Postural Aberrations in Low Back Pain

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• The purpose of this study was to measure and describe postural aberrations in chronic and acute low back pain in search of predictors of low back pain. The sample included 59 subjects recruited to the following three groups: chronic, acute, or no low back pain. Diagnoses included disc disease, mechanical back pain, and osteoarthritis. Lumbar lordosis, thoracic kyphosis, head position, shoulder position, shoulder height, pelvic tilt, and leg length were measured using a photographic technique. In standing, chronic pain patients exhibited an increased lumbar lordosis compared with controls ($p < .05$). Acute patients had an increased thoracic kyphosis and a forward head position compared with controls ($p < .05$). In sitting, acute patients had an increased thoracic kyphosis compared with controls ($p < .05$). These postural parameters identified discrete postural profiles but had moderate value as predictors of low back pain. Therefore other unidentified factors are also important in the prediction of low back pain.

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Low back pain is a significant problem in today's society, with lifetime incidence rates reported between 50% and 90%.[1-3] Low back pain has recurrence rates of up to 90%[4,5] even though many cases are self-limiting and require minimal treatment.[5,6] Many factors associated with low back pain are reported including degenerative disc disease, sprains and strains, age, and occupation.[7,8] Low back pain may have an insidious onset where the specific cause of the pain is unknown.[9]

Clinical observations suggest that aberrations of posture may play a role in the development of low back pain.[10] McKenzie[5] stated that low back pain (postural syndrome) could result from prolonged overstretching of the innervated soft tissues when poor sitting or standing postures were maintained. The ligaments of the spine (excluding ligamenta flava) are highly innervated and therefore may be of importance in the development of low back pain.[11-13] Janda[14] claimed that there was a unique, typical response of muscles to pain. The hamstrings and trunk extensors tended to respond by tightening, whereas the abdominals and glutei tended to weaken and atrophy. Muscles that tended to tighten usually had a postural function, whereas dynamic muscles tended to become weak. Alston and coworkers[15] found hamstring tightness in individuals with low back pain and postulated that postural adjustments would be necessary to compensate for this tightness. Abnormal habitual postures can cause abnormal stresses (increased shear or compressive forces) on the joints that lead to excessive wear of the articular surfaces.[10,16] With postural changes, a change in alignment with respect to the line of gravity occurs that may lead to other adaptive postural changes.[16,17]

Posture is both static and dynamic and is assessed in a variety of positions including sitting and standing.[18-20] Changes in alignment of body parts with respect to the center of gravity may change between sitting and standing,[21] and with the use of different chairs.[19,22] These changes can lead to adaptive changes in other aspects of posture.[16,17]

Ideal posture has not been universally agreed to and several different definitions have been advanced.[16,17,23] Even so, there is clinical consensus in the measurement of static standing and sitting postures.

Some changes in posture are considered to be normal, whereas others have been associated with disease states such as low back pain. When assessing static standing and sitting posture, it is not uncommon to find the dominant shoulder to be lower[16] or to find leg-length discrepancies of up to 1.0cm.[24] On the other hand, forward head posture is one postural adaptation likely related to occupations and activities requiring anterior head positions for prolonged periods.[25] Signs and symptoms such as pain in the lumbar spine and pelvis are correlated with forward head posture.[26] There is controversy in the literature regarding lumbosacral posture and low back pain. Thoracic kyphosis, lumbar lordosis, pelvic tilt, and abdominal strength have all been investigated with respect to low back pain in various groups of subjects.[10,27,28]

Traditionally, postural evaluation and education have been an important aspect of rehabilitation in individuals with low back pain.[5,16,18,20] Much of the research previously cited investigates only certain aspects of posture in any single study. Health care professionals are concerned with the total individual, not just single joints or limited body regions. Therefore, it is important to have an understanding of a more complete postural profile and any relationships between the individual parameters. Accordingly, the objectives of this study were to evaluate any static standing or sitting postural

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aberrations in chronic and acute low back pain patients in comparison with healthy individuals, in search of potential risk factors or associations for low back pain.

METHODS

Subjects

Thirty-nine informed participants with low back pain were recruited to two study groups and were categorized in either chronic or acute low back pain groups. Twenty subjects with no history of low back pain were recruited to a control group. Participants in all groups were in the 18 to 46 year age group. Subjects were recruited from selected medical institutions and a university campus.

Participants in the chronic group had low back pain of a continuous or recurrent nature for more than 6 months. Participants in the acute group had low back pain for less than 6 months and before this episode did not have low back pain for the past 12 months. All low back pain patients were diagnosed to have one of the following: degenerative disc disease with or without herniation, mechanical back pain (facet joint syndrome, muscular injury, ligamentous injury), or osteoarthritis of the spine.

Participants in the control group had no history of low back pain for the past year and never had low back pain lasting longer than 1 month.

Subjects with a self-reported diagnosis of spondylolisthesis, spondylolysis, myofascial pain syndrome, sacroiliac joint problems, osteoporosis, scoliotic deformity, pregnancy, metabolic diseases, or neoplasm were excluded from the study. In addition, individuals with congenital deformities, spinal surgery, or recent general surgery (last 12 months) were also excluded.

Procedure

The measures of posture used for standing and sitting postural analysis included lumbar lordosis, thoracic kyphosis, head position, shoulder position, shoulder height discrepancy, pelvic tilt (standing profile only), and leg-length discrepancy.

Nine other nonposture variables were documented. These were age, sex, body mass index (BMI), occupational category, pain intensity, pain duration, clinical diagnosis, vertebral level of pain, and activity precipitating injury.

Occupations were classified according to *The Canadian Classification and Dictionary of Occupations.*[29] In this classification system, the physical activity requirements for each occupation have been determined and are rated as sedentary, light, medium, heavy, or very heavy. Undergraduate students were classified as sedentary except those in professional fields doing practical work who were classified by those occupations. Pain intensity, in sitting, at the time of assessment was recorded using a visual analogue scale (VAS).[30,31] A standard 10cm horizontal line was used with "no pain" and "worst imaginable pain" as descriptors of the extremes. The duration of pain was recorded in years based on the patient's recall. The subject was then requested to indicate the level of the spine where the pain occurred. Height and weight were measured using a standard scale. BMI was then calculated using the Quetelet index (weight/height^2 in kg/m^2).[32]

Small balsa wood pointers, placed perpendicular to the surface of the curve, were used to mark the C7, T12 and L5 spinous processes. Dots were used to mark the tragus of the left ear, bilateral acromioclavicular joints, the posterior angle of the left acromion process, the left posterior superior iliac spine (PSIS) and the left anterior superior iliac spine (ASIS).

Anterior, posterior, and lateral photographic slides were taken in a relaxed upright standing position from a fixed distance with a horizontal calibration scale in view and with the appropriate surface markers exposed. Subjects were instructed to stand with their heels against a line marked on the floor, which was either parallel or perpendicular to the camera as appropriate. Patients were then seated in an upright position on a backless stool. The stool height was adjusted so that their feet were supported and their thighs (greater trochanter to centre of the knee joint) were parallel to the ground. Lateral and anterior slides were then taken in the sitting position. All slides were rear projected onto a ground glass screen for making measurements.

The degree of lumbar lordosis was measured using the method described by Flint.[33] Using the lateral photograph, lines were extended from the T12 and L5 pointers and the angle (⟨L) at their intersection was recorded (fig 1). Thoracic kyphosis was measured using an extension of Flint's[33] method for lumbar lordosis. Using the lateral photograph, lines were extended inwards from the C7 and T12 pointers, and the angle (⟨T) at their intersection was recorded (fig 1). Validity of this technique has been documented by Flint[33] and the correlation between X-rays and this measure was significant at the 0.01 level for the curve between L2 and L5S1.

Head position was also measured from a lateral photograph using a method similar to that described by Braun and Amundson.[34] The angle (⟨H) between the tragus-C7 line and horizontal was then calculated (fig 2). The relative protraction/retraction of the shoulders (shoulder position) was similarly measured.[34] The angle (⟨S) between horizontal and the C7-acromion process line was measured (fig 2). Braun and Amundson[34] validated this form of measurement when it was analyzed by digitization of the markers. Relative shoulder height was measured in a manner similar to that described by Shiau and Chai.[35] The angle (⟨R) between a line connecting the acromioclavicular joints and horizontal was measured. If the dominant side was higher, it was recorded as a positive angle; if the dominant side was lower, it was recorded as negative.

Pelvic tilt was measured using the method described by Sanders and Stravrakas.[36] Callipers were used to measure the distance between the ASIS and PSIS (A). The distance from a horizontal line to the ASIS was measured from the anterior view and the posterior view was used to measure the distance between the PSIS and the same horizontal line. The difference in these measures was calculated to give the height between the ASIS and the PSIS (B). Finally the angle of the pelvic tilt (Θ) was calculated ($\sin \Theta = B/A$). The reliability of this measurement has been calculated to be 0.88 using a Pearson product-moment correlation coefficient.[37]

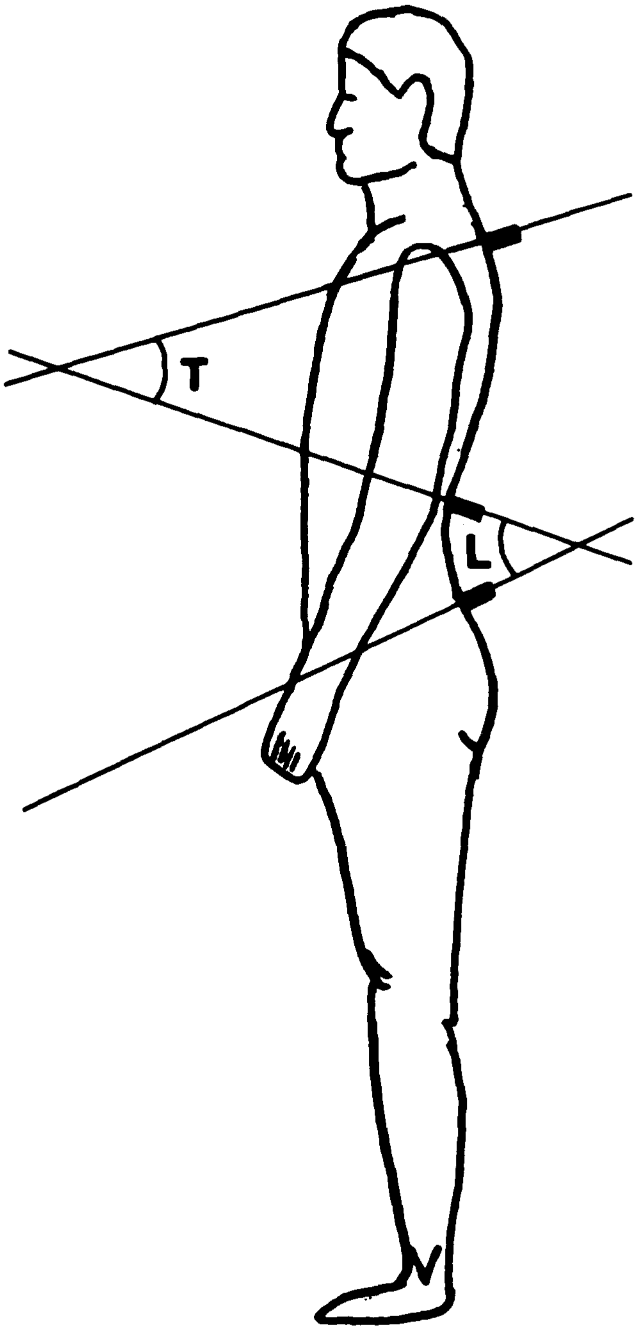

Fig 1—Measurement of lumbar lordosis (∠L) and thoracic kyphosis (∠T). (Adapted from the method described by Flint.[33])

Leg length was measured in supine. The distance from the inferior aspect of the ASIS to the medial malleolus (distal aspect) was recorded bilaterally. Any difference was recorded as a positive discrepancy.

Reliability of Measurements

A pilot study was undertaken before the commencement of data collection to address issues related to photograph distortion, the effect of visual fixation, the effect of changes in plane of measurement, the reliability of measurements and the effect of marker replacement. A change in plane was shown to affect head and shoulder measurements, therefore semipermanent lines were placed on the floor to ensure consistent subject and camera positioning. The only area of concern regarding the reliability of the measurements with and without marker replacement was sitting lumbar lordosis. Because of the high probability of variation in sitting positions, standard instructions were developed to be used with all subjects with respect to the sitting position to adopt.

Ethical Considerations

This study received approval from the Student Projects Ethical Research Review Committee. All participants read an information sheet for study participants, were given the opportunity to ask questions, and signed an informed consent form before participation in the study.

Analysis

Appropriate descriptive statistics[38] were used to characterize study participants in each of the study groups. Diagnosis, vertebral level, pain intensity and duration, and activity precipitating injury were factors only in the two pain groups and were therefore not measured in the normal control group. The precipitating event was a verbal description classified into comparable injuries such as falling, twisting, whiplash, or insidious onset.

The data was divided into two components, sitting posture and standing posture. These two components were analyzed separately yielding two separate postural profiles for each of the study groups.

The statistical significance of any differences between the three study groups with respect to the studied parameters was analyzed as follows:[38] age and BMI (one-way ANOVA), sex and occupational category (χ^2 test), and the seven postural parameters (one-way ANOVA). A Tukey post hoc analysis was used to determine where the group differences lay

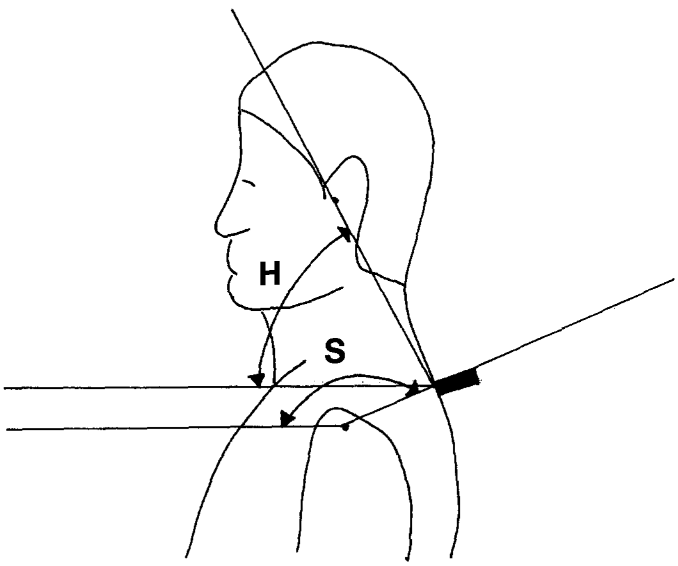

Fig 2—Measurement of head position (∠H) and shoulder position (∠S). (Adapted from the method described by Braun and Amundson.[34])

Table 1: Standing Postural Parameters—Means, Standard Deviations, and ANOVA Results

	Chronic (SD)	Acute (SD)	Control (SD)	p Value (ANOVA)
Lumbar	26.4*	22.6	19.3	0.05
Lordosis (°)	(9.0)	(7.9)	(9.2)	
Thoracic	45.1	47.4*	39.6	0.04
Kyphosis (°)	(9.2)	(9.3)	(9.9)	
Head	51.1	49.1*	53.5	0.03
Position (°)	(6.2)	(5.4)	(3.0)	
Shoulder	113.1	108.2	104.1	0.32
Position (°)	(16.3)	(24.2)	(15.1)	
Relative shoulder	−1.1	−0.8	−1.4	0.56
Height (°)	(1.6)	(1.8)	(1.9)	
Pelvic	12.8	11.2	10.7	0.69
Tilt (°)	(8.8)	(6.2)	(9.0)	
Leg length	0.6	0.4	0.4	0.13
Discrepancy (cm)	(0.5)	(0.4)	(0.4)	

* Significantly different from the control group using a Tukey post hoc analysis at the 0.05 level.

post-ANOVA. For the two pain groups, the statistical difference for pain intensity was analyzed with a t test and clinical diagnosis, vertebral level of pain and precipitating event were analyzed with a χ^2 test.[38]

Finally, those variables found to be statistically significant were analyzed using linear discriminant analysis for sitting and for standing. This analysis was used to determine the relative importance of the postural factors in predicting the low back pain group, and what proportion of the three subject groups was correctly classified by the scores on these factors.[38,39] The predictor variables were included in the analysis by a stepwise variable selection using minimization of Wilks' lambda.

For those parameters which were not significantly different a power analysis was performed.[40] Most variables had sufficient power, and those which did not (standing relative shoulder height, pelvic tilt, sitting head position) required sample sizes too large to be considered.

All statistical analyses were done using SPSS/PC+ Release 4.0.1.[a] An alpha level of 0.05 was set as the acceptable level of significance for this data.

RESULTS

Study Group Description

The BMI for the acute pain group was 25.9 ± 4.2kg/m^2 which was significantly higher ($p < .02$) than the BMIs of the chronic pain group (24.7 ± 3.3kg/m^2) and the control group (22.8 ± 2.3kg/m^2). There were no significant differences among the study groups on age, gender, or occupational category.

The chronic and acute pain groups were described further with respect to pain intensity and duration, clinical diagnosis, vertebral level of pain, and precipitating event. The mean duration of pain for the chronic group was 8.0 ± 5.0 years, whereas it was only 0.3 ± 0.2 years for the acute group. The study groups did not differ significantly with respect to pain intensity, clinical diagnosis, vertebral level of pain, and precipitating event.

The study groups were not significantly different with respect to 7 of the 9 nonposture variables. By definition, pain duration was necessarily different between groups. Therefore, only BMI was included in further analysis of the data.

Standing Postural Parameters

Table 1 outlines the group summary statistics and provides a postural description for each group. Lumbar lordosis, thoracic kyphosis, and head position had significant differences between groups ($p < .05$, $p < .04$, $p < .03$, respectively). For lumbar lordosis, the chronic pain group had a significantly increased lordosis compared with the control group. For thoracic kyphosis and head position the differences occurred between the acute and control groups. The acute group had an increased kyphosis and a more forward head position than the control group.

The linear discriminant analysis, using the parameters that showed significant differences between the groups, identified BMI, lumbar lordosis, and head position as the parameters most important in prediction of low back pain group. Thoracic kyphosis had a high correlation (0.60) with lumbar lordosis; it did not add any more predictive power than that obtained with lumbar lordosis. The analysis using BMI, lumbar lordosis, and head position was only able to correctly classify 52.5% of the cases, which was slightly higher than the classification rate by chance alone (33%). The percent of variance explained by the predictors was 25%. When all the standing postural parameters were included in the analysis leg length discrepancy was added to the prediction equations. This analysis improved the classification rate to 66.1% and the percent of variance explained by the predictors was 32%. A limitation of using all the parameters was the high number of variables included in the analysis for a study group of only 59 cases.

Sitting Postural Parameters

Table 2 outlines the group summary statistics and provides a postural description for each group. Only thoracic kyphosis showed a significant difference between groups ($p < .02$); individuals with acute pain had an increased thoracic kyphosis compared with the control group.

Table 2: Sitting Postural Parameters—Means (°), Standard Deviations, and ANOVA Results

	Chronic (SD)	Acute (SD)	Control (SD)	p Value (ANOVA)
Lumbar	3.6	6.1	0.3	0.10
Lordosis	(9.8)	(8.3)	(6.4)	
Thoracic	35.8	39.9*	31.6	0.02
Kyphosis	(10.6)	(8.0)	(7.6)	
Head	47.9	47.4	49.2	0.56
Position	(5.8)	(6.6)	(3.7)	
Shoulder	113.9	115.4	107.5	0.19
Position	(12.0)	(18.1)	(12.4)	
Relative shoulder	−1.8	−0.6	−1.4	0.13
Height	(1.6)	(2.2)	(1.9)	

* Significantly different from the control group using a Tukey post hoc analysis at the 0.05 level.

The linear discriminant analysis, using the parameters which showed significance, BMI, and thoracic kyphosis, indicated that the two parameters had an equal contribution to the prediction of study group. As with the standing posture, this analysis had a classification rate of only 55.9%. The percent of variance explained by the predictors was 19%. When all the sitting parameters were included in the analysis relative shoulder height was added to the prediction equations; its addition did not improve the classification rate but the percent of variance explained increased to 23%.

DISCUSSION

Study Group Description

Even though BMI showed a statistically significant difference, the mean BMI for the acute group was 25.9kg/m^2 which is not considered obese[32] and thus the difference was not clinically significant. In addition, those individuals in the control group had a BMI which was low for the general population. Therefore, the data was consistent with the finding in the literature that there is no strong evidence indicating BMI as a risk factor for low back pain.[9,41]

Finneson[20] stated that lumbosacral strain is one of the most frequently used diagnoses related to low back pain. Similarly, for this study, approximately 50% of the participants in each group had musculoligamentous complaints. Insidious onset accounted for 55% to 60% of the low back pain observed in this study. Rowe[9] also reported very high incidence of insidious onset low back pain in his study population. With respect to those with a specific injury, the precipitating event reported generally corresponded with those mentioned in the literature, eg, lifting, twisting, pushing, and pulling.[42,43]

Standing Posture

Only a few parameters can be directly compared with results of prior research because of the great variety of methods and landmarks used in recording posture. The control population used in this study was generally comparable with the control populations reported in previous research using various equipment for the standing postural parameters.[27,35,37,44,45]

The finding of increased lordosis in the chronic group, compared with the healthy population, was in contrast to the findings of Pope and coworkers[27] in moderate and severe low back pain, Day and coworkers[28] in chronic low back pain, and During and coworkers[10] in groups with unspecified pain duration, who all found no relationship between lumbar lordosis and low back pain. Magora[46] reported an increased incidence of hyperlordosis in low back pain sufferers but claimed that hypolordosis was a reliable indicator of severe low back pain. When the lordosis of study participants who reported greater than 20mm of pain on the VAS was reviewed, there was no indication of a trend toward hypolordosis. On the other hand, this data was consistent with the results found by Roncarati and McMullen,[47] that an increase in lordosis was correlated with low back pain.

The increased thoracic kyphosis in the acute pain group is in contrast to previous research conducted by Magora[46] that found no relationship between low back pain and thoracic posture. There was no indication, though, of the duration of low back pain studied. Magora[46] stated that he found an increase in thoracic posture abnormalities in heavy industry workers. When the data in this study was reviewed, it was found that for those exhibiting greater than 55° thoracic kyphosis there was a significantly different distribution with respect to occupation but the occurrence was more evenly distributed throughout all categories rather than being focused in the heavier occupations as predicted by Magora. Therefore the results of this research were not consistent with previous research with respect to thoracic kyphosis.

The change in head position found in acute patients was similar to that found by Shiau and Chai[35] among individuals with head and neck pain. No data was found that investigated head and shoulder posture with respect to low back pain in a manner similar to this study. Several authors[26,34] have suggested that a forward head position is accompanied by rounded shoulders but these two postures were not well correlated in this study. Magee[16] proposed that a forward head position is often associated with an increased lumbar lordosis. This study also found no correlation between these two parameters.

The pelvic tilt findings were consistent with the findings of During and coworkers[10] but Roncarati and McMullen[47] found an increased anterior pelvic tilt in low back pain subjects. This was one variable in which there was low power to find a difference between groups and further investigation is required to reach more powerful conclusions.

The results of this study indicate unique postural changes for acute low back pain and chronic low back pain; these parameters have not been previously studied with similar acute/chronic discrimination. The changes associated with acute low back pain were focused in the upper back and neck regions. A possible explanation for this finding is that with the onset of pain all aspects of the spinal curve initially respond to the pain with movement into a forward head position in an attempt to decrease the lumbar pain; supported by the correlations found between adjacent aspects of the curve. With chronic low back pain the individuals have adapted to the pain with a localization of the postural changes to the lumbar spine and a balancing of the upper spine changes so that they are no longer significantly changed from normal. A second theory is based on the forward head posture explanation advanced by Rocabado and Iglarsh.[26] The individuals with acute low back pain may have had a preexisting forward head position that resulted in flexion of the thoracic spine and signs and symptoms in the lumbar spine and pelvis.

Only one study was reviewed that investigated absolute measurements of leg-length inequality and they found an increase in leg-length discrepancy in individuals with severe low back pain even though when looking at a discrepancy of greater than 0.5cm there was no difference between groups.[27] Similarly, when groups were compared with respect to having a leg-length discrepancy of 1.0cm or greater, Giles and Taylor[24] and Roncarati and McMullen[47] found an increased incidence of leg-length discrepancy with low back pain. Therefore, the study data was reviewed in a similar manner but there remained no significant difference between study groups with respect to having a leg-length discrepancy of at least 1cm. In this study individuals with a diagnosed scoliosis were excluded from the study. This may account for the discrepancy between the present data and the literature findings with respect to leg-length discrepancy, which is biomechanically related to scoliotic deformities.

The only parameters found to have a strong, significant correlation were lumbar lordosis and thoracic kyphosis. A weak, significant correlation was found between forward head position and thoracic kyphosis, and between lumbar lordosis and anterior pelvic tilt. Therefore, each aspect of the spinal curve had at least a weak, significant correlation with adjacent aspects of the curve.

The linear discriminant analysis indicated that some postural parameters are important in the prediction of low back pain group but there are other unidentified variables which are also important and are required to improve the classification rate.

Sitting Posture

No previous research was found that investigated the sitting posture with respect to low back pain in a manner similar to this study so no direct comparisons can be made. There is more muscle activity in the upper lumbar and thoracic regions in sitting compared with increased muscle activity in lower lumbar regions in standing.[21,48] This is a probable reason for the finding that there was no longer any significant difference in lumbar lordosis between groups, whereas the thoracic kyphosis changes remained. Because sitting is a much more stable posture than standing, fewer postural aberrations were expected particularly when there were few individuals in the study population with disc disease which could result in increased pain in sitting. The sitting posture did not differ from standing with respect to correlations between head position and shoulder position or head position and lumbar lordosis; neither group had a significant correlation.

As found with the standing posture, some postural parameters were important in the prediction of low back pain group but other factors must also have an important role in prediction of low back pain.

Additional Analyses

An analysis was also performed to investigate low back pain with respect to clinical diagnosis rather than acute versus chronic. Those individuals with low back pain were categorized by clinical diagnosis. Significant differences were found by ANOVA testing in standing head position but a Tukey post-hoc analysis did not find a difference. Inspection of the data indicated a markedly forward head position for disc disease but this was based on a group size of only five cases. No significant differences were found between groups by an ANOVA test for the sitting posture. The linear discriminant analysis for standing used head position, leg length discrepancy and BMI as predictors but the classification rate was only 43.6%. Similarly for the sitting posture the classification rate was only 46.2%, when BMI, head position, relative shoulder height, and age were used as predictors. The classification rate by chance alone was 14%. This analysis was limited by the unequal group sizes and the small number of cases in some of the groups. Using study groups based on clinical diagnosis rather than acute versus chronic pain did not increase the value of postural parameters as predictors.

Another analysis was made to investigate the use of postural parameters in predicting low back pain in general compared with the normal population. These postural parameters did not differentiate between low back pain in general and a control group any better than between the three study groups.

CONCLUSIONS

Five conclusions were reached based on the results of this research.

1. Discrete postural profiles existed for chronic pain, acute pain, and control groups in the standing posture. The chronic pain group exhibited an increased lumbar lordosis as compared with the control group. The acute pain group exhibited an increased thoracic kyphosis and a forward head position compared with the control group.
2. A discrete postural profile existed for the acute pain group in the sitting posture. The acute pain group had an increased thoracic kyphosis compared with the control group. No further factors were found to discriminate between the other groups.
3. The postural parameters studied in this project were able to identify discrete postural profiles but they only had moderate value in the prediction of study group. Therefore, other unidentified factors, postural or nonpostural, are also important in the prediction of low back pain.
4. This study showed that postural parameters are significantly different between low back pain groups. However, based on this study, it cannot be stated whether poor posture leads to pain or precipitation of pain necessitates postural aberrations. It is surmised that both scenarios occur. Biomechanical stresses caused by postural deviations from normal may precipitate injury and pain. A precipitation of pain in an otherwise healthy spine may lead to postural adaptations.
5. Additional investigation is required to determine whether treatment of posture can have an effect on low back pain.

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