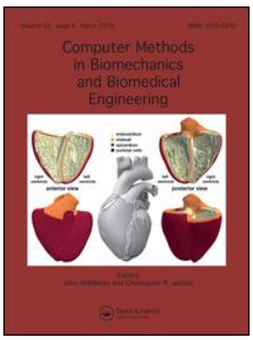

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Computer Methods in Biomechanics and Biomedical Engineering

ISSN: 1025-5842 (Print) 1476-8259 (Online) Journal homepage: https://www.tandfonline.com/loi/gcmb20

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To cite this article: J. Rossi, R. Slotala, P. Samozino, J. B. Morin & P. Edouard (2017) Sprint acceleration mechanics changes from children to adolescent, Computer Methods in Biomechanics and Biomedical Engineering, 20:sup1, S181-S182, DOI: 10.1080/10255842.2017.1382922

To link to this article: https://doi.org/10.1080/10255842.2017.1382922

Published online: 27 Oct 2017.

COMPUTER METHODS IN BIOMECHANICS AND BIOMEDICAL ENGINEERING, 2017
VOL. 20, NO. S1, S181–S182
https://doi.org/10.1080/10255842.2017.1382922

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Sprint acceleration mechanics changes from children to adolescent

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KEYWORDS Sprint; youth; power; force; velocity

1. Introduction

Sprint running is a critical performance parameter in many sports such as athletics, soccer or rugby that implies large forward acceleration. From a mechanical standpoint, previous studies showed that sprint performance is directly depending on the capacity to develop high amounts of horizontal force and power output over sprint acceleration (Morin et al. 2011). More precisely, the overall mechanical capability to produce horizontal external force during sprint acceleration is well described by the force-velocity (F-v) relationship (Morin et al. 2012; Rabita et al. 2015). This linear relationship characterizes the external mechanical limits of the entire neuromuscular system and is well summarized through the theoretical maximal horizontal force (F_0) and velocity (v_0) this system can develop, and the associated maximal power output (P_{max}, Samozino et al. 2015). These variables represent a complex integration of numerous individual mechanical muscle properties, morphological and neural factors, but also the technical ability to apply external force effectively onto the ground (Morin et al. 2011, 2012). Therefore, determining individual F–v and P–v relationships and mechanical effectiveness during sprint propulsion is of great interest for coaches or sport practitioners. Several studies have been conducted to identify and understand the mechanism of sprint performance acceleration in subjects ranging from adult recreational to world class sprinters (Morin et al. 2011, 2012), and masters athletes (Morin et al., 2016) or between male and female runners (Korhonen et al. 2003; Slawinski et al. 2017). Surprisingly, only few studies have specifically focussed on the effect of age on sprint mechanics during growth (Papaiakovou et al. 2009). If it has been reported that age positively affects sprint performance (Papaiakovou et al. 2009), there is no information regarding sprint acceleration mechanics explaining this change in performance during the growth period of children and adolescents. Therefore, the aim of the present study was to compare sprint acceleration mechanics between children and adolescent in order to better understand the underlying mechanisms in sprint performance with age.

2. Methods

2.1 Subjects

Sixty-eight boys and girls with a chronological age of 6 to 15 years were recruited in different athletics clubs and classified into two-year age groups (detailed characteristics are listed in Table 1).

The study protocol was performed in accordance with the ethical standards laid down in the Declaration of Helsinki II and approved by the local ethical committee.

2.2 Experimental protocol

After complete explanation of the protocol, all subjects underwent a warm-up program under the supervision of their coach. Running was sampled (31.25 Hz) using a radar device (Stalker ATS Pro, Applied concepts, Plano, TX, USA) placed at a height of 1 m over the ground and approximatively 3 m behind the starting line. Each subject performed 2 maximal 30-m sprints separated by a 5-min passive rest. To avoid subjects decelerating before the 30-m, the 40-m distance was set as the finish line.

2.3 Mechanical variables

According to Samozino's method (Samozino et al. 2016) the maximal velocity reached (V_{max}) F-v and P-v relationships were determined for the best sprint of both trials. F-v linear relationships were extrapolated to determine F_0 and V_0 (Samozino et al. 2016). From the F-v curve, the slope of the relationship ($S_{FV} = -F_0/V_0$) and P_{max} was calculated

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Table 1. Subject's anthropometric information.

	Children (n = 30)	Adolescent (n = 38)	p value *(effect size)*
Age (years)	8.1 ± 0.9	13.6 ± 0.8	$p < .05$ *(6.51)*
Height (m)	1.30 ± 0.08	1.61 ± 0.07	$p < .05$ *(4.16)*
B. Mass (kg)	27.9 ± 5.5	47.7 ± 7.8	$p < .05$ *(2.88)*

as $F_0 \times V_0/4$. The mechanical effectiveness of ground force application (D_{RF}) was also computed as the slope of the Ratio of forces (horizontal component / resultant ground reaction force for each support phase) – speed linear relationship (Morin et al. 2011).

2.4 Data analysis and statistics

Descriptive statistics are presented as mean value ± SD. Assumptions of normality and equal variances were examined using Kolmogorov-Smirnov and Levene's tests for all continuous variables. Unpaired Student's t-tests determined between-group differences in demographics and for each mechanical variable. The importance of the differences found between the two groups was assessed through the effect size and Cohen's d coefficient (Cohen 1988), interpreted as follows: small difference: $0.15 < d < 0.4$, medium difference: $0.40 < d < 0.75$, large difference: $0.75 < d < 1.10$ and very large difference: $d < 1.10$. All significance values were accepted at $p < .05$.

3. Results and discussion

Age had a significant effect on demographics, sprint performance and mechanical values (Table 1 and 2). Adolescents have faster 30-m time (+18% on average) than children. The increase in sprint performance with age was associated with an increase in P_{max}. Theoretical maximal horizontal force (per unit body mass, F_0) was not significantly different between the two groups whereas the theoretical maximal running speed (V_0) was significantly higher for adolescents (+25% on average). S_{FV}, describing the athlete's individual balance between force and velocity capabilities, showed a profile more oriented towards velocity capabilities for adolescents.

The D_{RF} describes the athlete's capability to maintain a net horizontal force production despite increasing running velocity. The present results showed that adolescents have a significantly better (i.e. less negative) value of D_{RF} than children. The speed improvement during sprinting at the growth period of children and adolescents has been reported previously (Papaiakovou et al. 2009). Although, to our knowledge, this is the first study that specifically reported experimental data of sprint mechanical outputs in two age groups of young athletes. An interesting finding of the present study is that the significant improvement in sprint performance is associated with the ability to develop horizontal force at high velocities and not to develop high level of force, which is mainly associated to an increase in the mechanical effectiveness of force application onto the ground with increasing velocity (D_{RF}).

Table 2. Changes in mechanical variables between the two groups.

	Children	Adolescent	p value *(effect size)*
30-m time (s)	6.1 ± 0.5	5.0 ± 0.3	$p < .05$ *(2.75)*
V_{max} (m/s)	5.5 ± 0.5	7.3 ± 0.6	$p < .05$ *(3.22)*
P_{max} (W/kg)	9.7 ± 2.0	12.9 ± 2.3	$p < .05$ *(1.47)*
F_0 (N/kg)	6.8 ± 1.2	6.8 ± 0.9	NS
V_0 (m/s)	5.7 ± 0.5	7.6 ± 0.7	$p < .05$ *(3.06)*
S_{FV}	−1.21 ± 0.22	−0.91 ± 0.12	$p < .05$ *(1.75)*
D_{RF} (%)	−10.9 ± 1.8	−8.0 ± 0.9	$p < .05$ *(2.12)*

4. Conclusions

The present study brought new insights into the effect of age on 30-m sprint performance during growth period. These results provide useful information for coaches and specialists of physical education. For example, these results may constitute a normative database in order to evaluate the current level and progress of the children and adolescent athletes in the sprint motor skill development.

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