



THE INFLUENCE OF CHRONIC LOW BACK PAIN ON THE SPINE AND HIP JOINT EXCURSIONS AND JOINT TORQUES DURING FORWARD BEND TASKS

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Introduction

Coupling of the spine and hip joint, or spine-hip ratio, has been described as an important aspect of clinical examination in patients with low back pain. Numerous studies have analyzed the movement between the spine and hip during a forward bend in healthy subjects (Thomas & Gibson 2007; Lee et al. 2002, Porter et al. 1997, McClure et al. 1997, Esola et al. 1996, Paquet et al. 1994). In these studies, agreement exists as to the gross pattern of movement between the spine and hip. Studies analyzing the spine-hip ratio during forward bending have concluded that spine movement is predominate in the initial phases of forward flexion, with the hip contributing more in the latter part of the movement. During the return to upright posture, hip movement predominates the initial movement, while the spine contributes more towards the latter part of extension (Lee et al. 2002, Porter et al. 1997, McClure et al. 1997, Esola et al. 1996, Paquet et al. 1994). However, in subjects with low back pain the normal spine-hip ratio may be altered as the subject attempts to protect their injury or prevent pain. Pain and fear may also influence changes in the kinematic patterns chosen by participants with chronic low back pain.

In addition to examining joint excursions of the spine and hip, the onset timing of these joints is thought to be important. However, data regarding onset timing of the spine and hip joints provides conflicting results. Several studies report simultaneous onset of the spine and hip motion during forward bending (Paquet et al. 1994, Esola et al. 1996, Lee et al. 2002, and Porter et al. 1997). However, only Lee et al. (2002) specifically analyzed onset timing. In contrast to these findings, Nelson et al. (1995) reported timing between the spine and hip to be simultaneous during spine flexion, but sequential during the return to upright posture with hip movement preceding that of the spine. A recent study by Thomas and Gibson (2007), provides evidence that there are clear differences in onset timing of the spine and hip during natural reaching movements. Therefore, the purpose of this was study to examine the influence of chronic low back pain on the timing and excursions of the spine and hip in participants performing a forward bend test. Additionally, we examined the peak-to-peak joint torques in this cohort.

Methods

Twenty subjects with chronic low back pain and twenty healthy controls matched according to age, height, weight, and gender performed two trials of the forward bending task. Subjects were instructed to bend forward as far as possible while keeping the knees extended, and then return to an upright posture. Participants performed the forward bend test at a self-selected speed. Motions of the trunk, pelvis, and limb segments were recorded using a 7-camera Vicon MX-13 System. An Euler angle sequence was used to derive the three dimensional joint motions of the lumbar spine (i.e. motion of the thorax relative to the pelvis), and right hip (i.e. motion of the pelvis relative to the right femur). For the joint kinematics, peak-to-peak excursion of the lumbar spine and right hip as well as the ratio of spine to hip excursions were calculated. Using custom algorithms, onset timing of the spine and hip was defined as the point where joint angular velocity first exceeded 5% of peak velocity. The spine hip latency was determined by subtracting hip joint onset from spine joint onset as defined above. General muscle torques of the lumbar spine and hip were also determined using a 15 segment inverse dynamic model developed in this lab using Matlab Simulink. The peak-to-peak spine and hip joint torques were extracted from the time series data.

Data Analysis

Univariate ANOVAs were used to analyze the effects of group on the peak-to-peak excursions of the spine and hip joints, the spine-hip ratio, the spine-hip latency, and joint torques of the spine and hip.

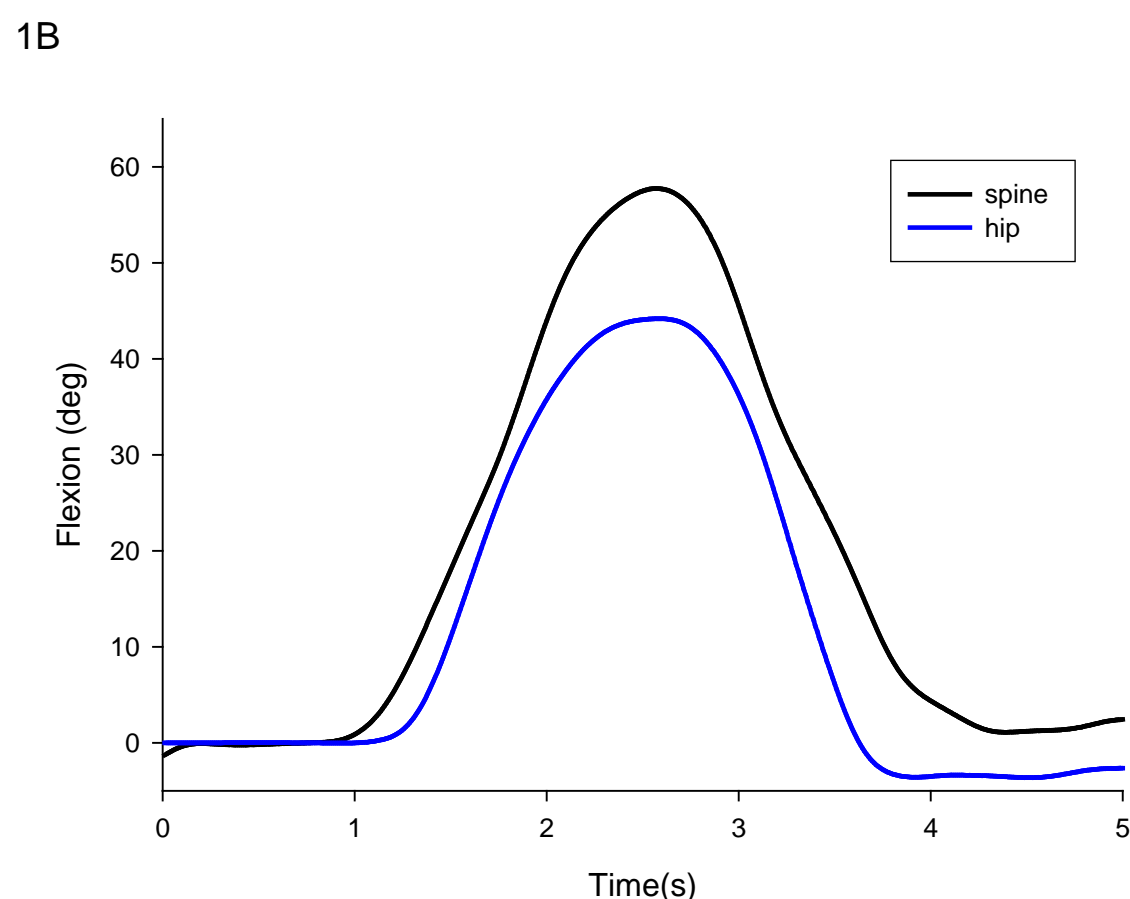
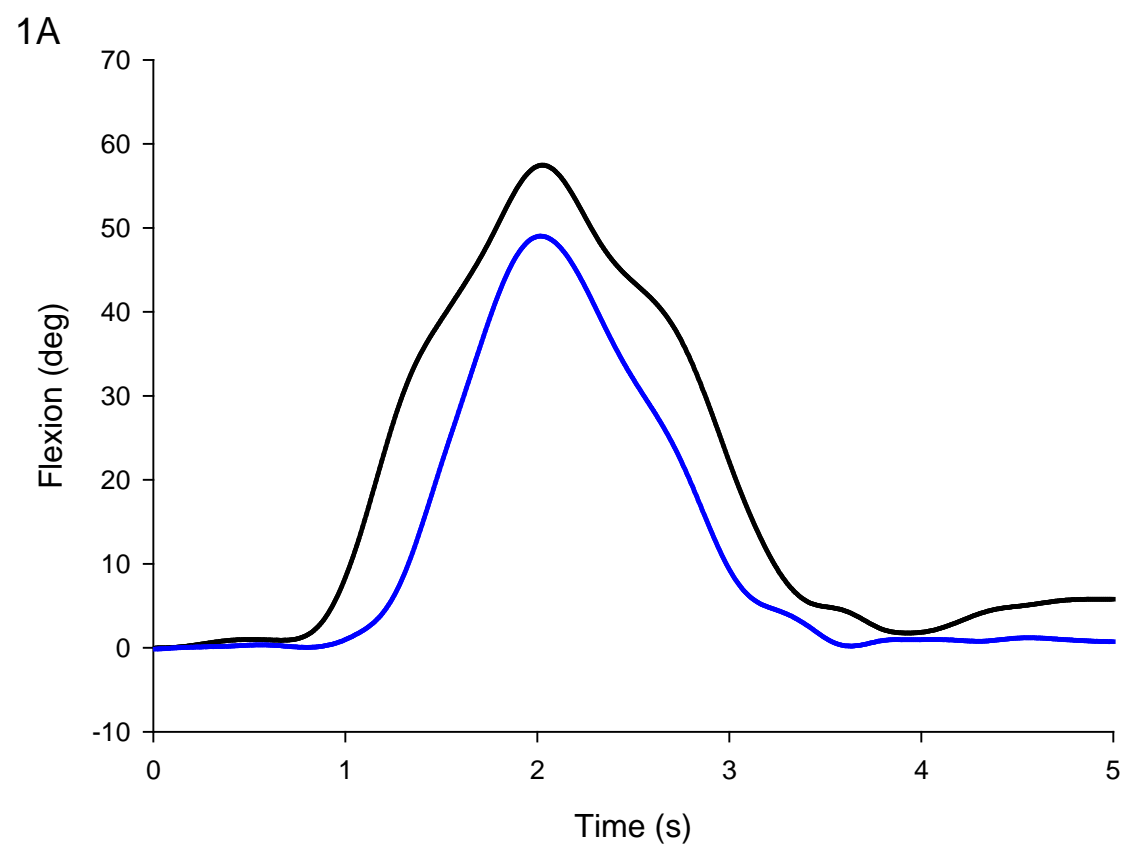


Figure 1: Time series displays of hip and spine flexion motion in a low back pain participant (A) and matched healthy control (B).

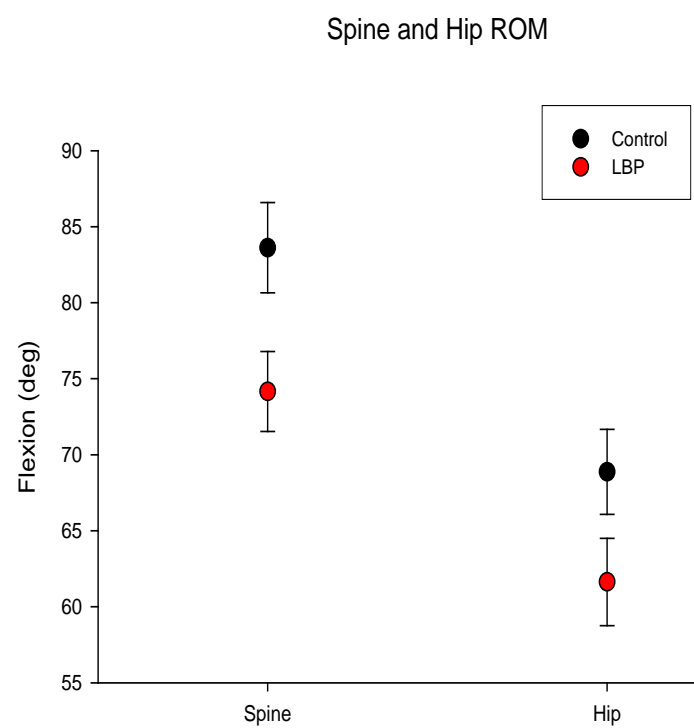


Figure 4: Aggregate data for low back pain participants and matched healthy controls during a forward bend test. Spine ROM was significantly different between groups but hip ROM was not.

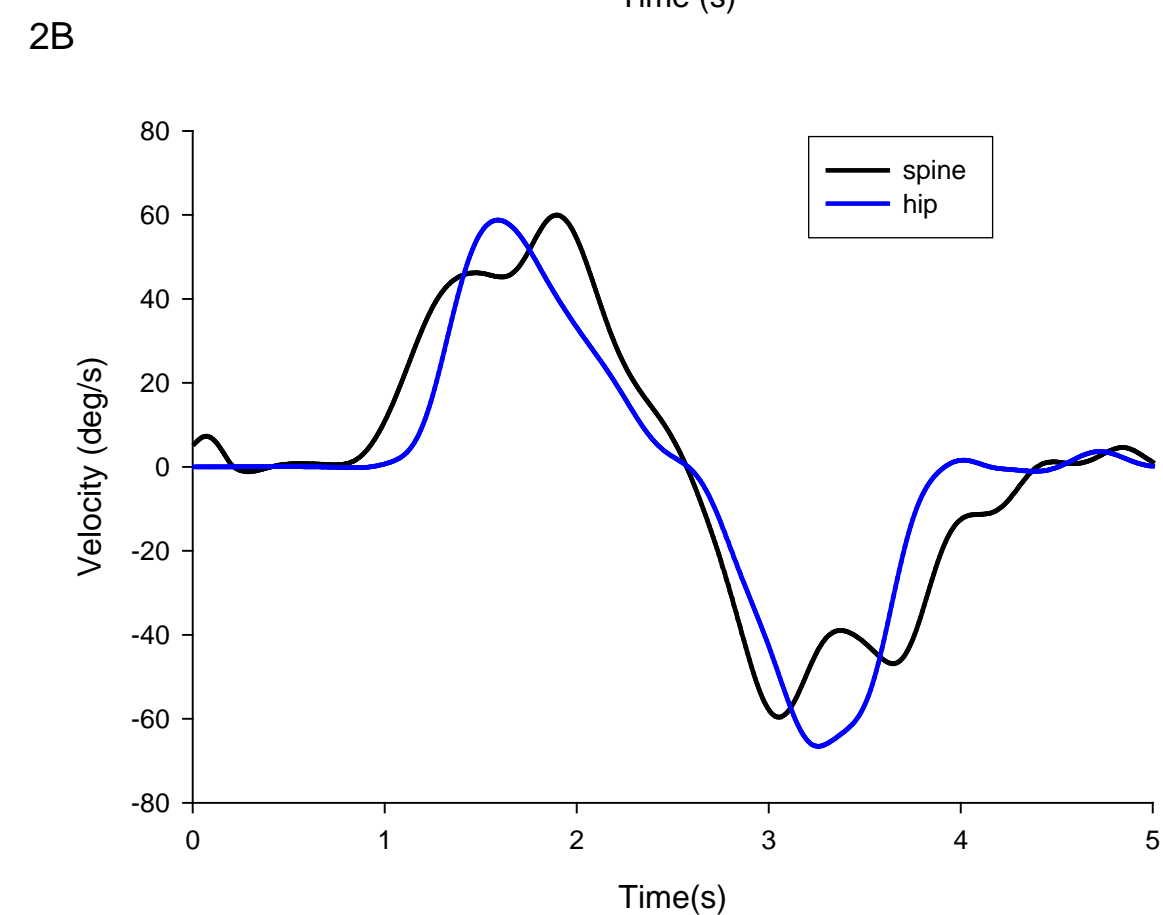
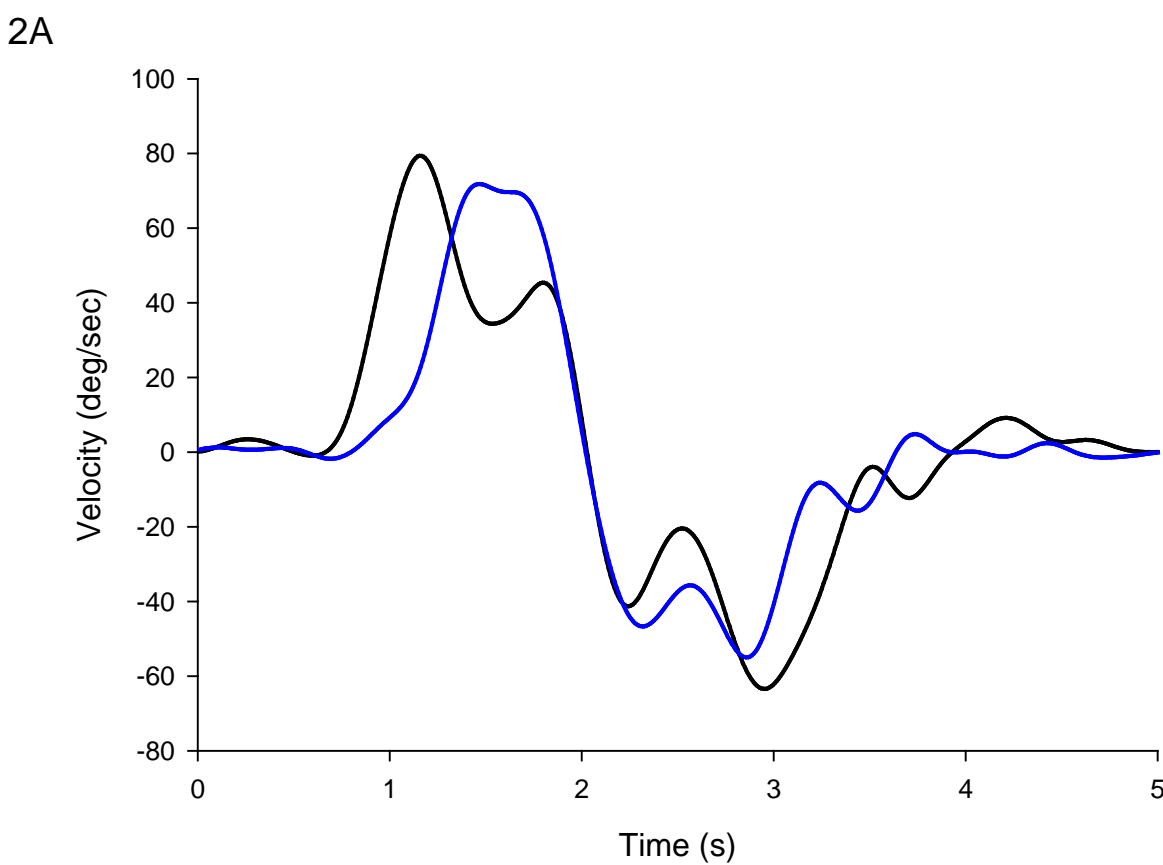


Figure 2: Time series displays of hip and spine velocity in a low back pain participant (A) and matched healthy control (B).

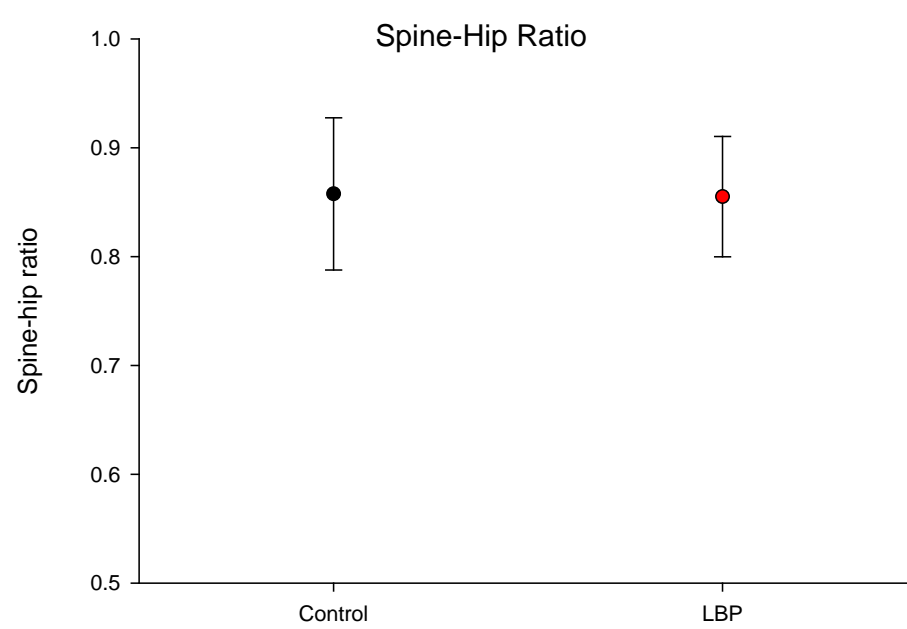


Figure 5: There was no significant difference in the spine hip ratio's of individuals with low back pain and matched controls.

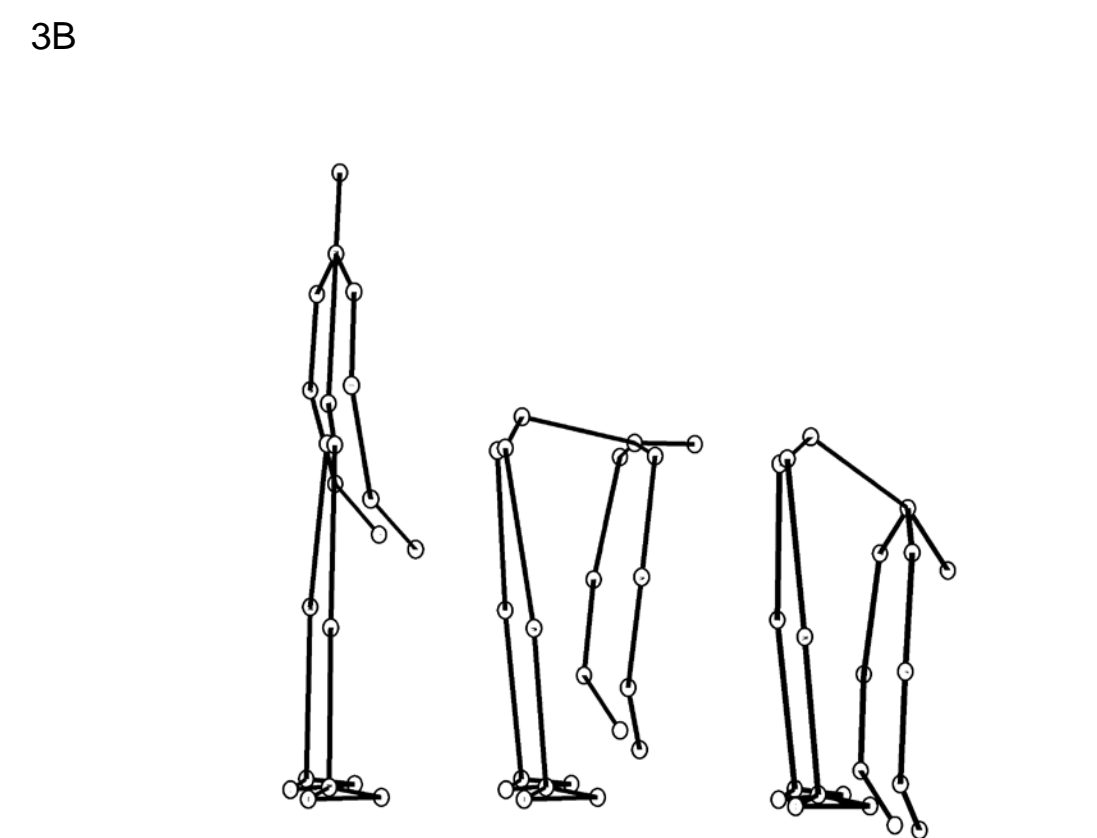
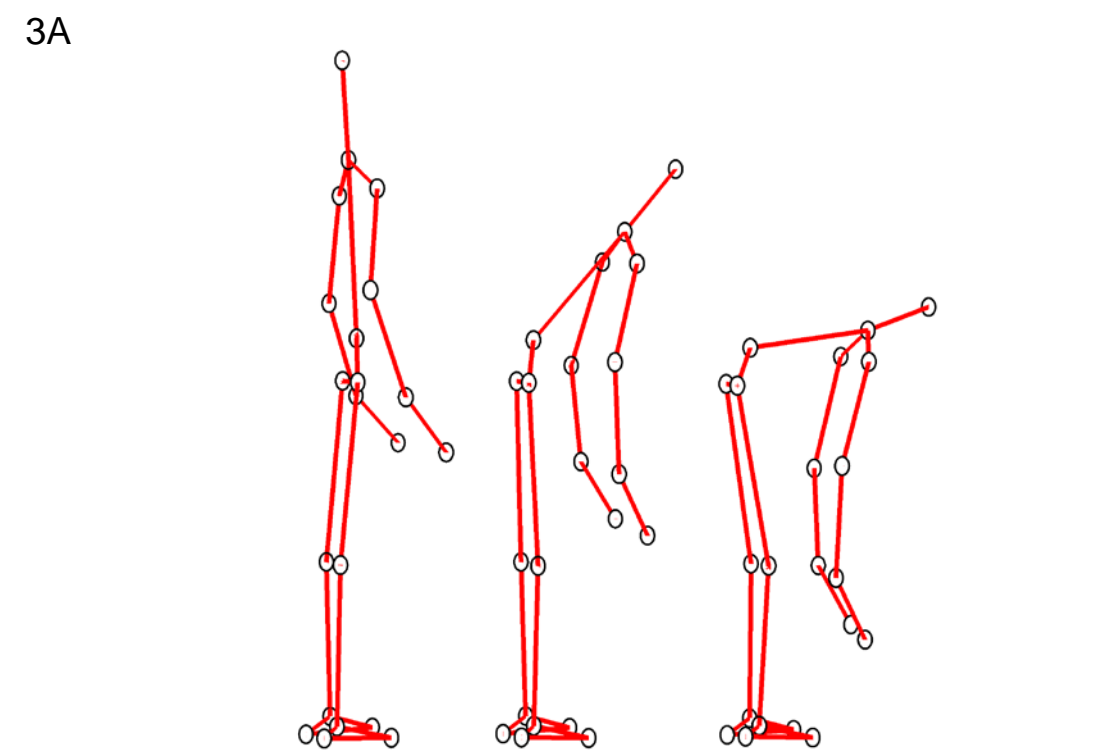


Figure 3: Stick figures illustrate a low back pain participant (A) and a matched healthy control (B) performing a FBT.

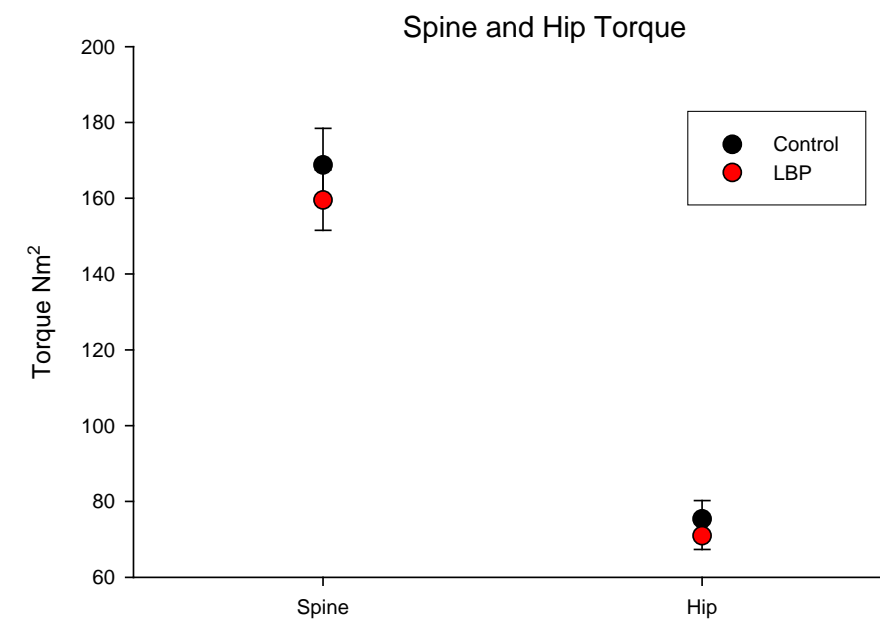


Figure 6: Aggregate data of participants with low back pain and matched healthy controls during a FBT demonstrate no significant differences between groups in joint torque at the spine or hip.

Results

Figure 1 displays time series kinematic data of a typical participant with chronic low back pain and a matched healthy control to illustrate the spine and hip joint motions used during this task. Subjects in both groups used more spine motion and less hip motion when performing the forward bend test. Further, Figure 2 illustrates the time series of hip and spine velocity of a participant with low back pain and a matched healthy control during the forward bend test. This figure clearly indicates that spine motion preceded hip motion for both subjects. The stick figures shown in Figure 3 provide insight into the differences in the excursions of the spine and hip joints in these subject groups. The participant with low back pain illustrated in Figure 3A used less spine motion, less hip motion, more flexion at the knee, and the participant was unable to touch the ground. In contrast, Figure 3B shows that the matched healthy control used more spine motion, less hip motion, and was able to touch the ground. In fact, on average, participants with chronic low back pain had significantly less spine motion than matched healthy controls ($F=5.73$, $p<.05$) (Figure 4). However, there were no group differences in hip joint motion ($F=3.2$, $p=.08$), or in the spine-hip ratio ($F=.001$, $p=.980$). Figure 5 shows that there were no significant group differences in the spine-hip ratio during the forward bend test. There were also no group differences in the onset timing of the spine and hip joints ($F=.036$, $p=.851$). On average, in the forward bend movement spine motion preceded hip motion by 77ms. Additionally, there was no group effect on the peak-to-peak joint torques of the lumbar spine ($F=.53$, $p=.46$), or hip joints ($F=.56$, $p=.456$) as presented in Figure 6.

Conclusions

During constrained forward bending tasks, subjects with chronic low back pain use less lumbar flexion, but had no differences in hip joint excursion, spine-hip ratio or onset timing of the spine and hip. Perhaps more importantly, the reduction in spine motion did not appear to reduce the general muscle torque on the lumbar spine.

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