Effect of Lumbar Lordosis Angle on Vertebral Loads during Walking

Jie Chen[1], Patria A. Hume[1,2,3,4], Hannah Wyatt[5,2], Ted Yeung[1], Julie Choisne[1]

[1] Auckland Bioengineering Institute, The University of Auckland, Auckland, New Zealand

[2] Sports Performance Research Institute New Zealand (SPRINZ), Faculty of Health and Environmental Science, Auckland University of Technology, New Zealand

[3] Traumatic Brain Injury Network (TBIN), Auckland University of Technology, Auckland, New Zealand

[4] Technology and Policy Lab - Law School, The University of Western Australia, Perth, Australia

[5] Sport, Health and Rehabilitation Research Cluster, Faculty of Health, The University of Canterbury, Christchurch, New Zealand

Email: jche973@aucklanduni.ac.nz

Summary

Atypical sagittal spinopelvic alignment is correlated with exacerbating lower back pain (LBP). This study investigated the effects of simulated sagittal spinopelvic alignment via altered lumbar lordosis (LL) on lumbar vertebral contact forces during walking. A full-body OpenSim model with custom lumbar joints was developed to estimate lumbar vertebral loads for self-selected speed walking gaits of 18 healthy participants. Limited LL during walking augmented the resultant vertebral compressive and shear forces, and vertebral body compression. Excessive LL increased resultant vertebral shear forces, compression at facet joints and L5/S1 vertebral body, potentially progressing to different types of LBP.

Introduction

Deviant sagittal spinopelvic alignment is commonly assumed as one of the factors to accelerate lumbar degenerative processes, which may lead to low back pain (LBP) [1]. This deviant alignment may result in abnormal lumbar loads or load distribution, exerting a pivotal mechanical influence on the etiology of LBP [2]. Nonetheless, association between spinopelvic alignment and LBP remains controversial, with studies yielding inconsistent findings [3]. This study aimed to investigate the effects of simulated sagittal spinopelvic alignment via altered lumbar lordosis (LL) on lumbar vertebral joint contact forces during walking.

Methods

A full-body OpenSim model with custom lumbar joints was developed to calculate lumbar vertebral joint loads, including resultant lumbar vertebral compressive and sagittal shear force, and distributed compression between the vertebral body and facet joints, for walking gaits of 18 healthy participants. LL values were set to simulate hyperlordosis (85°, 75°, 65°), normal lordosis (55°, 45°, 35°), and hypolordosis (25°, 15°, 5°) during walking. Relationships between sacral slope value and LL of each gait trial were outputted and compared with previous studies for the evaluation of modified gait simulations.

Results and Discussion

Starting from normal LL (45°), both lumbar resultant compressions and sagittal shear forces increased as the LL decreased from 45-5° in the walking simulation (Fig.1, A&B). The same trend was found in vertebral body compression (Fig.1, C).

From 45 to 85° of LL, the resultant lumbar compressive forces decreased during walking (Fig.1, A), but resultant sagittal shear force at the L3-L4 and L5-S1 levels, compression on the L5-S1 vertebral body and facet loads increased rapidly (Fig.1, B&C&D).

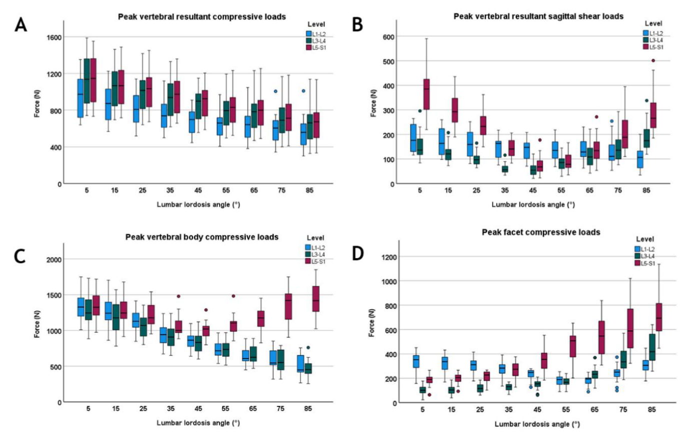

Figure 1: Average loads in (N) of (A) vertebral resultant compressive force, (B) vertebral resultant sagittal shear force, (C) vertebral body compressive force, and (D) facet compressive force at the L1-L2 (blue), L3-L4 (green) and L5-S1 (red) functional tissue unit.

Conclusions

The negative consequences of limited LL during walking included increased resultant compressive and shear forces between lumbar vertebrae. The consequences of excessive lordosis included increased lumbar sagittal shear force, facet joint compression and compression at vertebral bodies in caudal levels (L5-S1), which may progress to different types of LBP. Future studies should investigate LL in patients with different specific types of LBP and try to draw more definitive associations between LL and specific LBP.

References

[1] Nourbakhsh MR, et al. (2006). *J Back Musculoskelet Rehabil*, **19**:119-28.

[2] Adams MA, et al. (1982). *Orthopedics*, **5**:1461-5.

[3] Mirzashahi B, et al. (2023). *Med J Islam Repub Iran*, **37**:61.