Lower Extremity Kinematics Displayed During Running by Individuals with Adolescent Idiopathic Scoliosis

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BACKGROUND: Adolescent idiopathic scoliosis (AIS) is a three dimensional deformity of the spine that limits spinal motion during functional activities. Decreased spinal motions in walking have been reported for AIS individuals and walking gait patterns of scoliosis patients have been observed to have decreased step lengths and reduced ranges of motion throughout the lower extremity, especially with higher degrees of curvature (over a 30 degree Cobb angle).[1,2] Despite these findings, the effect AIS has on pelvis and lower extremity kinematics during high intensity physical activities like running is not clear. [1,2] This study aims to compare lower extremity kinematics displayed by AIS and matched controls (CON) during three different speeds, including perceived maximal effort treadmill running.

METHODS: Five skeletally mature AIS individuals (thoracolumbar structural curve with neutral pelvis; primary Cobb angle = 31.4°±11.9°) and five CON (respectively: age: 21.5±1.4 yrs, 21.1±0.5 yrs; height 168.2±8.2cm, 165.6±8.9cm; mass 57.1±10.1 kg, 57.6±4.6 kg; level of physical activity (IPAQ SF)[3]: 4284±1153.2 met-min/week, 3111.9±1353.75 met-min/week) were recruited. 18 reflective markers were placed on the pelvis and lower extremities according to the plug-in gait model.[4] Locations of these markers were captured (7-camera Vicon system, 120 Hz) while the participants ran at a self-selected jog for two minutes, a ten percent increase of the original speed for one minute and perceived maximal running speed for fifteen seconds (BORG scale for perceived exertion score[5] > 13). Lower extremity joint angular displacements (AngDisp) were calculated in all three planes; maximum AngDisp were averaged across ten strides. Mann Whitney U tests for differences between groups were used to compare maximum AngDisp between groups.

RESULTS: There were no statistically significant differences with regards to anthropometric data, speeds or BORG scale results as shown in table 1. There were no consistent findings of significant differences across all three speeds with regards to AngDisp during stance phase. Tables 2.1 -2.3 show results of the Mann-Whitney U tests ran and corresponding p-values. In all but one of the significant findings, the AIS group had greater AngDisp than the control group in either the transverse or frontal planes. The only finding that showed statistical significance in which the AIS group had smaller AngDisp was right knee flexion at running speed. There was no general trend regarding which group had greater AngDisp at any speed. Statistically significant results are depicted in Figure 3A-C below.

DISCUSSION: The results of this study suggest that physically active AIS individuals have the potential to demonstrate near typical lower extremity mechanics during physical activities like running, however minimal clinically relevant differences were observed for AngDisp between the groups during all three different running speeds. This may be due to high inter-participant variability in running techniques even in non-scoliotic runners and may not be an attribute of the spinal deformity. Although differences in spinal neuromuscular control have been reported in this population, including inappropriate feedback and increased electric activity to trunk muscles on the convex side, [6] physically active individuals with AIS may develop compensatory strategies to overcome these changes.[7]

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5. Pfeiffer KA, et al. *Med Sci Sports Exerc.* 2002 Dec;34(12):2057-61.
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Table 1 below shows the results of paired t-tests between groups for speeds, Borg readings, IPAQ SF[3] scores and forearm plank time.

	MEAN ± SD AIS	MEAN ± SD Control	2 tailed-sig
IPAQ scores	4284.2 ± 1153.2	3111.9 ± 1353.75	0.18
Jog Speed (m/s)	2.7 ± 0.4	2.5 ± 0.5	0.54
Run Speed m/s)	3.0 ± 0.4	2.8 ± 0.6	0.54
Max Speed (m/s)	3.8 ± 0.5	3.8 ± 0.8	0.95
Borg RPE Jog	10.8 ± .8	11.2 ± 0.8	0.47
Borg RPE Run	12.8 ± 0.8	13.4 ± 0.5	0.22
Borg RPE Max	14.6 ± 1.5	16.2 ± 0.8	0.08
Plank Time	43.6 ± 22.5	60.0 ± 0.0	0.18

Table 2.1 below shows the results of the Mann-Whitney U tests and corresponding p-values for differences in AngDisp between groups for each kinematic motion of three lower extremity joints examined bilaterally at the jogging speed. An * denotes statistical significance ($p < 0.05$).

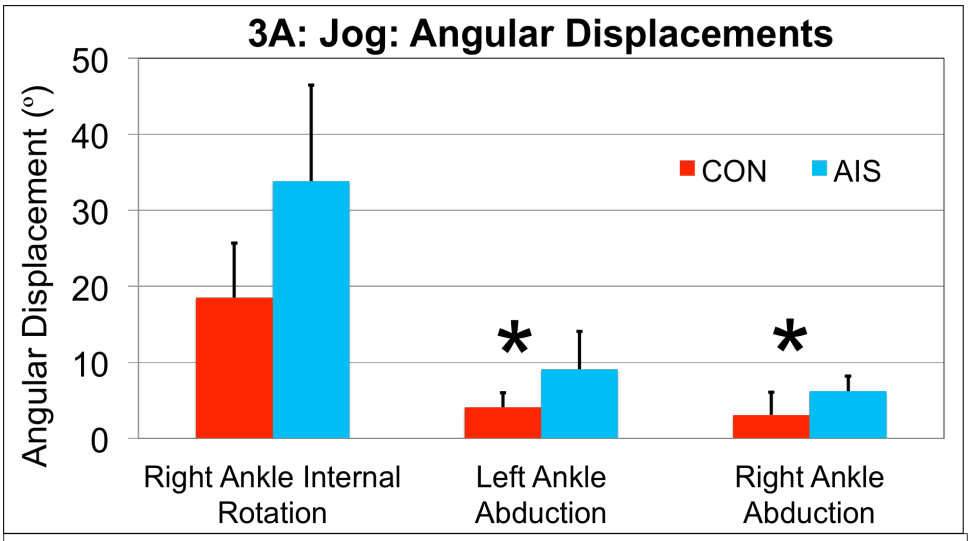
Results of Mann Whitney U /Tests		Extension	Flexion	Abduction	Adduction	External Rotation	Internal Rotation
Hip	Right	8.0 (0.35)	8.0 (0.35)	7.0 (0.25)	8.0 (0.35)	10.0 (0.60)	11.0 (0.75)
	Left	9.5 (0.53)	8.0 (0.35)	4.5 (0.09)	12.0 (0.92)	10.0 (0.60)	11.0 (0.75)
Knee	Right	8.0 (0.35)	6.0 (0.18)	11.0 (0.75)	12.5 (1.00)	9.5 (0.53)	7.0 (0.25)
	Left	11.0 (0.75)	9.0 (0.47)	12.0 (0.92)	6.0 (0.18)	9.0 (0.47)	12.0 (0.92)
Ankle	Right	6.0 (0.18)	9.0 (0.47)	3.0 (0.047)*	12.5 (1.00)	10.0 (0.60)	2.0 (0.028)*
	Left	11.0 (0.75)	9.0 (0.47)	2.5 (0.036)*	7.0 (0.25)	11.5 (0.83)	6.0 (0.18)

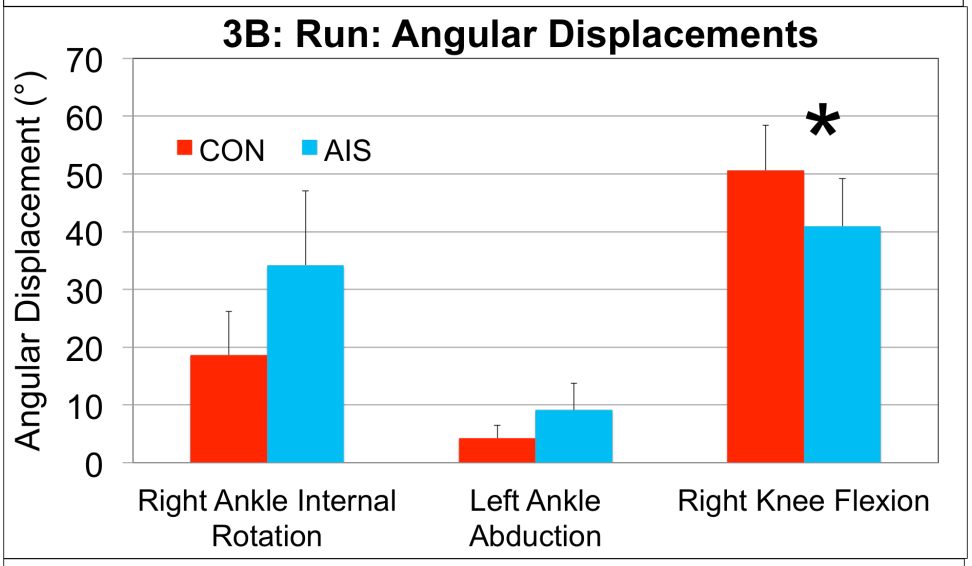
Table 2.2 Running Speed. An * denotes statistical significance ($p < 0.05$).

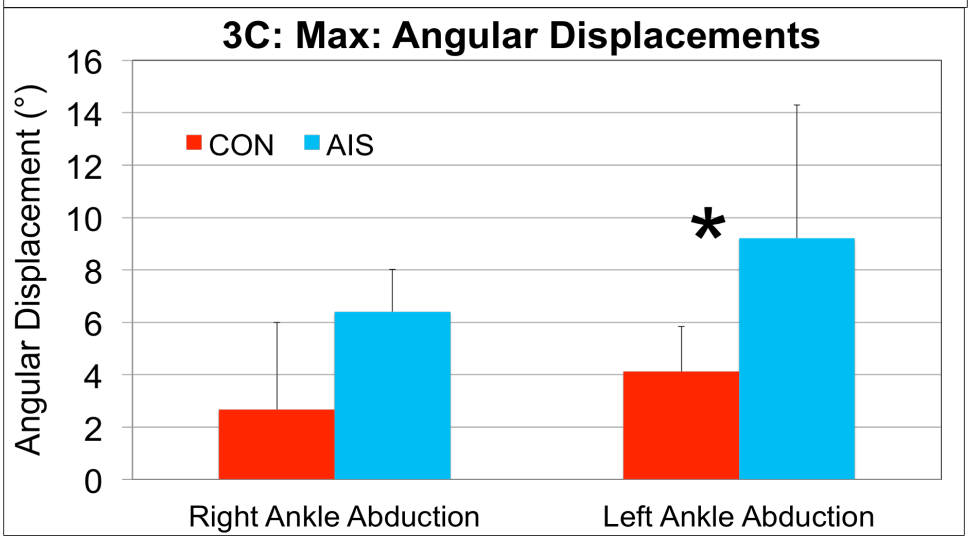
Results of Mann Whitney U /Tests		Extension	Flexion	Abduction	Adduction	External Rotation	Internal Rotation
Hip	Right	9.0 (0.47)	10.0 (0.60)	8.0 (0.35)	12.0 (0.92)	12.0 (0.92)	11.0 (0.75)
	Left	10.0 (0.60)	8.0 (0.35)	10.0 (0.60)	12.0 (0.92)	12.0 (0.92)	12.0 (0.92)
Knee	Right	12.0 (0.92)	3.0 (0.047)*	11.0 (0.75)	11.0 (0.75)	9.0 (0.47)	7.0 (0.25)
	Left	12.0 (0.92)	10.0 (0.60)	8.0 (0.35)	6.0 (0.18)	9.5 (0.53)	12.0 (0.92)
Ankle	Right	7.0 (0.25)	9.0 (0.47)	4.0 (0.08)	12.0 (0.92)	10.5 (0.68)	2.0 (0.028)*
	Left	11.0 (0.75)	10.0 (0.60)	3.0 (0.047)*	7.0 (0.25)	12.0 (0.92)	6.0 (0.18)

Table 2.3 Maximum speed. An * denotes statistical significance ($p < 0.05$).

Results of Mann Whitney U /Tests		Extension	Flexion	Abduction	Adduction	External Rotation	Internal Rotation
Hip	Right	11.0 (0.75)	7.5 (0.29)	9.0 (0.47)	10.5 (0.68)	11.0 (0.75)	6.0 (0.18)
	Left	7.0 (0.25)	11.5 (0.83)	12.0 (0.92)	9.0 (0.47)	12.0 (0.92)	9.0 (0.47)
Knee	Right	11.0 (0.75)	6.0 (0.18)	10.0 (0.60)	12.0 (0.92)	10.0 (0.60)	11.0 (0.75)
	Left	12.0 (0.92)	8.0 (0.35)	8.0 (0.35)	7.0 (0.25)	9.5 (0.53)	10.0 (0.60)
Ankle	Right	11.0 (0.75)	10.5 (0.68)	3.0 (0.047)*	9.0 (0.47)	8.0 (0.35)	3.5 (0.059)
	Left	7.0 (0.25)	8.0 (0.35)	3.0 (0.047)*	6.0 (0.18)	11.0 (0.75)	6.0 (0.18)







*Figures 3A-C depict significant AngDisp findings at all three speeds. An * indicates statistically significant differences*