Aerobic and anaerobic power characteristics of Saudi elite soccer players

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Background. **To assess the aerobic and anaerobic characteristics of Saudi elite soccer players, and to examine the interrelationship between measures of aerobic and anaerobic power in the elite soccer players.**

Methods. **Participant: twenty-three outfield elite soccer players representing the Saudi national team participated. Their means (±SD) for age, body mass, height and estimated fat % were: 25.2±2.3 years; 73.1±6.8 kg; 177.2±5.9 cm; and 12.3±2.7%, respectively. Measures: cardiorespiratory parameters, including maximal oxygen uptake ($\dot{V}O_{2\,max}$), were assessed by open-circuit spirometry during graded treadmill running. Anaerobic power measures were obtained using Wingate anaerobic test, and included peak power (PP), and average power for 5 sec (AP 5), 10 sec (AP 10), 20 sec (AP 20) and 30 sec (AP 30).**

Results. **Mean (±SD) values for $\dot{V}O_{2max}$ in absolute and relative to body mass were 4.16±0.34 l·min^{-1} and 56.8±4.8 ml·kg^{-1}·min^{-1}, respectively. Such $\dot{V}O_{2max}$ value was 118% and 80% of those reported for Saudi college males and distance runners, respectively. The ventilatory anaerobic thereshold (Tvent) averaged 43.6 ml·kg^{-1}·min^{-1}. There were no significant differences in $\dot{V}O_{2max}$ and Tvent between players based on positions, although the midfielders and the centre-backs had the highest and the lowest individual values for both measures, respectively. Values (±SD) of PP and AP 30 were 873.6±141.8 W (11.88±1.3 W·kg^{-1}), and 587.7±55.4 W (8.02±0.53 W·kg^{-1}), respectively. Only in absolute PP & AP 30 were the centre-backs significantly superior to the other players. In addition, $\dot{V}O_{2max}$ was inversely related to PP ($r=-0.54$; $p<0.05$) and positively related to AP 30 ($r=0.45$; $p<0.05$).**

Conclusions. **The aerobic power, expressed relative to body mass, of Saudi elite soccer players was in the lower range of values normally reported in the literatures for elite soccer players. Both PP and AP 30 were somewhat lower than values previously reported for elite soccer players from other countries.**

KEY WORDS: Aerobic power - Anaerobic power - soccer - Oxygen consumption - Anaerobic threshold - Exercise physiology.

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Soccer is considered a physically demanding sport, which requires a high degree of technical skill, strength, agility and endurance.[1-5] It is estimated that the total distance covered during the game amounts to about 10 km.[1 2 5 7] Furthermore, based on $\dot{V}O_{2max}$ values, soccer players, in general, seem to have good but not outstanding aerobic power, something in the range of 55 to 65 ml·kg^{-1}·min^{-1}.[1-4 8-11] Nevertheless, aerobic power has been well recognized as an important physiological contributer to soccer performance.[1-5 11] Previous studies have demonstrated a significant relationship between distance covered during the game and the players' maximal aerobic power.[1 3] Midfielders were shown to have the highest values for $\dot{V}O_{2max}$ (expressed relative to body mass) and to cover more distance during soccer match than the other players on the team.[1 3-5] However, when $\dot{V}O_{2max}$ was expressed relative to body mass raised to the power of 0.75, no significant differences was seen among players of different positions.[5]

In addition, today's soccer game has become faster and is played at higher intensity.[12] Activity profiling of competitive soccer revealed that the players engage in high intensity running (including sprinting) for over 8% of the total game time.[6] In fact, during the most decisive actions of the game, intense anaerobic exercise is performed. Because the game involves high intensity intermittent exercise, it has been suggested that a high anaerobic power is a required characteristic of elite soccer players, especially for centre-backs and forwards.[1,2,4,5] This requirement is likely to be pronounced in the contemporary game.

During recent years, the Saudi Arabian soccer team has reached an international level, placing first in Asia three times and qualifying for the World Cup finals in 1994 and 1998, as well as for the 1996 Olympic Games. There has been no published data on the physiological profile of the Saudi elite soccer players, despite numerous published reports for North American,[10,11] European,[1-3,5,8,13,14] and Australian elite soccer players.[4,9]

Therefore, the purposes of this study were: (a) to assess the aerobic and anaerobic characteristics of Saudi elite soccer players, and compare such values with those reported for similar players from other countries, and (b) to examine the interrelationships between measures of aerobic and anaerobic power in these elite soccer players.

Materials and methods

Subjects

The data were collected on 23 elite soccer players, representing the Saudi national team. The players were in their early phase of preparation for the World Cup 1998, in France. Testing was preceded by a comprehensive medical examination. The physiological data reported here were for outfield players only.

Physiological testing

The players reported to the laboratory on two occasions. First, the subject's height, body mass, skinfold thicknesses and $\dot{V}O_{2max}$ were assessed. Two days later the players returned to the laboratory for anaerobic power assessments. Body mass (kg) and height (cm) were measured using a Seca digital scale. Subscapular and triceps skinfolds were measured using Harpenden caliper, on the right side of the body. Body fat percent was then estimated using a previously published prediction equation.[15]

Aerobic power testing

Maximal oxygen uptake was determined during a continuous treadmill test. Following a 6-min warm-up period, the athlete began running while the treadmill speed was gradully increased until a velocity of 15.5 $km \cdot kg^{-1}$ was reached, after which the treadmill velocity was kept constant and the inclination was increased by 2% every 2 min until volitional exhaustion. All tests were conducted 2 hours after meals in a comfortable laboratory environment.

Expired air was collected and analyzed using an automated open-circuit system with 30-sec sampling intervals (EOS - Sprint, Jaeger, Germany). Gas analyzers were calibrated before each test with a known mixure of gases. Oxygen uptake was considered maximal when the respiratory exchange ratio exceeded 1.0, and heart rate level exceeded 90% of the predicted maximal heart rate.

Heart rate was continuously monitored and recorded during the exercise test using a CM5 lead and a single-channel ECG monitor and recorder (Helligi, Germany). In addition, ventilatory anaerobic threshold (Tvent) was determined non-invasively through the use of gas exchange parameters. A systematic increase in ventilatory equivalent for O_2 ($\dot{V}E/\dot{V}O_2$) without an increase in the ventilatory equivalent for CO_2 ($\dot{V}E/\dot{V}O_2$) was used as a marker of Tvent.[16]

Capillary blood samples were obtained, using finger prick, from the athletes at rest and during the first minute of recovery. Lactate was then analyzed from whole blood, right after collection, using a portable Accusport Lactate Analyzer according to the manufacturer's instructions. The Accusport Lactate Analyzer was recently found accurate and reliable.[17]

Anaerobic power testing

Anaerobic performance was measured using the Wingate anaerobic test, with a friction-loaded cycle ergometry (Monark) interfaced with a microcomputer. The resistance was set at 75 $g \cdot kg^{-1}$ of body mass.[18] The test was preceded by a 4-min warm-up on the cycle ergometer with a brief (3 sec) all-out sprint at the

TABLE I.—*Physical characteristics of the elite soccer players (mean±SD).*

Variable	Full-backs	Centre-backs	Midfielders	Forwards	All
No. of athletes	64	67	23		
Age (years)	24.2±3.2	23.8±1.5	24.6±3.6	27.3±3.6	25.2±3.3
Body mass (kg)	72.4+4.1	82.1±6.9 *	68.2±4.4 *	72.7±5.9	73.1±6.8
Body height (cm)	176.0±3.9	182.3±6.1	174.7±6.7	177.4±5.8	177.2±5.9
Sum of skinfolds (mm)[a]	14.4±2.8	17.0±0.86	12.8±2.3	13.3±2.4	14.2±2.6
Fat content (%)	12.5±2.9	15.1±0.83	10.9±2.4	11.4±2.4	12.3+2.7
Lean body mass (kg)	63.3±2.8	69.7+5.2	61.7+4.7	64.4+4.4	64.6+4.7
Body surface area (m^2)	1.88±0.07	2.04±0.12 *	1.82±0.09 *	1.90±0.10	1.90±0.11

a) Sum of triceps and subscapular skinfolds. *) Denotes a significant diffrerence at the 0.05 level, using Scheffe's test.

end of the warm-up period. The test was started after the subject reached a pedal rate of 80 rev·min-1 where the resistance was then applied. The following power variables were obtained during the test: peak power (PP), average power during the first 5 sec (AP5), 10 sec (AP10), 20 sec (AP20) and 30 sec (AP30) of the test.

Statistical analysis

Descriptive statistics using SPSS package were determined and were presented as mean±SD. Pearson correlation was used to test the relationship between aerobic and anaerobic power measures. One-way analysis of variance with Scheffe's *post hoc* test was also used to test differences in aerobic and anaerobic power among players of different positions. In addition to reporting $\dot{V}O_{2\,max}$ values relative to body mass (ml·kg-1·min-1), $\dot{V}O_{2max}$ was expressed relative to body mass raised to the power of 0.67 as recommended by Berg *et al.*[19] and to the power of 0.75 which was recently recommended for scaling $\dot{V}O_{2max}$ for soccer players.[5]

Results

Mean values and standard deviations of the physical characteristics of the Saudi elite soccer players are shown in Table I. Players' body mass ranged from 60.3 kg to 90.3 kg, while heights ranged from 163 to 189 cm. Players from centre-back position were significantly (F=5.6; p=0.006) heavier than midfielders. Differences between centre-back and the midfielders in body fat content (F= 2.66; p=0.08) and lean body mass (F=2.75; p=0.07) were also the largest. No significant differences (F=1.5; p=0.23) were seen in body height among the players from different position.

Results of cardiorespiratory responses of the elite soccer players to maximal treadmill running are shown in Table II. It seems that all of the soccer player attained maximal exercise capacity. The average maximal heart rate reached 188 beats·min-1. This represents somewhat above 96% of the expected maximal heart rate for their age. Mean respiratory exchange ratio also exceeded 1.1 value. Postexercise blood lactate level reached a relatively high mean value (9.8 mmol·l-1), confirming that maximal exercise capacity was reached.

The maximal oxygen uptake averaged 56.8 ml·kg-1·min-1 for the whole group, with the midfielders having the highest and the center-backs having the lowest values. The differences in $\dot{V}O_{2max}$ between players of different positions were not statistically significant (F=2.03; p=0.14). The absolute values of $\dot{V}O_{2max}$ (l·min-1) for the players of different positions were also similar (F=0.20; p=0.89). Furthermore, when $\dot{V}O_{2max}$ was expressed relative to body mass using the mass exponents of 0.75 and 0.67, the difference between the midfielders and the centre-backs was reduced to a greater extent.

Data on the ventilatory anaerobic threshold (T vent) were also presented in Table II. An average of 43.6 ml·kg-1·min-1 was found for the whole group. This represents 76.1% of $\dot{V}O_{2max}$ and 85.6% of maximal heart rate. The ventilatory anaerobic threshold, as a percent of $\dot{V}O_{2max}$, ranged from as low as 74.7% for the full-backs to as high as 77.7% for the midfielders. There were no significant differences (F=0.52; p=0.67) between players of different positions.

Table III presents the anaerobic power measures of the elite soccer players. Absolute peak power (F=11.42;

TABLE II.—*Physiological responses of the elite soccer players to treadmill testing (mean±SD).*

Variable	Full-backs	Centre backs	Midfielders	Forwards	All
$\dot{V}O_{2\,max}$ (l·min^{-1})	4.16±0.19	4.28±0.66	4.13±0.26	4.11±0.29	4.16+0.34
$\dot{V}O_{2\,max}$ (ml·m^{-2})	2210±160	2100±290	2250±60	2170±90	2190±160
$\dot{V}O_{2\,max}$ (ml·kg^{-1}·min^{-1})	57.7±5.1	52.3±7.3	59.9±0.93	56.9±2.5	56.8+4.8
$\dot{V}O_{2\,max}$ (ml·kg$^{-0.67}$·min^{-1})	236.6±17.1	223.7±31.1	241.6±3.5	233.5±7.5	234.1±16.8
$\dot{V}O_{2\,max}$ (ml·kg$^{-0.75}$·min^{-1})	168.0±12.8	157.3±21.8	172.2±1.7	165.8±5.4	166.0±12.3
$\dot{V}E_{max}$ (l·min^{-1})	129.6±10.8	119.8±29.1	125.7±17.1	126.8±24.2	126.0±19.4
$\dot{V}E_{max}/\dot{V}O_{2\,max}$	31.2±2.4	27.7±3.2	30.4+3.5	30.8±4.9	30.2±3.6
HR max (beats·min^{-1})	185±5	187±6	195±9	189±6	188±7
Tvent (ml·min^{-1})	43.1±4.6	40.3±8.3	46.5+2.3	43.8±2.3	43.6±4.4
Tvent (% $\dot{V}O_{2\,max}$)	74.7±4.6	75.2±3.8	77.7±2.9	77.0±4.9	76.1±4.1
HR at Tvent (beats·min^{-1})	160+8	156±12	170±12	161±6	162±9
HR - Tvent (% HR max)	86.5±3.3	82.8±5.9	87.3±3.2	85.0±4.2	85.6±3.9
Resting lactate (mmol·l^{-1})	1.2+0.31	1.2±0.26	1.1±0.35	1.8±0.40	1.3±0.41
Peak lactate (mmol·l^{-1})	10.5±0.99	9.3±1.1	9.9±0.57	9.2±1.2	9.8±1.1

TABLE III.—*Anaerobic power measures of the elite soccer players (mean±SD).*

Variable	Full-backs	Centre-backs	Midfielders	Forwards	All
Peak power (W)	816.5±98.9 *	1097.8±119.5 *	783.8±80.3	870.4±48.4	873.6±141.8
Peak power (W·kg^{-1})	11.31±0.85	13.50±1.8	11.56±1.0	11.67±0.79	11.88±1.3
Average power 5 sec (W·kg^{-1})	9.85±0.27	10.46±0.65	9.91±0.72	10.24±0.39	10.08±0.55
Average power 10 sec (W·kg^{-1})	9.53±0.29	9.81±0.58	9.59±0.62	9.78±0.45	9.67±0.48
Average power 20 sec (W·kg^{-1})	8.82±0.50	9.14±0.51	9.04±0.53	8.99±0.60	8.98±0.51
Average power 30 sec (W·kg^{-1})	7.87±0.62	8.23±0.49	8.04±0.50	8.01±0.58	8.02±0.53
Average power 30 sec (W)	565.3±22.9 *	673.5±52.6 *	544.2±17.1	598.0±34.2	587.7±55.4

*) Denotes a significant difference at the 0.05 level, using Scheffe's test.

p=0.0002) as well as average power for 30 s (F=14.75; p=0.0001) showed significant differences between players based on position. The centre-backs were superior on both measures of absolute anaerobic power compared to the other players. When peak and average anaerobic power values were expressed relative to body mass (W·kg^{-1}), there were no significant positional differences (at 0.05 level) among the players of the four positions, though the centre-backs still had the highest values compared to the other players throughout the entire 30 sec test.

The correlation coefficients between aerobic and anaerobic parameters for the elite soccer players are presented in Table IV. As can be seen clearly from that table, the peak anaerobic power exhibited fairly moderate inverse relationships with all measures of aerobic power. Moreover, average anaerobic power for 5 and 10 sec did not show any relationship with measures of aerobic power. For average anaerobic power over 30 sec, the correlations became higher but were only significant with $\dot{V}O_{2max}$ relative to body mass. Figure 1 highlights the relationship between $\dot{V}O_{2max}$ (ml·kg^{-1}·min^{-1}) and peak and average anaerobic power. As can be seen from the figure, the relationship starts with a significantly negative correlation (r=-0.54) and ends with a moderate positive correlation (r=0.45).

Discussion and conclusions

Although there seems to be no optimal stature for soccer players,[1,3] height can offer an advantage for

TABLE IV.—*Correlation coefficients between aerobic and anaerobic power parameters in elite soccer players.*

Anaerobic parameter	$\dot{V}O_{2max}$				Tvent
	$ml \cdot m^{-2}$	$ml \cdot kg^{-1} \cdot min^{-1}$	$ml \cdot kg^{-0.67} \cdot min^{-1}$	$ml \cdot kg^{-0.75} \cdot min^{-1}$	$ml.kg^{-1} \cdot min^{-1}$
Peak power ($W \cdot kg^{-1}$)	-0.51*	-0.54*	-0.52*	-0.53*	-0.23
Average power for 5 sec ($W \cdot kg^{-1}$)	-0.17	-0.11	-0.18	-0.16	0.26
Average power for 10 sec ($W \cdot kg^{-1}$)	0.06	0.19	0.08	0.11	0.43
Average power for 20 sec ($W \cdot kg^{-1}$)	0.19	0.36	0.24	0.28	0.43
Average power for 30 sec ($W \cdot kg^{-1}$)	0.33	0.45*	0.37	0.40	0.44

$ml \cdot m^{-2}$ = $\dot{V}O_{2max}$ relative to body surface area. Tvent=Ventilatory anaerobic threshold. *=$p<0.05$.

center-backs and forwards. Players with a particular stature are often oriented towards certain positions. The present study showed that the center-backs were the tallest and the heaviest among the players. The players in the present study had similar height and weight to the English First Division Soccer League,[20] the South Australian semi-professional soccer players,[9] and the Canadian Olympic soccer team.[11] They were shorter and weighed less than some European soccer players.[1 3 8] Mean body fat percent for the elite Saudi soccer player was not far different from those previously reported for elite soccer players.[8 10 11] Nevertheless, comparison of fat percent is limited by the different methods used to assess body composition.

Mean $\dot{V}O_{2max}$ of elite soccer players is normally reported between 55 and 65 $ml \cdot kg^{-1} \cdot min^{-1}$.[1-5 8-11 13 14] The Saudi elite soccer players, with a mean value of about 57 $ml \cdot kg^{-1} \cdot min^{-1}$, can be placed within the lower range of what is normally reported in the literature for elite soccer players. This seemingly low $\dot{V}O_{2max}$ level can be partially explained by the fact that some of the players had not been training for few weeks prior to joining the national team. Table V presents a comparison of $\dot{V}O_{2max}$ values for the Saudi soccer players with those reported for similiar players from other countries. It can be seen clearly from that table that the midfielders always have the highest $\dot{V}O_{2max}$ relative to body mass. Midfielders cover greater total distances than any other players in the other positions.[6] Because they perform both defensive and offensive skills and are always required to make long run,[1] the midfielders must have high level of aerobic fitness. Players in the centre-back position invariably require much less movement during soccer games than full-backs or midfielders, as evident by motion analysis studies.[7] In the present study, no significant differences were detected in $\dot{V}O_{2max}$, expressed relative to body mass, among players of different positions. This finding must be interpreted with caution, since the number of subjects in each group was fairly small.

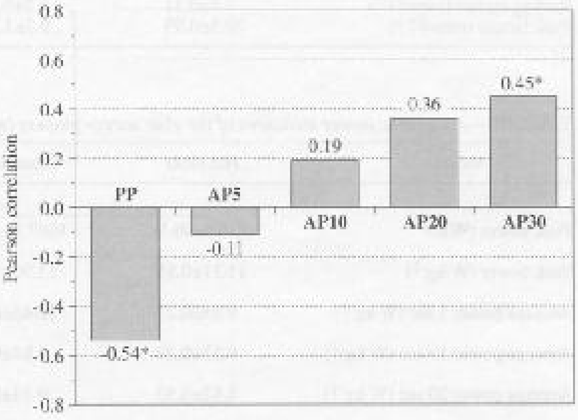

Fig. 1.—Correlation coefficients of aerobic power ($ml \cdot kg^{-1} \cdot min^{-1}$) with peak anaerobic power relative to body mass (PP), average anaerobic power relative to body mass during 5 sec (AP5), 10 sec (AP10), 20 sec (AP20), and 30 sec (AP30) in elite soccer players (*$p<0.05$).

Maximal oxygen uptake has been shown to have a genetic component,[21] so comparison of athletes from different ethnic background may not always be without reservation. Therefore, the Saudi soccer players were compared with two local groups of subjects, as shown in Figure 2. It is obvious that the Saudi soccer players have higher mean $\dot{V}O_{2max}$ value than that of Saudi college males,[22] but much lower mean than that of the Saudi long-distance runners.[23] In fact, the Saudi soccer players attained about 80% of that of the long distance runners. Distance runners, though, were known to have very high $\dot{V}O_{2max}$ value, expressed relative to body mass.

When $\dot{V}O_{2max}$ was expressed relative to body mass raised to the power of 0.67 or to the power of 0.75 as

TABLE V.—*Comparison of the $\dot{V}O_{2\,max}$ values ($ml \cdot kg^{-1} \cdot min^{-1}$) for the Saudi elite soccer players with some previously reported values for players from other countries.*

Players	All players	Position			References
		Defender	Midfielders	Forwards	
Saudi national	56.8	FB: 57.7 CB: 52.3	59.9	56.9	Present study
American professional	58.9	59.3	56.1	59.6	10
English professional	60.4	FB: 60.7 CB: 59.5	61.4	60.1	8
Norwegian elite	63.7	61.5	66.4	63.5	5
Danish elite	60.5	FB: 61.9 CB: 56.4	62.4	60.2	1
German national and regional	59.5				13
South Australian national	57.6				9
Canadian olympic	58.7				11
Swedish elite	61.0				2
Czechoslovakian internationals	60.9				12

FB: full-back ; CB: centre-back.

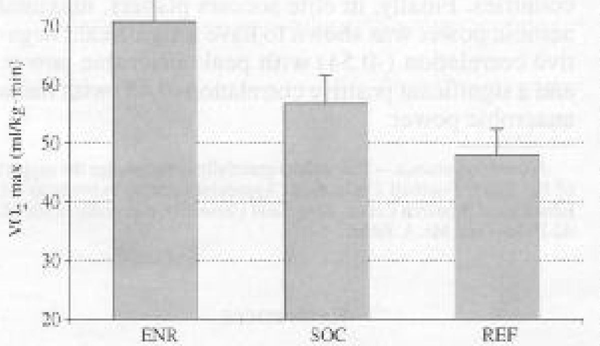

Fig. 2.—$\dot{V}O_{2\,max}$ relative to body mass ($ml \cdot kg^{-1} \cdot min^{-1}$) for the Saudi elite soccer players (SOC) in comparison with Saudi elite endurance runners (ENR), and reference group (REF) of moderately active Saudi college males. The ENR data were from [23], and the REF data were from [22] (data are means±SD).

has been suggested previously,[5,18] the difference between the midfielders and the centre-backs became much smaller than when using the traditional value per kg of body mass. In activities involving running, the oxygen cost of running as well as $\dot{V}O_{2max}$ values do not increase in direct proportion to body mass, and therefore expressing $\dot{V}O_{2max}$ relative to body mass raised to the power of 2/3 was found most indicative of performance capacity.[19] In the present study, the centre-backs were significantly heavier than the midfielders, and scaling $\dot{V}O_{2max}$ to 2/3 of body mass did reduce the differences between the midfielders and the centre-backs. A similar finding was recently observed when $\dot{V}O_{2max}$ comparisons with and without scaling were made between midfielders and centre-backs.[5]

The Tvent values observed in the present study were similar to those of South Australian national team,[9] but lower than those reported for other soccer players.[11,13] The anaerobic threshold gives an indication of the level of sustained work output. Several studies have reported the average intensity of a soccer match to be around the anaerobic threshold, or 80-90% of HR max.[1,3] In the present study the Tvent occurred at roughly 76% of $\dot{V}O_{2max}$, which corresponded to about 86% of HR max. Data from the First Division English league[3] and Scandanivian elite soccer players[1,2] indicated that on the average soccer players were exercising at close to 75% of $\dot{V}O_{2max}$. Moreover, during the 1[st] half of a competitive match, mean heart rate for a group of Danish soccer players was 164 beats/min.[1] Similar findings (86.7% HR max) were also reported for a Belgian university team.[24] Heart rate at the ventilatory anaerobic threshold in the present study was 162 beats·min-1, or at 86% of HR max.

Studies comparing anaerobic power characteristics among soccer players are made difficult by a large number of different indices of anaerobic power (*e.g.* verical jump, stair run, sprint running, and Wingate cycle ergometer). In the present study the Wingate anaerobic test was used, and the mean values for peak power and average power during 30 sec expressed relative to body mass, were much lower than those values reported for elite Swedish soccer players,[2] English professional soccer players,[8] or South Australian soccer players.[25] In the present study, the centre-backs attained significantly the highest peak as well as average anaerobic power of all soccer players. When anaerobic power was expressed relative to body mass, there were no significant differences among players of different positions. A previous study on English professional soccer players did not find any significant difference among players of different positions when anaerobic power was expressed relative to body mass.[8] However, in another study, utilizing the vertical jump test, midfielder players significantly demonstrated inferior anaerobic power compared to forward and defence players.[5]

In the present study, aerobic power of the elite Saudi soccer players was negatively related to peak anaerobic power ($r=-0.54$; $p<0.05$). Generally speaking, this means those players who have superior aerobic power do possess somewhat inferior anaerobic power. Whether this is mainly due to genetic factors or to training regimens can not be determined from this study. This inverse correlation between aerobic and anaerobic power is certainly in accordance with the metabolic specialization concept. Each of the two power variables represents a distinct energy system and different fibre type recruitment patterns.[26] In modern soccer, conditioning regimens are made somewhat more specific to the players position (*e.g.* defenders as apposed to midfielders), thus resulting in specific adaptation. In agreement with our findings, Katch and Weltman[27] had reported a similar correlation between peak anaerobic power and aerobic power ($r=-0.57$). The finding of a significantly positive correlation between $\dot{V}O_{2max}$ and the average anaerobic power for 30 s ($r=0.45$) indicates that there is an aerobic component ($r^2=0.20$) in the Wingate 30-sec anaerobic test. The magnitude of such aerobic contribution during the short-term high intensity exercise of about 30 sec has been estimated to be 14.4-28.6%,[28, 29] or as high as 40%.[30]

In the present study, the correlation between $\dot{V}O_{2max}$ and anaerobic power indices shifted from a negative relationship during the early part of the test (peak power) to a positive correlation during the later part of the test (average power for 30 sec). This shift is attributed in part to the increased contribution of aerobic metabolism to energy turn over during the later period of the test. Studies comparing the rate of ATP resynthesis from phosphocreatine (PC) during 30 sec of maximal electrically evoked isometric contraction indicated that ATP resynthesis from PC was at its highest rate within 2 sec of the initiation of contraction.[26] However, the contribution of PC to ATP resynthesis in the last 10 sec of the 30 sec contraction was only 2% of the initial rate.[26] In practical terms, this means aerobic power system is to some extents involved during intense activities lasting 30 sec or so in a soccer game.

In conclusion, the present study indicated that the aerobic power, expressed relative to body mass, of Saudi elite soccer players was in the lower range of values normally reported in the literatures for elite soccer players. Also, when compared with local endurance runners, $\dot{V}O_{2max}$ values of the Saudi soccer players were not high. In addition, peak and mean anaerobic power were somewhat lower than values previously reported for soccer players from other countries. Finally, in elite soccers players, maximal aerobic power was shown to have a significant negative correlation (-0.54) with peak anaerobic power, and a significant positive correlation (0.45) with mean anaerobic power.

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