**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. Studies of male soccer players demonstrate that capabilities such as endurance, agility, sprint and power skills should be well developed in order to become a successful player. Unfortunately, fewer studies are available regarding physical characteristics of female players. While the influence of sprinting speed and vertical jump capabilities has been well described, there is a lack of knowledge regarding the role of \( \text{VO}_{2 \text{max}} \) in women’s soccer. The aim of this study was therefore to quantify possible differences in \( \text{VO}_{2 \text{max}} \) as a function of: 1) athlete performance level, 2) field position, and 3) age. Additionally, we evaluated the evolution of \( \text{VO}_{2 \text{max}} \) in the Norwegian national squad over an 18 year period.

**Methods**

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. 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. In total, 569 \( \text{VO}_{2 \text{max}} \) 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 at the Norwegian Olympic Training Center in Oslo.

**Results**

Figure 1 shows \( \text{VO}_{2 \text{max}} \) values for all performance level categories. Senior national team players had 4.6 % higher \( \text{VO}_{2 \text{max}} \) 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 \( \text{VO}_{2 \text{max}} \) than 2nd division players \((p=0.004, \ d=0.7)\). Junior national team players had 10 % higher \( \text{VO}_{2 \text{max}} \) 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 4 shows 95 % CIs for \( \text{VO}_{2 \text{max}} \) among national team players by time epoch. No significant differences were observed across categories, but 95 % CIs tended slightly downward by ~2 ml kg \(^{-1}\) min \(^{-1}\) over the time period investigated.

**Discussion**

In the present study, a large sample of test results demonstrates a clear trend towards higher \( \text{VO}_{2 \text{max}} \) values with higher standard of play. No differences in \( \text{VO}_{2 \text{max}} \) among outfield players or age groups were observed. Relative to body mass, \( \text{VO}_{2 \text{max}} \) 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. The magnitude of the \( \text{vVO}_{2 \text{max}} \) and absolute \( \text{VO}_{2 \text{max}} \) values showed practically identical trends as for the relative \( \text{VO}_{2 \text{max}} \) values.

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**Figure 1.** 95% confidence intervals for relative \( \text{VO}_{2 \text{max}} \) as a function of performance level (upper panel) and time epoch (lower panel). Differing letters indicate significant differences among groups.