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Non-invasive Measurement of Thoracic Kyphosis and Lumbar lordosis among Agricultural workers and Corporate Professionals (IT) using Flexicurve Ruler

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Abstract

Background: This study was undertaken to introduce a non- invasive technique for clinical diagnosis of spinal cord deformities. The purpose of the present study is to evaluate the postural deformities and onset of thoracic Kyphosis and lumber Lordosis among agricultural workers and Information Technology workers.

Methodology: This cross-sectional study was carried out on thirty Agricultural workers (41-45 years) and twenty-five Information Technology workers (21-25 years) and their age matched control groups. The subjects were taken from their respective population by simple random sampling method. Measurements were made by Flexicurve Ruler in special standing posture. Kyphosis and Lordosis angles and Indices were calculated.

Results: It indicates that maximum percentage of subjects had kyphotic angle between 40^0-60^0. Twenty-three out of 30 agricultural workers (76.66%) and 22 out of 25(88%) information technology workers had kyphosis angle between 40^0- 60^0 but the same in case of control groups were 60% and 64% respectively. Maximum subjects had lordotic angle between 30^0 - 50^0. Thirteen out of 30 agricultural workers (43.33%) and 17 out of 25 information technology workers (68%) had lordotic angle in between 30^0-50^0.The same in case of control groups were 43.33% and 56% respectively . Kyphosis index, Kyphosis angle and lordosis index, lordosis angle are significantly lower ($p<0.05$) in agriculture workers in comparison to its control group but the differences are not significant in case of information technology workers as well as between agriculture group and information technology group. But information technology workers show higher values of Kyphosis and lordotic index than agriculture workers, probably due to prolong sitting posture at work. Again 47% agricultural workers and 11% IT workers reported lumbar pain when compared to control groups (10% and none respectively).

Conclusion: Although no significant deviation of kyphotic and lordotic angle has been observed in agricultural and information technology workers but significantly higher percentage of these 2 groups reported shoulder and lumbar pain indicating risk of dysfunction in shoulder, pelvic girdle and spine. Thus measurement of thoracic kyphosis and lumbar lordosis may be useful in examining the degree of spinal cord deformities. By utilizing these information therapeutic and ergonomic intervention can be applied and application of modern sophisticated machine for improvement in postural condition can reduce their work stress and disabilities.

Key words: Agricultural worker, Flexicurve Ruler, IT workers, Kyphosis, Lordosis

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Introduction

The Kyphotic and Lordotic curves in a human skeleton ensures balance in its standing position (head above hip). The standing posture of a regular healthy human subject minimizes the effect of gravity and facilitates the consumption of least energy while in motion (physical movement). Thus, weakness in spinal muscles cause positional abnormalities, leading to imbalances in body posture. These abnormalities

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ultimately affect the subject's physiological as well as socio-psychological wellbeing.

Thoracic Kyphosis is an abnormally excessive convex kyphotic curvature of the spine as it occurs in the cervical, thoracic and sacral regions. Thoracic pain is one of the common conditions observed within any given population and nowadays its prevalence is increasing resulting in decrease in mobility, an increase in weight of the trunk, inappropriate positioning of the spine during daily activities, and increasing use of computers.[1] It can cause from degenerative diseases such as arthritis, developmental problems, most commonly Scheuermann's disease, osteoporosis with compression fractures of the vertebra and multiple myeloma or trauma.

Lumbar lordosis is the ventral curvature of the spine formed by wedging of the lumbar vertebrae and intervertebral discs.[2] Lumbar lordosis is a key component in maintaining the sagittal balance. According to some studies ~~as~~ lordosis increases and thoracic kyphosis also increases; however, some studies have indicated that an increase in lordosis is accompanied by a decrease in kyphosis.[3,4] The abnormal lumbar curvature can lead to imbalance in the standing position.[5]

Assessment of kyphosis and lordosis is usually performed via lateral radiography of the spine imposed on an X-ray. Continuous radiography is expensive and also potentially life threatening; hence researchers have attempted to perform this assessment via non-invasive techniques.

The use of a flexible ruler as a means of non-invasive measurement of kyphosis and lordosis is cheap and accessible with a simple application.[6,7] Therefore the purpose of the present study is to

evaluate the postural deformities and onset of thoracic kyphosis and lumbar lordosis in young Information Technology (IT). industry personals and middle aged farmers working in bending position and to compare these parameters with their age matched control groups.

Methods

According to the Occupational Safety and Health Administration (OSHA), back injuries are one of the leading causes of disability in the workplace and thus cause human suffering and loss of productivity and strain the compensation system. The flexicurve measurement was done on two different sample subject groups. The first group was agriculture group and the second group was information technology (IT). Each test group was compared with a control group which had the same age range as that of test group.

Agricultural Group: Farmers spend almost 40-50 years in the field. They are vulnerable to developing back injuries because of risk factors in the workplace such as awkward postures, whole-body vibration, repetitive motions, and forceful exertions, including heaving, lifting. Prolonged driving of vehicles that cause whole-body vibration, such as tractors or trucks, can be a risk factor for developing a back impairment.[8]

Agriculture Experiment Group and Control Group

Number(N) = 30 for both the groups
Sex = Male
Age Range = 41years to 45 years

Information Technology: IT employees spend a considerable period of time in offices that is about 8-10 hours. The time spent in office and sitting position leads to posturogenesis. The excess stress placed on back and neck muscles causes the person to arch forward his/her head and this change in posture would lead to imbalance in the spinal extensor and flexor muscle groups which in turn would render the person easily fatigable and lethargic.

IT Experiment Group and Control Group

n = 25 for both the groups
Sex = Male
Age Range = 21years to 25 years

Inclusion criteria-

- Subjects without spinal cord deformities already exist
- No history of surgical operation of spine

Measurement of anthropometric parameters

Stature: The stature was measured by International Society for the Advancement of Kinanthropometry (ISAK) method using an anthropometric rod in standing posture with bare foot.

Body weight: The body weight was measured by standard analogue weighing machine (Crown) with minimum clothing.

Shoulder height: The shoulder height was measured by ISAK method using an anthropometric rod in standing posture with bare foot.

Leg length: The leg length was measured by ISAK method using a cescorp anthropometric measuring tape in standing posture with bare foot

Measurements process of Flexicurve ruler

The flexible ruler is widely used to measure the degree of spinal curvature in the sagittal plane such as kyphosis and lumbar lordosis in physiotherapy and sports medicine field.

Spinal Cord Segment Finding Process: The spinous processes were identified using palpation.

Firstly to indentify Cervical (C7) spinal process hands were placed above the neck, then the subject was asked to move his head up and down; by this movement of neck the most protruded portion of the spinal cord on the neck was identified and marked as C7.

Secondly the hands were placed on the last rib cage bone on the abdominal region then the hands were horizontally moved towards the back to the point where both thumbs reach together. Then the subject was asked to bend forward, by this the most protruded portion of the spinal cord on the back was identified and marked as Thoracic (T12). Then the Lumbar (L1) spinal process is identified by counting down from T12 position. Lastly To identify L5, hands were pressed on the lower back above the iliac crest in order to move the soft tissue laterally where the two thumbs reach horizontally together on the L5 spinal process. While the spinal processes of the C7, T12, L1, and L5 vertebrae were identified they are marked with non-allergic and washable highlighter pen.[9]

Special Standing Posture for Measurement: For the flexicurve evaluation, the subject was instructed to stand up straight and as tall as possible, each subject stood barefoot with the back uncovered. During the procedure, the subjects were instructed to remain standing with the knees straight, feet parallel and the shoulders and elbows at 90° of flexion. This position was adopted in order to avoid the humerus appearing in front of the spinal column.[7]

Curvature Taking Process: Spinal kyphosis and lordosis were measured in each subject using flexicurve ruler (Made in Taiwan) which was of 60 cm in length. First, the flexicurve was cleaned using a damp paper towel to remove previous marks. It was checked thoroughly for presence of any bumps and that it was in a smooth ‘S’ shape. Keeping the subject in same posture, the flexicurve was placed in the mid-line contour shape of the spinal cord and the ruler was placed on the back gently to mould the curvature. While moulding, the C7, T12, L1 and L5 spinal segment was located and marked using metric scale incorporated in the instrument. After moulding the contour of the spine, the flexicurve was removed and the internal edge (the side of the flexicurve in contact with the skin) was traced on to the chart paper, representing the thoracic and lumbar curvature in the sagittal plane with the spinal processes having identified. Then the marks of the marker pen were cleaned.[5]

Calculation of Kyphosis and lumbar index

A straight line was then drawn by a ruler from position of C7 to T12 that corresponded to the length of thoracic kyphosis and was measured in cm, the length is known as thoracic length (TL).

Similarly a straight line was then drawn by a ruler from position of L1 to L5 that corresponded to the length of lumbar lordosis and was measured in cm, the length is known as lumbar length (LL).

Calculation of Kyphosis and lumbar angle

The width of the thoracic kyphosis in cm was determined by drawing a perpendicular line from the highest point in the thoracic curve to the point at which it intersected the straight line drawn fromC7 to T12. This is known as thoracic width (TW).

Similarly the width of the lumbar lordosis in cm was determined by drawing a perpendicular line from the highest point in the lumbar curve to the point at which it intersected the straight line drawn from L1 to L5. This is known as lumbar width (LW).

Formulas used:

- Formula for Kyphosis index: Kyphotic Index = [(TW/TL) ×100] [10,11]
- Formula for Kyphosis angle: Kyphosis Angle θ = 4 arc tan [(2 ×TW)/TL] [9,12]
- Where, TW = Thoracic width and TL = Thoracic length
- Formula for Lordosis index: Lordosis Index = [(LW/LL) ×100] [10,11]
- Formula for Lordosis angle: Lordosis Angle θ = 4 arc tan [(2 ×LW)/LL] [9,12]

  Where, LW = Lordosis width and LL =Lordosis length

Result

Table 1 represents the mean and the standard deviation values of selected anthropometric variables, such as age (years), height (cm), weight (kg), BMI (kg/m^2), shoulder height (cm), leg length (cm) and the result of kyphosis index, kyphosis angle (degree) and lordosis index, lordosis angle (degree) of the experimental agriculture and information technology (IT) group and their age matched control group.

The Table 2 represents correlation value and its level of significance between kyphosis index - lordosis angle & lordosis index - kyphosis angle in agriculture group and information technology group and also their control group. Significant positive correlation has been observed in agriculture group and its control and also IT control group. But significant negative correlation is observed in IT experiment group subjects. It is observed that all the correlation values are significant ($p<0.05$).

Figure 1 and 2 shows the graphical representation of Positive Correlation between Kyphosis Index–Lordosis Angle and Lordosis Index-Kyphosis Angle of Agriculture Experimental Group.

Figure 3 and 4 shows the graphical representation of Positive Correlation between Kyphosis Index–Lordosis Angle and Lordosis Index-Kyphosis Angle of both IT Experimental Group and IT control Group.

Table 3 shows values t-test of kyphosis index, kyphosis angle and lordosis index, lordosis angle are significantly lower ($p<0.05$) in agriculture workers in comparison to its control group. Although reduce values have been found, no significant difference has been found in kyphosis index, kyphosis angle and lordosis index, lordosis angle in between IT group and its control group, as well as between agriculture group and IT group.

Table 4 represents the comparison of prevalence of change of kyphotic angle among agriculture professionals and IT professionals and their control subjects. Maximum percentage of subjects has kyphotic angle between 40^o – 60^o, in case of agriculture workers it is 76.66% and 88% in case of IT workers. The same in case of control group worker is 60% and 64% respectively.

Table 5 represents the comparison of prevalence of change of lordotic angle among agriculture professionals and IT professionals and their control subjects. Maximum percentage of subjects has lordotic angle between 30^o – 50^o, in case of agriculture workers it is 43.33% and 68% in case of IT workers. The same in case of control group worker is 43.33% and 56% respectively. 53.33% of agricultural workers have lordotic angle <30^o and 24% in case of IT worker.

Table 1: Mean and Standard Deviation of Different Physical Parameters, Kyphosis Index, Kyphosis Angle (Degree), Lordosis Index and Lordosis Angle (Degree) of Experimental Group and Control Group of Agriculture And Information Technology [*n=Sample Number]

Variables	Agriculture		Information Technology	
	Test Group (N=30)*	Control Group (N=30)*	Test Group (N=25)*	Control Group (N=25)*
	Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd
Age (Years)	43.43 ±1.61	43.1 ±1.45	23.24 ±0.88	22.68 ±1.35
Height (Cm)	161.33 ±5.51	164.55 ±5.62	168.95 ±7.31	169.31 ±5.69
Weight (Kg)	52.62 ±11.62	63.08 ±7.68	67.08 ±10.97	66.72 ±11.51
Bmi (Kg/M2)	20.15 ±4.01	23.26 ±2.23	23.47 ±3.22	23.22 ±3.51
Shoulder Height (Cm)	135.76 ±5.19	138.89 ±5.22	141.16 ±7.56	140.94±5.10
Leg Length (Cm)	88.57 ±6.31	91.63 ±4.25	91.05 ±5.75	95.94 ±4.07
Kyphosis Index	10.96 ±2.25	12.39 ±2.16	11.46 ±1.86	12.12 ±1.99
Kyphosis Angle(Degree)	49.18 ±9.32	55.61 ±9.31	51.57 ±8.04	54.46 ±8.64
Lordosis Index	6.43 ±2.44	10.58 ±4.06	8.28 ±2.26	9.20 ±2.82
Lordosis Angle(Degree)	29.27 ±10.97	47.53 ±17.69	37.58 ±10.05	41.62 ±12.49

Table 2: P value, Ho hypothesis and distribution curve of normality test by Shapiro-Wilk normality test & Pearson's r correlation test with level of significance. [*n=sample number,**p= probability of error due to random sampling]

Statistics Test		Shapiro-Wilk Normality Test			Pearson's R Test	
Statistics		P Value	Ho Hypothesis	Distribution Curve	R Value	Level Of Correlation
Agriculture Experimental Group (N=30)	Kyphosis Index	0.32	Accepted	Normally Distributed	0.40	Positive Correlation (P<0.05**)
	Lordosis Angle	0.52	Accepted	Normally Distributed		
	Lordosis Index	0.49	Accepted	Normally Distributed	0.41	Positive Correlation (P<0.05**)
	Kyphosis Angle	0.18	Accepted	Normally Distributed		
Agriculture Control Group (N=30)	Kyphosis Index	0.80	Accepted	Normally Distributed	0.01	Positive Correlation (P<0.05**)
	Lordosis Angle	0.95	Accepted	Normally Distributed		
	Lordosis Index	0.92	Accepted	Normally Distributed	0.01	Positive Correlation (P<0.05**)
	Kyphosis Angle	0.80	Accepted	Normally Distributed		
It Experimental Group (N=25)	Kyphosis Index	0.34	Accepted	Normally Distributed	-0.13	Negative Correlation (P<0.05**)
	Lordosis Angle	0.89	Accepted	Normally Distributed		
	Lordosis Index	0.85	Accepted	Normally Distributed	-0.13	Negative Correlation (P<0.05**)
	Kyphosis Angle	0.41	Accepted	Normally Distributed		
It Control Group (N=25)	Kyphosis Index	0.57	Accepted	Normally Distributed	0.37	Positive Correlation (P<0.05**)
	Lordosis Angle	0.37	Accepted	Normally Distributed		
	Lordosis Index	0.37	Accepted	Normally Distributed	0.37	Positive Correlation (P<0.05**)
	Kyphosis Angle	0.49	Accepted	Normally Distributed		

Table 3: t test between Experimental Group and Control Group of Agriculture and Information Technology

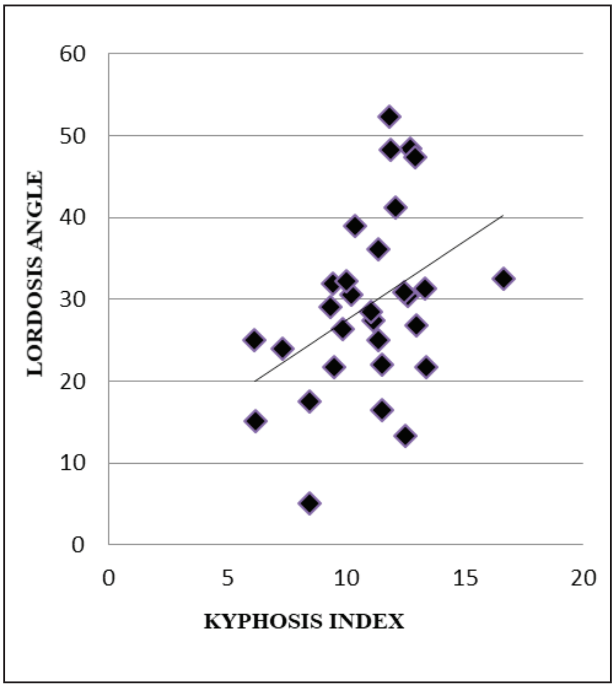
Statistics		T Value	P Value	Result
Experimental And Control Agriculture Group (N=30+30=60)	Kyphosis Index	-2.51687	.014627	Significant (P<0.05)
	Kyphosis Angle	-2.67032	.009816	Significant (P<0.05)
	Lordosis Index	-4.79628	.000012	Significant(P<0.05)
	Lordosis Angle	-4.80584	.000011	Significant (P<0.05)
Experimental And Control Information Technology Group (N=25+25=50)	Kyphosis Index	-1.2267	.22592	Not Significant
	Kyphosis Angle	-1.2251	.226516	Not Significant
	Lordosis Index	-1.27241	.209357	Not Significant
	Lordosis Angle	-1.26232	.212933	Not Significant
Combined Agriculture Group And Information Technology Group (N=60+50=110)	Kyphosis Index	-0.27849	.781171	Not Significant
	Kyphosis Angle	-0.35439	.723737	Not Significant
	Lordosis Index	-0.36661	.714628	Not Significant
	Lordosis Angle	-0.42022	.675158	Not Significant

Table 4: Prevalence of Kyphotic Angle among agriculture professionals and IT professionals and their control subjects

Degree of the Angle	Frequency (%)			
	Agriculture Group (N=30)		It Group (N=25)	
	Experiment Group	Control Group	Experiment Group	Control Group
	Kyphosis Angle	Kyphosis Angle	Kyphosis Angle	Kyphosis Angle
< 40	5 (16.66%)	1 (3.33%)	1 (4%)	2 (8%)
40-60	23 (76.66%)	18 (60.00%)	22 (88%)	16 (64%)
>60	2 (6.66%)	11 (36.66%)	2 (8%)	7 (28%)

Table 5: Prevalence of Lordotic Angle among agriculture professionals and IT professionals and their control subjects

Degree of the Angle	Frequency (%)			
	Agriculture Group (N=30)		It Group (N=25)	
	Experiment Group	Control Group	Experiment Group	Control Group
	Lordosis Angle	Lordosis Angle	Lordosis Angle	Lordosis Angle
< 30	16 (53.33%)	5 (16.66%)	6 (24%)	5 (20%)
30-50	13 (43.33%)	13 (43.33%)	17 (68%)	14 (56%)
>50	1 (3.33%)	12 (40%)	2 (8%)	6 (24%)



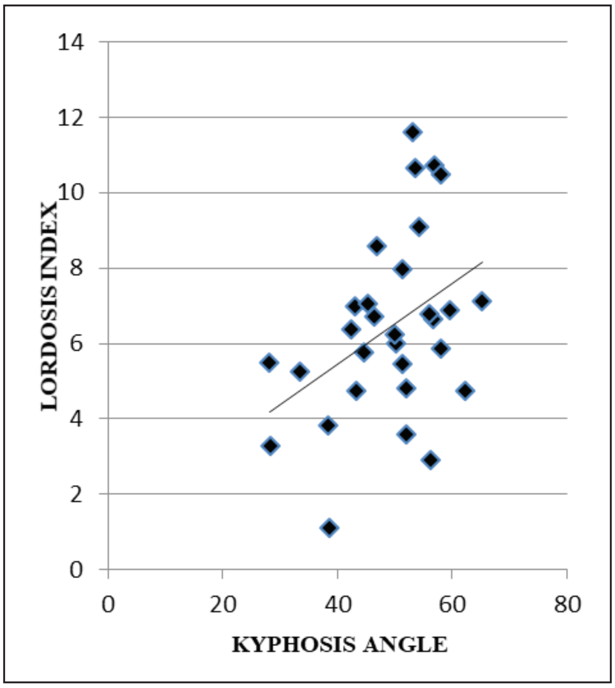
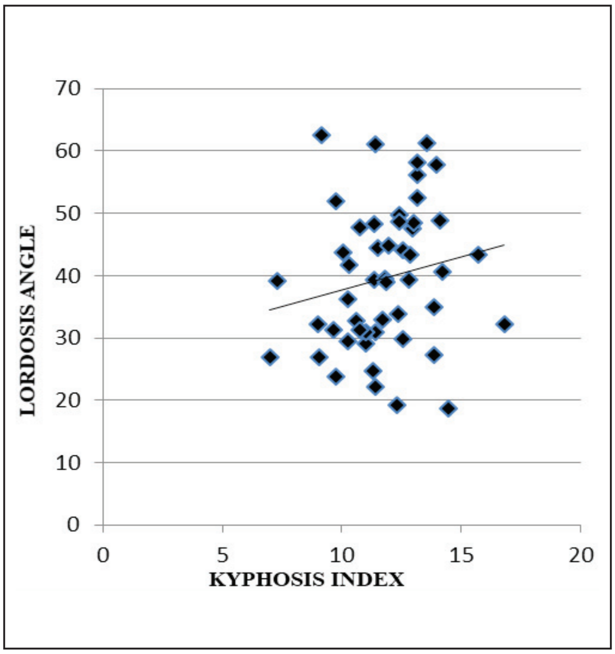


Figure 1 and 2: Correlation between Kyphosis Index–Lordosis Angle & Lordosis Index-Kyphosis Angle of Agriculture Experimental Group.



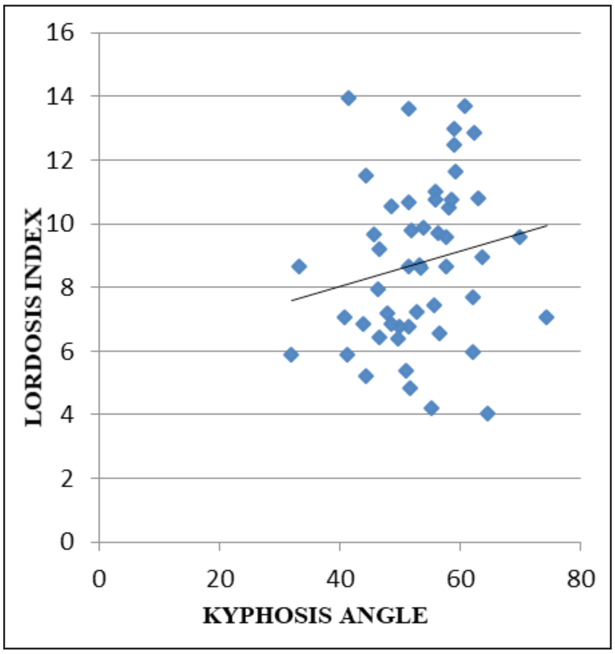
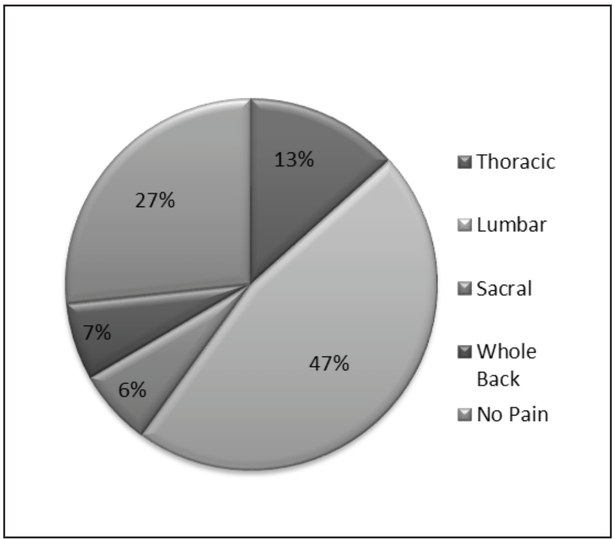


Figure 3 and 4: Correlation between Kyphosis Index–Lordosis Angle & Lordosis Index-Kyphosis Angle of Both IT Experimental Group and Control Group.



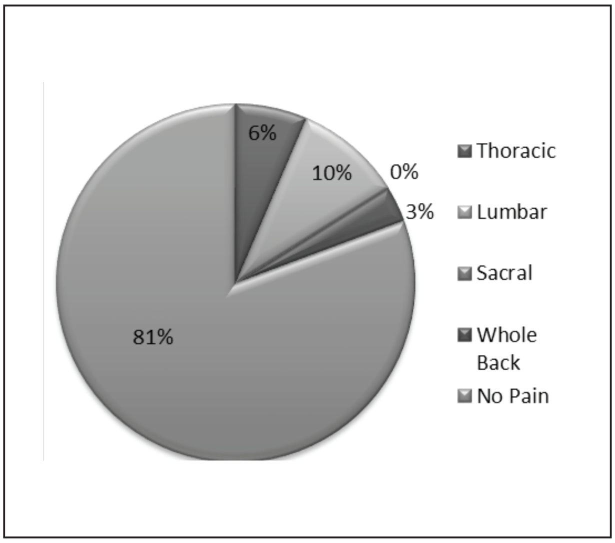
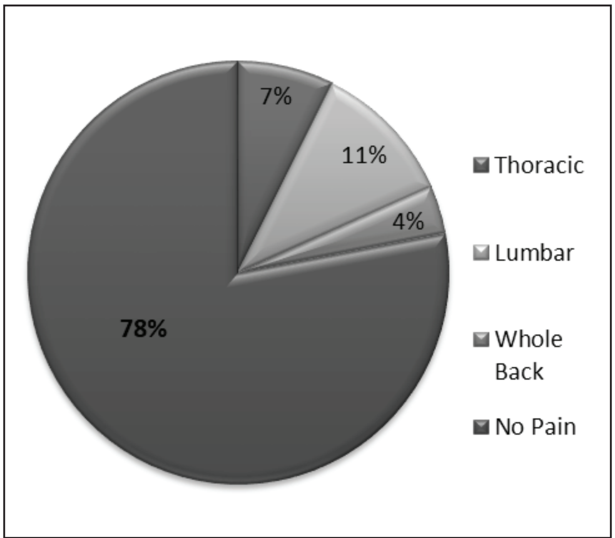


Figure 5 and 6: The prevalence of Pain at Different Spinal Level of the subjects of experimental group and control group of agriculture professionals



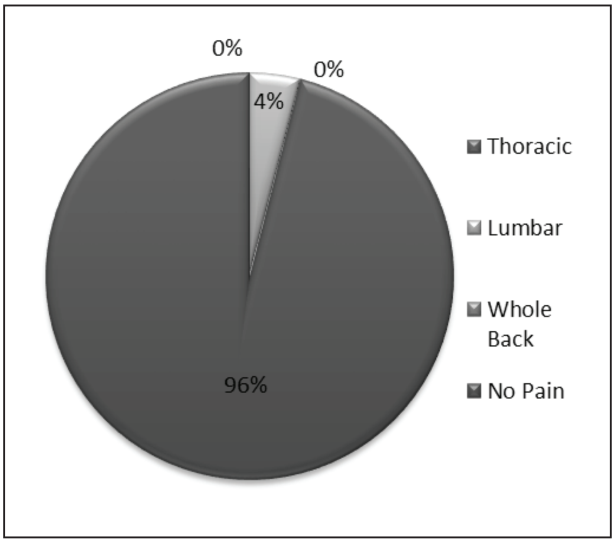


Figure 7 and 8: The prevalence of Pain at Different Spinal Level of the subjects of experiment group and control group of IT Professionals

Figure 5 and 6 shows prevalence of back pain at different spinal level among agriculture workers in comparison to its control. It has been found that agriculture workers reported highest percentage of lumbar pain (47%) in comparison to control group (10%).This indicates that persons engaged in agricultural work have more risk of developing spinal problems and back pain.

Figure 7 and 8 shows prevalence of back pain at different spinal level among IT workers in comparison to its control. Prevalence of lumbar pain (11%) and thoracic pain (7%) occur in IT workers in comparison to control group where prevalence of such pain has not been reported. This indicates that, persons engaged in information technological (IT work involving long hours of sitting in same posture) work have more risk of developing spinal problems and back pain.

The frequency and severity of chronic back pain in different spinal regions (thoracic, lumbar and sacral) were recorded by questionnaire method in case report form and descriptive analysis was used to analyse the answers to the questionnaire in the case report form.

Discussion

The use of the flexicurve for repeated measurements is probably more important for detecting overall change rather than making absolute measurements. This instrument can be used in determining the change in spinal curvature as a result of advancement in age and deteriorating general health.

The measurement of spinal curvature was a good indicator for bio-mechanical assessment of stress. The study of spinal curvature indicated that lumbar spinal angle of working posture was markedly deviated from normal erect posture for the workers engaged in different operation like agriculture or industrial work or computer based work as a profession.

In our study, agriculture worker (age ranged from 41 years - 45 years) performed their job mostly in bending posture as well as in squatting posture. In bending and squatting posture the body becomes folded at hip and knee joints. The upper part of the lower limb (thighs) comes closure to the trunk causing a sliding of pelvic bone and the spinal angle become lower than that in the standing posture. The deviation of the spinal angle was related to the posture adopted by workers during performing the task.[13] According to Granata and Marras[14] the rate of change of spinal load (load occurred during postural change) is one the risk factor for spinal stress and injury, the cause for lower back disorders. According to Burton et al[15] the musculoskeletal symptoms are likely to develop in workers whose work environment produces high level of dynamic and/or maintained postural load as their musculoskeletal symptoms.

Agricultural workers and also IT workers suffered from health problem, because of prolonged working hours, awkward posture and use of less safety measures while working Das and Gangopadhyay[16] studied on potato cultivators and reported that prolonged worked activity, repetitiveness and remaining constantly in an awkward posture for a prolonged period of time may lead to musculoskeletal disorders (MSDs).

Osborne et al[17] studied on farmers and reported that lower back pain was the most common musculoskeletal disorders (MSDs) among the farmers followed by upper and then lower extremities MSDs. Investigator suggested that bending and twisting of back awkwardly and working in same position were both significantly associated with prevalence of lower back problem[18,19], job factors contributing to pain and injury.

Kyphosis is due to the poor posture and weakened muscles, increase of which may lead to pain and risk of dysfunction in shoulder, pelvic, girdle and spine. Symptoms may include back pain, muscle fatigue, and stiffness at the back which would affect the basic activities of daily living. While increased lordosis may increase the risk of disc degeneration and injury to spinal ligaments.

In the present study age and BMI of the agricultural workers (41years - 45years) are not significantly related with kyphosis and lordosis indexes and angles but in IT workers (21years - 25years) age is significantly related with lordosis index and angle and BMI is significantly related with kyphosis index and angle. This is due to the difference in age. When kyphosis and lordosis was compared by age, highest mean value was found in the age group 41years - 45 years. Kyphosis and lordosis indexes of agricultural workers and IT workers when compared, no significant difference was found but IT workers show higher values than agriculture workers, probably due to their prolong sitting posture at work. [20]

In this study, 47% agricultural workers reported lumbar pain and 13% suffer from thoracic pain. But 11% and 7% IT workers reported lumbar and thoracic pain respectively. In agricultural workers the predominant posture is bending one, squat sitting and twisting posture for a long period of time in a day which are responsible for low back pain. The higher prevalence of work related MSDs at different segments of the body of the workers might be due to use of significant force, repetitive movements and longer duration of exposure.[21] Prevalence of lumbar and thoracic pain in IT workers might be due to the prolonged work in sitting posture which might produce disc degeneration, muscle stretch, age and occupation .Christie et al[22] and McKenzie et al [23] showed that low back pain occurred as a result of long and inaccurate overstretching of soft tissue in an abnormal posture. That is, as the extensor muscles become overloaded during lordosis, low back pain may emerge. Besides, cervical, thoracic and lumbar spinal regions are biomechanically related; any change in each arch might be due to the postural alteration in other arches .[24]

Conclusions and Recommendations

No significant deviation of kyphotic and lordotic angle has been observed in agricultural and IT workers by assessment of spinal curvature by flexicurve Ruler,but significantly higher percentage of these 2 groups reported shoulder and lumbar pain indicating risk of dysfunction in shoulder, pelvic girdle and spine. It can also produce spinal stress and injury. Thus measurement of thoracic kyphosis and lumbar lordosis may be useful in examining the degree of spinal cord deformities. By utilizing these information therapeutic and ergonomic intervention can be applied and application of modern sophisticated machine for improvement in postural condition can reduce their work stress and disabilities.

Again, it is recommended that a team of professional in occupational hazards, physical therapy, ergonomic and orthopedic surgery is necessary in order to provide information to individual about anatomy and biomechanical of spine and risk factors that contribute to abnormalities, accurate positions for sitting, standing, bending, repetitive actions, carrying objects and using of instruments and performing exercise to strengthen the weak muscles and correct the abnormal posture.

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