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Maturation-related adaptations in running speed in response to sprint training in youth soccer players

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ABSTRACT

Objectives: This study investigated the effects of a previously recommended dose of sprint training (ST) in young male soccer players of differing maturity status.
Design: Quasi-experimental design.
Methods: Male soccer players from two professional academies were divided into Pre-PHV (Training: n = 12; Control: n = 13) and Mid-PHV (Training: n = 7; Control = 10) groups. The training groups completed 16 sprints of 20 m with 90 s recovery, once per week.
Results: Between-group effect sizes (ES) were substantially larger in Pre-PHV (10 m [1.54, CI: 0.74–2.23]; 20 m [1.49, CI: 0.75–2.23]; 5-10-5 [0.92, CI: 0.23–1.61]) than in Mid-PHV (10 m [−0.00, CI: −0.81 to 0.81]; 20 m [−0.12, CI: −0.93 to 0.69]; 5-10-5 [−0.41, CI: −1.22 to 0.41]). Within-group effects demonstrated a similar, though less accentuated, trend which revealed ST to be effective in both Pre-PHV (10 m [0.44, CI: −0.24 to 1.12]; 20 m [0.45, CI: −0.23 to 1.13]; 5-10-5 [0.69, CI: 0.00–1.38]) and Mid-PHV (10 m [0.51, CI: −0.38 to 1.40]; 20 m [0.33, CI: −0.56 to 1.21]; 5-10-5 [0.43, CI: −0.46 to 1.32]).
Conclusions: ST, in the amount of 16 sprints over 20 m with a 90 s rest, may be more effective in Pre-PHV youths than in Mid-PHV youths.

1. Introduction

The term ‘speed’ is defined as distance divided by time and in athletic terms refers to the movement of a body or part of a body over a given distance.[1] Depending on this distance, a differentiation can be made between ‘acceleration speed’ (5–20 m) and ‘maximum speed’ (30–60 m)[1] with good performance over these distances being associated with greater sporting ability.[2] As sprinting is a common event in youth sport,[3] its inclusion in a training programme is an important factor in the fitness of young athletes. This is reinforced by the potential existence of windows of trainability in youth. For example, it may be necessary to ingrain particular motor skills prior to the emergence of ‘synaptic pruning’.[4] This process, which cultivates higher-order cognitive processes, is affected by environmental stimuli which exert an influence over which synapses will, and will not, be required as a youth develops. Theoretically, this could result in impaired motor skill development if particular movements are not ingrained prior to its onset in the first and second decades of life.[5,6]

The biological maturity of an individual is indicated by the degree to which they have progressed towards the adult state with a combination of sexual, somatic and skeletal factors denoting maturity status.[7] Recent evidence suggests that youths of differing maturity status could respond to sprint training (ST) to different magnitudes with pubertal and post-pubertal individuals seeming more responsive than pre-pubertal to this type of exercise.[8] This was demonstrated in a recent meta-analytical review which showed far larger effects in postpubertal (d = 1.39) and pubertal (d = 1.15) athletes than in prepubertal (d = –0.18).[8] This could be due to the variability of intertwined maturational factors relating to the development of muscle mass, the growth of limbs, changes to musculotendinous tissue, enhanced neural and motor development and greater neuromuscular coordination.[9] In support of this, Meyers et al.[10] reported that maximal sprinting speed tends to

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develop at a quicker rate after the initiation of the growth spurt, highlighting increases in stride length, and stabilisation of stride frequency and ground contact times, as influencers of sprint speed in youth. The same research group showed that over a 21 month period, youths who entered their growth spurt demonstrated larger increases in sprint speed (10.4 vs. 5.6%) and relative vertical stiffness (12.1 vs. 5.6%) than a group which was yet to reach the growth spurt.[11] Increases in growth hormone and testosterone could serve to reinforce these processes.[12] Such factors could potentially be indicative of the presence of a maturational threshold which moderates adaptations to ST around peak height velocity (PHV).[13] However, these factors are related to growth and maturation rather than training and the lack of ST studies carried out in prepubertal youths means that conclusions on trainability at this stage of maturation remain speculative.

Current literature is undermined by a number of limitations. The authors of a recent meta-analysis[8] on ST in youth athletes were unable to find any qualifying studies which measured the biological maturity status of youths with one of the most commonly used methods in sport: the maturity offset.[14] The results of that study suggested that ST in prepubertal youth athletes was ineffective, and though this was in line with other studies in youth training,[15,16] a lack of data prevented definitive conclusions being made.[8] Moreover, researchers have thus far failed to include comparison groups of disparate maturity status in ST intervention studies making it difficult to compare adaptations at different stages of development. Also, recommendations on the optimal load of ST in youth are scarce. It has been recommended that an effective training session load for increasing sprinting speed across the spectrum of maturation is 16 sprints of approximately 20 m distance, with a recovery period of 90 s or greater (or work to rest ratio of 1:25).[8] On that basis, the aim of this study was to assess the effects of such a dose of ST on sprint speed before (Pre-PHV) and during (Mid-PHV) the growth spurt in youth soccer players. To date, no intervention has described adaptations to an evidence-based dose of ST in youths of differing maturity status.

2. Methods

The study was approved by the university's ethics committee and participants and their parents granted consent to partake. The study was undertaken in accordance with the Declaration of Helsinki. The experimental cohort comprised of youth soccer players from an English professional category three academy (n = 19). To prevent cross-group contamination, the control group were members of a nearby category three academy (n = 23). English soccer academies are divided into four categories by independent audit with category 1 being the highest and category 4 the lowest. Participants were further divided into Pre-PHV (Experimental: n = 12; Control = 13) and Mid-PHV (Experimental: n = 7; Control = 10) groups for analysis, as recommended by Mirwald et al.[14] (Pre-PHV = ≥−4.0 and <−1 years from PHV; Mid-PHV = ≥−1.0 and <+0.99 years from PHV). There was 1.4 years between the maturity offset of the most mature member of the Pre-PHV group and the least mature member of the Mid-PHV group, reducing the chances of participants being allocated to the wrong group based on error of measurement (approx. ±6 months) associated with the utilised method.[14] The characteristics of the participants are in Table 1.

Testing was carried out by the soccer clubs' sports science staff and was in accordance with the English Premier League's Elite Player Performance Plan. To estimate participant maturity status, anthropometric measurements (height, sitting height, body mass) were entered into an equation to predict maturity offset[14]: maturity offset = −9.236 + (0.0002708 × leg length and sitting height interaction) + (−0.001663 × age and leg length interaction) + (0.007216 × age and sitting height interaction) + (0.02292 × weight by height ratio). The equation can measure maturity offset within an error of ±1 year, 95% of the time.[14]

Table 1
Descriptive data for participants.

Pre-PHV group	Training (n = 12)	Control (n = 13)
Age (years)	10.4 ± 0.8	10.0 ± 1.0
Age range (years)	9.4–11.8	8.7–11.3
Maturity offset (years)	−3.4 ± 0.4	−3.2 ± 0.6
Height (cm)	139.0 ± 5.6	139.7 ± 6.7
Mass (kg)	31.3 ± 3.8	34.4 ± 4.4
Mid-PHV group	**Training (n = 7)**	**Control (n = 10)**
Age (years)	13.6 ± 0.7	14.5 ± 1.0
Age range (years)	12.9–14.9	12.8–15.5
Maturity offset (years)	−0.3 ± 0.5	0.0 ± 0.6
Height (cm)	166.9 ± 5.5	163.5 ± 5.6
Mass (kg)	55.4 ± 9.2	53.2 ± 5.7

To measure linear sprint (10 m and 20 m) and multidirectional change of direction (COD [5-10-5 test]) speed, electronic timing gates were used (Brower Timing Systems, Draper, Utah, United States). This equipment has shown excellent test-retest reliability (ICC = 0.91–0.99) in the measurement of linear sprint speed in adult athletes.[17] For the utilised performance measures, our reliability testing showed consistently high Cronbach's alpha values ranging from 0.93 to 0.97.

Subjects began each sprint in a front-facing, crouched, standing 'two-point position' behind the start line. They were instructed to sprint straight through each timing gate line (10 m, 20 m) maximally until they were past target markers placed 5 m after the final line. There was 3 min of recovery between trials and the best of 3 was recorded for each distance and used in the analysis. For COD, the pro agility (5-10-5) test was used with the aforementioned start protocol. The test mirrored that of a previous investigation.[18] A 10 m distance was measured and bisected to indicate the timing gate's start point. Timing started when the participant initiated movement to his left or right and he was required to run to the end of the 10 m line before changing course to run to the opposite end. Changing direction once more, the test concluded when the participant crossed the middle line for a second time, culminating in a total run distance of 20 m. There was 3 min of recovery between trials and the best of 3 was used in the analysis.

The ST intervention was based on the findings of a meta-analysis[8] which suggested that effective speed development programmes for youth athletes consisted of 16 sprints over a distance of 20 m with 90 s recovery time between each effort. We adopted this protocol, exposing experimental groups to 1 ST session per week. All experimental groups trained under the supervision of a qualified sport scientist. We deliberately did not periodise the weekly training sessions with a view to establishing a base session dose for the improvement of sprint speed. We did this to provide maturation-specific recommendations to coaches which could then be periodised around athletic competition, with coaches increasing or decreasing the base dose of sixteen 20 m sprints per session when and where appropriate. All participants were engaged in a comprehensive programme of athletic development which included complementary strength and plyometric training. The control groups continued with their usual training schedule but did not carry out any specific ST during the course of the period of observation.

Magnitude-based inferences were used to calculate effect sizes which were interpreted using previously outlined ranges (<0.2 = trivial; 0.2–0.6 = small, 0.6–1.2 = moderate, 1.2–2.0 = large, 2.0–4.0 = very large, >4.0 = extremely large).[19] An effect size of 0.2