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The effect of leg length discrepancy on paraspinal muscles activation using surface electromyography

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Introduction

▸ Leg length discrepancy (LLD) was correlated with symmetrical postural balance and scoliosis with lumbar and thoracolumbar curves.
▸ Even though the effect of gait on the paraspinal muscles is low intensity, its repetitive nature can have a significant impact especially on genetically vulnerable individuals.
▸ This study aimed to assess the influence of induced LLD on the paraspinal muscle activity and kinematic variables during gait.

Methods

Study population

▸ Healthy participants aged from 5 to 12 years
▸ Having no LLD
▸ Willingness to participate in the study, and provision of informed consent.

Exclusion criteria

▸ Any history of back or lower extremity surgery and neuromuscular disorder
▸ LLD of > 0.5cm
▸ Acute low back pain for 12 weeks prior to recruitment.

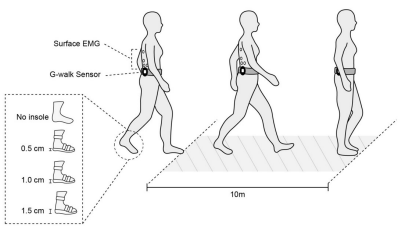
Experiment setup

▸ Surface EMG
1) Bilateral 7th and 12th thoracic erector spinae muscles (EST7 and EST12)
2) Bilateral 3rd lumbar erector spinae and multifidus muscles (ESL3 and MuL3)
3) Bilateral Iliopsoas and quadratus lumborum muscles (QL)
▸ G-walk sensor: on the waist, positioning the center at the 5th lumbar vertebrae.

Experiment procedure

▸ Maximal voluntary contraction (MVC) by maintaining both hands and legs raised in the prone position (superman position)
▸ 10-meter walk test with Surface EMG and G-walk sensor for the following two different conditions **(Figure 1)**.
1) non-LLD condition without an insole (LLD 0cm)
2) induced LLD condition with an insole on the right leg at three different heights (0.5cm, 1.0cm, and 1.5cm; LLD 0.5cm, LLD 1.0cm, LLD 1.5cm, respectively)

Figure 1. Experimental procedure



Data collection

▸ The mean of normalized root mean square (RMS) values of each muscles
▸ Normalization methods
1) MVC method using the mean RMS measured by superman position (RMS_MVC)
2) Reference voluntary contraction method using the mean RMS of LLD 0cm (RMS_ref)
▸ Gait parameter
1) Cadence, speed, stride length
2) Stance phase (% Gait cycle, GC), swing phase (% GC), double support (% GC), single leg support (% GC)
3) The symmetry of the pelvic tilt, the pelvic obliquity, the pelvic rotation

Table 1. Demographics of participants

	Mean ± SD [min, max] or number (%)
Age (years)	8.69 ± 2.20
Sex, n (%)	
Male	24 (61.5%)
Female	15 (38.5%)
Height (cm)	134.62 ± 14.98
BMI (kg/m²)	18.12 ± 2.89
True LLD (cm)	0.04 ± 0.08
Apparent LLD (cm)	0.03 ± 0.06

Data are presented as mean ± standard deviation, or number (percentage); BMI: Body mass index; LLD: Leg length discrepancy; SD: Standard deviation

Results

▸ Thirty-nine participants were enrolled in the study and demographics are presented in **Table 1**.
▸ In LLD 0cm, the mean RMS_MVC and RMS_ref were not different between the sides except for iliopsoas.
▸ The mean RMS_MVC of EST12 on the right side was significantly higher at LLD 0.5cm and 1cm than the left side. In the case of MuL3, the mean RMS_MVC was significantly higher at LLD 1.5cm than that of the left side. **(Table 2)**.
▸ The mean RMS_ref of EST12 was higher on the right side than on the left side in all LLD level. In the MuL3, the mean RMS_ref was higher on the right side than on the left side although it is clearly noticeable at LLD 1.0cm. **(Figure 2)**.
▸ For gait analysis, there was a significant decrease in the symmetry of pelvic obliquity and pelvic rotation at LLD 1.5cm compared to LLD 0cm **(Table 3)**.

Table 2. Comparison of the S-EMG mean RMS_MVC values

	Location	Left	Right	P value
Mean RMS_MVC LLD 0cm	EST7	0.07 ± 0.05	0.19 ± 0.40	0.065
	EST12	0.28 ± 0.53	0.25 ± 0.24	0.757
	MuL3	0.22 ± 0.66	0.16 ± 0.21	0.598
	ESL3	0.57 ± 1.27	0.29 ± 0.42	0.200
	QL	0.51 ± 1.07	0.49 ± 1.04	0.940
	Iliopsoas	**0.25 ± 0.24**	**0.81 ± 1.05**	**0.014**
Mean RMS_MVC LLD 0.5cm	EST7	0.08 ± 0.06	0.18 ± 0.29	0.439
	EST12	**0.23 ± 0.22**	**0.55 ± 0.68**	**0.010**
	MuL3	0.11 ± 0.07	0.21 ± 0.32	0.072
	ESL3	0.56 ± 0.98	0.31 ± 0.41	0.156
	QL	0.53 ± 1.00	0.37 ± 0.40	0.444
	Iliopsoas	**0.26 ± 0.23**	**0.76 ± 0.89**	**0.014**
Mean RMS_MVC LLD 1.0cm	EST7	0.09 ± 0.13	0.20 ± 0.30	0.335
	EST12	**0.27 ± 0.31**	**0.61 ± 0.84**	**0.023**
	MuL3	0.12 ± 0.08	0.18 ± 0.19	0.069
	ESL3	0.49 ± 0.82	0.33 ± 0.60	0.345
	QL	0.54 ± 1.05	0.39 ± 0.49	0.504
	Iliopsoas	**0.27 ± 0.23**	**0.77 ± 0.62**	**0.001**
Mean RMS_MVC LLD 1.5cm	EST7	0.09 ± 0.16	0.21 ± 0.28	0.053
	EST12	0.31 ± 0.45	0.51 ± 0.64	0.125
	MuL3	**0.11 ± 0.06**	**0.20 ± 0.21**	**0.041**
	ESL3	0.31 ± 0.39	0.38 ± 0.62	0.591
	QL	0.48 ± 0.77	0.36 ± 0.47	0.637
	Iliopsoas	0.33 ± 0.45	0.77 ± 0.94	0.054

Data are presented as mean ± standard deviation. P-values below 0.05 are shown in bold.; RMS: Root mean square; MVC: Maximal voluntary contraction; LLD: Leg length discrepancy; EST7: T7 erector spinae; EST12: T12 erector spinae; MuL3: L3 multifidus; ESL3: L3 erector spinae.; QL: Quadratus lumborum

Figure 2. Comparison of the S-EMG mean RMS_ref values

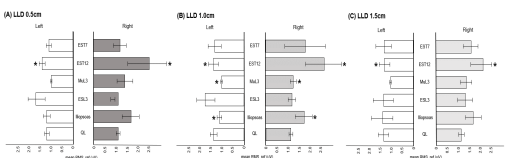


Table 3. Comparison of gait parameters between non-LLD and LLD conditions

	LLD 0cm	LLD 0.5cm	LLD 1.0cm	LLD 1.5cm
Cadence (strides/min)	111.46±13.57	109.27±11.23	110.03±12.49	109.60±13.69
Speed (m/s)	0.75±0.16	0.74±0.17	0.79±0.22	0.76±0.19
Stride length (m)	0.81±0.15	0.81±0.18	0.86±0.20	0.84±0.19
Pelvic tilt (%)	48.13±23.04	47.44±27.22	47.93±26.37	49.83±23.75
Pelvic obliquity (%)	96.36±3.11	95.04±4.21	95.15±4.04	**93.82±7.38***
Pelvic rotation (%)	97.39±2.26	96.35±3.52	96.83±2.23	**95.80±3.59***
Right stance phase (%, GC)	61.05±1.99	**59.59±2.55***	**59.64±2.51***	**58.84±2.48***
Right swing phase (%, GC)	38.95±1.99	**40.41±2.55***	**40.36±2.51***	**41.16±2.48***
Right double support (% GC)	11.45±1.71	11.20±1.77	11.57±1.71	11.41±1.94
Right single support (% GC)	38.26±2.14	37.41±2.56	37.45±2.11	37.77±2.35
Left stance phase (%, GC)	61.43±2.27	**62.56±2.60***	**62.44±2.01***	62.23±2.39
Left swing phase (%, GC)	38.57±2.27	**37.43±2.60***	**37.56±2.01***	37.77±2.39
Left double support (%, GC)	11.27±2.02	11.13±1.95	10.89±2.16	**9.79±2.06***
Left single support (%, GC)	38.66±2.10	**40.12±2.76***	**39.97±2.58***	**41.09±2.55***

Data are presented as mean ± standard deviation. P-values below 0.05 are shown in bold and given asterisk.; LLD: Leg length discrepancy; GC: Gait cycle

Conclusion

▸ Even a small difference in LLD developed a significant effect on the asymmetric hyperactivation of the MuL3 and EST12 muscles during gait.
▸ Considering the action of multifidus and erector spinae muscle, asymmetric hyperactivation can result in the rotation and bending of the lumbar spine and the bending of the thoracolumbar spine.

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