A comparison of overground sprint kinematics of elite cerebral palsy and able-bodied athletes

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Summary

This is only the second such study to compare lower limb kinematics of elite cerebral palsy (CP) and able-bodied (AB) athletes running at similar overground speeds. CP athletes use higher stride frequency to achieve faster running speeds, have lesser knee range of motion, and use different coordination strategies across the stride when compared to AB athletes.

Introduction

Much literature reports sprint biomechanics of AB athletes, using a variety of experimental and theoretical approaches. Despite increased numbers participating in para-athletics, there is minimal literature [1] to help practitioners optimize performance or musculoskeletal health. Therefore, the aim of this study was to compare the kinematics of a group of elite CP and AB athletes running at the same speed overground to establish if the manner a CP athlete achieves maximal velocity is different to that of an AB athlete moving at the same speed.

Methods

Following university ethical committee approval, four CP athletes (age: 21.8 ±3.8 years, height: 1.68 ± 0.7 m, mass: 64.6 ±13.4 kg) and four AB athletes (age: 22.5 ±0.6 years, height: 1.79 ±0.9 m, mass: 70.6 ±10.9 kg) participated in this study. Groups were matched for age, gender (three males, one female in each), and event. One CP athlete was the current world record holder for their sprint event at time of testing. Lower body kinematics were acquired using a 20 camera 3D motion analysis system (250 Hz, Vicon MX13, Vicon, Oxford, UK) as participants ran at group mean speeds of 6.9 $m.s^{-1}$ (AB) or 6.6 $m.s^{-1}$ (CP), which was at or close to the CP athlete's maximal sprint velocity, through a 16 m capture volume. This difference was not statistically significantly different. All data processing was completed in Visual 3D (x64 v2021.09.1, HAS Motion, Ontario, Canada). Stride time (ST) was defined as the time between consecutive ground contacts, stride frequency (SF) as the number of strides taken per minute, and stride length (SL) as the Euclidian distance between the lateral 5MTP markers on the same side during consecutive ground contacts. Joint coordination was quantified using modified vector coding [2] with periods in-phase referring to when segments were simultaneously flexing/extending and antiphase when one flexed as the other extended (or vice versa). Statistical significance of between-group differences was determined using t-tests ($\alpha<0.05$).

Results and Discussion

Running speed was similar between groups but achieved differently. AB athletes had longer SL and lower SF, whereas CP athletes reached faster speeds with higher SF. This is likely due to the neuromuscular limitations imposed by CP. CP SL was larger than the 3.11 and 2.74 m previously reported [1], likely as these were elite athletes running at higher speed. Step width of CP athletes was highly variable, highlighting the different ways athletes overcome anatomical restrictions.

Ankle and knee flexion-extension angles were similar in both groups but less knee flexion (~13-18°) was observed with CP. This would be expected given the known potential range of motion limitations of these athletes.

The largest differences in phasing between groups occurred in the coordination between shank and thigh rotation, with anti-phase coupling dominating the stride cycle of CP athletes (82% of the early stride, 80% of late stride) compared to 68% and 54% for AB athletes. Differences may be related to altered capacity for neuromuscular control and endurance with CP.

Conclusions

CP athletes use shorter SL, higher SF, and different kinematics and coordination when compared to AB athletes sprinting at similar speeds. Further detailed research is justified to investigate the underlying neuromuscular mechanisms to optimize performance and long-term health.

References

[1] Pope, C and Wilkerson, J (1986). *Proceedings of the 4th International Symposium on Biomechanics in Sports*, 233-238.

[2] Sparrow, W *et al.* (1987). *J Motor Behaviour,* **19**, 115-129.

Table 1: Differences in stride parameters of elite CP and AB athletes running at the same overground velocity. Between-group differences in ST, SF, and SL were all statistically significant.; between-side differences were not, in both groups.

	Speed ($m.s^{-1}$)	ST (ms)		SF ($strides.min^{-1}$)		SL (m)		Step width (m)
		R	L	R	L	R	L	
AB	6.89 ±0.71	543 ±64	541 ±57	112 ±15	112 ±13	3.69 ±0.17	3.71 ±0.14	0.16 ±0.05
CP	6.60 ±0.44	491 ±34	486 ±35	123 ±9	124 ±9	3.24 ±0.23	3.20 ±0.22	0.20 ±0.11