TRANSVERSE PLANE TRUNK ROTATION DURING GAIT IN LOW-BACK PAIN PATIENTS

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SUMMARY
We hypothesized that patients with low-back pain prevent unplanned lumbar movements during gait by coupling of rotations of pelvis and thorax through increased impedance. 14 patients and 12 matched controls walked on a treadmill, while kinematics were recorded. Transverse plane rotations between pelvis and thorax were less variable in patients. This was due to a higher correlation of residual rotations of the pelvis and thorax, i.e. of the deviations from the rotational movements of these segments averaged over all strides. These results support the hypothesis that patients increase lumbar impedance to increase control over lumbar rotations.

INTRODUCTION
During gait, roughly periodic, transverse plane trunk rotations occur at the stride frequency with some stride-to-stride variability at higher frequencies. Individuals with low-back pain (LBP) may demonstrate splinting and guarding behavior to avoid uncontrolled trunk rotations, possibly by an increase of the mechanical impedance between the pelvis and thorax [1]. Lower relative phase and higher coherence between pelvis and thorax rotations at the dominant movement frequency (stride frequency) have been reported and may reflect such behavior, but are not consistently observed in all patients [2]. Impedance control may act as a filter leaving the main component of movement intact, while reducing movement variability at other frequencies [3]. Therefore, we hypothesized that in LBP patients, the variability of transverse plane rotation between the pelvis and thorax is lower. Furthermore, we hypothesized that in a regression of the pelvic rotations deviating from the average pattern of rotation (residual rotations) against the corresponding thoracic residual rotations, the correlation coefficient is higher and the regression coefficient is closer to 1 in LBP patients than in healthy controls.

METHODS
14 participants with chronic LBP (9 females, 35.3±11.3 years, 72.3±13.9 kg) and 12 healthy controls (8 females, 32.2±13.1 years, 75.3±11.2 kg) walked on a treadmill at speeds varying from 1.8 to 6.2 km/h in steps of 0.4 km/h. Thorax, pelvis and foot kinematics were measured using clusters of three LED markers attached to these segments using an automated motion analysis system (Optotrak, Waterloo ON Canada). Time series of pelvis and thorax rotations in the global reference frame were calculated through Euler decomposition. In addition a time-series of thorax orientation in the pelvis axis system (lumbar rotation) was calculated. Time-series were divided into strides based on foot kinematics, and strides were time-normalized to 101 samples. To calculate horizontal plane residual pelvis, thorax and lumbar rotations, first the average pattern over strides of each time series was determined. Second, the average rotation was subtracted from every normalized stride cycle to yield a matrix of residual rotations. The residual rotations represent the presumably unplanned rotations that deviate from the average pattern and thus have a frequency other than the average pattern. The root-mean-squares of these residual rotations were used to express variability of pelvis, thorax and lumbar rotations in a single number per participant and speed. The residual rotations of the pelvis and the thorax in the global frame were correlated to each other to assess mechanical coupling between these segments. If these residual rotations are perfectly correlated with a slope of 1, no 'unplanned' lumbar rotations occur. Therefore, coefficients of correlation and regression coefficients were used as dependent variables. Statistical analysis was performed using generalized estimated equations (GEE) with group as factor and speed as covariate.

RESULTS
Average pain at the time of testing was 29.8 ± 14.7 mm on 100 mm VAS in the LBP group. The patients showed less variability of lumbar horizontal plane rotation than control (GEE: 0.81 – 0.19 (if LBP, p=0.01) + 0.03 * Speed (km/h)). Figure 1 shows a typical example of residual rotations at 5.8 km/h in a patient and a healthy control subject. Figure 2 shows examples of the regression between pelvis and thorax residual rotations at two speeds. Both figures show a higher similarity between the residual rotations of pelvis and thorax in the patient. At the group level, the correlations between the residual rotations of the pelvis and the thorax were higher in the LBP group than in the controls (GEE: 0.85 + 0.07 (if LBP, p=0.03) – 0.04 * Speed (km/h)). In addition, the slopes of the regression between pelvis and thorax were closer to 1 in the LBP group (GEE: 0.92 + 0.08 (if LBP, p=0.05) – 0.04 * Speed (km/h)).
**DISCUSSION**

Previous studies had shown higher coherence and lower phase differences at the stride frequency between pelvis and thorax rotations in LBP patients compared to healthy controls [2,4]. This finding was not consistent though and it is noteworthy that in the present study such an effect was not significant and in fact clearly present in only 2 patients. Nevertheless coupling between pelvis and thorax rotations at other frequencies than the stride frequency was stronger in the patients, as was demonstrated by the higher correlations between residual rotations. The patient group in the present study was characterized by relatively lower pain levels than those in the previous studies. This may suggest that the planned trunk movement is only affected by an in more severe LBP.

Overall, these studies support the assumption that LBP patients use a protective movement strategy in which unplanned lumbar rotations during gait are prevented through increased impedance between the pelvis and thorax.

**REFERENCES**