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Physical performance characteristics of high-level female soccer players 12–21 years of age

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Performance assessment has become an invaluable component of monitoring player development and within talent identification programs in soccer, yet limited performance data are available for female soccer players across a wide age range. The aim of this study was to describe the physical performance characteristics of female soccer players ranging in age from 12 to 21 years. High-level female soccer players ($n = 414$) were evaluated on linear sprinting (36.6 m with 9.1 m splits), countermovement jump (CMJ), and two agility tests. Separate one-way ANOVAs were used to compare performance characteristics between (1) each year of chronological age and (2) three age groups: 12–13 years, $n = 78$, 14–17 years, $n = 223$, and 18–21 years, $n = 113$. Mean linear sprint speed over 9.1 m was similar across all chronological ages, however sprint speed over the final 9.1 m, CMJ height and agility scores improved until approximately 15–16 years. Outcomes from the group data indicated better performance on all tests for the 14–17-year-old group compared with the 12–13-year-old group. Additionally, sprint speed on the second and fourth 9.1 m splits and 36.6 m sprint speed as well as performance on the Illinois agility test was better in the 18–21-year-old group compared with the 14–17-year-old group. The findings from this study indicate that marked improvements of high intensity short duration work occur up until 15–16 years. Smaller gains in performance were observed beyond 16 years of age as evidenced by better performance on 36.6 m sprint speed, several sprint splits and the Illinois agility test in the college aged players (i.e., 18–21-year-old group).

Implementing objective methods to assess physical performance has become an invaluable component of player development, monitoring, and talent identification in soccer (Reilly et al., 2000a, b; Williams & Reilly, 2000). For example, several investigators have demonstrated that elite players (Reilly et al., 2000a, b; Cometti et al., 2001; Gissis et al., 2006; Vaeyens et al., 2006) and selected players (Hoare & Warr, 2000; Gissis et al., 2006) perform better on linear sprint, agility or jump tests compared with sub-elite and non-selected players indicating the importance of these performance characteristics for soccer. While no single skill (i.e., technical, tactical) or characteristic (i.e., physical, physiological, psychological) can be used in isolation to identify success in soccer, outcomes from validated field-based tests (e.g., Yo-Yo test) (Krustrup et al., 2003, 2005) have been linked to match performance (Bangsbo et al., 2008), and when a comprehensive battery of tests is implemented can provide a detailed fitness profile for an individual athlete (Svensson & Drust, 2005).

The popularity of women's soccer continues to grow as evidenced by the six to eight million female athletes between the ages of 6 and 24 years playing soccer in the United States (SGMA, 2002) including over 335 000 high school (2006–2007) and 21 000 college (2005–2006) female participants (SGMA, 2002; NCAA, 2007; NFSHSA, 2007). Standing, walking, and low intensity running account for 90–95% of total match time during elite female soccer matches (Krustrup et al., 2005; Mohr et al., 2008), however the amount of sprinting performed during a match can distinguish between higher and lower standards of play (Mohr et al., 2003, 2008). Yet there is a disparity in the literature with the number of studies that characterize anaerobic performance in male players (Davis et al., 1992; Reilly et al., 2000a, b; Cometti et al., 2001; Chamari et al., 2004; Iglesias-Gutierrez et al., 2005; Gissis et al., 2006; Vaeyens et al., 2006; Gil et al., 2007; Mujika et al., 2009) far exceeding the number of published reports for female players (Hoare & Warr, 2000; Vescovi et al., 2006; Mujika et al., 2009).

Investigations designed to assess anaerobic performance of soccer players have typically included athletes that span a small age range (i.e., 2–4 years) (Hoare & Warr, 2000; Reilly et al., 2000a, b; Vescovi et al., 2006; Gravina et al., 2008; Figueiredo et al., 2009). Despite this limitation, Vaeyens et al. (2006) and Gil et al. (2007) reported that jumping and sprint ability continued to improve until approximately 16–17 years of age in two large cohorts of male soccer players. However, sex differences exist for improvements in anaerobic performance whereby vertical jump height tends to increase only through early adolescence and high-intensity work lasting 8–10 s seems to plateau at even younger ages in girls (Malina et al., 2004; Rowland, 2005). In contrast to data gathered from the general population, Mujika et al. (2009) reported that senior level female soccer players (first division, 20–26 years) performed better on countermovement jump (CMJ) and agility tests compared with junior players (second division, 16–19 years) suggesting female soccer players may continue to improve short duration anaerobic performance beyond the teenage years. Thus, investigations that have isolated groups of female athletes within a small age range may lack the ability to identify critical chronological windows where changes in various anaerobic indices important to soccer might occur.

To our knowledge no study has determined the physical performance characteristics of female soccer players across a wide age range. Data extending across the teenage years could have far reaching applications for coaches and sports scientists who use performance indices to evaluate players within the current sport structure (i.e., under-13, U-14, U-15, etc.) by providing expected values for comparative chronological ages. Thus, the primary purpose of this study was to determine performance characteristics of high-level female youth soccer players ranging in age from 12 to 21 years on linear sprinting, CMJ, and agility. A secondary aim was to present percentiles and ranges for this cohort of athletes.

Materials and methods

The athletes, and when necessary parents, were verbally informed of all experimental procedures and informed consent was completed before participation. The investigation was conducted in accordance to the Declaration of Helsinki. Participants included 78 youth (age: 12.6 ± 0.5 years), 223 high school (15.3 ± 1.0 years), and 113 college (19.4 ± 1.1 years) female soccer players. The youth and high school athletes were participating on high level club teams that practiced three to five times per week and competed regularly in regional and national tournaments. The college players were all NCAA Division I athletes and had practices four to five times per week. The two younger age groups were tested early in their summer season and the college players were assessed towards the end of their spring season. Athletes had a minimum of 5, 7, and 10 years of soccer experience in the youth, high school, and college groups, respectively. All athletes were free from any injury that would prevent maximal effort during performance testing. This cohort spanned 10 years and included 12 ($n = 33$)-, 13 ($n = 45$)-, 14 ($n = 59$)-, 15 ($n = 72$)-, 16 ($n = 64$)-, 17 ($n = 28$)-, 18 ($n = 34$)-, 19 ($n = 27$)-, 20 ($n = 27$)-, and 21 ($n = 25$)-year-old athletes.

Soccer requires athletes to perform short sprints, repeatedly change directions, and complete numerous jumps during a 90-min match (Krustrup et al., 2005; Stolen et al., 2005). Therefore, the assessment of linear sprinting, jumping, and agility are common to soccer (Hoare & Warr, 2000; Chamari et al., 2004) and were included in our battery of tests. The assessment of linear sprints using infrared timing gates and CMJ with a timing mat are highly reliable and do not require familiarization (Markovic et al., 2004; Moir et al., 2004, 2008). Standard tests for agility in soccer are not universally agreed upon (Tumilty, 2000; Svensson & Drust, 2005) and so the Pro-agility and Illinois agility tests were selected for the current study. Despite a lack of evidence on the reliability for these two particular agility tests other investigators have demonstrated high intraclass correlation coefficients (ICC) between repeated trials of several different agility tests (Alricsson et al., 2001; Sheppard et al., 2006; Beekhuizen et al., 2009; Sassi et al., 2009).

Performance assessment

Details for the assessment protocol are described elsewhere (Vescovi & McGuigan, 2008). Athletes were requested not to perform strenuous exercise 24 h before testing and were informed to refrain from the use of ergogenic aids. All athletes performed a standardized warm-up of 10–15 min that included general exercises such as jogging, shuffling, sprinting, multi-directional movements, and dynamic stretching exercises. Performance was assessed in a single session with the tests completed in the following order: linear sprint, CMJ, Illinois agility, and pro-agility. Immediately following the warm-up, the athletes were brought to the linear sprint station to initiate testing. Athletes performed two to three trials of each test with the best score used for statistical analysis. A minimum of three minutes of rest was provided between trials and approximately 6–7 min between tests to reduce the likelihood of fatigue. To ensure each participant received the same amount of rest a handheld stopwatch was used to time the interval between trials and tests. No more than 20 athletes were assessed in a single session, therefore rest periods were kept constant during all test sessions. Participants wore shorts, t-shirts, and soccer boots during testing.

Linear sprint speed was evaluated over 36.6 m. Infrared timing gates (Brower Timing, Utah) were positioned at the start line and at 9.1, 18.3, 27.4, and 36.6 m at a height of approximately 1.0 m. Participants stood upright at the start line and began when ready. The athletes were instructed to run at maximal speed through the final pair of sensors. Timing started when the laser of the starting gate was broken (i.e., first movement). The ICC ranged between 0.87 and 0.98 for the four sprint speed distances.

CMJ height was determined using an electronic timing mat (Just Jump System, Probotics Inc., Huntsville, Alabama, USA). Participants began from a standing position, performed a crouching action followed immediately by a jump for maximal height. Hands remained on the hips for the entire movement to eliminate any influence of arm swing. This system determines flight time which is converted to jump height using the following equation: $1/8\ (g/t^2)$ (where g is the acceleration due to gravity and t the air time). Performance using a timing mat can be influenced by body position during flight, therefore the subjects were instructed and carefully observed to maintain straight legs while airborne. If the knees were bent or raised the trial was discarded and the subject was given another attempt following a rest period. Since jumping

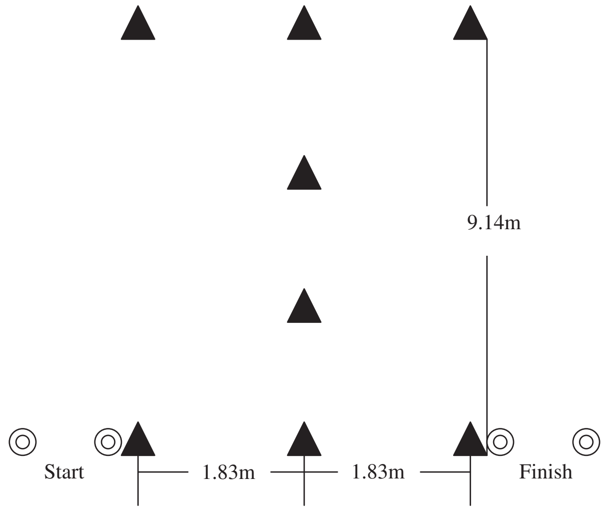

Fig. 1. Schematic view of Illinois agility test set-up. To complete the modified Illinois protocol athletes sprinted 9.1 m from the start position to the second corner cone, turned to weave down and back through the center line of cones, made one final change of direction at the third corner cone and finished with another sprint (9.1 m) across the finish line.

without arm action is not common in sport, technique was demonstrated to each participant, followed by two sub-maximal attempts by the athletes. The ICC was 0.98 for CMJ performance.

Agility was examined using a modified version of the Illinois (Fig. 1) and pro-agility (Fig. 2) tests as described previously (Vescovi & McGuigan, 2008). To complete the modified Illinois protocol athletes sprinted 9.1 m from the start position to the second corner cone, turned to weave down and back through the center line of cones, made one final change of direction at the third corner cone and finished with another sprint (9.1 m) across the finish line. Following a demonstration, each athlete was allowed to jog through the cones once before the testing trials. The pro-agility was modified by using a flying start to incorporate the use of the timing gates, which were placed at the center cone at a height of approximately 1.0 m. Athletes sprinted maximally from the starting line to the other end cone (9.1 m), touched the ground with one hand, changed direction, sprinted back to the start line, again touched the ground with one hand, made a final change of direction to sprint through the finish line at the center cone (4.6 m). The ICC was 0.98 and 0.94 for the Illinois and pro-agility tests, respectively.

Statistical analysis

A one-way ANOVA was used to compare the performance characteristics between each year of chronological age. Participants were also divided based on age into the following groups: 12–13 years, $n = 78$; 14–17 years, $n = 223$; and 18–21 years, $n = 113$ and comparisons made using a one-way ANOVA. When a significant F-value was observed, LSD *post hoc* analyses were conducted to determine pairwise differences. Percentiles and ranges were also determined for each test in all three age groups. Statistical significance was accepted at $P < 0.05$. Data are presented as mean ± SD. All statistical procedures were performed using SPSS Version 11.0.1 (Chicago, Illinois, USA).

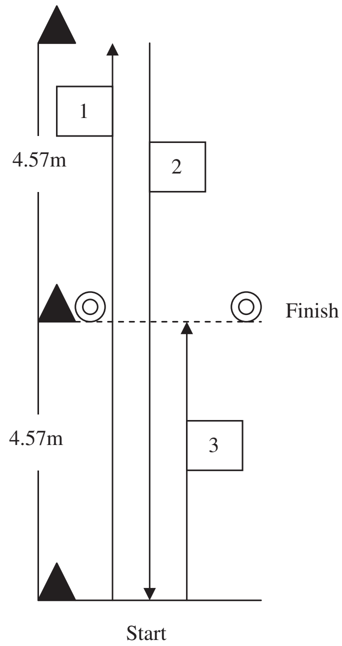

Fig. 2. Schematic view of Pro-agility test set-up. Athletes sprinted maximally from the starting line to the other end cone (9.1 m), touched the ground with one hand, changed direction, sprinted back to the start line, again touched the ground with one hand, made a final change of direction to sprint through the finish line at the center cone (4.6 m).

Results

Sprint speeds for each 9.1 m split across chronological ages are presented in Fig. 3. Results for linear sprint performance indicated differences for the second ($P \leq 0.001$), third ($P \leq 0.001$), and fourth ($P \leq 0.001$) 9.1 m splits. *Post hoc* analysis revealed 12-year-old athletes had slower speeds for the second (6.31 ± 0.35 m/s, $P \leq 0.001$), third (6.60 ± 0.44 m/s, $P \leq 0.001$), and fourth (6.34 ± 0.50 m/s, $P \leq 0.001$) 9.1 m splits compared with all other ages except for 13-year-old players. The 13-year-old players also showed differences on each of the final three 9.1 m splits (6.47 ± 0.36, 6.76 ± 0.41, 6.69 ± 0.42 m/s, respectively) compared with players from 16 to 17 and up to 21 years of age. Fourteen (6.84 ± 0.43 m/s, $P \leq 0.001$)-, 15 (6.84 ± 0.56 m/s, $P \leq 0.001$)-, and 16 (7.01 ± 0.44 m/s, $P \leq 0.001$)-year-old players had slower individual split speeds predominantly on the final 9.1 m compared with players ranging in age from 18 to 20 years.

CMJ height and times on both agility tests across chronological age are displayed in Fig. 4. Differences were observed for CMJ height ($P \leq 0.001$) and both agility tests ($P \leq 0.001$). *Post hoc* analysis revealed players 12 (37.4 ± 4.6 cm, $P \leq 0.023$) and 13 (37.4 ± 4.9 cm, $P \leq 0.015$) years old had lower CMJ height compared with players 17–21 ($\geq 40.3 \pm 3.5$ cm) years old. Additionally, 14–16-year-old players had lower CMJ height values

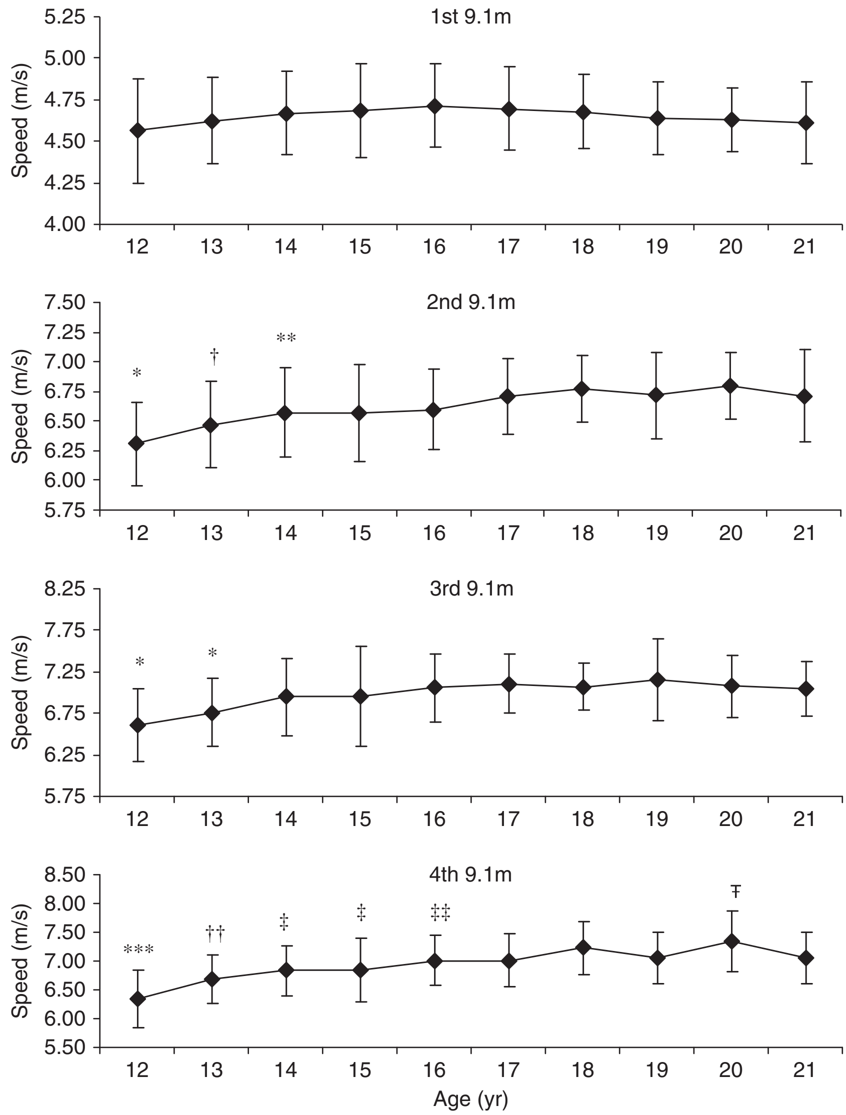

Fig. 3. Linear sprint speed for individual splits for each age. Sample size for each year of chronological age were: 12 ($n = 33$), 13 ($n = 45$), 14 ($n = 59$), 15 ($n = 72$), 16 ($n = 64$), 17 ($n = 28$), 18 ($n = 34$), 19 ($n = 27$), 20 ($n = 27$), and 21 ($n = 25$)-year-olds. *Different compared with 14–21 years.**Different compared with 18 and 20 years.***Different compared with all ages. †Different compared with 17–21 years.††Different compared with 16–21 years.ŦDifferent compared with 16, 18–20 years. ‡‡Different compared with 18–20 years. †Different compared with 17, 19, and 20 years.

(approximately 38.5 cm, $P \leq 0.048$) compared with 18–21-year-old players (>41.0 cm). The 12-year-old players had slower scores on both agility tests (pro-agility = 5.40 ± 0.28 s and Illinois = 11.22 ± 0.60 s) compared with all other ages and there was the tendency for younger athletes (e.g., 13–15 years old) to have slower times on the agility tests compared with the older athletes (e.g., 17–20 years old).

Comparisons between the three age groups as well as percentiles and ranges of performance scores are presented in Table 1. The 12–13-year-old age group demonstrated poorer scores on linear sprint speed (2.5–9.6%) compared with the two older age groups, except for 9.1 m sprint speed which was different only compared with the 14–17-year-old players by 2%. Additionally, the 12–13-year-old group showed lower CMJ height compared with the 14–17-year-old group (3.5%) and the 18–21-year-old group (12.5%) and slower agility times (4.1–5.8%) compared with the two older age groups. The 14–17-year-old players showed slower speeds on the 36.6 m sprint (1.3%) and the second (2.4%) and fourth (3.8%) 9.1 m splits as well as lower CMJ height (8.5%) and greater time on the Illinois agility test (1.5%) compared with the 18–21-year-old group.

Discussion

To our knowledge, this is the first study to report physical performance characteristics in a large cohort

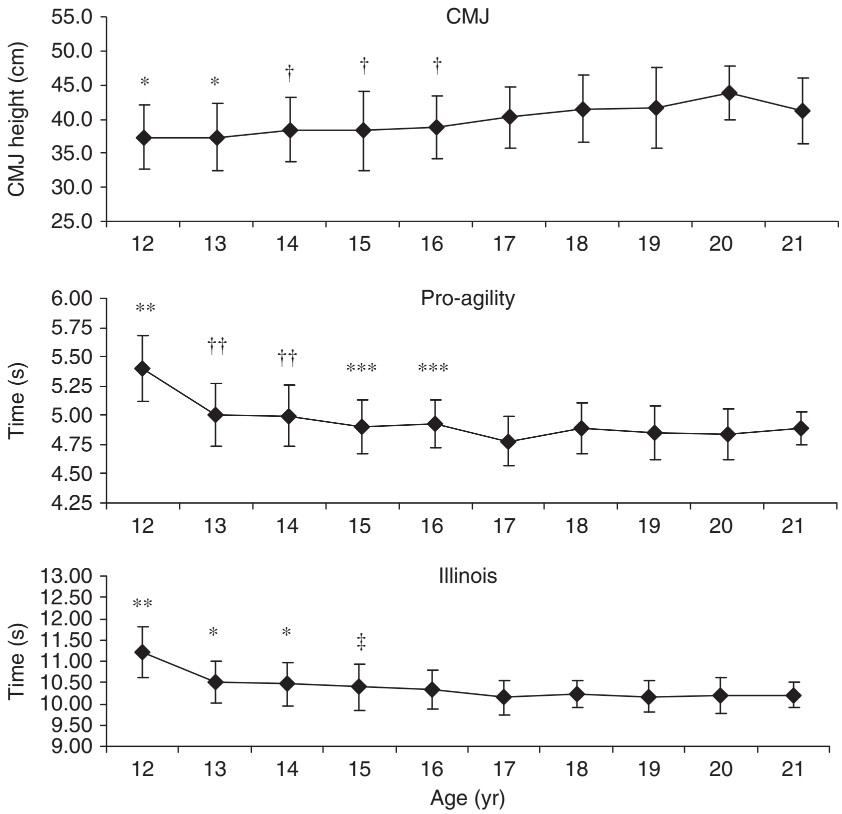

Fig. 4. Countermovement jump (CMJ) height and agility performance for each age. Sample size for each year of chronological age were: 12 ($n = 33$), 13 ($n = 45$), 14 ($n = 59$), 15 ($n = 72$), 16 ($n = 64$), 17 ($n = 28$), 18 ($n = 34$), 19 ($n = 27$), 20 ($n = 27$), and 21 ($n = 25$)-year-olds. *Different compared with 17–21 years. **Different compared with all ages. ***Different from 17 years. †Different compared with 18–21 years. ††Different compared with 15, 17–20 years. ‡Different from 17 and 19 years.

of female soccer players ranging in age from 12 to 21 years. Our data supports and expands upon previous findings that indicate performance of high intensity tasks lasting only several seconds plateaus during the early to mid-teenage years in young women (Loko et al., 2000, 2003; Malina et al., 2004; Rowland, 2005). Our data also uniquely suggests that 36.6 m speed, CMJ height, and Illinois agility performance are improved in female soccer players beyond the chronological ages associated with high school.

Results from the current investigation showed no difference in 9.1 m speed across the entire age range with a plateau in the second and third 9.1 m splits occurring by 13–14 years. This is not surprising considering that other investigators have reported that the greatest rate of improvement in sprint ability occurs between the ages of 10–13 years (Loko et al., 2000, 2003). Additionally, Barber-Westin et al. (2006) observed maximum isokinetic quadriceps and hamstring strength in girls 13 and 11 years old, respectively, supportive of the link previously demonstrated between strength, sprint performance, and jump height in male soccer players (Wisloff et al., 2004). Sprint speed continued to increase in the fourth 9.1 m split until 16 years and between the ages of 13 and 17 improved by an average of 4.8%, similar to the approximate 5% increase over 30 m reported by Loko et al. (2003) in a group of physically active Estonian girls. In contrast to much of the literature describing age related changes in sprint ability, Mujika et al. (2009) reported senior level female soccer players had a faster mean sprint speed (0.13 m/s or 2.1%) over 15 m compared with junior players. The 15 m sprint implemented by Mujika et al. (2009) included a 3 m flying start, which would be comparable in total distance – 18 m – to the second 9.1 m split from the current study (i.e., total distance 18.2 m). Our results revealed a 0.16 m/s (2.4%) difference between the 14 and 17-year-old age group compared with the 18–21-year-old group in the second 9.1 m split and a 3.8% increase from the younger to the older age group in the fourth 9.1 m split (Table 1). In contrast to the individual sprint splits, speed for 9.1, 18.2, and 27.3 m was similar between the two older age groups. Taken together with the findings of Mujika et al. (2009) these outcomes suggest that flying sprint ability can continue to improve beyond the teenage years in female soccer players.

The assessment of linear sprint splits provides added insight into sprint performance that is not available by simply examining total sprint speed over a given distance (Brown et al., 2004). For example, the cumulative sprint speeds (Table 1) indicate that within each age group sprint performance improved with increasing distance. However, mean split speed improved up to the third 9.1 m split in the 12–13 and 14–17-year-old age groups, but showed a 1–2% decline between the third and fourth splits. In contrast to the younger age groups, mean sprint speed continued to increase through the final 9.1 m split in the 18–21-year-old players indicating an enhanced ability to maintain sprint speed through 36.6 m. Short-term muscle power increases with age, which may be linked to changes in muscle structure, size, or metabolism (Van Praagh & Dore, 2002). For example, children and young adolescence have reduced glycolytic capacity, but have greater rates of PCr re-synthesis (Van Praagh & Dore, 2002), which could be a likely reason why the younger athletes in the current study had similar 9.1 m sprint speed compared with the older athletes. Later during puberty there is an elevation in glycolytic enzyme activity (e.g., aldolase, pyruvate kinase, and phosphofructokinase) (Malina et al., 2004), which might contribute to the observed ability of the older athletes in the current study to maintain or improve speed over 36.6 m.

Other investigators have reported a 40–45% increase in mean sprint speed when comparing the first 10 m to flying 20 m (i.e., 10–30 m) in male field sport athletes (Cronin & Hansen, 2005; Ronnestad et al., 2008). The current data and previous work from our group (Vescovi & McGuigan, 2008) have demonstrated similar changes ranging from 42% to 49% in female soccer players over comparable distances (i.e., 9.1 m and flying 18.2 m). Interestingly, the relative difference in sprint speed between 9.1 m and flying 18.2 m changed from 43% to 47% and 49% for the 12–13, 14–17, and 18–21-year-old age groups, respectively, indicating a greater ability of the older athletes to increase speed after 9.1 m, suggestive of age-related improvements in muscle size, function or metabolism (Van Praagh & Dore, 2002). We also found that the relationships between sprint splits was weaker for the 18–21-year-old age group (range $r = 0.51–0.56$) compared with the 12–13 (range $r = 0.72–0.74$)-year-old age group indicating independent sprint qualities over 36.6 m in the older athletes. The current findings demonstrate the utility of individual sprint splits in the determination of specific sprint performance characteristics in female soccer players of varying ages.

CMJ showed improvements until 15–16 years after which there was a plateau until 21 years. In contrast to our results Loko et al. (2000) reported improvements in vertical jump until 13 years of age in a large cohort of Estonian girls, but later identified improvements until the age of 15 in a group of age-matched girls who were regularly involved with track and field

Table 1. Percentiles and ranges

	12–13 years (*n* = 78)					14–17 years (*n* = 223)					18–21 years (*n* = 113)				
	Mean ± SD	25	50	75	Range	Mean ± SD	25	50	75	Range	Mean ± SD	25	50	75	Range
9.1 m (m/s)	4.60 ± 0.29*	4.40	4.57	4.80	3.99–5.29	4.69 ± 0.26	4.50	4.72	4.87	3.78–5.42	4.64 ± 0.22	4.50	4.62	4.79	4.10–5.29
18.2 m (m/s)	5.35 ± 0.30†	5.10	5.36	5.57	4.78–6.13	5.48 ± 0.27	5.31	5.48	5.67	4.50–6.11	5.50 ± 0.24	5.35	5.52	5.65	4.92–6.11
27.3 m (m/s)	5.73 ± 0.32†	5.45	5.75	5.98	5.19–6.53	5.90 ± 0.31	5.72	5.91	6.13	4.89–6.69	5.94 ± 0.25	5.78	5.96	6.06	5.29–6.52
36.6 m (m/s)	5.95 ± 0.35†	5.63	5.96	6.21	5.30–6.79	6.16 ± 0.34‡	5.97	6.16	6.42	5.12–7.01	6.24 ± 0.28	6.06	6.26	6.42	5.55–6.84
Second 9.1 m (m s)	6.40 ± 0.37†	6.07	6.41	6.65	5.69–7.34	6.59 ± 0.37‡	6.36	6.59	6.89	5.58–7.34	6.75 ± 0.33	6.55	6.74	6.95	5.99–7.65
Third 9.1 m (m/s)	6.69 ± 0.42†	6.36	6.69	6.96	5.80–7.65	7.00 ± 0.39	6.74	7.00	7.34	5.72–8.58	7.09 ± 0.37	6.84	7.05	7.25	6.23–8.27
Fourth 9.1 m (m/s)	6.54 ± 0.49†	6.19	6.55	6.91	5.35–7.52	6.91 ± 0.39‡	6.59	6.89	7.28	5.69–7.98	7.17 ± 0.48	6.89	7.11	7.43	6.11–8.50
CMJ (cm)	37.4 ± 4.8†	34.5	37.0	40.7	27.2–48.3	38.7 ± 5.0‡	35.3	38.9	42.2	27.2–51.3	42.0 ± 5.0	38.6	42.4	45.2	30.0–54.8
Pro-agility (s)	5.17 ± 0.33†	5.38	5.21	4.93	4.38–5.91	4.92 ± 0.24	5.05	4.91	4.74	4.42–5.57	4.87 ± 0.21	4.99	4.85	4.72	4.54–5.62
Illinois (s)	10.80 ± 0.64†	11.14	10.79	10.35	9.47–12.45	10.36 ± 0.50‡	10.66	10.28	10.02	9.17–12.07	10.20 ± 0.36	10.34	10.18	9.97	9.63–11.21

*Different compared with 14–17 years players.
†Different compared with 14–17 and 18–21 years players.
‡Different from 18 to 21 years players.
CMJ, countermovement jump.

(Loko et al., 2003). More recently, Temfemo et al. (2009) evaluated CMJ height in a group of 11–16-year-old girls and demonstrated steady increases averaging 2–3 cm per year until 15 years. CMJ height in the current group of 16-year-old girls (38.8 cm) was similar to the performance in the same age group reported by Temfemo et al. (2009) (36.8 cm), however, they showed a difference of nearly 10 cm compared with their 12-year-old girls (27.5 cm), whereas the difference in CMJ height between those two ages in our sample of athletes was substantially smaller because of a greater mean jump height in our 12-year-old girls (37.4 cm). The noticeable 35% difference between studies for CMJ height in the 12-year-old girls (i.e., 37.4 vs 27.5 cm) may likely be related to the training status of participants as a similar comparison of the data presented by Loko et al. (2003) indicated an approximate 20% difference in CMJ height between physically active and non-active 12-year-old girls.

Agility is a specific athletic attribute (Little & Williams, 2005; Vescovi & McGuigan, 2008) that can distinguish between senior and junior players (Mujika et al., 2009) as well as selected and non-selected developmental female soccer players (Hoare & Warr, 2000). Performance on both agility tests showed the largest change between 12 and 13 years, then modest improvements were observed until 15–16 years when a plateau occurred. Between the three age groups pro-agility scores were stable after 12–13 years, however there was a continued improvement across each group for the Illinois test. The data from several studies collectively demonstrate that participation in sport may help to improve motor skill performance in younger athletes compared with non-active age-matched individuals and that continued involvement in athletics could potentially elongate the age at which a plateau in anaerobic performance is observed. Whether these benefits reflect continued participation in sport or adaptations to specific training regimens aimed at enhanced performance (e.g., resistance training, plyometric drills, etc.) is unknown.

Several limitations for this study warrant consideration. First, there is a possibility that training status influenced the outcomes since it is common for NCAA Division I programs to have strength and conditioning coaches working with athletes throughout the academic year. Additionally, some high school athletes also participate in specialized training regimens beyond sport practices. Since a plateau in performance was observed by age 15 or 16 years it would seem unlikely that the data suggests a majority of the athletes younger than this age did not perform any additional training whereas a majority of the athletes older than this age regularly engaged in performance enhancing training strategies. Second, we cannot ignore that biological differences likely exist within the age groups included in this study and the possibility that biological age influenced the outcomes. Still the fact remains that the current structure within soccer is based on chronological ages (i.e., U-13, U-14, U-15, etc.), therefore biological differences will certainly exist in any cohort and so the current outcomes provide a good source of normative standards for linear sprint speed, CMJ height and agility for female soccer players. Lastly, the athletes included in this study all competed on high level teams, however, the teams competed for different clubs (youth and high school) and within different conferences (college), thus making direct comparisons of the standard of play challenging.

Perspectives

There are many reasons to implement physical performance tests with soccer players including the determination of individual strength and limitations, evaluating responses to a training regimen, monitoring normal growth and development (Svensson & Drust, 2005) or as a component of talent identification and selection programs (Hoare & Warr, 2000; Reilly et al., 2000a, b; Williams & Reilly, 2000). Within the limitations of this study, the present data can be used by sport scientists and coaches to evaluate and monitor the physical performance characteristics of female soccer players, and in conjunction with other recent reports (Mujika et al., 2009) suggests that participation in soccer into early adulthood may provide the stimulus necessary for continued improvements of high intensity short duration work into late adolescence and possibly early adulthood. We also provide evidence for the utility of evaluating sprint splits to determine specific sprint qualities in female soccer players, which tend to vary between 12 and 21 years.

Key words: female soccer, growth and development, sprint speed, agility.

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