

Do anthropometric and fitness characteristics vary according to birth date distribution in elite youth academy soccer players?

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We examined whether maturity, anthropometric profiles and fitness measures vary according to birth date distribution in elite, under-14 youth academy soccer players. The selection year was divided into four quarters, with 160 male players grouped according to individual birth date. Players had their skeletal age determined and were assessed using a battery of standard anthropometric and physical performance tests. Players born across all quarters of the year were investigated for differences in the various performance characteristics using multi- and univariate analyses. An uneven birth distribution was observed, with players born

early in the selection year highly represented ($P < 0.01$). A significant difference in height was observed across quarters ($P < 0.01$) with higher values reported in the earlier-born players. No significant differences were observed across any of the fitness measures, although the trend was for players born in the first quarter to out-perform peers born in the later quarters. These findings suggest that the relative age of the performer may not always be linked to a significant advantage in physical components. The selection criteria for entry into the academy may explain the present results.

The focus on youth soccer and the emphasis on identifying and developing young talent at an early age have grown dramatically over recent years (Stratton et al., 2004). Many factors are relevant in determining the success of a soccer player and the requirements for high-level play are multifactorial, ensuring that the process of predicting ultimate performance potential at an early age is difficult and complex (Reilly et al., 2000a). Over recent years, researchers have nevertheless attempted to identify factors that predispose certain players toward success in soccer with attention being paid to anthropometric and fitness characteristics (Janjovic et al., 1993; Reilly et al., 2000a; Gil et al., 2007). However, in youth players, these features are often determined by the rate of maturation and growth of the individual. At certain ages, players may be advantaged or disadvantaged in terms of physical capacity and coaches and scouts tend to favor the physically advanced players as these are shown to be better performers in physical tasks compared with later maturing peers (Malina et al., 2000, 2004).

Closely linked to this talent selection problem is the well-reported relative age effect (RAE). In youth sports generally, players are divided into age categories based on their date of birth or chronological age. A start and finish date is used to determine the

selection year and players are selected from individuals born in the same 12-month period. Therefore, within the same age category, there can be a difference of almost full year between the oldest and youngest participants. A bias has been documented toward recruitment of individuals born early in the year across different age categories and standards in soccer (Helsen et al., 2005). Several explanations have been forwarded to explain the increased success for players born earlier in the selection year, with differences in development and maturation and the advantages that a greater physique can provide suggested as major contributing factors (Helsen et al., 2000; Musch & Grondin, 2001; Malina et al., 2007).

In professional soccer, the percentage of players born early in the selection year is particularly high because talent identification and selection processes within elite youth academies tend to aggravate the RAE bias (Mujika et al., 2007; Jullien et al., 2008). Although not verified empirically, there are suggestions that athletes may be perceived as being more “talented” and selected purely because of maturity-related advantages in body size, strength, speed and endurance (Sherar et al., 2007). An investigation into the link between physical characteristics and the

RAE in elite youth soccer players and how this may have impacted on whether these individuals progress or not to professional level is warranted.

In this study, we present three hypotheses. First, players who are born later in the selection year are likely to differ across a range of anthropometric and fitness measures of performance compared with those born earlier in the year. Second, players who do not achieve professional status are likely to differ across a range of anthropometric and fitness measures compared with peers who do progress to professional status and are born in the same periods of the selection year. Finally, anthropometric and fitness measures in professional graduates born in different quarters of the selection year are likely not to differ.

Material and methods

A total of 160 elite youth soccer players, all born in France, who attended the Clairefontaine Institut National du Football [National Institute of Football (INF)] participated. Players were assessed over an 11-year period (1994–2005). The INF is a pre-apprenticeship center for future French professional soccer players aged from 14 to 16 years of age and acts as a “feeder” for professional clubs. The Institute has a three-year residency policy, which segregates its players into three age categories: INF first year (Under 14 years of age), INF second year (Under 15 years of age) and INF third year (Under 16 years of age). Before joining the INF, players progress through several talent identification and selection stages where they undergo assessment of technical, tactical, physical and mental skills. On acceptance into the INF, players undergo stringent pre-participation medical screening to identify the existence of any pathophysiological condition which may contraindicate playing elite soccer (Le Gall et al., 2007). Players accepted into the center are “highly selected” and considered to be among the very best in French youth soccer.

On graduation from the INF, players either joined or did not join a professional club. In the present study, players classed as professionals were those who had played at least one competitive match for a club as a full-time professional, whereas “non-professionals” were players who on leaving the institution did not acquire a professional contract at a club. In this study, players in the first year group (Under 14) were selected for investigation.

Consent forms were completed for each participant by a parent or guardian because the players were under the legal age of consent. The ethical approval for the study was granted by the Fédération Française de Football. All test procedures over the entire study period were undertaken by the same physician specialized in sports medicine. Players performed a battery of fitness tests at the beginning of the competitive season, before pre-season training, as part of their development program. The determination of skeletal age was carried out as part of the INF’s pre-participation medical screening program.

To ensure standardization of test administration across the entire study period, all tests were scheduled at the same time of day and carried out in the same order and using the same apparatus. Each test was preceded by a standardized warm-up and familiarization session. Participants were instructed to refrain from strenuous exercise for at least 48 h before the fitness test sessions and to consume their normal pre-training

diet before the testing session. These assessment procedures are in general accordance with the guidelines for fitness testing recommended by the British Association of Sport and Exercise Sciences (Winter et al., 2007).

The participants’ dates of birth and skeletal age were recorded to examine the RAE and to determine biological maturity status, respectively. Measurements were undertaken according to two main categories: anthropometric profiles and fitness performance characteristics. The procedures in each element of assessment are described in turn.

RAE

To investigate birth distribution and the RAE, players were divided into one of four groups (referring to quarters of the year) according to their date of birth in the selection year (Helsen et al., 2005). In France, before 1996, the cut-off date for the selection year in youth soccer ran from 1 August to 31 July. After 1996, the cut-off date for the selection year in youth soccer runs from 1 January to December 31. Therefore, before 1996, Group 1 (first quarter or 1Q) included players born in August, September and October, Group 2 (second quarter or 2Q) those from November, December and January, Group 3 (third quarter or 3Q) those from February, March and April and Group 4 (fourth quarter or 4Q) from May, June and July, respectively. After 1996, Group 1 (first quarter or 1Q) included players born in January, February and March, Group 2 (second quarter or 2Q) those from April, May and June, Group 3 (third quarter or 3Q) those from July, August and September and Group 4 (fourth quarter or 4Q) from October, November and December, respectively.

Biological maturity status

A standard radiological examination of the left hand and wrist of each player was carried out at the beginning of the season to determine skeletal age using the matching atlas of Greulich and Pyle (1959). The physician assessed the hand-wrist radiographs by comparing them to the plates in the Greulich and Pyle atlas. Bone-specific skeletal ages were not evaluated. Skeletal age is an indicator of biological maturity status and players were classed according to their skeletal age compared with chronological age (Vaeyens et al., 2006). A positive score indicates that skeletal age is in advance of chronological age, whereas a negative score indicates that skeletal age lags behind chronological age (Malina et al., 2000).

To assess intra-observer reproducibility, the radiographs of 15 players were randomly selected from the sample as a whole and subsequently re-assessed 6 months after the initial assessments were made (Malina et al., 2000; Le Gall et al., 2007). The mean difference between assessments of SA was 0.1 years [standard deviation (SD) = 0.14], indicating a high level of intra-observer reproducibility. The correlation between assessments was 0.94.

While the Greulich–Pyle method is used internationally as a standard means for determining skeletal age, one must acknowledge limitations previously outlined by Malina et al. (2004) when applying this method (notably the influence of ethnic variation and external factors on skeletal maturation). Nevertheless, we chose the Greulich–Pyle method as its implementation is logistically practical for use in the working practices of elite soccer (Le Gall et al., 2007) and its acceptable level of reliability when compared with other methods of determining skeletal age (Groell et al., 1999; Haiter-Neto et al., 2006).

Anthropometry

Anthropometric measurements were obtained using portable measurement devices (Holtain Instruments Ltd., Crymych, UK) and standardized laboratory procedures. Calibrated precision weighing scales were used to obtain body mass (in kilograms) and a cursor was placed on each participant's head to help measure height (in centimeters).

As an estimate of adiposity, skinfold thicknesses were measured at four sites using a Harpenden skinfold calliper (British Indicators Ltd., Luton, UK). Measures taken at the triceps, biceps, subscapular and suprailiac were used for calculation of percent body fat according to the equations described by Durnin and Womersley (1974).

Anaerobic capacity

The running speed of players was evaluated on a synthetic field from a standing start over distances of 10 and 40 m, respectively, using electronic timing gates (Tag Heuer, Biel, Switzerland). Two efforts, separated by a 10-min rest interval, were undertaken with data from the fastest 40 m effort being recorded (along with the corresponding time over 10 m). The recorded time over the last 10 m of the fastest 40 m sprint was used to derive the maximal anaerobic power output of each participant (Le Gall et al., 2002).

Players also performed a vertical jump to determine lower body explosive strength using a Bosco jump mat (Ergojump, Magica, Rome, Italy). Using a countermovement jump with arm-swing, the best of the three double-leg vertical jumps without run up was recorded.

The strength of the knee flexors of both the dominant and non-dominant lower members was measured on a Cybex 340 isokinetic dynamometer (Cybex, New York, New York, USA). Leg strength was assessed by determining the peak concentric torque at angular velocities of 1.05 and 4.19 rad/s. Three maximal voluntary repetitions were undertaken with test order proceeding from the slower to the faster speed. The best of the three efforts was recorded.

Endurance capacity

The estimated $\dot{V}O_{2\max}$ values were calculated using a 20-m continuous progressive track run test (Chtara et al., 2005) for the measurement of maximal aerobic speed ($v\dot{V}O_{2\max}$). This test took place on a 400 m track with cones placed every 20 m. A pre-recorded soundtrack indicated with brief sounds the instant when the player had to pass near a cone to maintain the imposed speed. A longer sound marked a change of stage. The first stage was set at 8 km/h with subsequent increments of 0.5 km/h per 1-min stage. The test was finished when the player was unable to maintain the imposed running speed. The speed corresponding to the last completed stage was recorded as $v\dot{V}O_{2\max}$ (km/h) which was then used to estimate the participant's $\dot{V}O_{2\max}$.

Analyses

A chi-square test was used to test the observed and expected birth distribution across the sample of players. Group data are expressed as means and standard deviations ($M \pm SD$) for 12 dependant variables (height, body mass, percent body fat, 10 and 40 m sprint times, counter-movement jump, peak concentric torque for quadriceps at 1.05 and 4.19 rad/s, maximal anaerobic power and estimated aerobic power). The data sets were analyzed using multivariate analyses of co-variance (MANCOVA). As per the study by Malina et al. (2007), we

used chronological age as a covariate in all the multivariate analyses. Chronological age was controlled for as this is a potential confounding factor in the analysis especially as we observed a significant difference in this variable across birth quarters ($P < 0.001$). A two-way MANCOVA was used to compare performance on all 12 variables for the two groups (professional vs non-professional) across the four birth quartiles (1Q vs 2Q vs 3Q vs 4Q). A separate one-way MANCOVA was run across the four quartiles of birth using data from the professional players only. The level of significance was set at $P < 0.05$. Follow-up univariate analyses were undertaken using ANOVA and post-hoc Bonferroni-corrected pair-wise comparisons tests where appropriate. All calculations were performed using Microsoft Excel (Microsoft, Seattle, Washington, USA) and Statistica (Statsoft, Tulsa, Oklahoma, USA).

Results

The birth date distribution according to the selection year quarter in which players were born is presented in Fig. 1. Players born early in the selection year were highly represented with a decreasing number of players born in the subsequent quarters ($\chi^2_{(3)} = 60.05$, $P < 0.01$). Players in both the professional ($\chi^2_{(3)} = 20.09$, $P < 0.01$) and non-professional groups ($\chi^2_{(3)} = 41.112$, $P < 0.01$) demonstrated a bias toward the first quarter. Figure 2 presents the percentage of players born in each quarter that succeeded or not in achieving professional status. Out of a total of 75 and 49 players born in the 1Q and 2Q periods, respectively, 45.6% and 38.8% achieved professional status. This figure compares to a total of 26 (43.3%) and 10 (70%) players who were born in the 3Q and 4Q periods, respectively.

Professional and non-professional players were compared across the four birth quarters for differences in skeletal age and anthropometric and fitness characteristics. These data are presented in Tables 1 and 2. The MANCOVA indicated no significant group differences across the professional and non-professional players, $F(12, 124) = 1.11$, Wilks' $\lambda = 0.90$, $P > 0.05$. Also, the interaction between group and quartile of birth was not significant, $F(36, 367) = 1.14$, Wilks' $\lambda = 0.73$, $P > 0.05$. However, there was a significant difference across the

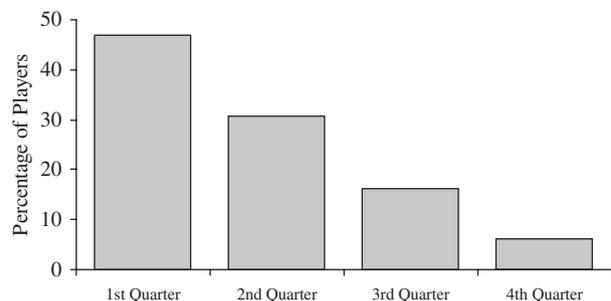


Fig. 1. Percentage of players born in each of the four quarters of the year.

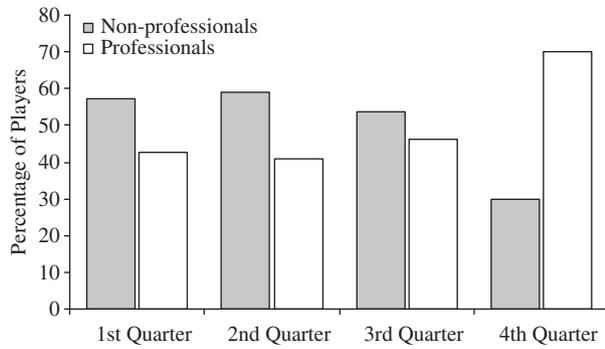


Fig. 2. Percentage of players born in each of the four quarters of the year according to graduate status.

four birth quartiles, $F(36, 367) = 1.60$, Wilks' $\lambda = 0.65$, $P < 0.05$. Follow-up univariate analyses on the latter main effect revealed a significant difference for chronological age in 1Q players compared with all other quarters and 2Q players vs 4Q players ($P < 0.001$). A significant difference ($P = 0.009$) was reported for height in 4Q players compared with peers born in the other quarters. A value approaching significant between quarters was obtained for mass ($P = 0.0625$) with players born in the last quarter recording the lowest value. Although superior values were reported across the majority of the fitness variables in players born in the first three quarters compared with the last quarter, no significant differences were recorded across any of the performance characteristics.

We also compared performance across the four quarters for professional players only using a one-way MANCOVA. This analysis revealed a significant effect across the four quarters, $F(36, 127) = 1.79$, Wilks' $\lambda = 0.29$, $P < 0.05$. Follow-up univariate analyses showed a significant difference in chronological age (Q1 vs all other Qs, $P < 0.001$), height (all Qs vs Q4, $P < 0.001$), weight (Q3 vs Q4 $P = 0.049$), estimated VO_{2max} (Q1 and Q2 vs Q3, $P = 0.007$), maximal anaerobic power (Q1 and Q3 vs Q4, $P = 0.039$) and maximal concentric strength of the non-dominant limb at 1.05 rad/s (Q4 vs all other Qs, $P < 0.001$). A significant difference was also obtained for sprint speed over 10 m ($P = 0.035$), but the post-hoc test was unable to discriminate between the four quarters although players with birth dates in the second quarter presented the slowest times.

Discussion

Our results confirmed previous observations that players selected to join the present elite academy demonstrated an uneven birth distribution. The percentage of players born in the final quarter of the year is in the range previously reported for other elite youth soccer players (Helsen et al., 2000, 2005; Simmons & Paull, 2001). Similarly, Gil et al. (2007) reported that 79% of Under-14 Spanish players belonging to a high-level club were born in the first

Table 1. Age, biological maturity and anthropometric characteristics of elite youth soccer players according to birth distribution

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Chronological Age (years)*	13.69 ± 0.40	13.43 ± 0.37	13.24 ± 0.28	13.03 ± 0.35
Skeletal Age (years)	13.95 ± 1.34	13.79 ± 1.49	13.43 ± 0.95	12.85 ± 1.33
Skeletal Age–Chronological Age (years)**	0.26 ± 1.30	0.36 ± 1.34	0.19 ± 0.99	– 0.18 ± 1.39
Anthropometry				
Weight (k)	52.77 ± 9.41	52.34 ± 8.89	51.67 ± 10.74	45.52 ± 6.47
Height (cm)	164.96 ± 9.63	163.5 ± 7.74	162.02 ± 8.99	155.00 ± 8.02
Body Fat (%)	12.12 ± 2.26	12.13 ± 2.27	13.22 ± 2.55	13.02 ± 2.24

*Significant difference for chronological age between 1Q players vs players from all other quarters and 2Q and 4Q players ($P < 0.001$).

**Significant difference for height between 4Q players vs players from all other quarters ($P < 0.05$).

Table 2. Fitness characteristics of elite youth soccer players according to birth distribution

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Vertical jump (cm)	43.06 ± 5.98	42.03 ± 4.51	44.05 ± 6.91	41.87 ± 5.88
10 m sprint (s)	1.95 ± 0.09	1.98 ± 0.07	1.94 ± 0.08	1.97 ± 0.12
40 m sprint (s)	5.88 ± 0.29	5.94 ± 0.26	5.86 ± 0.29	6.03 ± 0.31
Maximal anaerobic power (W)	1689.60 ± 505.68	1643.24 ± 443.79	1681.69 ± 542.94	1290.5 ± 410.04
Peak torque (Nm)				
Quadriceps				
1.05 rad/s Dominant leg	163.00 ± 37.65	164.71 ± 26.33	154.21 ± 38.91	138.56 ± 37.21
4.19 rad/s Dominant leg	96.14 ± 23.3	93.64 ± 17.71	89.67 ± 20.75	83.00 ± 23.4
1.05 rad/s Non-Dominant leg	166.64 ± 32.9	163.16 ± 27.92	159.88 ± 35.23	135.86 ± 30.87
4.19 rad/s Non-Dominant leg	98.47 ± 21.94	96.53 ± 20.39	94.21 ± 25.29	81.33 ± 21.94
VO_{2max} (mL/kg/min)	58.5 ± 2.93	58.05 ± 3.81	56.8 ± 2.71	58.14 ± 1.83

6-months of the selection year, which is highly comparable to the 72% figure reported in the present study. However, what is novel is the lack of differences in the percentages for the INF players born across the first three quarters of the year who eventually became professional. In addition, out of all the players born in the last quarter, a higher proportion was reported for those who on graduation, succeeded in turning professional compared with those who did not succeed. Therefore, these results suggest that once the players had integrated into the elite youth academy, their date of birth did not influence the opportunity to progress to professional levels. However, caution is necessary when interpreting these results due to the smaller numbers of players belonging to the last birth quarter.

The overrepresentation of INF players born early in the selection year would strengthen the suggestion that talent identification and selection in soccer during early adolescence appear to be influenced significantly by a child's physical attributes rather than skill (Helsen et al., 2000). Yet, no differences in any of the fitness characteristics were observed between players born across different periods of the selection year or when we distinguished between professional and non-professional graduates, although trends were noted for players born in the first quarter to generally out perform those born in the other quarters. This result confirms the findings of Malina et al. (2007) who observed no clear trend in functional capacities in a group of youngest to oldest 14-year-old boys. These observations suggest that in a group of highly selected under-14-year elite players being born later in the year does not necessarily mean that a player is significantly "physically" disadvantaged.

Nevertheless, the significant difference in height (~ 10 cm) observed in the present investigation confirmed the findings reported by Sherar et al. (2007) and Delorme and Raspaud (in press). In these papers, a significant difference was observed in stature in elite ice hockey and basketball players, respectively, who were born early in the selection year compared with peers born later in the year. In the present group of players, a substantial difference was also observed in body mass (~ 7 kg) and in some anaerobic measures (notably sprint and peak concentric strength) between players born in the first and fourth quarter, respectively. The mean chronological age of the first quarter group was highly comparable to the mean chronological age for peak height and weight velocity reported in amateur youth soccer players (Philippaerts et al., 2006) and may partly explain the differences (albeit non-significant) in anthropometric and fitness measures. A similar study on the effects of peak height and weight velocity on fitness and anthropometric variables in elite youth soccer players is warranted.

The non-inclusion of information on the ethnic origins of the present players is a limitation of this study. This information would have been important when interpreting the present results as previous work has shown that the ethnic origin of adolescents is linked notably to variations in age at peak height velocity, timing of stages of puberty and skeletal age (Malina et al., 2004).

The Institute's selection policies seem to have led to the formation of "homogenous" groups of players in terms of physical ability, whatever their birth date within a 1-year period. It is difficult to provide full explanations for the lack of evidence of a significant link between anthropometric and fitness characteristics and birth date in the present study although we can suggest that this discrepancy is most likely due to the holistic assessment criteria used when selecting players at under-14 level to join the INF. While anthropometric and fitness measures are considered important, the selection policies of the present center are based on equal opportunities and ensure that talented players are rarely rejected on the basis that they have demonstrated weaknesses in physical characteristics of performance. Furthermore, the policies of the institution include the determination of biological maturity on acceptance, which provides practitioners with an accurate indicator of the growth and physical potential of players. This procedure is important as inter-individual differences in physical performance are generally transient as late maturers, on average, catch up in many aspects of performance in young adulthood (Lefevre et al., 1990) and can eventually outscore players who previously demonstrated advanced maturity (Le Gall et al., 2002).

However, Reilly et al. (2000a) reported that while elite soccer players may not need to have an extraordinary capacity within any of the areas of physical performance, they must possess a reasonably high level within all areas. During the talent identification and selection process, selectors while aiming to choose performers who respected the center's requirements across a wide range of skills, may have been biased towards and only picked players (including those born in the latter quarters) who displayed the highest levels of physical performance (or again who have the greater potential). This may be a more valid explanation for the relative homogeneity across the group than the reasons mentioned earlier in the discussion. The practice history profiles of the players may also be linked to this suggestion. Before joining the center, players previously identified as being more mature or physically larger can be given more practice or opportunities for learning, thereby facilitating their development and eventual selection (Musch & Grondin, 2001). A future comparison of the physical characteristics of players born across the four quarters of the year and the practice history

profiles of those who were accepted or rejected by the center is merited.

The finding that professional graduates born in the latter quarters of the year were significantly disadvantaged in certain anthropometric and fitness measures compared with “older” professional peers is noteworthy. Although these players demonstrated lower physical ability, they had an equal chance of achieving professional status than graduates born earlier and who performed better “physically”. Therefore, assessing and choosing players according to anthropometric measures and fitness ability at under-14 level may not be a basis for future success. Malina et al. (2007) recently provided evidence that height can be a negative predictor of skill in players aged 13–15 years, while Vaeyens et al. (2006) observed that improvements in functional and sport-specific parameters measures in youth soccer players vary according to competitive age levels. Technical skill was identified as the most determinant characteristic in elite and non-elite under-13 and under-14 players, while cardio-respiratory endurance was more important in under-15 and under-16 players.

Therefore, talent selection and youth development at an early age should provide opportunities for changes due to growth and maturity during adolescence across a wide range of soccer-specific skills. A longitudinal study on the present players using a multidisciplinary approach to talent identification would be relevant for comparing other skills such as personality, anticipation and football-specific technical ability across successful and unsuccessful players born in different periods of the selection year (e.g. see Reilly et al., 2000b). In addition, a study comparing the fitness characteristics and birth dates of the present players over the 11-year span would be worthwhile to investigate secular trends in these performance-related factors.

As previously mentioned, it would be relevant to compare the players’ practice history and game experience (e.g., see Ward et al., 2007; Ford et al., 2008) before joining the center as playing background may have had a more determining effect than relative age. In addition, the combination of information on the characteristics of youth players across different age categories classified into quintiles of skill based on a composite score for soccer-specific tests and individual playing experience, as recently described by Malina et al. (2007), would be relevant.

Unfortunately, the present players leave the center at 16 years of age to pursue their careers and therefore data from this age through to adulthood are unavailable. There may be certain periods during a male youth player’s career when he demonstrates major gains in various performance parameters which aided selection, firstly into the INF and later, into a professional club. The majority of the INF players are recruited by professional clubs in their second and final year and it may be that after the first year spent at the INF, which appears extremely important in the acquisition of technical and tactical skills, the very best players (who as the present results show are not always superior physically) demonstrated greater progress in other game-related skills.

Perspectives

Previously, the trend of selecting players born earlier in the selection year has often been perceived as unfair and flawed. Simply basing selection policy on the physical precocity or maturation of players may lead to a high rate of drop out of late maturing, yet highly skilled players. While the talent identification and selection process of the present elite soccer training center seems to follow the trend in choosing “older” players, the differences in age were not reflected across several anthropometric and fitness measures of performance. Therefore, in a group of highly selected youth soccer players, the relative age of the performer may not provide a significant advantage in terms of physical ability. Furthermore, in these players, those born later in the selection year had an equal chance of progressing to higher levels of the game. These findings highlight the importance of an appropriate training environment when developing future professional players. They are also in line with the recommendations of Malina (2003) who suggested that opportunities need to be provided for smaller and/or later maturing talented boys during adolescence. These observations may point toward a change in selection policies in elite soccer that encourages practitioners to select greater numbers of players born in the latter part of the selection year.

Key words: development, talent, selection, relative age effect.

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