Variable long-term developmental trajectories of short sprint speed and jumping height in English Premier League academy soccer players: an applied case study

Jason Moran [1]

Kevin Paxton[2]

Ben Jones[1]

Urs Granacher[3]

Gavin RH Sandercock[1]

Edward Hope[1]

Rodrigo Ramirez-Campillo[4]

1. School of Sport, Rehabilitation, and Exercise Sciences, University of Essex, Colchester, United Kingdom
2. Leicester City Football Club, Leicester, United Kingdom
3. Division of Training and Movement Science, University of Potsdam, Potsdam, Germany
4. Department of Physical Activity Sciences, Universidad de Los Lagos, Osorno, Chile

Corresponding author contact details: jmorana@essex.ac.uk, +44 75 10833714

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Abstract

Growth and maturation can affect physical performance over the long term, making the appraisal of athletic ability difficult. Using a previously published method, we sought to longitudinally track youth soccer players to assess the developmental trajectory of athletic performance over a six-year period in an English Premier League academy. Age-specific z-scores were calculated for sprint and jump performance from a sample of male youth soccer players (n = 140). A case study approach was used to analyse the longitudinal curves of the six players with the longest tenure. A regression equation for each fitness variable facilitated comparison of participants to the wider sample. The trajectories of the sprint times of players 1 and 3 were characterised by a marked difference in respective performance levels up until peak height velocity (PHV) when player 1 achieved a substantial increase in sprint speed and player 3 experienced a large decrease. Player 5 was consistently a better performer than player 2 until PHV when the sprint and jump performance of the former markedly decreased and he was overtaken by the latter. Fluctuations in players' physical performance can occur quickly and in drastic fashion. Coaches must be aware that suppressed, or inflated, performance could be temporary and selection and deselection decisions should not be made based on information gathered over a short time period.

Keywords: Youth, football, talent, running velocity, muscular power

INTRODUCTION

Growth and maturation refer to the processes that characterise a youth's progression towards a mature state [1]. Growth is simply an increase in body dimensions that is characterised by increases in fat and fat free mass whilst maturation refers to qualitative biological changes to tissues and organs [1]. Progressing growth and maturation can result in increased or decreased physical performance and because of this, can make it difficult to determine the true ability and potential of a young athlete prior to full maturity [2]. For example, greater stride length, due to growth of the lower limbs, can result in enhanced sprint speed in youth [3]. However, a high rate of growth has also been associated with impaired movement coordination which could negatively affect sprint speed [4]. Accordingly, the accurate appraisal of athletic ability and potential is difficult in the maturing youth athlete making the identification of talent a challenging process.

Related to this issue is the concept of the 'relative age effect'. The relative age effect refers to the preferential selection of children born in the earlier part of the sporting year [5]. This means that those individuals who are chronologically older than their peers are favoured by coaches due to being more physically developed. For example, in some cases, there can be an age gap of almost an entire year between youths who compete at the same age grade of a given sport and this can result in a competitive imbalance that can have implications on individuals' ability to thrive and sustain involvement in sport [6]. For example, a relatively young under 13 soccer player might be closer in age to a comparatively older under 12 player than he is to a relatively older peer in the under 13 age group. If growth and maturation are progressing in these players at an average rate, the relatively younger under 13 player is likely to be less physically accomplished than their older peer and could therefore be at a disadvantage for talent selection, regardless of soccer ability.

Previous case study approaches have demonstrated the highly variable trajectories of fitness qualities in youth athletes as they biologically mature. Cobley et al. [7] presented longitudinal data in youth rugby league players spanning a two year period, reporting that late-maturing players could ultimately improve performance levels, thereby “catching up” with their early-maturing peers in the fullness of time. In light of this finding, the authors advocated an inclusive form of talent development which incorporates multiple fitness assessments over the long term and the avoidance of deselection at too early a stage in a youth athlete’s developmental journey.

This concept of non-linear physical development in youth athletes has been discussed in the literature. However, what has not been explored in depth is the erratic, and quite drastic, fluctuations that can occur in the physical development of youth soccer players [8]. This can have implications for long term selection and deselection decisions with the relative age effect persisting into adulthood [6]. Given the erratic dynamism of developing motor competencies in youth athletes, the current study seeks to build on previous work [7] by comparing single subjects in a case study approach to demonstrate the non-linear development of performance (sprint speed and jump height) over the long term (6 seasons) in English Premier League youth soccer players. In doing this we describe scenarios which soccer coaches could potentially be confronted with, highlighting the challenges associated with developing talent in a holistic manner. To date, longitudinal data on such players is exceedingly rare.

METHODS

For this study, data from a wider sample of 140 youth soccer players from the English Premier League were analysed, with six individuals serving as the subjects for the case analysis which was supported by the formulation of performance z-scores based on the entire cohort. These individuals were chosen because their tenure at the club spanned the entire six-year study period, the only players in the cohort to achieve such longevity.

Descriptive data for the group and individual players at the beginning and the end of the case study period are shown in Tables 1 and 2.

*****Tables 1 and 2 near here*****

Sprint and jump testing was carried out by practitioners from the soccer club's sports science department in September, January and April of each season. All players were familiar with the utilised tests which were a regular part of their programmes of physical preparation. To estimate participant maturity status, anthropometric measurements (stature, sitting stature and body mass) were entered into an equation to predict maturity offset [9]: Maturity Offset = -9.236 + (0.0002708 x leg length and sitting height interaction) + (-0.001663 x age and leg length interaction) + (0.007216 x age and sitting height interaction) + (0.02292 x weight by height ratio). The equation can measure maturity offset within an error of ± 1 year, 95% of the time [9].

To measure sprinting speed, electronic timing gates were used (Fusion Sport, Canberra, Australia) on an indoor astroturf surface. This equipment has shown excellent test-retest reliability (ICC = 0.88 to 0.97) in the measurement of linear sprint speed in athletes [10]. Participants began each sprint in a front-facing, crouched standing position with the dominant hand on a start cone placed 0.25 m in front of the start line. Participants sprinted straight through each timing gate line (10 m, 20 m) maximally until they were past target markers placed five metres beyond the finishing line. The best of three trials was recorded for each distance and used in the analyses. There was three minutes recovery between trials.

To measure countermovement jump (CMJ), participants performed a jump on an electronic jump height calculator mat (Fusion Sport, Canberra, Australia). This equipment has shown excellent test-retest reliability (ICC > 0.9) in the measurement of CMJ in athletes [11]. Participants started in a standing position with the hands positioned on the hips and the feet flat on the floor. They descended into a squat position to a self-selected depth before ascending into a maximal vertical jump with the torso upright. At the maximal height of the jump, the hips, knees and ankles must have been fully extended, with no tuck or pike position allowed at any point of the movement. Participants were required to land back in the starting position and the best of two trials was recorded for analysis. There was two to three minutes recovery between trials.

CASE DESCRIPTION

As case study designs represent an effective means to reduce the gap between research and practice, through the presentation of a rich form of qualitative information, we chose to utilise such an approach [12]. Across the full sample of players (n = 140), the statistical method recently described by Till et al. [13] was used. Briefly, rolling averages for sprint speed (10 m and 20 m) and CMJ, over a near-six-year period, were calculated with respect to the maturity offset [9], a traditional way to gauge biological maturation in youth athletes. This produced a regression equation for each variable facilitating the comparison of participants to their peers at a specific stage of maturity, measured in years from PHV. To do this, a z-score for each variable was calculated using the following formula:

$$\text{Z-score} = \frac{\text{Participant's score} - \text{mean score}}{\text{Standard deviation}}$$

In the above equation, the mean score is substituted for the regression equation for each anthropometric or fitness variable and the standard deviation is that which was calculated for each squad as a whole over the six-year period of the case study (i.e. under 10s, under 11s, under 12s etc.). This reduces the greater variability associated with the calculation of a standard deviations across a dataset whose youngest participant was eight years old and whose oldest was sixteen [13]. Once missing data were removed, longitudinal curves (Figures 1 through 9) were formed in Microsoft Excel. In each graph, a secondary y-axis was included on the right hand side to demonstrate the trajectory of fitness variables, relative to progressing maturity status, over time. From the wider dataset, and for the final analysis, we included only players (n = 6) whose tenure at the club academy spanned the entire case study period of ~six years. This period comprised of between eleven and 13 fitness testing occasions on which participants had their sprint and CMJ performance measured.

Comparison of Trajectories Between Players

Longitudinal curves for the group (n=6) and player versus player comparisons are displayed in Figures 1, and Figures 2 and 3 respectively. Figure 1 shows the group-level development of 10 m sprint speed, 20 m sprint speed and CMJ. Figures 2 and 3 display player vs. player comparisons for each of the physical qualities.

Group comparisons

The group-comparison of longitudinal curves (n=6) is displayed in Figure 1. There is variability in the performances of players for much of the six-year study period, though sprint speed converges in all players near the time of PHV. Of note, player 5 transitions from being one of the fastest players, to being one of the slowest after PHV (10 m and 20 m sprint). It is also notable that across an approximate one year period from -1 years before PHV to +0.15 years after PHV, players 1 and 2 graduate from being two of the worst performers in the 20 m sprint, to being the two best. Figure 1 also shows the changes in CMJ performance over time. Of note are the scores of players 1 and 6 who occupy last and first place respectively at around -1 to -1.5 years before PHV, being separated by around four standard deviations. However, prior to the final CMJ test, the players occupy second (Player 6) and third (Player 1) place in this group and are separated by less than one standard deviation.

Figure 1. 10 m sprint time, 20 m sprint time and countermovement jump for all six players

Player versus player comparisons

Player 1 vs. player 3

Figure 2 shows the comparisons of players 1 and 3 over the six-year study timescale. The trajectories of both 10 m and 20 m sprint times of players 1 and 3 are characterised by a marked difference in respective performance levels up until PHV when player 1 achieves a substantial increase in sprint speed and player 3 experiences a decrease. When their trajectories converge, both players experience a decrease in performance before displaying trends of recovery. Following the substantial difference in sprint performance up to PHV, the players are relatively well matched towards the end of the timeframe in question. A similar trend is seen for CMJ but both players are more closely aligned over their time in the academy system.

Figure 2. 10 m sprint time, 20 m sprint time and countermovement jump comparison for Player 1 vs. Player 3

Figure 3 shows the comparisons of players 1 and 3 over the six-year study timescale. Though player 5 is consistently a better performer than player 2 throughout the time in the academy system, there is relative linearity in how these individuals progress over time. Development is linear until around the time of PHV when the performance levels of player 5, in all measured variables, markedly decreases and he is overtaken by player 2 who maintains a consistent level of performance relative to his peers as seen in Figure 1.

Figure 2. 10 m sprint time, 20 m sprint time and countermovement jump comparison for Player 2 vs. Player 5

DISCUSSION

The purpose of this study was to demonstrate the varying and irregular trajectories in the development of sprint speed and jump height in English Premier League male youth soccer players. Our comparisons show that the time around PHV appears to be a key period of development that does not always favour the individual player with both increases and decreases in performance being possible. This is well-exemplified by the comparison of players 1 and 3 whose disparity in sprint speed was eliminated at this time. This is also typified by player 5 whose apparent physical superiority prior to PHV was completely eradicated after PHV. The case study demonstrates the highly erratic nature of physical development trajectories over the long term in male youth academy soccer players in the English Premier League. The findings of this work demonstrate that an individual player can lag behind his peers in terms of athletic ability but can rapidly improve his standing alongside changes in maturation status. This work adds to the very small body of longitudinal literature in this population and demonstrates to coaches the erratic nature of physical development in youth players. This can enable such coaches to make more informed decisions on selection and deselection to elite squads. To our knowledge, no study has previously used a case study of players from an English Premier League club to present such data over an extensive period of time (~6 years) and longitudinal research, in general, is unfortunately rare in youth players. Crucially, this allowed us to observe developmental trajectories of sprint speed and jump height prior to, during, and after the important mid-PHV stage of maturation.

A common criticism of talent development programmes in youth sport is the rejection of late maturing players before they have a chance to realise the full extent of their athletic potential. This could cause psychological harm to the rejected player and drop-out from sport, and can also prevent a team from being able to select their best available players in the future, given that late maturing players can ultimately achieve similar performance levels as their early maturing peers [14]. On this, it has been previously shown that a player whose physical performance levels lag behind those of her or his peers, similar to that in the case of Player 1 in the current study, can ultimately match or surpass other individuals if given the time and physical development support to do so [7]. This could point to an upper limit on performance above which further increases are slower, or less likely to occur, in early maturing players. On this basis, the physical advantages enjoyed by early maturing soccer players in the pre-PHV phase of development, may not be apparent at the post-PHV stage when growth and maturation have slowed [7]. Hypothetically, this could result in the preferential selection bias of a player whose potential is falsely inflated at a relatively younger age, and the deselection of one whose full potential has not yet been achieved. For much of the study period in question, the sprint speed and jump height of Player 1 does not compare favourably to those of his peers. However, at the final observation, this deficit has been closed as the player converges with his teammates and matches their performance levels. The retention of this player in the talent pipeline allows this scenario to play out and gives coaches a longer period of time within which to make an important selection decision that is based on tangible data rather than educated guesswork.

It is important to indicate that even a coach's appreciation of the erratic nature of fitness testing results over time may not be sufficient to prevent negative outcomes in a scenario such as that described above: if relatively poor fitness tests manifest as lower technical performance on the field of play, players could still be deselected on the basis that they are considered to not be of the required standard to continue playing at a professional academy. To this end, fitness practitioners must liaise closely with skills coaches to determine the optimal course of action in relation to the selection or deselection of a particular player. Relatively poorer performance may not be permanent, nor is it necessarily unresponsive to the right type of training at the right time of development [15–17]. Indeed, even with an appropriate training programme in place, its effectiveness could be undermined by some negative elements of the developmental process, such as impaired motor coordination or decreasing relative strength levels [4,18,19]. In relation to these points, it has previously been shown that the athletic superiority enjoyed by early maturing players was eliminated by the time that all players exited a soccer academy, with technical development cited as a key component in the equalisation of physical abilities over time [14]. In light of such evidence, coaches should be cognisant that physical attributes in the youth player are inherently unstable and can improve or deteriorate at key times during the maturation process. As demonstrated by the comparisons of players 1 and 3, and players 2 and 5, physically inferior players have a reasonable expectation of performance improvement over time. Moreover, their performance relative to their peers could be further enhanced as physically superior players can undergo marked decreases in performance as they mature, thus "levelling the playing field".

In our dataset, there seems to be an inherent trend that in tasks that require high relative strength, performance decreases are common around the time of PHV. To varying degrees, all six case players display erratic developmental trajectories that are commonly characterised by a decrease in performance around PHV, most markedly seen here in the 10 m and 20 m sprint tests. As youths mature and gain bodyweight, relative strength can decrease. If the gaining of weight outpaces that of relative strength, a decrease in performance can result as an individual becomes relatively less capable of propelling their own body mass [17]. The comparison between players 2 and 5 is interesting in this regard. In the sprint tests, player 5 is consistently superior to player 2 until the time of PHV when his performance drastically decreases and he falls behind player 2. Following these decreased performance levels, player 5 does not demonstrate a trend of recovery as player 2 continues to progress. Such decreases in performance could also be attributed to temporary growth-related disruptions to motor coordination, termed adolescent awkwardness [8], and coaches should therefore allow a player sufficient time to come to terms, and correct, such issues. This could potentially involve amendments to the player's training programme whereby an increased emphasis is placed on movement quality whilst contraindicated forms of training, or training volume, are reduced or discontinued. At this particular time, coaches should also be cognisant of the higher potential for young athletes to sustain injuries during PHV [20].

The above example demonstrates the delicate nature of the key period in and around the growth spurt in youth athletes. Whereas one individual can experience drastically lower performance at this time, others' progression can be enhanced due to the underlying maturational processes, such as increasing stride length [21]. To date there are few viable tests to determine which individuals are likely to suffer from impaired performance at this time and this should be a focus of future research. Selection decisions should therefore be delayed until coaches can make a more informed appraisal of a player. However, this also has implications outside competitive sport where selection or deselection by coaches is not an influencing factor. For example, in the school environment, if children perform poorer at sport due to temporary declines in physical capabilities, they may become discouraged and avoid certain types of physical activity. Despite being encouraged to partake in sport, overweight children can tend to avoid more traditional forms of exercise such as aerobic training, which includes soccer [22]. Moreover, engagement in this type of exercise could lead to overuse injury in this population [22]. It is the task of the coach and physical education practitioner to direct children towards tasks that they can excel at and to educate children on the possible changes that can occur non-linearly as they grow, and which can negatively affect performance. To this end, the direction of overweight or movement-impaired children to alternative forms of exercise, such as resistance training, could be beneficial as it provides an opportunity for this group to outperform their underweight or understrength peers [23,24]. Such a strategy can also be utilised in the high-performance academy environment where players experiencing rapid increases in bodyweight can be exposed to resistance training which can help them to overcome any movement-related impairments due to this stage of maturation. At such times, it is also important for coaches to appreciate the differences between absolute and relative strength. As a youth matures, absolute strength will likely increase [25] meaning that an individual would be better prepared to move increasingly heavy external loads. However, relative strength, which is correlated to the ability to overcome one's body mass during a task such as sprinting, may not increase as rapidly due to maturation-related gains in bodyweight [25]. In this way, a player could theoretically become relatively slower as he becomes stronger, a rather paradoxical scenario that coaches must be cognisant of.

Given the above points, the value of single-occasion fitness testing as a talent-identification and development tool in the youth athlete can be questioned [7]. Moreover, the benefit of having players within an academy environment for a longer period facilitates a greater likelihood of the identification of elite traits such as those mentioned, alongside psychological capabilities such as robustness, resilience, leadership and autonomy. Developmental trajectories seem too variable and recoverable to justify making selection decisions on limited information gained at a single fixed point in time. It is therefore important for coaches to be cognisant of the impact that performance in common fitness tests, such as those presented in the current study, can have on technical play. For example, it is interesting to note that two investigations by Trecroci et al. [26,27] showed that sprint and agility tests and CMJ were significant differentiators between elite and sub-elite soccer players. Short sprints are a common and important determinant of performance in youth sport [28] and Mendez-Villanueva et al. [29] have previously reported youth soccer players reaching speeds of up to 29.5 ± 1.4 (km · h– 1) in match play. Moreover, straight sprints have been shown to be the most common type of movement prior to goal-scoring [30], underlining the importance of training sprint speed, though not necessarily using it as a selection tool, from a young age. Trecroci et al. [26,27] found that 10 m sprint and CMJ could discriminate between elite and sub-elite under 15 soccer players. However, for under 16 players, they found that only CMJ and agility could discriminate the level of play. On this basis, coaches should be aware that as youth players progress through the age grades, the dynamic nature of their physical development makes it difficult to determine talent based on singular test types.

An arguable weakness of this case study is the lack of a measure of relative or maximal strength over the observed study period. We have suggested that one of the reasons for the common decrease in performance levels in and around the growth spurt could be due to decreasing relative strength precipitated by increased bodyweight and a lagging ability to propel that bodyweight. Alternatively, decreased motor coordination due to an individual's rapidly heightened centre of gravity due to growth could also play a vital role. The addition of a measure of strength in a similar investigation could assist coaches and researchers in identifying which of these factors, if any, are most prominent as a youth player matures. The case study research design used here makes it somewhat difficult to generalise the results to a wider population of soccer players but, conversely, it also facilitates the observation of precise trajectories of individual development that were not disadvantaged by the smoothing effect of pooling data. In this way, the player cases presented here could be demonstrative of typological developmental trajectories that are reminiscent of those seen across the soccer-playing youth population. Indeed, the calculation of z-scores from a wider population of 140 players reinforces this point.

CONCLUSION

To maximise the development of soccer players and to ensure that club academies fully leverage the benefits of operating an academy system, both fitness and technical coaches must work in close collaboration to track the developmental trajectories of their players over time. Fluctuations in players' physical performance can occur quickly and in drastic fashion but this does not necessarily represent a decline in footballing ability. An essential element in achieving positive outcomes in talent development is an awareness that suppressed, or inflated, performance could be temporary and selection and deselection decisions should not be made based on the information gathered over a short period of time. The longitudinal curves presented in the current study demonstrate the unstable nature of physical development in youths and coaches can use our data to discourage the early deselection of youth players, safe in the knowledge that depressed performance can recover in time. Coaches must be cognisant of the connection between physical and technical skills in that the former can affect the latter and, to this end, it is worthwhile educating players on how their bodies develop during the academy years. Educational efforts of this type are more likely to assist players in understanding the natural fluctuations in performance and could potentially result in the reduction of self-deselection from the sport. To facilitate this, coaches are encouraged to longitudinally apply the method proposed by Till et al. [13]. There are ways in which researchers can expand on our approach in the future. We observed trends indicating temporary growth-related disruptions to motor coordination, termed "adolescent awkwardness" [8], and we believe this can have a negative outcome on player performance and welfare. On this basis, a longitudinal investigation of motor coordination is warranted using tests that may be more conducive to identifying growth-related disruptions as a player matures. Such information could further assist coaches in the strategic structuring of programmes of physical development for youth soccer players. This additionally emphasises the importance of frequently assessing each player's biological maturity status.

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