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$VO_{2\,max}$ characteristics of elite female soccer players 1989-2007

$VO_{2\,max}$ in female soccer

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Abstract

Purpose: The purpose of this investigation was to quantify $VO_{2\,max}$ among female competitive soccer players as a function of performance level, field position, and age. In addition, we quantified the evolution of $VO_{2\,max}$ among world class players over an 18 year period. **Methods:** Female players (n=199, 22 ±4 yr, 63 ±6 kg, height 169 ±6 cm), including an Olympic winning squad, tested $VO_{2\,max}$ at the Norwegian Olympic Training Center between 1989 and 2007. **Results:** National team players had 5 % higher $VO_{2\,max}$ than 1st division players (p=0.042, d=0.4), 13 % higher than 2nd division players (p<0.001, d=1.2) and 9 % higher than junior players (p=0.005, d=1.0). Midfielders had 8 % higher $VO_{2\,max}$ than goalkeepers (p=0.048, d=1.1). No significant differences were observed across outfield players or different age categories. There was a trend towards lower relative $VO_{2\,max}$ across time epochs. **Conclusions:** This study demonstrated that $VO_{2\,max}$ vary across playing standard level in female soccer. No significant differences in $VO_{2\,max}$ were observed across outfield positions and age categories. Over time, there has been a slight negative development in $VO_{2\,max}$ among Norwegian elite soccer players.

Key words: Maximum oxygen uptake; physical performance; physical demands; national team soccer players; aerobic capacity

Introduction

In recent years, women`s soccer has become one of the most popular female sports worldwide. According to FIFA, more than 4 million female players are registered in soccer associations.[1] Studies of male soccer players demonstrate that capabilities such as endurance,[2] agility,[3] sprint[4] and power[5] skills should be well developed in order to become a successful player. Unfortunately, fewer studies are available regarding physical characteristics of female players.

Game analysis show that female soccer players run 8,500-10,300 m during a 90 min match.[6-8] This *average* movement velocity of 5.7 to 6.9 $km \cdot h^{-1}$ corresponds to only walking or slow jogging. However, during matches exercise intensity is measured between 85-90 % of HR_{max}.[7] The discordance is explained by a large number of maximal or near-maximal sprints of short duration interspersed by brief recovery periods.[6,7,9] Repeated sprints lead to rapid metabolic responses, such as a decrease in intramuscular pH, PCr and ATP concentration, activation of anaerobic glycolysis and a significant contribution from aerobic metabolism.[10-12] This exertion pattern requires periods of low-intensity activity to resynthesize PCr and remove accumulated lactate and hydrogen ions from working muscles.[11,12] The rate of lactate clearance depends on lactate concentration, activity during the recovery period and aerobic capacity. Players with higher VO_{2max} have improved lactate removal capability and enhanced phosphocreatine regeneration.[11-13]

While the influence of sprinting speed and vertical jump capabilities has been well described,[6,14-17] there is a lack of knowledge regarding the role of $VO_{2\,max}$ in women´s soccer. Group VO_{2max} values between 47 and 57 $mL \cdot kg^{-1} \cdot min^{-1}$ have been reported.[6,7] Unfortunately, previously published studies do not adequately represent variation in performance level, playing position or age. No studies have examined $VO_{2\,max}$ among female international class soccer players over time. Many coaches claim that international athletes have better $VO_{2\,max}$ now than 10 years ago, but objective data supporting this claim are not available. The Norwegian Olympic Training Center has served as a standard testing facility for a large number of teams across a broad range of performance levels, including the champions of Sydney-2000 Olympics and other international medal winning squads. A database of $VO_{2\,max}$ results collected over nearly two decades, provides the potential for addressing several different questions related to the role of $VO_{2\,max}$ in women`s soccer. The aim of this study was therefore to quantify possible differences in $VO_{2\,max}$ as a function of: 1) athlete performance level, 2) field position, and 3) age.

Additionally, we evaluated the evolution of $VO_{2\,max}$ in the Norwegian national squad over an 18 year period.

Materials and methods

Subjects

Data from 199 female soccer players (21 ±4 yr, body mass 62 ±7 kg, height 169 ±6 cm), representing a broad range of performance levels, were collected between 1989 and 2007 (Table 1). Senior national team athletes were defined as players who represented Norway in Olympic Games, World Cup, Euro Cup, qualifying matches or training matches. Since 1989, the Norwegian squad has won gold and bronze in the Olympic Games, gold in World Cup, and gold and silver medal in the Euro Cup. Junior national team players in the database had represented Norway in the < 20 age group. First division athletes represented female clubs from the highest division level in the Norwegian soccer league system, while 2nd division athletes were playing in the second highest division. The junior elite players in the database were representing a sports high school in Oslo with a soccer program. Those athletes were all playing in the highest junior division for different clubs in Norway.

Due to different testing routines implemented by the female national team`s coaching staff, we have no directly comparable data after 2007. In total, 569 $VO_{2\,max}$ tests formed the basis for this investigation: Eighty-nine players were tested once, 35 tested twice and 75 tested three times or more. All tests were performed between 11 AM and 8 PM at the Norwegian Olympic Training Center in Oslo. These were preexisting data from the quarterly, semiannual or annual testing that these teams performed for training purposes. The Norwegian Olympic and paralympic Committee and Confederation of Sports approved the use of data, provided that the anonymity of all individual test results was maintained. This study was approved by the ethics committee of the Faculty for Health and Sport, University of Agder, in accordance to the Helsinki Declaration.

Apparatus

A 200x70 cm ELG Woodway treadmill (Woodway Gmbh, Weil am Rhein, Germany) calibrated for speed and inclination was used for all tests. For this athlete group, maximal treadmill testing was always performed at a constant treadmill inclination of 3^{o} (5.25 %). During the test, the subjects breathed into a Hans Rudolph two-way breathing valve (2700 series; Hans Rudolph Inc, Kansas City, USA) connected to metabolic gas analyzers. Gas exchange and ventilatory variables were continuously sampled in a mixing chamber and averaged each

30 sec. Oxygen uptake was measured using EOS Sprint (Jaeger-Toennis, Wurtzburg, Germany) from 1989 to 2002 (June), while an Oxycon Pro (Jaeger-Toennis, Wurtzburg, Germany) metabolic test system was used from June 2002. The test equipment underwent a standard calibration procedure before each test.

An internal comparison between the two analyzers was conducted during the shift in 2002. We analyzed the VO_2 values of female cross country skiers who ran on four fixed workloads on different occasions using both metabolic systems. The duration was 5 min. per workload. Mean VO_2 between 3 and 5 min. was defined as steady state. To ensure aerobic conditions, blood lactate was measured after each bout. Lactate levels > 2.0 led to exclusion of the sample of the current workload. The results showed identical regression lines for the running velocity – VO_2 relationship before and after the apparatus shift (Table 1).

(Table 1 here)

Testing procedures

Athletes were instructed to prepare themselves as they would for a regular competition, including no high intensity training the last 2-3 days before testing. Each subject completed a standard 20 minute warm up program on a treadmill prior to testing. The warm up consisted of 15 min low intensity jogging (55-70 % of $VO_{2\,max}$) followed by 2-3 short strides equivalent to the expected average velocity of the $VO_{2\,max}$ test. The testing procedure was a stepwise increase in running velocity every minute until exhaustion occurred after 4-6 minutes. Starting velocity for all athletes was 85-90 % of $VO_{2\,max}$. The increase was 1 $km \cdot h^{-1} \cdot min^{-1}$, and the last velocity step was held for at least 1 min. During each test, athletes were continuously updated with VO_2 values, time and running velocity, in order to motivate for true voluntary exhaustion. Primarily two exercise physiologists supervised all testing during the entire period. The test was terminated before voluntary exhaustion if the VO_2 values leveled off or decreased in spite of increasing workload and ventilation, in addition to respiratory exchange ratio (RER) > 1.1. $VO_{2\,max}$ was defined as the highest average of two consecutive 30 s measurements. Velocity at $VO_{2\,max}$ ($vVO_{2\,max}$) is the slowest velocity associated with $VO_{2\,max}$. In accordance to Billat et al., we identified $vVO_{2\,max}$ as the running velocity between the two highest consecutive 30 s measurements of VO_2.[18] Test results with peak RER below 1.05 were excluded. The reliability and validity of our testing procedures are supported by Midgley et al.[19]

Statistics

SPSS 18 was used for all analyses. Mean and SD of absolute $VO_{2\ max}$ and $vVO_{2\ max}$ were calculated for each group or category in the presented table. Mean and 95 % confidence intervals of $VO_{2\ max}$ relative to bodyweight ($ml \cdot kg^{-1} \cdot min^{-1}$) are presented for all analyzed categories in the figures. Data from a single athlete was only included in one category for each analysis. That category was the athlete's affiliation on the day of their best result. Player positions were identified for each athlete by their coaches or by self-report as: goalkeepers, defense players, midfielders or forwards. Athlete age was calculated from date of birth and testing date and categorized as: under 20, 20-24, and 24 plus. To quantify the development of $VO_{2\ max}$ over time, the database was divided into three time epochs; 1989-1994, 1995-2001 and 2002-2007. The performance level analysis included all outfield players (n=185), while position (n=98), age (n=87) and time epoch (n=87) analyses were restricted to junior and senior national team players at the time of testing. Goalkeepers were only included in the position analysis, as they were unequally distributed across the other categories. The rationale behind the age and time epoch categories was based on sample size distribution and equal split. All data were normally distributed. Therefore, one-way ANOVA followed by Tukey's post hoc test where necessary, was used to identify differences among groups or categories. Effect size (Cohen`s *d*) was calculated to evaluate the meaningfulness of the difference between category means. Effect magnitude was interpreted categorically as small (*d* from 0.2 to 0.6), moderate (*d* from 0.6 to 1.2) or large (*d* from 1.2 to 2.0) using the scale presented by Hopkins et al.[20] Moderate or larger effects (d>0.6) are reported, even though they are non-significant.

Results

(Figure 1 here)

Figure 1 shows $VO_{2\ max}$ values for all performance level categories. Senior national team players had 4.6 % higher $VO_{2\ max}$ than 1st division players (p=0.042, d=0.4), 13.1 % higher than 2nd division players (p<0.001, d=1.2) and 8.9 % higher than the junior players (p=0.005, d=1.0). 1st division players had 8.0 % higher $VO_{2\ max}$ than 2nd division players (p=0.004, d=0.7). Junior national team players had 10 % higher $VO_{2\ max}$ than 2nd division players (p=0.022, d=1.0).

(Figure 2 here)

Figure 2 presents 95 % CIs for $VO_{2\ max}$ values by position for national team players. Midfielders had 7.8 % higher $VO_{2\ max}$ than goalkeepers (*p*=0.048, *d*=1.1). No other significant position differences were observed, although 95% CIs for midfielders trended highest among outfield positions (midfielders vs. forwards; d=0.6).

(Figure 3 here)

Figure 3 shows $VO_{2\ max}$ across age groups. No significant differences were observed.

(Figure 4 here)

Figure 4 shows 95 % CIs for $VO_{2\ max}$ among national team players by time epoch. No significant differences were observed across categories, but 95 % CIs trended slightly downward by ~2 $ml \cdot kg^{-1} \cdot min^{-1}$ over the time period investigated.

(Table 2 here)

Table 2 shows that absolute $VO_{2\ max}$ was ~ 10-16 % higher among senior national team players compared to 1st division, 2nd division and junior players (*p*<0.002, *d* between 0.9 and 1.4). Furthermore, $vVO_{2\ max}$ was ~ 4-12 % higher among national team and 1st division players than the other performance level categories (p<0.001, *d* between 1.0 and 1.7). Midfielders had 7.2 % higher $vVO_{2\ max}$ than goalkeepers (*p*=0.049, *d*=1.0).

Discussion

In the present study, a large sample of test results demonstrates a clear trend towards higher $VO_{2\ max}$ values with higher standard of play. No differences in $VO_{2\ max}$ among outfield players or age groups were observed. There was a slight, but non-significant trend towards lower VO_{2max} values over an 18 year period of testing. The magnitude of the $vVO_{2\ max}$ and absolute $VO_{2\ max}$ values showed practically identical trends as for the relative $VO_{2\ max}$ values.

Performance level: To our knowledge, this is the first investigation to describe $VO_{2\ max}$ across a broad range of performance levels in female soccer. National team players had better $VO_{2\ max}$ than 1st and 2nd division players. Furthermore, junior national team members had higher values than other junior players. All the significant group differences observed here were larger than the $VO_{2\ max}$ test-retest reliability (~3 %)

suggested by Howley et al.,[21] and the effect magnitudes were small to moderate. The national team players` $VO_{2\ max}$ values in this study were higher than those reported for the Danish national team[7] which to our knowledge is the only other report of female performers at the national team level. Our findings indicate that $VO_{2\ max}$ is a distinguishing variable that separate female players of different standard. This is in contrast to the recent findings by Tønnessen et al.,[4] who revealed practically no group differences in relative VO_2 uptake among male players from a broad range of playing standard. This conflicting finding might be explained by differences in sample size among the studies, as the study by Tønnessen involved 7-8 times more players than the present study. It could also be due to the fact that fewer females play soccer. In the Norwegian soccer system, there are up to ten divisions for men and only four for women. Thus, one female division difference equals 2-3 male division difference in playing standard.

In male soccer, neither total distance covered nor high intensity running are distinguishing variables that separate players of different standard.[22-24] In female soccer, Mohr et al.[8] reported that top-class international players perform more high-intensity running during games than elite players at a lower level. It has been suggested that $VO_{2\ max}$ above 60 ml represents a threshold to possess the physiological attributes for success in male elite soccer.[4,25] Our present findings indicate that a relative $VO_{2\ max}$ of ~ 55 $ml \cdot min^{-1} \cdot kg^{-1}$ is sufficient to perform on a high international level in female soccer.

Playing position: Not unexpectedly, the results showed a clear and significant difference in $VO_{2\ max}$ between midfielders and goalkeepers. Inspection of 95 % CIs shows that midfielders also tended to have higher $VO_{2\ max}$ than forwards (moderate effect) and defenders, but these differences were within ~2 $ml \cdot kg^{-1} \cdot min^{-1}$ and not statistically significant (Figure 2). We are not aware of other studies investigating $VO_{2\ max}$ across playing positions in female players. Vescovi et al.[16] used a 20 m Beep Test to estimate endurance performance among female Division I college soccer players, but reported no differences according to positions. $VO_{2\ max}$ should be seen in relationship to the physical demands of the different positions on the field. Time motion analyses have shown large position differences in covered distance during games.[7] Our playing position categorization is somewhat limited, but we observed that midfielders, who typically cover the longest distances during games[7] had somewhat higher $VO_{2\ max}$. Buchheit et al.[26] and Mendez-Villanueva[27] claim that fitness is unlikely a limiting factor of game running demands, as soccer players use different proportion of their capacity to match the game demands. Nevertheless, based on observed differences in covered distance during games, we are somewhat surprised that the mean group difference between midfielders and goalkeepers in the present study is only ~ 5 mL· kg^{-1} $·min^{-1}$ or about 10 %.

Age: We observed no age related differences in $VO_{2\,max}$. Our findings suggest that female soccer players achieve little improvement in $VO_{2\,max}$ from junior age. Due to the low participation rate among older senior players (>24 yr) in Norwegian soccer, only two senior age categories were created. No other studies have analyzed VO_{2max} through different age stages for female soccer players. Mujika et al.[14] reported better specific endurance performance (Yo-Yo IR1 test) for seniors than juniors in a Spanish female 1st division club. Similar findings are observed in statistics from Norwegian athletics[28] as for the girls in this study. Female middle- and long distance runners improved their performance level from 13 to 17 years of age before plateauing, while corresponding male athletes achieve their peak performance level several years later. Krahenbuhl et al.[29] showed that aerobic capacity deteriorates in the mid-teens among girls in general. According to the Norwegian elite series team coaches, primarily their very best players continue participating in soccer after 23-24 years of age. National team athletes represented 71 % of all subjects older than 24 years in this study. That is, in this sample, only the very best female athletes tended to continue their careers beyond age 24. This selection bias may mask a potential decline in $VO_{2\,max}$ beyond this age among females.

Trends over time: Although no significant differences were observed, the 95 % CIs (Figure 4) trended negatively for $VO_{2\,max}$ for elite players over time. Players from time epoch 2002-2007 had a non-significant ~ 4 % lower $VO_{2\,max}$ values compared to epoch 1995-2001, but the effect magnitude was small. No studies have so far monitored female elite soccer players` $VO_{2\,max}$ characteristics in a long-term perspective. Our data do not support the contention that $VO_{2\,max}$ of elite female players has improved over time, at least in Norway. The time epoch analysis was restricted to national team players, and all national squad athletes were tested across time epochs as a part of routine testing procedures. Therefore, the observed trend cannot be explained by a selection bias. In theory, our findings could have been affected by the analyzer shift in June 2002. However, we do not believe this is the case, as both instruments demonstrated identical regression lines for the running velocity – VO_2 relationship before and after the apparatus shift (Table 1). Instead, we hypothesize that the Norwegian national team have prioritized other physical qualities. A moderate improvement in sprinting velocity over time has been recently reported for the same group of players.[15]

$vVO_{2\,max}$ and absolute VO2 max: In theory, it would be reasonable to expect that vVO_{2max} is a better determinant of match running performance, since it integrates running economy in addition to VO_{2max}, (di Prampero 1986). In practice, our results (Table 2) show that vVO_{2max} does not show a different pattern compared to $VO_{2\,max}$, as the magnitude of the differences is quite similar. However, it is important to keep in mind that the present $vVO_{2\,max}$ values were achieved on a treadmill inclination of 3° (5.25 %), which lowered the speed compared with the literature. Absolute $VO_{2\,max}$ does not consider the players` body mass. This is most likely the reason why the absolute $VO_{2\,max}$ values in Table 2 do not demonstrate a slight negative trend across time epochs, in contrast to relative $VO_{2\,max}$ and $vVO_{2\,max}$. The slight trend towards higher absolute $VO_{2\,max}$ with increasing age should be seen in the context of increasing body mass with increasing age. Otherwise, the absolute $VO_{2\,max}$ values showed identical trends across playing standard and position categories.

Practical applications

In the present study, national team players had better $VO_{2\,max}$ than players at lower performance level. No significant positional differences among outfield players were observed, and no positive development in $VO_{2\,max}$ was seen after 20 years of age. Relative to body mass, $VO_{2\,max}$ among the female elite soccer players in this study has not improved over time and may have slightly declined at the same time that other physical characteristics have improved. Soccer performance is dependent on a large physiological and technical skill set, and coaches must take $VO_{2\,max}$ and its development into account within the larger skill set of soccer. Selection of players, testing, and physical conditioning of the athletes should reflect the balance between aerobic endurance and anaerobic power and capacity required. Based on this information, coaches and conditioning experts can balance their training plans in order to optimize the different skills in relation to their contribution to overall soccer performance. Future research should focus more on the relationship between physical demands of the game, capacity profiles among players, and consequences for long term planning of individual fitness programs in female soccer.

Conclusion

This study provides effect magnitude estimates for the influence of performance level, player position and age on $VO_{2\,max}$ in female elite soccer. $VO_{2\,max}$ separate players across playing standard level, but no significant differences in $VO_{2\,max}$ were observed across outfield positions or age categories. Over time, there has been a slight, non-significant trend towards lower $VO_{2\,max}$ values among Norwegian elite soccer players.

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TABLES

Table 1. VO_2 comparisons between the EOS sprint and Oxycon Pro analyzer, including 95 % CIs of the differences in VO_2.

Table 2. Sample size, age, body height, body mass, absolute $VO_{2\,max}$ and velocity at $VO_{2\,max}$ for analyzed categories (mean ± SD).

FIGURE CAPTIONS

Figure 1. 95 % confidence intervals for relative $VO_{2\,max}$ as a function of performance level. CIs with the same letters are not statistically different from each other.

Figure 2. 95 % confidence intervals for relative $VO_{2\,max}$ as a function of playing position. CIs with the same letters are not statistically different from each other.

Figure 3. 95 % confidence intervals for relative $VO_{2\,max}$ as a function of age. CIs with the same letters are not statistically different from each other.

Figure 4. 95 % confidence intervals for relative $VO_{2\,max}$ as a function of time epoch. CIs with the same letters are not statistically different from each other.

Table 1. VO_2 comparisons between the EOS Sprint and Oxycon Pro analyzer, including 95 % CIs of the differences in VO_2

WL ($km \cdot h^{-1}$)	**n=**	**VO_2 EOS** ($mL \cdot kg^{-1} \cdot min^{-1}$)	**VO_2 Oxycon** ($mL \cdot kg^{-1} \cdot min^{-1}$)	**Mean diff.** ($mL \cdot kg^{-1} \cdot min^{-1}$)	**Upper level** ($mL \cdot kg^{-1} \cdot min^{-1}$)	**Lower level** ($mL \cdot kg^{-1} \cdot min^{-1}$)
6.6	32	38.23	38.24	0.01	0.15	-0.14
7.5	56	42.43	42.66	0.23	0.35	0.12
8.4	58	46.94	46.73	0.21	0.34	0.09
9.3	48	50.98	51.01	0.03	0.14	-0.08

WL= work load, n= number of measurments

Table 2. Sample size, age, body height, body mass, absolute $VO_{2\,max}$ and velocity at $VO_{2\,max}$ for analyzed categories (mean ± SD).

Category	n=	Age (yr)	Body height (cm)	Body mass (kg)	Abs. $VO_{2\,max}$ (l)	vVO_{2max} ($km \cdot h^{-1}$)
Nat. team	76	22.8 ±3.5[A]	169 ±5.5	63.2 ±5.5	3.58 ±0.37[F]	14.8 ±1.1[H]
1st division	53	21.1 ±3.5	167 ±5.0	60.6 ±5.9	3.25 ±0.30	14.4 ±0.9[H]
2nd division	28	20.9 ±3.4	-	61.6 ±8.6	3.08 ±0.35	13.4 ±1.1
Jr. nat. team	11	17.1 ±1.1	168 ±5.3	61.2 ±4.9	3.39 ±0.36	13.9 ±1.1
Juniors	17	17.5 ±1.7	168 ±7.1	62.7 ±8.3	3.23 ±0.38	13.2 ±0.8
Forwards	21	21.4 ±3.7	168 ±5.2	62.9 ±6.1	3.46 ±0.41	14.4 ±1.3
Defenders	34	22.3 ±3.4	169 ±5.2	63.1 ±4.9	3.54 ±0.31	14.7 ±1.0
Midfielders	32	22.3 ±4.3	169 ±5.9	62.9 ±5.6	3.63 ±0.40	14.8 ±1.1[I]
Goalkeepers	11	21.6 ±5.2	174 ±4.1[C]	66.9 ±4.4[D]	3.50 ±0.20	13.8 ±1.0
<20 yr	27	18.1 ±1.4	168 ±6.2	60.8 ±5.0[E]	3.42 ±0.39	14.6 ±1.3
20-24 yr	38	22.0 ±1.2	170 ±4.4	63.5 ±4.6	3.56 ±0.34	14.7 ±1.0
>24 yr	22	27.2 ±2.7	170 ±5.8	64.7 ±6.5	3.70 ±0.36[G]	14.7 ±1.2
1989-1994	37	20.7 ±3.8[B]	169 ±5.1	62.2 ±5.0	3.57 ±0.42	14.9 ±1.3[J]
1995-2001	25	23.0 ±3.6	169 ±6.6	62.1 ±6.7	3.51 ±0.36	14.7 ±1.0
2002-2007	25	23.2 ±3.5	170 ±4.7	65.0 ±4.0	3.58 ±0.31	14.2 ±0.8

A: National team players > 1st division ($p=0.031$, $d=0.5$), jr. nat.team ($p<0.001$, $d=2.3$) and juniors ($p<0.001$, $d=1.2$). **B**: Players from epoch 1989-1994 < 2002-2007 ($p=0.030$, $d=0.7$) and 1995-2001 (p=not significant, $d=0.6$). **C**: Goalkeepers > forwards ($p=0.031$, $d=1.3$), defenders ($p=0.031$, $d=1.1$) and midfielders ($p=0.031$, $d=1.0$). **D**: Goalkeepers > other positions (p=not significant, $d=0.8$ for all comparisons). **E**: <20 players lighter than >24 yr players ($p=0.036$, $d=0.7$) and 20-24 yr players (p=not significant, $d=0.7$). **F**: National team players > than 1st division ($p<0.001$, $d=1.0$)), 2nd division ($p<0.001$, $d=1.4$)) and juniors ($p=0.002$, $d=0.9$). **G**: >24 yr players > than <20 yr players ($p=0.024$, $d=0.7$). **H**: National team > 2nd div ($p<0.001$, $d=1.3$) and juniors ($p<0.001$, $d=1.7$). 1st division >2nd division ($p<0.001$, $d=1.0$) and juniors ($p<0.001$, $d=1.4$). **I**: Midfielders > goalkeepers ($p=0.049$, $d=1.0$). **J**: 1989-1994 players > 2002-2007 players (p=not significant, $d=0.7$).

Figure 1.

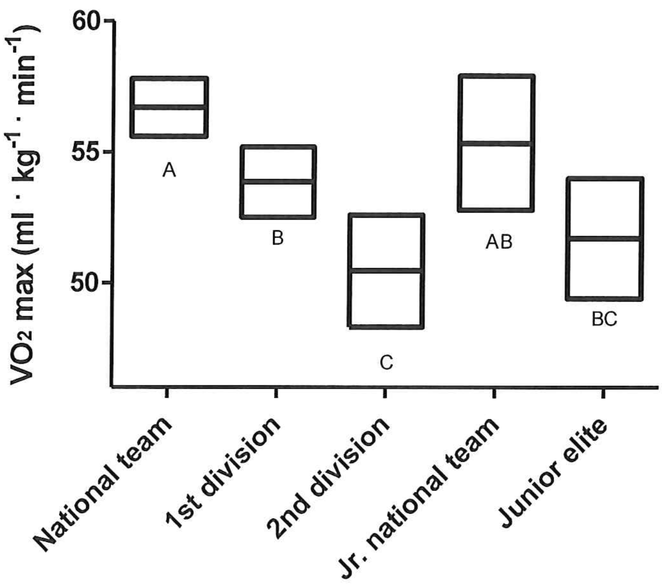

VO2 max (ml · kg-1 · min-1)
60
55
50
A
B
C
AB
BC
National team
1st division
2nd division
Jr. national team
Junior elite

Figure 2.

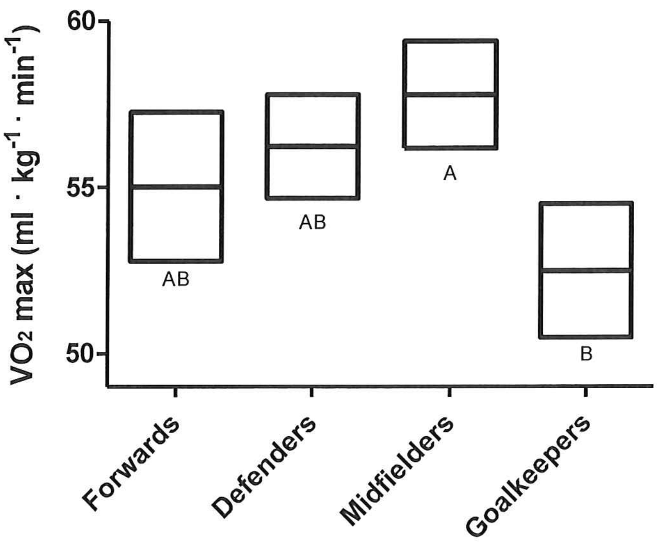

VO2 max (ml · kg-1 · min-1)
60
55
50
AB
AB
A
B
Forwards
Defenders
Midfielders
Goalkeepers

Figure 3.

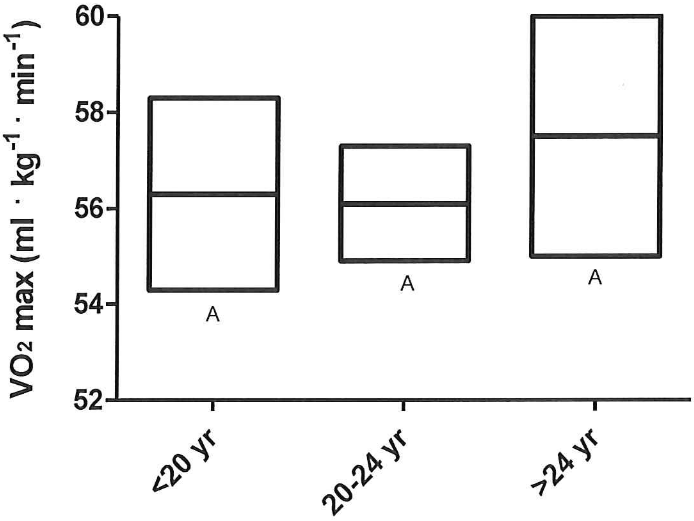
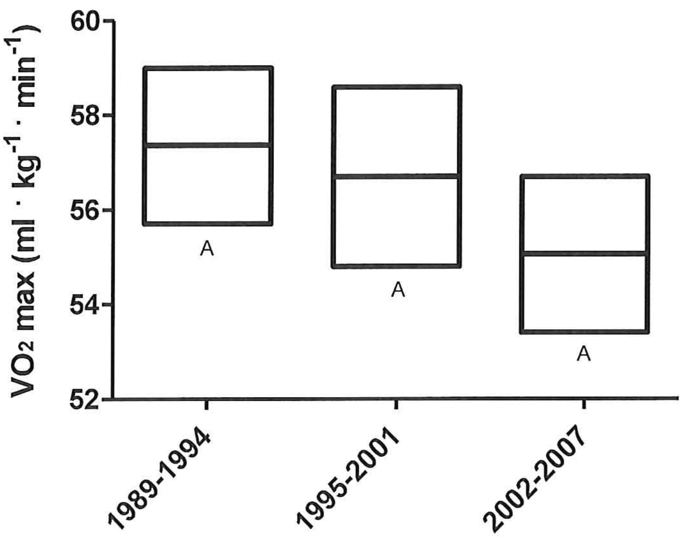


Figure 4.


VO2 max (ml · kg-1 · min-1)
60
58
56
54
52
A
A
A
1989-1994
1995-2001
2002-2007