaerobic tests. In the team position comparison it was evident that there were no significant differences between team positions in the compared test parameters. The knowledge about team performance and team position physical performance can alert the need for further differentiation or similarity as well as new training methods that can serve different purposes. Furthermore, future integration of physiological parameters and tactics may allow an allocation of training time that develops physical performance in parallel with tactical improvement.

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