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Kinematics and Kinetics Differences between Female Runners with and without Scoliosis

Sports Science

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ABSTRACT

The differences in running kinematics and kinetics were compared between two groups of recreational runners, with scoliosis and without scoli osis. Six females participated in the study, three runners in each group. Lumbar spine, pelvic and lower extremity kinematics, and lumbar erector spinae muscle activity were measured during running on a treadmill. In addition, static vertical ground reaction force (VGRF) was collected. The averaged data were compared between the scoliosis and non-scoliosis groups. No significance differences were found between groups, likely due to the small sample size. However, subjects without scoliosis demonstrated greater differences between sides in peak EMG, pelvic tilt and rotation, and smaller differences in static VGRF and pelvic obliquity compared to scoliosis subjects.

Introduction

Scoliosis is a deformity of the spine defined by a lateral curvature of at least 10 degrees in the frontal plane, as measured by the Cobb Method. It is associated with transverse rotation of vertebrae, which also affects sagittal curvature of the spine creating three-dimensional deformities (Schiller & Eberson, 2008). Studies have identified differences in gait parameters between scoliotic and non-scoliotic subjects (Kramers-de Quervain, Muller, Stacoff, Grob, & Stussi, 2004; Mahaudens, Banse, Mousny, & Detrembleur, 2009). Significant lower step length and stance phase were observed in scoliosis adolescence group, 7% and 2 % respectively (Mahaudens, et al., 2009). When assessing lumbo-pelvic kinematics, researchers found that motion in the frontal and transverse planes were significantly reduced compared to normal subjects. Hip and shoulder showed significantly less motion and axial trunk rotations were asymmetric, with the convex side of the spine being more limited in range of motion in the transverse plane (Kramers-de Quervain, et al., 2004). In addition, kinetic parameters asymmetries were identified in subjects with scoliosis during gait analysis, specifically in ground reaction forces in the medio-lateral and antero-posterior planes, which are significantly higher in the affected subjects (Giakas, Baltzopoulos, Dangerfield, Dorgan, & Dalmira, 1996). In adolescence, compensations of kinetic parameters seem to appear on the affected, or convex, side of the body (Chockalingam, Dangerfield, Rahmatalla, Ahmed el, & Cochrane, 2004).

Movements of the lumbar spine and pelvis are affected and controlled by the function of the trunk musculature including the transverse abdominis, multifidus, internal and external obliques, quadratus lumborum, diaphragm, pelvic floor muscles, rectus abdominis, psoas major, and erector spinae (Faries & Greenwood, 2007). Electromyography data of these muscles have been measured at various walking and running speeds to determine their contribution to movement control and timing contractions with respect to the walking/running cycle (Behm, Cappa, & Power, 2009; Saunders, Rath, & Hodges, 2004). Saunders, Rath, and Hodges (2004) found that erector spinae activity increased significantly from 26% to 67% of gait cycle when subjects ran at 2 m/s compared to when they walked at the same speed. However, abdominal muscle activity did not increase significantly. Moreover, Erector spinae function increased progressively as speed increased from 1 m/s to 5 m/s and at the fastest speed tested all trunk muscles were active for greater than 70% of the gait cycle (Saunders, et al., 2004).

The purpose of this study was to compare kinetics, kinematics, and muscle activation patterns variables during running between female runners with and without scoliosis.

Methods Subjects

Six female recreational runners participated in this study age 26.2 (2.2) yrs, height 163.2 (2.2) cm, and 58.5 (3.4) kg. Subjects were divided into two groups of three, with or without scoliosis, confirmed by a physician or athletic trainer. Inclusion criteria included running at least 14 km/week and not experiencing limiting injury/pain at the time of testing. The study was approved by the University Institutional Review Board.

Instrumentation

All running sessions were completed on a Treadmill. Three-dimensional data were captured using seven Vicon MX-3+ high-speed 240 Hz cameras. Data were processed using the Vicon Nexus software and analyzed using Vicon Polygon software. Raw data were smoothed using a Woltring quintic spline. Static forces were measured using two AMTI force plates sampled at 1000 Hz. Electromyography (EMG) data were collected using a Delsys Bagnoli system with a gain of 1000 Hz.

Procedures

Lumbar spine kinematic data were collected using a rigid cluster of reflective markers mounted over the 12th thoracic vertebra (Schache, Blanch, Rath, Wrigley, & Bennell, 2002). Fifteen reflective markers were also placed on the lower body based on Vicon lower body Plug-in Gait (Figure 1). Electromyography electrodes were attached to the right and left erector spinae (ES) muscles (Behm, et al., 2009). All data were collected in one day. Runners were asked to wear tight fitting attire and their own footwear to allow for typical gait patterns. Prior to data collection on the treadmill, static vertical ground reaction force (VGRF) was measured on the force plates to identify weight distribution between the right and left sides. Subjects then run on the treadmill at a speed of 2.7 m/s until consistent running pattern achieved, at which point three sets of 10 seconds of kinematics and EMG data were captured.

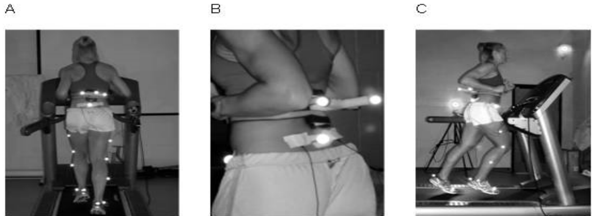

Figure 1: Markers and EMG electrodes placements.

Data Analysis

Statistical analysis was performed using SPSS. For all parameters, data from five gait cycles of one 10-second trial were analyzed. Convex and concave sides in scoliosis subjects and right and left sides in non-scoliosis subjects were compared. Chi-squared analysis was used to compare differences in step time, stride time, cadence, and static VGRF. In addition, average peak EMG of the erector Spinae and pelvic tilt during stance phased, and total range of motion of pelvic obliquity and rotation were analyzed using Chi-squared analysis.

Results

T-test analyses revealed no significant differences between groups for age, height, weight, or miles run per week. Chi-squared analysis showed no significant differences between groups for step time, stride time, or cadence, p-value > 0.05, (Table 1). Although the means appeared different, no significant difference were found for static VGRF, erector spinae EMG, and pelvis kinematics, p-value > 0.05, (Table 2).

Table 1: Mean (SD) difference in running temporal variables.

Group	Step time (s)	Stride time (s)	Cadence (s)
Non-Scoliosis	0.01 (0.01)	0.02 (0.01)	5 (2.65)
Scoliosis	0.02 (0.02)	0.02 (0.03)	5 (6.08)

Table 2: Mean (SD) difference in VGRF, peak EMG, and pelvic kinematics.

Group	VGRF (N)	EMG (mV)	Tilt (deg)	Obliquity (deg)	Rotation (deg)
Non-Scoliosis	18.2 (1.2)	0.27 (0.27)	1.03 (0.67)	8.84 (3.31)	19.26 (8.75)
Scoliosis	31.7 (38.6)	0.06 (0.01)	0.48 (0.34)	13.01 (5.95)	13.71 (0.92)

Discussion

Although there were no statistically significant differences, there could be a clinical relevance in this study. The data comparing pelvic range of motion in the three planes indicated that rotations of the pelvis were limited in the sagittal and transverse planes in subjects with scoliosis. Non-scoliosis subjects had 0.55 and 5.55 more range of motion than scoliosis subjects did in the sagittal and transverse planes respectively. Hence, subjects with scoliosis seemed to be compensating for this lack of range of motion with higher pelvic obliquity than non-scoliosis subjects, 13.01 and 8.84 respectively.

Differences between sides for step time, stride time, and cadence showed that the scoliosis group had a greater difference between sides. Average running cadence was lower in the scoliosis group than the non-scoliosis group, 162.8 steps/min and 166.5 steps/min respectively. Mahaudens et al. (2009) found that during gait analysis the scoliosis group had a higher cadence than the non-scoliosis group, although not significant. These differences could be related to our small sample size and to difference between activities, running vs. walking .

EMG data were calculated to determine the differences of peak EMG during stance phase between sides in the two different groups, no statistical differences were found. It was hypothesized that subjects with scoliosis would show higher averaged peak EMG differences between sides, however we found that the scoliosis group showed smaller difference (0.06 mV) than the non-scoliosis group (0.27 mV). One explanation could be that the non-scoliosis group had greater differences in pelvic tilt between right and left sides during contact phase than the scoliosis group. Lack of range of motion of the spine in subjects with scoliosis could result in decreased muscle activity.

Studies that measured walking gait in subjects with scoliosis identified differences in kinetic parameters between right and left sides, and when compared to subjects without scoliosis . In this study static standing vertical ground reaction force was measured to determine if any differences were present between the scoliosis and non-scoliosis groups. Although not statistically significant, the scoliosis group has shown a higher VGRF differences between sides than the non-scoliosis group, 31.7 N and 18.2 N respectively. However, standard deviation of the VGRF was larger in the scoliosis group (38.6 N) than the non-scoliosis group (1.2 N), by almost 30 folds. This may indicates that the subjects in the scoliosis groups have different patterns and strategies to compensate for the differences in sides. To do so they may adjust their body posture (which was not measure in the current study) and/or their weight distribution between sides.

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