A Comparison of the Effects of Two Sitting Postures on Back and Referred Pain

MAYNARD M. WILLIAMS, Ms, BSc, Dip Tchg,* JOHN A. HAWLEY, MA, PGCE, BSc (Hons),† ROBIN A. McKENZIE, Dip MT, FNZSP (Hon),‡ and PAULA M. van WIJMEN, Dip MT, MNZSP,‡

This study compared the effects of sitting with portable supports in either a kyphotic or lordotic posture on low-back and referred pain. Two hundred ten patients with low-back and/or referred pain were randomly assigned to either a kyphotic posture or lordotic posture group. The kyphotic and lordotic postures were facilitated by the use of a flat foam cushion or lumbar roll, respectively. Pain location, back pain, and leg pain intensity were assessed over a 24–48-hour period under both standardized clinical settings and general sitting environments. When sitting with a lordotic posture, back and leg pain were significantly reduced and referred pain shifted towards the low back. This study demonstrates that in general sitting environments a lumbar roll results in: 1) reductions in back and leg pain; and 2) centralization of pain. These findings do not apply to patients with stenosis or spondylolisthesis, whose symptoms may be aggravated by use of a lumbar roll. [Key words: kyphosis, lordosis, low-back pain, lumbar support, sciatic pain, sitting]

Epidemiologic studies have shown that individuals in occupations that involve prolonged periods of sitting experience a high incidence of low-back pain.[17,19,21–23] When changing from a standing to a sitting posture, there is a flattening of the lumbar lordosis[9] and an increased load on the spine as measured by intervertebral disc pressure.[7,26,27] Adams and Hutton have demonstrated both anular failure[1] and gradual disc prolapse[2] following fatigue loading of lumbar discs wedged in flexion. Additionally, Wilder, Pope, and Frymoyer[34] have shown that sitting for 1 hour results in significant changes in the mechanical properties of the lumbar intervertebral disc. In response to an axially applied load, the motion segments of the spine can suddenly buckle and apply a tensile impact loading to the posterolateral region of the disc. Wilder et al[34] propose that lumbar disc herniations can be a direct mechanical consequence of prolonged sitting.

There exist two sharply contrasting views as to what constitutes correct sitting posture. One theory[3,35] postulates that a flexed lumbar spine or kyphotic posture (KP) provides the optimal sitting position. Adams and Hutton[3] have argued that a KP reduces stresses at the apophyseal joints, reduces compressive stress on the posterior anulus, improves transport of disc metabolites, and results in high compressive strength of the spine.

The second theory regarding correct sitting position contends that maintenance of the lumbar lordosis, or a lordotic posture (LP), is important. To this end, use of a lumbar support during sitting is frequently advocated.[8,15,24,29,32] Such a device prevents pelvic rotation and preserves lordosis,[18] which in turn removes tension from the posterior anulus[16] and reduces both disc pressure[5,7,8] and the myoelectric activity of the posterior paraspinal muscles.[4–6,8] Twomey et al[32] have noted that many sitting postures permit the spine to sag into full lumbar flexion and creep beyond the normal range due to the weight of the upper body. They recommend the use of a lumbar support to prevent abnormal stresses on the collagenous elements of the intervertebral discs and zygapophyseal joint cartilages.

With regard to comfort, studies[14,20] have shown that subjects with or without back pain are more comfortable sitting with a lumbar support in a LP compared to a KP. These investigations, however, have been undertaken in laboratory settings with specially constructed experimental chairs. To date, no research has been undertaken to assess the effects of portable lumbar supports that can be used in the variety of seating environments typically encountered in day-to-day living. Further, previous studies have only compared the effects of sitting postures on back pain. No attempts have been made to assess the effects of sitting with a KP or LP on referred pain.

McKenzie[24] describes a "centralization" phenomenon whereby certain lumbar movements and positions result in a change in the distribution of referred symptoms from a distal to a more central location. Other lumbar movements and positions may "peripheralize" symptoms. In a retrospective study of 87 patients presenting with referred pain, and treated with McKenzie techniques, Donelson et al[13] reported that 76 patients (87%) demonstrated centralization. Further, all individuals exhibiting this phenomenon did so following extension rather than flexion movements. To date, no studies have assessed the effects of sitting posture on pain location.

The purpose of the current investigation was to compare the effects of sitting with a portable support in either a LP or KP on the intensity and location of back and referred pain. Comparisons were undertaken during both standardized laboratory settings and in general sitting environments over a 24–48-hour period.

METHODS

Twelve New Zealand-registered physiotherapists from ten physiotherapy clinics and one hospital physiotherapy department participated in this multicenter clinical study. At commencement, therapists sent a standardized letter to referring medical practitioners informing them of the purpose of the study and criteria for patient inclusion/exclusion.

Patients presenting at the clinics, aged 15 years and over with low-back pain and/or pain referred to the leg, were informed of the purpose of the study and requested to sign a consent form.

Excluded from the study were patients with:

1. Medically diagnosed stenosis, spondylolisthesis or recent fractures;
2. Neurologic motor deficit;
3. Surgical intervention for the present episode;
4. Apophyseal joint or epidural injections administered within the previous 4 weeks;
5. Chemonucleolysis administered within the previous 6 months;
6. Evidence of inflammatory joint disease;

From the *School of Physiotherapy, Faculty of Health Studies, Auckland Institute of Technology, Auckland, New Zealand, the †MRC/UCT Bioenergetics of Exercise Research Unit, Department of Physiology, Sports Science Center, University of Cape Town Medical School, Cape Town, South Africa, and ‡The McKenzie Institute (N.Z.), Wellington, New Zealand.

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7. Obvious deformity of acute list or lateral shift or lumbar kyphosis;
8. Symptoms of hysteria or anxiety neurosis.

Patients not excluded on the basis of the above criteria and who agreed to participate in the study were grouped into one of three categories according to the location of their symptoms: Category I—low back only; Category II—pain referred to the buttocks and/or lower limb above the knee; Category III—pain referred to the lower limb below the knee.

Categorization was determined by an initial questionnaire that also gathered selected demographic data.

The first 70 patients to present within each of the categories were randomly assigned to either a KP or LP group (N = 210). Whenever required to sit, the KP group were instructed to do so with their back in a supported but flexed posture. Conversely, the LP group were instructed to sit with their back in a supported but lordotic posture.

When sitting in their assigned posture within the clinic, patients were given specific instructions by the therapist and seated on a standard wooden straight-backed chair (seat height = 0.48 m, seat depth = 0.39 m, backrest height from seat of chair = 0.13 m, Figures 1–2).

The LP was facilitated by use of a lumbar roll (Figure 1) placed approximately at the level of the third and fourth lumbar vertebrae.[24] The roll measured 0.28 m long and had a diameter of 0.13 m. The density was 28 kg/m^3.

As a lumbar roll was provided to the LP group, and such a physical stimulus could be perceived by patients to have beneficial effects, it was felt necessary also to provide a physical stimulus to the KP group. The KP group was therefore supplied with a small foam cushion that was placed on the seat of the chair (Figure 2). Dimensions of the cushion were 0.43 m wide, 0.36 m deep, and 0.04 m high. Density specifications were as for the lumbar roll.

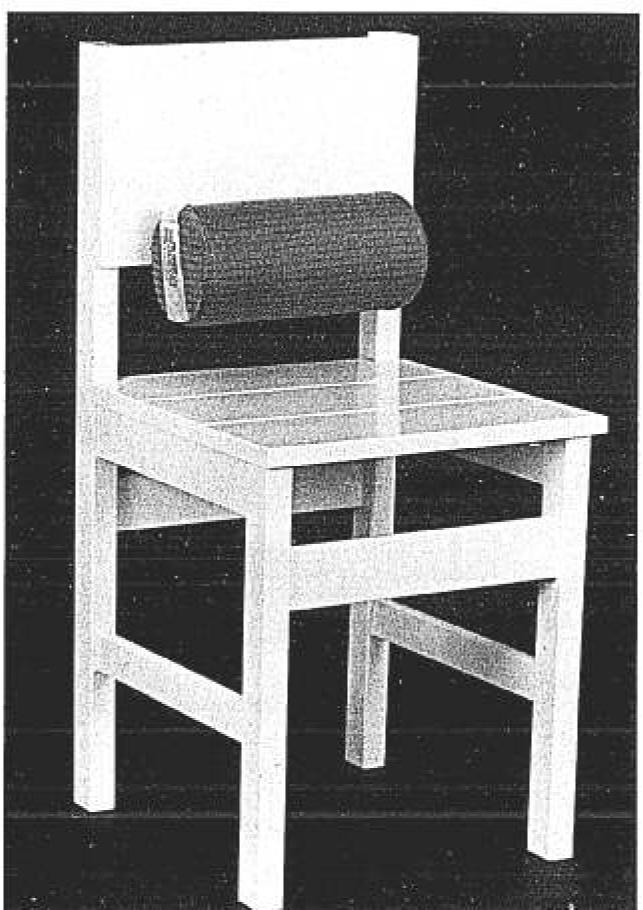

Fig 1. Portable lumbar roll and standardized chair. Roll positioned for illustrative purpose only.

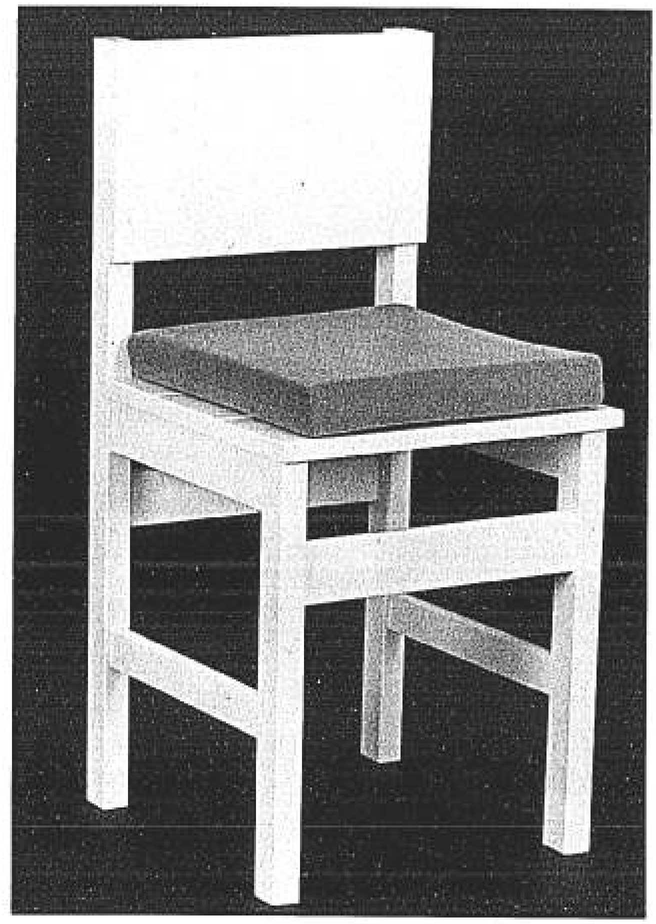

Fig 2. Portable cushion and standardized chair.

Pain location (PL), back-pain intensity (BPI), and leg pain intensity (LPI) were assessed by means of a questionnaire. This consisted of anterior and posterior body outline diagrams for patients to draw in the location of their pain, and 10-cm visual analogue scales for BPI and LPI ratings. The latter scales employed the descriptions "no pain" and "worst possible pain."

During their first visit to the clinic, patients were seated on the standard chair and immediately given the questionnaire to complete (PRE-TEST). They were then seated in their assigned posture (KP or LP) for 10 minutes, and the questionnaire was readministered (POST-TEST1).

Before leaving the clinic, patients were instructed as to the position they were to adopt, whenever seated, over the next 24–48 hours. They were provided with written instructions describing the correct sitting posture, and given either a lumbar roll or foam cushion.

Patients returned to the clinic within 48 hours, were immediately seated in their assigned posture, and again given the questionnaire to complete (POST-TEST2). Following a further 10 minutes of sitting in their assigned posture, the questionnaire was readministered (POST-TEST3).

POST-TEST3 contained a question not included in any of the previous tests. Patients were asked to rate any change in pain (CP) they experienced when seated in their assigned posture over the previous 24–48 hours, compared to the pain they would have experienced when sitting in their usual posture. CP was assessed on a five-point ordinal rating scale (Figure 3).

No other mechanical tests or maneuvers were applied to the patients

−2	−1	0	1	2
Much Less Pain	Less Pain	Same	More Pain	Much More Pain

Fig 3. Rating scale for CP during sitting over previous 24–48 hours.

for the duration of the study, and no restrictions were placed on patients' activity levels.

Data were collected during a 10-month period.

Data Analysis. All scoring procedures were performed by an individual who was blind as to the treatment status of the patients.

PL was determined by placing a template over the pain drawings and measuring the distance of patients' most distal symptoms from a horizontal line drawn at the region of L5–S1. The measurements were transformed to produce a PL score ranging from zero to ten. A score of zero indicated that pain existed only above L5–S1, while a score of ten indicated that pain radiated to the most distal point of the lower extremity. Pain drawings that indicated absence of pain could not be assigned a PL value. PL scores were determined for Category III patients only.

In addition to quantifying PL according to the extent to which pain radiated toward the lower extremity, the pain drawings were also assessed as to whether pain extended above or below the knee. This was determined by reference to a second horizontal line on the template, located at the position of the knee.

Statistical tests included chi-square analysis for categorical data, and analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) for continuous data.

CP ratings were analyzed by two-way factorial ANOVA, the independent variables being patient category and posture. Variables involving repeated measurements (BPI, LPI, and PL scores) were assessed by factorial MANOVA.[28] This method of analysis does not involve the assumption of sphericity, which can affect the Type I error rates and power of the traditional mixed-model ANOVA.[28] The multivariate tests were based on Pillai's statistic.

Separate three-way MANOVAs were employed for BPI and LPI, the independent variables being patient category, posture, and time. A two-way MANOVA assessed the effects of posture and time on the PL scores of Category III patients. Probes for significant changes from the PRE-TEST values were conducted using the Bonferroni procedure. Contrasts were performed for each posture group separately and for differences between the groups.

Data were analyzed using the computer software package SYSTAT (SYSTAT Inc., Evanston, Illinois), with results being considered significant where $P < 0.05$.

RESULTS

No significant differences existed between the two posture groups for the variables age, sex, or duration of present episode. Further, BPI, LPI, and PL did not differ significantly for the two groups at the PRE-TEST.

Table 1 presents the mean ages and sex characteristics for each of the patient categories. ANOVA revealed significant ($P = 0.001$) age differences, with Category III patients being older ($P = 0.001$, Tukey HSD test) than Category I patients. No sex differences were found.

Table 2 displays the duration of patients symptoms for each of the three patient categories. Patients are grouped according to whether their symptoms were acute (less than 7 days), subacute (7 days to 7 weeks), or chronic (greater than 7 weeks).[30] The proportions of patients falling within these three groupings differed significantly ($P < 0.05$) for the three patient categories.

Table 1. Age and Sex of Patients

	Patient Category (N = 210)		
	I (n = 70)	*II (n = 70)*	*III (n = 70)*
Age* (yr)	32.43 (±12.02)	37.21 (±13.07)	40.23 (±11.60)
Sex (F/M)	27/43	40/30	36/34

*Values for age are mean ± standard deviation.
Note: Patient categories joined by underlines not significantly different ($P > 0.05$), Tukey honest significant difference test.

Table 2. Frequency Distribution for Duration of Patients' Symptoms

	Patient Category		
Duration (Days)	*I (n = 68)*	*II (n = 69)*	*III (n = 70)*
<7	22 (32)	19 (28)	9 (13)
7-49	29 (43)	25 (36)	30 (43)
>49	17 (25)	25 (36)	31 (44)

Note: Values in parentheses are percentages. Proportions of patients within the three categories differ significantly (chi-square test, $P < 0.05$).

Figure 4 presents the mean BPI ratings for the two experimental groups at each test point. There were no significant category effects (main nor interaction), and therefore only the overall means are displayed. The time ($P = 0.015$) and posture by time interaction ($P = 0.016$) effects were significant. For the LP group the mean pain scores at POST-TEST2 ($P = 0.009$) and POST-TEST3 ($P = 0.045$) were significantly less than the PRE-TEST. In contrast, the POST-TEST means for the KP group did not differ significantly from the PRE-TEST. The two posture groups differed significantly ($P = 0.009$) at POST-TEST3 in terms of change in BPI from the PRE-TEST.

The mean LPI ratings for patients in Categories II and III who indicated the presence of leg pain (n = 119) are shown in Figure 5. There were no significant category effects, and therefore only the overall group means are displayed. The time ($P < 0.001$) and posture by time interaction ($P = 0.012$) effects were significant. For the LP group, POST-TEST1 ($P = 0.006$), POST-TEST2 ($P < 0.001$), and POST-TEST3 ($P < 0.001$) all differed significantly from the PRE-TEST. In contrast, the POST-TEST means for the KP group were not significantly different from the PRE-TEST. The two groups differed significantly ($P = 0.018$) at POST-TEST3 in terms of alteration in LPI from the PRE-TEST.

Figure 6 presents the mean values for the CP ratings. A highly significant posture main effect was found ($P < 0.001$), but neither the category main effect nor its interaction with posture reached statistical significance. One-sample t tests revealed that both the LP and KP change in pain values differed significantly ($P < 0.01$) from zero (no change in pain).

The mean PL scores of Category III patients at each test point are displayed in Figure 7. Six patients from the LP group and seven from the

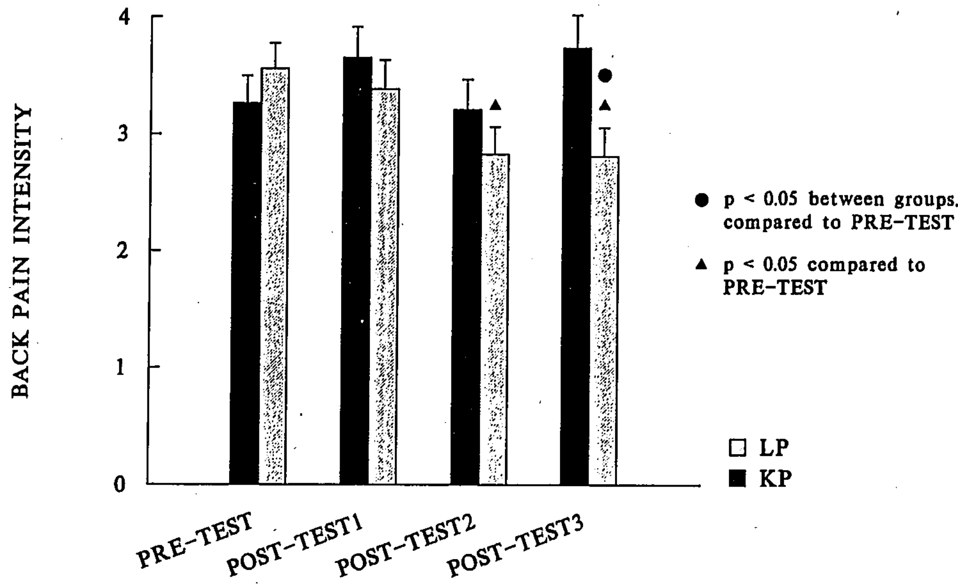

Fig 4. Back pain intensity ratings for LP and KP posture groups at successive test points (N = 210). Values are means ± SEM.

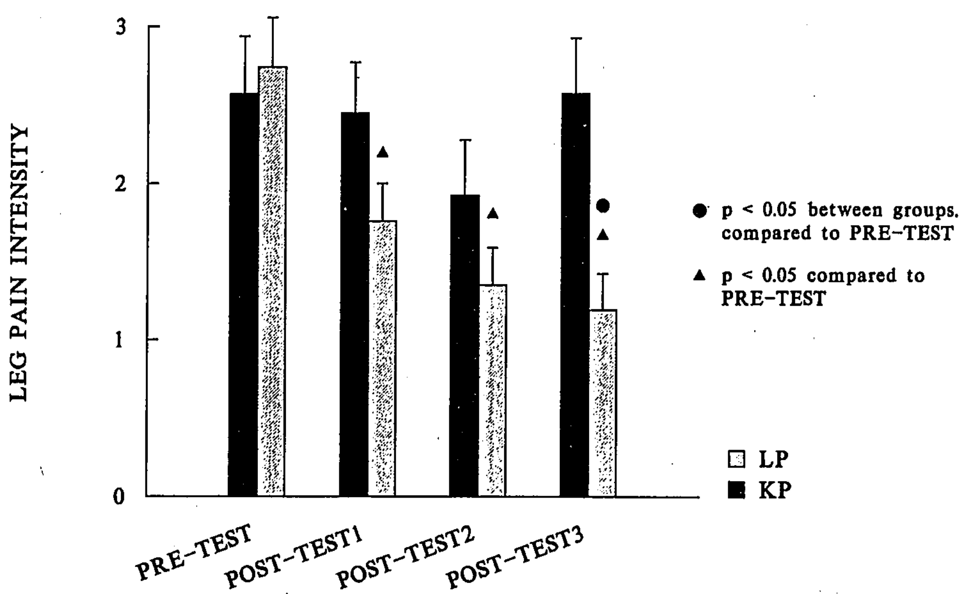

Fig 5. Leg pain intensity ratings for LP and kyphotic KP posture groups at successive test points (N = 210). Values are means ± SEM.

KP group were asymptomatic during one or more of the tests, and were excluded from the analysis. Of these patients, two were asymptomatic (both from the LP group) at POST-TEST 3. There were revealed significant posture ($P = 0.046$), time ($P = 0.004$), and posture by time interaction ($P = 0.007$) effects. For the LP group, significant reductions in pain radiation were found at POST-TEST1 ($P = 0.045$), POST-TEST2 ($P = 0.027$), and POST-TEST3 ($P = 0.018$). No such differences were found for the KP group. Significant differences existed between the groups at POST-TEST2 ($P = 0.002$) and POST-TEST3 ($P = 0.048$) in terms of change from PRE-TEST values.

Table 3 shows the proportions of Category III patients (n = 45) whose pain centralized from a position below the knee at the PRE-TEST to above the knee at each POST-TEST. One patient (from the LP group) became asymptomatic and was not included in the analysis. Significant differences existed between the groups at POST-TEST1 and POST-TEST3.

An additional test for pain location changes was performed on Category II and III patients who experienced leg pain above the knee at the PRE-TEST and whose pain shifted below the knee at POST-TEST3. The number of patients with pain above the knee at the PRE-TEST was 39 and 45 for the LP and KP groups, respectively. At POST-TEST3, 33 patients from the LP group continued to have pain above the knee, two patients had pain below the knee, and four became asymptomatic. Corresponding figures for the KP group were 32, ten, and three. After removing the seven patients who became asymptomatic, a chi-square test showed the proportions of patients whose pain shifted below the knee (5.7% and 23.8% for LP and KP groups, respectively) differed significantly ($P = 0.017$).

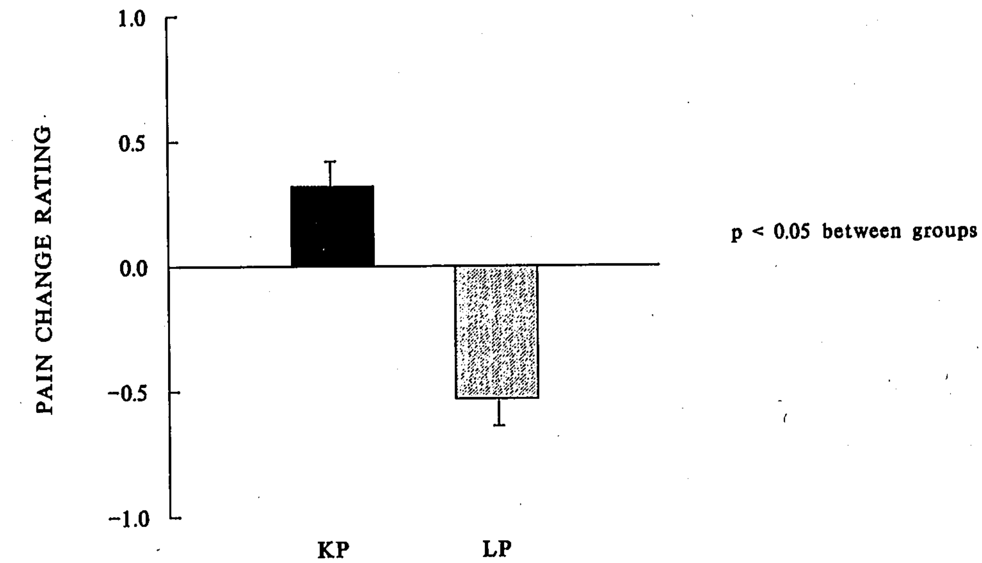

Fig 6. Change in pain rating for LP and KP posture groups. Values are means ± SEM.

Table 3. Category III Patients Whose Pain Centralized Above the Knee

	*Lordotic Posture (n = 25)**	*Kyphotic Posture (n = 20)**	*Significance*
Post-test 1	12 (48)	2 (10)	$P = 0.006$
Post-test 2	11 (44)	4 (20)	NS
Post-test 3	14 (56)	2 (10)	$P = 0.001$

*Patients with pain below the knee at the pretest.
Note: Values in parenthesis are percentages.

DISCUSSION

The mean age of our patients increased as pain radiated further toward the lower extremity, with Category III patients being significantly older ($P < 0.05$) than those in Category I (Table 1). Direct comparisons of the current data with previous research are difficult, and we have been unable to find any studies that verify our finding. However, Weber[33] reports that on average, 15 years pass between the onset of low-back symptoms and the onset of radiating pain associated with confirmed disc protrusion.

No significant differences were found in the number of men and women in each of the three patient categories. Previous studies have shown that low-back pain affects men and women equally.[11,31]

Table 2 shows that 32% of Category I patients had symptoms for less than 7 days, and 25% had symptoms for more than 7 weeks. In contrast, the corresponding figures for Category III patients were 13% and 44%, respectively. The data reveal a tendency for patients with more distal pain to have had their symptoms for longer periods of time. This finding is supported by previous research, indicating a slower recovery for patients with sciatic pain.[10] Additionally, our results support Dimaggio and Mooney's[12] assertion that, generally, the further back pain radiates into the lower extremities, the more complex the patient's condition is. In studies involving injection of hypertonic saline into the facet joint, Mooney and Robertson[25] reported a direct relationship between the amount of noxious stimulus and the extent of pain referral. Successively greater amounts of the stimulus resulted in pain referral first to the buttock, then to the thigh, and then to the calf.

BPI was significantly reduced following 24–48 hours of sitting in the lordotic posture (Figure 4). In contrast, the KP group showed no such effect. Indeed, while there was a 21% decrease in BPI for the LP group, there was a corresponding 14.5% increase in pain for the KP group (POST-TEST3). This time by posture interaction resulted in the groups differing significantly at POST-TEST3 relative to their PRE-TEST values.

The results for LPI (Figure 5) are similar to those for BPI. Of interest, however, was the significant ($P = 0.006$) reduction in leg pain for the LP group after only 10 minutes of sitting (POST-TEST1). Additionally, the very marked reduction in leg pain (56%) for the LP group ($P = 0.001$, PRE-TEST to POST-TEST3) contrasts with no significant change in pain for the KP group. As for BPI, a significant ($P = 0.018$) difference existed between the groups for LPI at POST-TEST3 compared to PRE-TEST values.

The significant difference between the groups for CP (Figure 6) demonstrates that patients sitting with a lordotic posture felt their pain to be significantly less during the previous 24–48 hours than patients in the KP group.

This study demonstrates the effects that changes in posture have on pain location. For patients sitting with a lordotic posture, PL scores showed significant reductions (pain centralization) at each POST-TEST (Figure 7). Table 3 illustrates that for patients with pain below the knee, adoption of a LP resulted in 48% of these patients having pain that centralized above the knee after only 10 minutes of sitting. This contrasts with a corresponding figure of 10% for the KP group. Further, with regard to those patients with leg pain above the knee who did not become asymptomatic, 24% of the KP group's pain peripheralized below the knee at POST-TEST3 compared to 6% for the LP group.

These findings of pain centralization for patients sitting in lordosis are in agreement with those of Donelson et al,[13] who demonstrated centralization following repeated extension but not flexion movements.

The report of the Quebec Task Force on Spinal Disorders[30] recommends the adoption of a system of classification of spinal disorders related to pain patterns. Three distinct patient groupings are advocated. The results of our study indicate that changes in posture have the

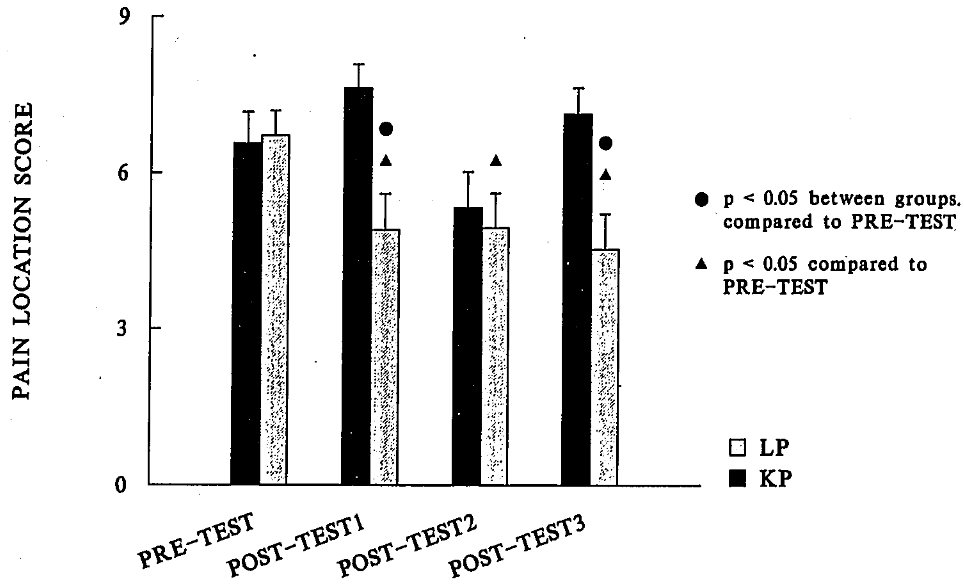

Fig 7. Pain location scores for LP and KP posture groups at successive test points. High scores indicate greater extent of pain radiation to the lower extremity (n = 57). Values are means ± SEM.

potential to change pain patterns while in a seated position. Further investigations are needed to determine whether adoption of a LP when sitting results in similar pain pattern changes during other activities of daily living.

In summary, this study confirms previous findings[14,20] that a LP results in less back pain than a KP, and also demonstrates that a lumbar roll is a useful aid in the facilitation of a LP in general sitting environments. Further, use of a lumbar roll while sitting results in a reduction of leg pain and a shift in referred pain symptoms toward the low back. These findings, however, do not apply to patients with spondylolisthesis or stenosis, whose symptoms may be aggravated by use of a lumbar roll.

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Address reprint requests to

Maynard M. Williams, MS, Dip Tchg
Senior Lecturer, School of Physiotherapy
Faculty of Health Studies
Auckland Institute of Technology
Private Bag, Wellesley Street
Auckland, New Zealand