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Correlation and comparison between pelvic position and lumbar lordosis in pregnant women

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ABSTRACT

Background: The purpose of this study was to determine if posture and back pain changed from the first to the third trimester of pregnancy and whether there was a relationship between the two.

Aim: To measure, correlate and compare lumbar lordosis with pelvic posture in pregnant women of all three trimesters.

Methodology

A cross-sectional study was conducted comprising a total of 160 subjects, with an equal number of subjects (n=40) from 1st trimester, 2nd trimester, 3rd trimester and a control group which included non pregnant healthy individuals. Group 1= Ladies in the First Trimester, Group 2= Ladies in the Second Trimester, Group 3= Ladies in the Third Trimester and Group 4= Age and BMI matched women. Each subject from each group had their pelvic inclination angle, lumbar lordosis angle, height and weight for calculating BMI, and hip circumference measured in relaxed standing posture.

Results

Bonferroni test was used to compare the variables in all the groups of the experiment. A significant difference at $p<0.05$ was obtained between pelvic inclination angle measured in the pregnant ladies from all trimesters. A non-significant difference was obtained between Women in the first trimester and control group. Significant difference at $p<0.05$ was obtained in the lumbar lordosis angle measured in the pregnant ladies when mothers in the 1st Trimester were compared with mothers in the 2nd Trimester and 3rd Trimester. However there was no significant difference in the lumbar lordosis angle values in between 2nd Trimester mothers & 3rd Trimester and between 1st Trimester and control group. There was no correlation between lumbar lordosis and pelvic inclination measured in the experimental group. Also no correlation was established between BMI and waist hip ratio when associated with lumbar lordosis and pelvic inclination.

Conclusion

It is made evident that measurement of Lumbar Lordosis angle does not vary significantly in the pregnant women throughout their pregnancy. On the contrary, there was a gradual increase in the measurement of Pelvic inclination angle that was seen from the first through the third trimesters. Also, there was no association obtained between the two measurements denoting the pelvic posture and the lumbar spine posture.

Keywords: Pregnant Women, Lumbar Lordosis Angle, Pelvic Inclination Angle, Pelvic Postures, Sacral Pain, Low Back Pain.

INTRODUCTION

Pregnancy is the time of rapid biological change and all the bodily organs and systems are affected by the process Danforth (1967)[1]. The period of pregnancy involves profound physiological changes along with postural adjustments that can have considerable implications in the discomfort of the women experienced during pregnancy. One of the main physiological changes in pregnancy is the release of excessive amounts of a peptide hormone 'relaxin' which is responsible for the changes in the components of non-contractile connective tissue. Of particular importance to physiotherapist is the laxity of the fascia of the abdominal wall; through this change there is reduced resistance both to protrusion of the abdomen and increase in the angle of pelvic tilt. An increase in the degree of separation possible at the pubic symphysis, and corresponding changes in the sacroiliac joints, allow the anteroposterior and transverse diameters of the pelvis to increase during delivery beyond the values which exist in the non gravid state. Until 4 months the gravid uterus is confined to the pelvis and the lower abdomen, during which time the mother may assume a normal erect posture; by 5 months the top of the uterine fundus is in line with the umbilicus and by term in line with the xiphisternum. The weight of the gravid uterus is taken by the anterior abdominal wall, pubic symphysis and pelvic floor in succession.[2]

Increase in maternal and foetal weight, altered line of weight bearing, and ligamentous laxity account for a number of postural changes, particularly lumbar lordosis with hip flexion. Sacroiliac joint rotation, negligible or nonexistent in some cases prior to pregnancy, occurs to a significant degree in pregnancy and is undoubtedly responsible, in part for the increase in pelvic tilt. This change in anatomy associated with an increase in the weight of the uterus and its contents, accounts for a ventral shift of the centre of gravity which necessitates a compensatory postural adjustment in the form of increased pelvic tilt and lumbar spinal extension. [2]

Although never substantiated, postural changes have been often implicated as a major cause of back pain in pregnant women[3,4,5]. Women commonly experience back pain during pregnancy incidence of back pain during pregnancy has reported to range from 47% to 82% [6,7,8,9,10,11]. An excellent review of different theories has been written by Rungee which says that the aetiology of back pain during pregnancy is the hormonal influences causing laxity of the joints in pelvis and postural changes from the increasing growth of foetus.[12] Though the literature provides evidence of pregnancy related alterations in the posture, there is no consensus about the type of changes in the lumbar lordosis angle; some report it to be aggravated Bullock Saxton, J.E Dumas G.A., Elizabeth Noble [13,14,15] & some report it to be flattened , Snijders G.J , Simson S R Wendy L. Gilleard Britnell A.J.[16,17,18,19.] Whereas Hummel P, K Moor &Paul Sanderson[20,21,22] et al report about highly variable alterations. Many authors have speculated that low back pain may occur as a result of excessive stress on the structures around the lumbar spine and the sacroiliac joints due to an exaggerated anterior pelvic tilt posture [23-28]. Treatments based on decreasing the amount of anterior pelvic tilt and concurrently reducing the lumbar lordosis or vice versa, are often prescribed in an attempt to correct postural deviations and to treat the pain and dysfunction related to the postural syndromes.[23,29]

Low back pain is not only associated with the postural changes in pregnancy, but also the increase in BMI [30]. Obesity is nowadays a pandemic condition. Obese subjects are commonly characterized by musculoskeletal disorders and particularly by a postural change. During stance, obese patients show a hyperextension of the lumbar spine [31, 32] similar to the anterior translation of the centre of mass described by Whitcome in pregnant women[33]. However, the relationship between obesity and postural change still remains; till date unsupported by an objective measurement of the mechanical behavior of the spine and its morphology in obese subjects. Such analysis may provide a deeper understanding of the relationships between function and the onset of clinical symptoms. A study done by Luca Vismara et al[30] on the Effect of obesity and low back pain on spinal mobility in women found an increase in the

lumbar lordosis and anterior pelvic tilt. Since postural changes due to musculoskeletal problems in obese people are more often said to linked to their increased BMI of being the major cause; we often advice the patients to reduce their weight, mentioning increased BMI as being one of the causative factors for low back pain due to the postural change. Thus a better understanding still needs to be achieved about the relation of increased BMI on the postural change. Therefore postural correction forms an integral part of antenatal program and in obese patients as a preventive measure of low back pain[34-36]. However prior understanding of pregnancy related postural alteration if any, it is essential for planning individual need based exercise program as per the type of alteration in lumbar lordosis and pelvic inclination angle.

Based on our observation during clinical practice and literature review, it was hypothesized that lumbar lordosis does alter during pregnancy and in people with increased BMI. This preliminary observational study was therefore aimed at verifying the hypothesis and to study the alterations if any in the lumbar lordosis and pelvic inclination or a correlation between the two, within the pregnant woman of all the three trimesters and to also see if; BMI or waist hip circumference ratio has any effect on the pelvic posture and the lumbar spine.

METHODOLOGY

A cross-sectional study was conducted with a total of 160 subjects, comprising an equal number of subjects (n=40) from 1st trimester, 2nd trimester, 3rd trimester and a control group which included non pregnant healthy individuals. All the individuals who participated in the study were age and gender matched subjects between the mean age group of 20 to 30 years of age. The subjects were randomly selected; both primigravida and multigravidae women were included in the study. Pregnant mothers who were having uncomplicated pregnancies were referred from the Obstetrics and Gynaecology Antenatal O.P.D of D.Y Patil Hospital and Research Centre. Informed consent was obtained from all the subjects prior to the study. Proforma was filled by the therapist that included details regarding the name, age, gestation period, gravidity, last menstrual period and any musculoskeletal pain or problem if present were all obtained from the subjects.

Participating subjects were grouped as follows, Group 1= Women in the First Trimester, Group 2= Women in the Second Trimester, Group 3= Women in the Third Trimester and Group 4= Age and BMI matched women.

All the subjects were explained about the experiment through and information sheet in the language best understood by them. Subjects were recruited once they consented for participation in the study. All high risk, bed-ridden, and handicapped pregnant women, pregnant ladies having any kind of musculoskeletal structural deformities were excluded from the study. Each subject from each group had their pelvic inclination angle (using an indigenously designed Pelvic inclinometer PELVIN®TM, *Figure 1*), lumbar lordosis angle (using a Flexicurve; *Figure 2*), height and weight for calculating Body mass index (BMI), and hip circumference (using a measuring tape) measured in relaxed standing posture. Reliability and Validity of PELVIN was established in earlier studies.[37]

Figure:1 Pelvic Inclinometer mounted on a stand

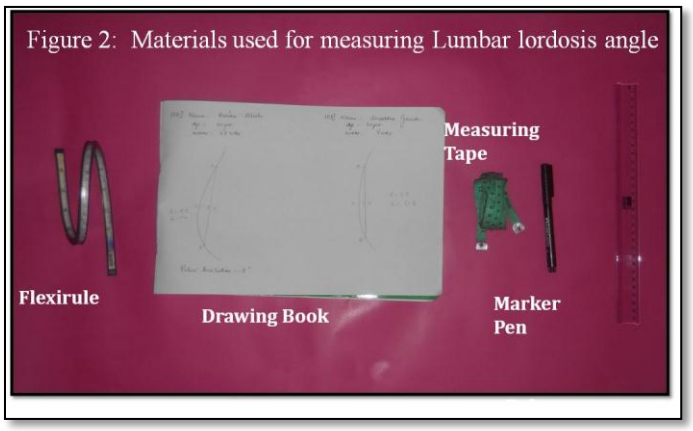

Figure 2: Materials used for measuring Lumbar lordosis angle

Following outcome measures were considered, Measurement of pelvic inclination angle, Measurement of Lumbar lordosis angle, Measurement of the hip and the waist circumference to find the hip waist ratio, Measurement of the height and weight to find the BMI. Figures 3, 4 and 5 show the methods of recording the same.

Figure 3: Method of assessing the Pelvic inclination angle using PELVIN

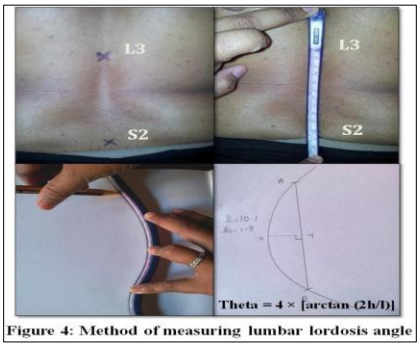

Figure 4: Method of measuring lumbar lordosis angle

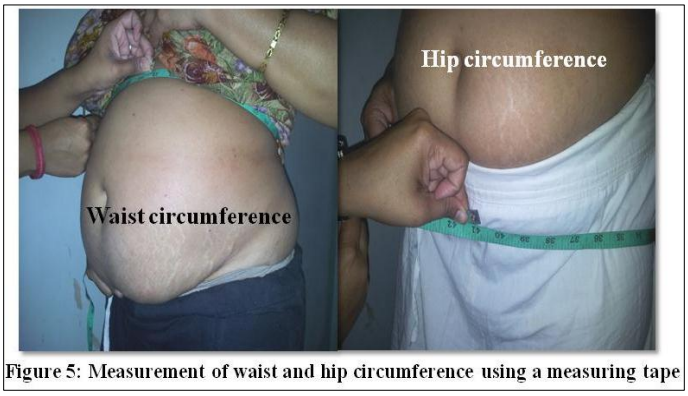

Figure 5: Measurement of waist and hip circumference using a measuring tape

RESULTS

Statistical analysis was done using **SPSS software** version 16. Validity and Reliability of PELVIN was established earlier in the previous published studies.

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Table 1: Variations in pelvic inclination angle and lumbar lordosis angle in the 4 groups of the study.

Pelvic Inclination Angle	Groups	N	Mean	Std. Deviation
	1	40	6.275	1.21924
	2	40	7.5125	1.40734
	3	40	9.3875	1.54624
	4	40	5.8049	1.41809
	Total	**160**	**7.236**	**1.96537**
Lumbar Lordosis angle				
	1	40	0.8887	0.23192
	2	40	1.118	0.25687
	3	40	1.2002	0.22164
	4	40	0.8893	0.19432
	Total	**160**	**1.0232**	**0.26421**

Comparison of pelvic inclination angles and lumbar lordosis angle within all four groups

Post hoc Bonferroni test was used which is one of the types of Post Hoc test used to compare a single variable in multiple groups. The analysis yielded a significant difference between the pelvic inclination angles measured in the pregnant ladies when group 1 was compared with 2nd and 3rd; and also when Group 2 was compared with 3rd, 4th and similarly when Group 3 was compared with the other groups i.e. Group 2, 3 and 4 it showed high significance. However there was no significant difference in the pelvic inclination measured in the pregnant ladies between Group 1 and 4. Thus the null hypothesis was rejected and the alternate hypothesis was accepted that there is a difference in the measurement of pelvic inclination angle within the pregnant ladies of the three trimesters.

Similarly, a highly significant difference in the lumbar lordosis angle was noted in the pregnant ladies when compared between Group 1 and 2 and Group 1 and 3. However there was no significant difference in the lumbar lordosis angle values when compared between Group 2 and 3 and between Group 1 and 4. Thus we accepted the null hypothesis which stated that there was no significant difference in the lumbar lordosis angle within the three trimesters. Table 2 shows the values of statistical analysis as obtained in the groups. Pearson correlation test yielded correlation between neither of the variables as seen in Table 3. No association between lumbar lordosis and pelvic inclination could be maintained. Also, we accepted the null hypothesis that there was no association between BMI and Lumbar lordosis or BMI and Pelvic inclination. No linear relation was maintained between waist-hip ratio, Pelvic Inclination angle and Lumbar lordosis angle.

Table 2: Comparison of pelvic inclination angle within all four groups

Dependent Variable	Statistical Test	Group	Group	Significance
Pelvic Inclination Angle	Bonferroni	1	2	0.001
			3	0.000
			4	0.801
		2	1	0.001
			3	0.000
			4	0.000
		3	1	0.000
			2	0.000
			4	0.000
		4	1	0.801
			2	0.000
			3	0.000
Lumbar Lordosis Angle	Bonferroni	1	2	0.000
			3	0.000
			4	1.000
		2	1	0.000
			3	0.644
			4	.000
		3	1	0.000
			2	0.644
			4	0.000
		4	1	0.801
			2	0.000
			3	0.000

1= First Trimester, 2= Second Trimester, 3= Third Trimester, 4 = Control

Table 3- Correlation between BMI, Lumbar lordosis, Pelvic Inclination and Waist-hip ratio

		BMI	Lumbar Lordosis Angle	Pelvic Inclination angle	Waist-hip ratio
BMI	Pearson Correlation	1	.430	.170	
	Sig. (2-tailed)		.000	.063	
	N	120	120	120	
Lumbar Lordosis Angle	Pearson Correlation	.430	1	.486	-.039
	Sig. (2-tailed)	.000		.000	.671
	N	120	120	120	120
Pelvic Inclination angle	Pearson Correlation	.170	.486	1	-.295
	Sig. (2-tailed)	.063	.000		.008
	N	120	120	120	120
Waist-hip ratio	Pearson Correlation		-.039	-.295	1
	Sig. (2-tailed)		.671	.008	
	N		120	120	120

DISCUSSION

The popular theory for the cause of low back pain presumes that lumbar lordosis increases during pregnancy because of the gravid uterus enlarging, weight gain[38]. The increasing lumbar lordosis induces the mechanical strain on lower back, which causes pain[39-41]. However, Moor et al[21] have challenged the traditional belief of pregnancy related low back pain to increased Lumbar lordosis angle & stated that, adaptation, their patterns & relation with low back pain if any, may be more complex than usually thought. Moore et al[21] gave one of the explanation for non significant change of lumbar lordosis in pregnancy; as a possible result of hormonally induced relaxation of dorsolumbar fascia leading to straightening of lumbar spine. This study showed a non significant difference or a negligible change in Lumbar Lordosis angle between the 2nd and 3rd trimesters when compared to age and BMI matched non pregnant ladies and a significant change was present between the 1st and 2nd trimester but they were within normal angle limits. One of the reasons for this could be the changes in the pelvic joint mobility, that are related to ligamentous relaxation stimulated by; increased levels of circulating sex hormones during pregnancy and albeit to a lesser extent, during menstruation[42]. The hormonally induced changes in the pelvic mobility have been confirmed radiographically [43]. Increased levels of sex hormones as well as the peptide hormone relaxin produced by the corpus luteum, during pregnancy and menstruation are credited by some with the relaxation of the pelvic joint ligaments[44,45]. Three ligaments are in intimate contact with the joint and three others, though better termed accessory, they make important contributions to the joints integrity. The sacroiliac joint capsule is closely attached to the joints margins and the dorsal sacroiliac ligament crosses the joint. The dorsal sacroiliac ligament is heavier and most extensive than its companion on the ventral surface; for descriptive and functional purposes it is divided into short and long fibres. Short dorsal sacroiliac ligament are deep and pass inferomedially from the PSIS to the back of the lateral part of the 1st and 2nd sacral ligaments. Positioned more superficially; fibres of the long dorsal sacroiliac ligament connect the PSIS to the same area of the 3rd, 4th sacral ligaments; these fibres are continuous inferolaterally with the sacrotuberous ligament and superomedially with the posterior lamina of the thoracolumbar fascia[46,47] . It was proved by A.Vleeming in a study that during incremental loading of the sacrum, the dorsal sacroiliac ligament becomes tense when the base of the sacrum is counternutated and slackens with movement in the opposite direction (nutation)[48].

During pregnancy due to hormonal influences there is laxity of the ligaments in the sacroiliac joints; because of which there is nutation occurring;

but this nutation is counternutated by the following forces [48]:-

- Because of the incremental loading of the foetus over the sacroiliac joint the dorsal sacroiliac ligament becomes tense and thus counternutates the sacrum.
- During nutation the sacrotuberous ligament is more tense which along with the erector spinae muscle which is greatly connected to the long dorsal sacroiliac ligament counterbalances the excessive slackening of the dorsal sacroiliac ligament.
- Deep to and blended with the sacrospinous ligament at its medial attachments the sacrospinous ligament passes from the ischial spine to the lower sacrum and coccyx. On its deep surface the fibres of the coccygeus (part of the pelvic diaphragm) blend with it. Both the sacrotuberous and the sacrospinous ligaments convert the greater and lesser sciatic notches into the foramina and resist forward movement of the base of the sacrum under load.

Our study did show an increase in the pelvic inclination from the 1st to the 3rd trimesters, but on a higher side towards the third trimesters; but they were within their normal pelvic inclination angle limits.

This study showed no correlation between lumbar lordosis and its changes in pregnant women. This result can be correlated with Bullock et al in his study on relationship of postural changes in pregnancy, in the study, which used a reliable and validated posture assessment instrument found no relationship between the spinal posture (thoracic kyphosis, lumbar lordosis and pelvic tilt magnitude or changes during pregnancy). No correlation was found between BMI of the pregnant women and lumbar lordosis or BMI and Pelvic inclination in comparison to the previous study done by Luca Vismara et al [49] who found a correlation between BMI and Pelvic inclination and Lumbar Lordosis. No correlation was also found between waist hip ratio and pelvic inclination or waist hip ratio and lumbar lordosis.

Thus our study ascertains that in pregnant women there is a progressive increase in the pelvic inclination angle in the first to the third trimester. Though the lumbar lordosis did alter from the first to the second trimester when compared to the age and BMI matched control group, there was no significant change in the lumbar lordosis angle in the second and third trimesters.

CONCLUSION

It is evident that measurement of Lumbar Lordosis angle does not vary significantly in the pregnant women throughout their pregnancy. On the contrary, there was a gradual increase in the measurement of Pelvic inclination angle that was seen from the first through the third trimesters. Also, there was no association obtained between the two measurements denoting pelvic posture and the lumbar spine posture. The theoretical findings in the belief that deviations in the lumbar lordosis occurring in pregnant women as the contributing factor to the clinical problem of low back pain and sacral pain for quite some time now, is not supported by our findings rather it could be the deviations in the measurement of Pelvic Inclination angle throughout the pregnancy period that could lead to the aforementioned clinical problems.

Thus, clinically it is of grave importance that pelvic postures should be assessed in pregnant ladies to acknowledge their problems and form a precise, specific and holistic rehabilitation program for them in their pregnancy term.

There was no association obtained either between BMI and Pelvic Inclination or between BMI and Lumbar Lordosis. Thus leading us to a fact that weight increments may not be linked to deviations in spinal posture as far as lumbar spine is concerned, likewise with pelvic postures. It was also observed that the measurement of central obesity denoted by waist-hip ratio was not associated with either of the clinical measurement parameters of lumbar spine and pelvic posture.

Therefore, this study warrants a revision of our age old theories of biomechanical changes that occur in the musculoskeletal system in pregnancy leading to various associated clinical problems based on further systematic researches.

REFERENCES

[1]. Danforth D.N (1967) , pregnancy and labour from the vantage point of physical therapist , American journal of physical medicine, 46 (1), 633-658.

[2]. Barry .C. Stillman, (1969), physiology of pregnancy, australian journal of physiotherapy, 15, 1969.
[3]. Andersson GBJ: Low back pain in pregnancy. In: Weinstein IN, Wiesel SW(eds), The Lumbar Spine (3rd Ed), Philadelphia, PA: W.B. Saunders Cornpany,1990
[4]. Black E, Anastasi SC: Pregnancy and the lower extremities. Biomechanics 2(4):22-25, 68- 69, 7995.
[5]. Bushnell L F: The postural pains of pregnancy. West J Surg Obstet Gynecol 57, 1949, 123-127,
[6]. Berg G, Hammar M, Moiler-Nielsen J, Linden U, Thorblad 1: Low back pain during pregnancy. Obstet Gynecol 71, 1988, 77-75,.
[7]. Bullock jE, lull GA, Bullock MI: The relationship of low back pain to postural changes during pregnancy. Aust JPhysiother 33, 1987, 10-7.
[8]. Fast A, Shaperio D**,** Weiss L, Ducommun El, Friedmann L W, Bouklas T, Floman Y: Low back pain in pregnancy. Spine 12, 1987, 368-371.
[9]. Mantle MJ, Greenwood RM, Currey HLF: Backache in pregnancy. Rheumato1 Rehabil 16:9S-lOl, 1977.
[10]. Ostgaard HC, Andersson GBI, Karlsson K: Prevalence of back pain in pregnancy. Spine 16, 1991, 432-436,
[11]. Ostgaard HC, Zetherstrom G, Roos- Hansson E, Svanberg B: Reduction of back and posterior pelvic pain in pregnancy. Spine 19(8), 1994, 894-900.
[12]. Rungee JL: Low back pain in pregnancy. Orthopedics 16, 1993, 1339-1344.
[13]. Bullock Saxton J.E Changes in posture measured in standing associated with pregnancy & early postnatal period; Physiotherapy Theory Practice. 7(2) , 1991, 103-109
[14]. 16. Dumas G.A., Reid J.G., Wolfe LA et al Exercise &posture pain during pregnancy: Part-I Exercise , posture & back ,Clinical Biomechanics 10, 1995a , 104-109
[15]. 17. Elizabeth Noble: Essential exercises for the Child bearing year [1995], 4th edn , 28
[16]. Snijders G.J, Snijder J D,& Hoest H T Change in the form of the spine as a consequence pregnancy [1976] Digest of the 11th International conference on Medical & Biological Engineering; Ottawa, Canada :670-671.
[17]. Simson S R: Evaluation of flexirular technique for measuring lumbar lordosis in the clinical assessment of low back pin [1989] J Soc Occ Med: 39[1], 25-9
[18]. Wendy L.Gilleard, Jack Crosbie, Richard Smith Static trunk posture in sitting & standing during pregnancy &early post partum .American Academy of Physical medicine &Rehabilitation, 83 (12), 2002, 1739-1744.
[19]. Britnell A.J, Cole J.V & Isherwood L Postural health in women: The role of Physiotherapy [2005] J Obst Gynecol Can: MAI 493-500.
[20]. Hummel P -Changes in posture during pregnancy PhD thesis [1987] Vrije universiteit de Amsterdam Academisch Pragshrift.
[21]. K Moor, GA Dumas, JG Reid; Postural changes during pregnancy & their relationship with low back Pain [1990] Clinical Biomechanics 5[3], 169-174.
[22]. Paul Standerson et al The influence of pregnancy on the development of degenerative spondylolysthesis [1996]- J.Bone Joint Surg ; 78, 951-4.
[23]. Cailliet R.: low back pain syndrome 3rd edition, pp 53-58. philadelphia:F.A davis company , 1981.
[24]. Denslow JS, Chace J.A: machanical stresses in the human lumbar spine and pelvis. j am osteopath assoc 61, 1962, 706-712.
[25]. Kendall HO, Kendall FP, Boynton DA: posture and pain, pp 125-131. Baltimore: Williams and Wilkins, 1977.
[26]. Kisner C, Colby L.A: therapeutic exercise: foundations and techniques (2nd ed), pp 437- 439. Philadelphia: F.A Davis Company, 1990.
[27]. Polster J, Spieker U, Hoefert H.R, Krenz ju: Biomechanics in lumbar lordosis. in: Melson RC, Morehouse ca (eds), biomechanics 4, pp 365-371. Baltimore university press, 1974.
[28]. Thomas P.E: an analysis of the interactions among various assymetric osseous pelvic and lumbar structures. J Am osteopath assoc 64, 1965, 956-957,.
[29]. Kendall FP, MC Creary EK: muscles: testing and function 3rd (ed), pp 189- 192, 219. baltimore : Williams Wilkins 1983.

[30]. Vismara et al.: Effect of obesity and low back pain on spinal mobility: a cross sectional study in women. Journal of Neuro Engineering and Rehabilitation 2010, 7:3.
[31]. Leboeuf-Yde C: Body weight and low back pain. A systematic literature review of 56 journal articles reporting on 65 epidemiologic studies. Spine 2000, 25:226-237. Fabris de Souza SA, Faintuch J, Valezi AC, Sant'Anna AF, Gama-Rodrigues JJ, de Batista Fonseca IC, de Melo RD: Postural changes in morbidly obese patients. Obes Surg 15(7), 2005, 1013-6.
[32]. O'Sullivan PB, Dankaerts W, Burnett AF, Farrell GT, Jefford E, Naylor CS, O'Sullivan KJ: Effect of different upright sitting postures on spinal-pelvic curvature and trunk muscle activation in a pain-free population. Spine 31(19), 2006, E707-12.
[33]. Whitcome KK, Shapiro JL, Lieberman DL: Fetal load and the evolution of lumbar lordosis in bipedal hominins. Nature 450(7172), 2007, 1075-8.
[34]. Elizabeth Noble-Essential exercises for the Child bearing year [1995], 4th edn Chapter 5-107-146
[35]. Carrie Hall, Lori Thein Broody Therapeutic exercise –moving towards function[1998]-pub-Lippincott Williums & Walkins – 213-231
[36]. Jill Mantle, Jeanette Haslam,, Sue Barton ;Physiotherapy in Obstetrics and Gynecology [2004], 2nd ed-pg-14 1 -164
[37]. Intertester and Intratester Reliability and Validity of Measures of Innominate one Inclination in Standing Using PELVIN®TM , International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 7, July 2015, 5069-5077, ISSN(Online) : 2319-8753, ISSN (Print) : 2347-6710, Impact factor 5.4421
[38]. Sapsford R, J Bullock-Saxton,S Markswell Women`s health, [1998] W.B. Sounders company- Indian print14:136-140.
[39]. Wang SM, Dezinno P, Maranets I, Berman MR,Caldwell-Andrews AA, Kain ZN. Low backpain during pregnancy: prevalence, risk factors, and o u t c ome s . (2004) Obstetric Gynecol;104(1), 65-70.
[40]. Borg-Stein J, Dugan SA, Gruber J.Musculoskeletal aspects of pregnancy; Am J Phys Med Rehabil. 84(3), 2005, 180-92.
[41]. Sneag DB, Bendo JA. Pregnancy-related Low Back Pain. Orthopaedics. 30, 2007, 839 - 847.
[42]. Chamberlain WE: The symphysis pubis in the roentgen examination of sacroiliac joint. AM J Roentgenol 24, 1930, 621-625.
[43]. Abramson D et al: relaxation of the pelvic joints during pregnancy. surg gynaecology obstet 58, 1934, 594-613.
[44]. Calguneri m, bird HAWA: changes in joint laxity occurring during pregnancy. Ann Rheum Dis 41, 1982, 126 - 128.
[45]. Krisstiansson P et al: serum relaxin , symphyseal pain , and backpain during pregnancy. Am J Obstet and Gynaec 175, 1996, 1342-1347.
[46]. Soames RW: skeletal system in; Williams PL, ed Grays anatomy. The anatomical basis of medicine and surgery. New York: Churchill Livingstone, 1995, 425- 736.
[47]. Terry RJ, Trotter M the articulations. In schaeffer Jp , ed Morris Human anatomy . New York: Blakiston , 1953 b; 287 - 398.
[48]. Vleeming A, Pool Goudzwaard AL, Hammudoghlu D et al: The function of the long dorsal sacroiliac ligament. Spine 21, 1996, 556-562.
[49]. Vismara et al. Journal of NeuroEngineering and Rehabilitation 2010,7:3 http://www.jneuroengrehab.com/content/7/1/3.