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Integrated spinal motion: A study of two cases

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Serial measurements of intervertebral angles from L2–5 were carried out during sidebending in two asymptomatic subjects, using digital videofluoroscopy. One subject exhibited free motion at all three functional spinal units (FSUs), whilst the other had a fixation at L4/5. Both subjects demonstrated irregular motion at the mobile FSUs. However, these irregularities were simultaneously compensated for as the motion progressed, especially in the fixation-free subject. The results lend anecdotal support for the notion that freedom from joint fixation promotes integrated spinal motion. However, further studies and larger numbers will be necessary to confirm or refute this.
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KEY WORDS: digital videofluoroscopy, spinal motion, functional spinal units, chiropractic, manipulation.

On a procédé à des mensurations en série des angles intervertébraux à partir du L2–5 sur deux sujets asymptomatiques, en se servant de la fluoroscopie numérique, pendant que les sujets faisaient des flexions latérales. Le premier avait une liberté de mouvements aux trois unités spinales fonctionnelles (USF), alors que l'autre avait une fixation au L415. Les deux sujets avaient eu des mouvements irréguliers aux USF mobiles. Ces irrégularités se compensèrent cependant simultanément au cours des mouvements, notamment chez le sujet sans fixations. Ces résultats ajoutent un appui anecdotique à la notion que l'absence de fixation des joints encourage un mouvement spinal intégré. Il faudra cependant d'autres études et des cas plus nombreux, avant de pouvoir confirmer ou réfuter cette hypothèse.
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MOTS CLÉS : vidéofluoroscopie numérique, mouvements spinaux, unités spinales fonctionnelles, chiropratique, manipulation.

Introduction

The integrated nature of spinal function was stressed by Gillet and Liekens[1] long ago and this thinking has influenced the education of most European chiropractors. Indeed, when these suggestions were first made, they provided something of a balance to the "vertebral position school". However, vertebral motion is even less readily quantifiable than segmental position and the hypothesis that the promotion of movement at a level other than the pain site can be advantageous was difficult to prove. This in turn rested on the idea that irregular movement in a painful functional spinal unit may prejudice its recovery. Studies of the prevalance of paradoxical motion in sidebending in the lumbar spine also reflect this concern.[2,3]

The advent of digital videofluoroscopy (DVF)[4–6] has made it possible to obtain many pictures of motion sequences and thereby to quantify serial intervertebral angles in the spine to an accuracy of approximately +/− 1°. The technique involves digitising x-ray images of spine motion from an image intensifier. These are subsequently marked for vertebral position on the computer's monitor using a screen cursor (Figure 1). The results are calculated on-line and from them, rotational motion between vertebrae can be represented in detail. As for all techniques associated with marking x-rays, the procedure is error prone if established limits of image quality and geometric distortion are ignored. Indeed, the level of accuracy can only be obtained with rigorous attention to observer standardisation.[7]

The aim of this study was to portray, using DVF, the interactions between lumbar functional spinal units (FSUs) during sidebending motion and to compare the patterns obtained in two subjects who were clinically distinctive.

Methods and materials

Two volunteer subjects were screened in lumbar spine lateral bending using a modern x-ray machine and image intensifier (Figure 2), with local Medical Ethics Committee approval. Selection was based on their availability and willingness as adult males who had not been x-rayed in the previous four years. The subjects were screened in the sitting position with the

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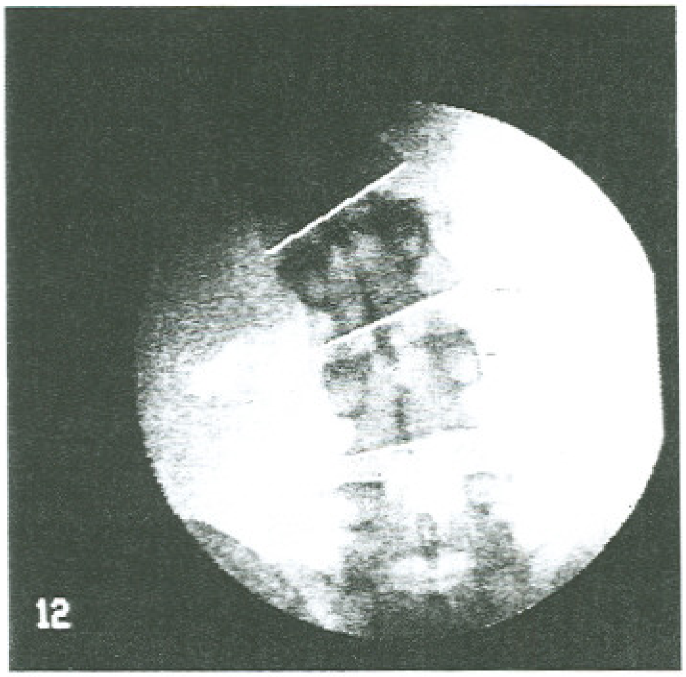

Figure 1 Digitised videoframe of lumbar spine sidebending, electronically marked to determine intervertebral angles.

primary beam directed anterior to posterior. They received gonadal shielding and were stabilised during bending using only a single strap across the thighs. They were instructed to side-bend with arms folded clear of the beam and, after two or three rehearsals, performed this action over approximately five seconds in each direction (left and right).

The mean time for screening was 15 seconds (including alignment), giving a mean x-ray absorbed dose of 2.0 mSv (Effective Dose Equivalents). The sequences were recorded on (¾" U-matic) videotape and subsequently a number of frames representing the full range of lateral flexion were digitised using a PDP11-based image processor. The digitised images were serially marked by a single observer to calculate intervertebral angles from L2–5 throughout the motion sequence. The neutral position was normalised and L5–S1 was omitted in the light of its small lateral flexion range.

All angles were the result of averaging three digitisations of each level. (This is a standard procedure for improving the accuracy of digitising coordinates.) These produced within-observer variation which was less than that obtained in the calibration studies (+/− 0.74°). These mean outputs were in the form of absolute angles, from which were obtained the intervertebral angles of the three FSUs at equal time increments throughout the motion sequences. The duration of each increment was 0.31 seconds for Subject 1 and 0.34 seconds for Subject 2. Thirty-two frames were digitised for each subject. Of these, all L2–5 motion had ended within 16 increments for Subject 1 and within 28 increments for Subject 2.

For the purposes of this study, intersegmental motion irregularity (ß) was defined as variation (SD) in size of the increments as expressed as a proportion of the overall range, viz:

$$ß = \frac{\text{SD of size of increment}}{\text{Overall angular range}} \times 100$$

This expression allows comparison of the variations in increment sizes to be made between FSUs which have different ranges of motion.

Patient 1: This male volunteer, aged 24, had a radiologically normal spine. He had no history of low back pain.

Patient 2: This 54-year-old asymptomatic male volunteer had radiological evidence of disc degeneration at the L4/5 level. He had suffered episodic debilitating back pain between the ages of 28 and 44 but had been trouble free since then.

Results

Patient 1: Figure 3a–c illustrates the intervertebral motion from L2–5 in Patient 1. Figure 3d represents the composite motion of these three FSUs. In these graphs, smooth motion would be represented as a gradual falling of the Y co-ordinate as the increments accumulate. Irregular motion, on the other hand, is seen as a more jagged appearance in these graphs. It can be seen that all three FSUs demonstrate a considerable degree of irregularity of motion. When taken together, to examine the regularity of the composite motion, this appears to be somewhat smoothed, as seen by the lower ß – value.

Patient 2: There was intervertebral joint fixation (i.e. absence of a discernable range of motion) at L4–5 in lateral bending, which is expressed in Figure 4c. The two FSUs above (Figure 4a,b) show a degree of irregularity in their sidebending motion, some of which is also reflected in the composite motion of all three FSUs (Figure 4d).

The error bars in Figures 3 and 4 represent +/− 2SD of the difference between true and observed measurements over a similar range and under similar conditions as in our calibration studies.[4–6] The variation (SD) in the size of the increments of composite motion represented 6% of the overall range in Subject 1 and 9% in Subject 2, suggesting greater irregularity of composite motion in Subject 2.

Discussion

The above results suggest that, in these two cases, lumbar FSUs functioned collectively to provide a kind of mechanical homeostasis by compensating for motion-irregularities at nearby

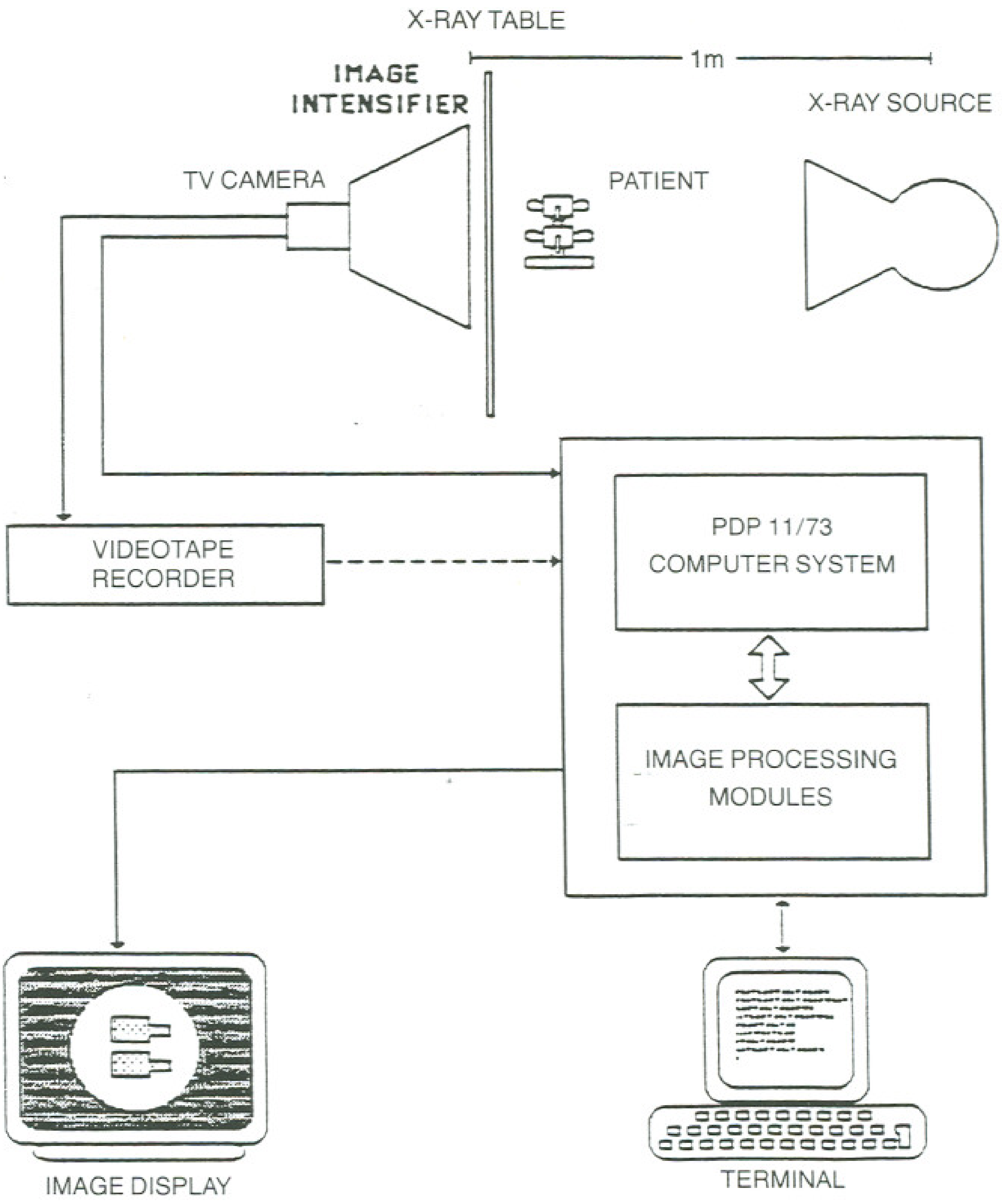

Figure 2 Diagram of digital videofluoroscopy system. (Reproduced with kind permission: Butterworth Scientific)

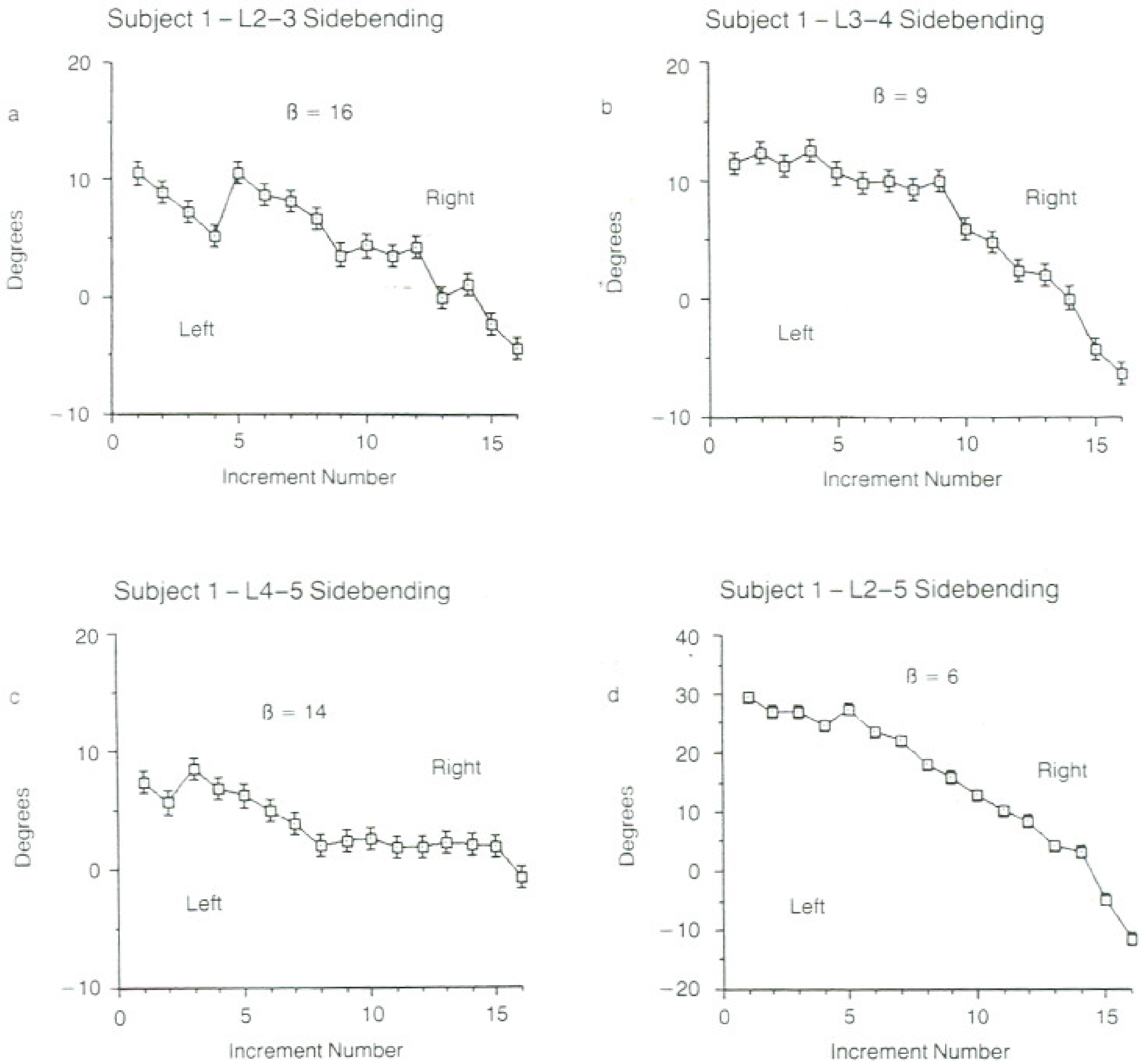

Figure 3a–d Graphs of 16 increments of sidebending from L2–5 in Subject 1. (Error bars represent +/− 2SD of the error found in calibration studies.)

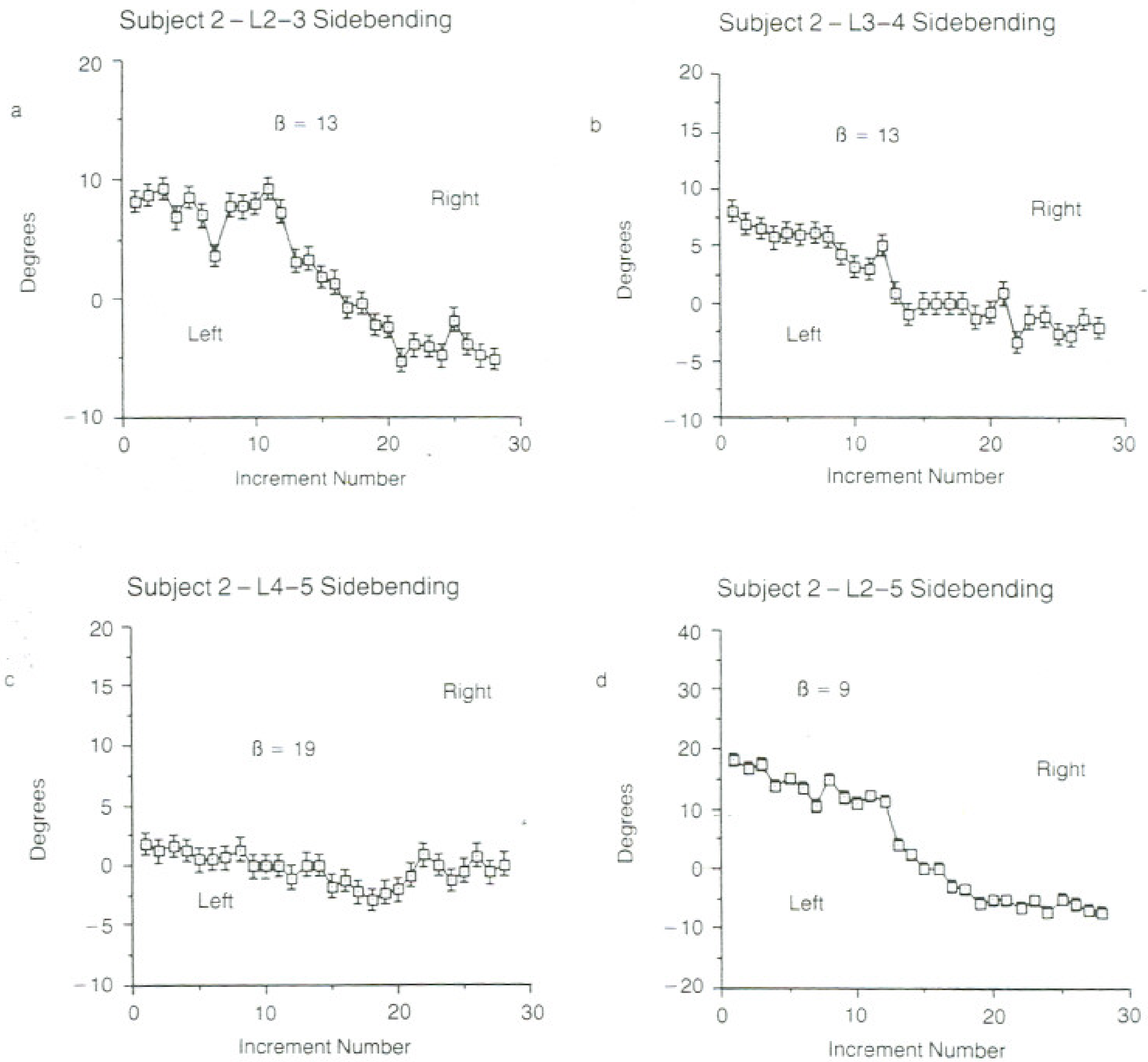

Figure 4a–d Graphs of 28 increments of sidebending from L2–5 in Subject 2.
(Error bars represent +/− 2SD of the error found in calibration studies.)

levels. This is seen by comparing the ß values (irregularity) for intersegmental motion with those for composite (L2–5) motion. In both subjects, the latter are less irregular. In Subject 2, however, composite motion irregularity is greater than in Subject 1.

It is important to consider any aspects of the methodology which could explain this as an artefact. Since it is not feasible to expect subjects to move naturally to a precise timing, a difference between them in terms of velocity of motion is to be expected. Subject 2, in this study, took nearly a second longer than in Subject 1 to complete his motion and the overall sampling rate was, therefore, slightly slower. However, it is difficult to see how the size of the increments could have been influenced by this, although a considerable difference in velocity could conceivably affect increment size and thereby influence the ß – value.

Of greater influence to the overall motion profile was the marked difference in the number of increments used between the two subjects. This is a factor which cannot be anticipated since FSUs outside the useful radius might contribute considerably, causing many redundant digitisations. Once again, however, it is the increment size in relation to its duration and the overall range which determines the result. If anything, more increments, as in Subject 2, would lower the standard deviation of increment sizes but in this study, the reverse was found.

As appreciated from clinical practice, everyone has his/her own uniquely individual pattern of segmental motion and the two subjects described here are no exception. What is apparent from these data is the reduction in smooth motion in the presence of the joint fixation in Subject 2 and, while other factors such as age may influence this in ways not considered here, the results are of interest in the light of Gillet and Liekens' original hypothesis.[1]

Conclusion

It cannot be established, at this stage, whether or not the difference found in these two examples is significant. While the results were objective and the measurement technique has been rigorously tested for reliability, what is demonstrated here may not be representative of what happens in populations. To ascertain this would require the study of a larger number of subjects. In order to identify just what determines "normality" in this regard, such population studies are a first priority.

Also of importance would be to establish objectively how spinal manual therapy may influence vertebral motion patterns. This may turn out to be the source of some unique surprises for the chiropractic profession. In particular, it could reveal to what extent we do restore "normal" mechanics. It has never been shown what the segmental effects of adjusting are, much less the trained chiropractor's ability to target the intended segment with this intervention.

Lastly, and perhaps most importantly, this technique could be used to seek relationships between dyskinesias and spinal pain syndromes; knowledge of which is fundamental to the scientific basis of chiropractic. Difficult therapeutic decisions, such as when to refer for surgery, often rest on knowledge, at present tenuous, of the kinematics of the affected segment.

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