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Research article

Effect of habitual lumbar curvature on electromyographic activity of trunk muscle and intravaginal pressure during still standing and dynamic task among non-osteoporotic post-menopausal women

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ABSTRACT

The pelvic floor muscles support vital organs like the bladder, colon, and internal reproductive systems. These muscles synergistically function with the abdominal muscle to control continence. Pelvic floor muscle insufficiency results in poor control over continence during various activities. The efficient control of abdominal muscles to support the pelvic floor function require stabilization of the spine which in turn gets affected by the change in the mechanics due to the altered lumbar spine angle. In the present study, we intended to find the effect of lumbar spine angle on trunk muscle tonic activity, and pelvic floor function. A total of seventy-eight non-osteoporotic menopausal continent women were recruited and based on their lumbar lordotic angle, they were allocated to three groups (Hyper, hypo, and normal lordosis). The electromyographic tonic activity of erector spinae (ES), rectus abdominis (RA), and vaginal pressure was recorded during standing still (SS), maximal coughing (MC), and Valsalva maneuver (VM). The data were analyzed using a one-way analysis of variance and the Tukey post hoc test. The confidence level was kept at 95%, i.e., $p<0.05$. We found the trunk muscle tonic activity and vaginal pressure reduced as the lumbar lordotic angle changed to a hyper and hypo lordotic spine.

Keywords: Hypo lordosis, Hyper lordosis, Pelvic Floor Dysfunction, Electromyography (EMG), Erector Spinae (ES), Rectus Abdominis (RA) and Vaginal Pressure (VP).

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INTRODUCTION

The pelvic floor is made up of connective tissues and muscles that support vital organs like the bladder, colon, and internal reproductive systems during a variety of activities of daily living. Pelvic floor muscle insufficiency results in poor control over continence during various activities (like coughing and sneezing) which involves a rise in intra-abdominal pressure. Delayed muscle recruitment, reduced tonic activity, and muscle weakness are some common characteristics of pelvic floor sufficiency [1,2]. Factors like obesity, chronic coughing, heavy weightlifting, frequent constipation, parity, number of childbirth, presence of low back aches, and many other health conditions are found to be related to pelvic floor dysfunction (PFD) [3-5]. PFD is an umbrella term that includes urge incontinence, stress incontinence, overactive bladder, and organ prolapse. The functioning of the pelvic floor becomes more important among females due to its high prevalence [6]. The prevalence of PFD in various forms varies from 14.2% to 34.3% [7]. Data for the Indian population is not available, but studies reported that prevalence at the district level is around 21% among women [8]. The actual prevalence may be higher in different ethnicity as women consider PFD as a normal part of life, hence remaining unreported.

Pelvic floor functions in synergy with the rectus and transverse abdominis muscle to control continence by regulating intra-abdominal pressure [9]. These muscles along with erector spinae play a key role in stabilizing the spine during various functional activities and postures. Co-contraction of various global and local muscles is required to have better spinal stability. The spinal stability gets compromised in case of high Body mass index (BMI), which in turn reduces the postural control ability of erector spinae. Global muscles functions to transfer the load to the pelvis while local muscles are responsible for segmental stability [10-13]. Optimal spinal stability facilitates pelvic floor functioning by improving lumbopelvic rhythm. This function of pelvic floor with co-contraction of abdominal muscles becomes more challenging in gravity-dependent postures like standing. The lumbar posture affects muscle recruitment and its tone to regulate spinal stability [14]. Limited mobility, weakness of muscles, and laxity in ligaments supporting the spine results in a change in the normal curvature of the lumbar spine among menopausal women [15]. When this change in the lumbar spine becomes habitual, this not only affects the pattern of trunk muscle activation, but also the tonic activity of these muscle [16,17].

Study investigated the association between lumbar lordotic angle and spinal stability, but how spinal instability affects the trunk muscle activation remains unanswered [18]. Despite being the key stabilizer of the spine which in turns affects the lumbopelvic rhythm, evidence finding the association between trunk muscle activity with variety of habitual lumbar curvature among post-menopausal women are still lacking. Few studies also investigated the role of trunk muscle coactivation during pelvic floor functioning [9], but this coactivation of trunk muscle in presence of different lumbar spine curvature in sagittal plane is still no studied. Where the present literature studied and identified the association between trunk muscle activation with voluntary adopted lumbar posture and with pelvic floor functioning separately, none of them identified this muscle activation and pelvic floor function with respect to different habitual lumbar posture. In this study we tried to identify this gap that, how the variety of habitual lumbar posture effects the tonic activity of rectus abdominis and erector spinae along with intravaginal pressure as a function of pelvic floor muscle in antigravity position while standing still and doing the task which raises intra-abdominal pressure post-menopausal women.

MATERIALS AND METHODS

A cross-sectional and observational design was chosen for this study. Females who have achieved menopause at least two years ago, with the history of vaginal delivery, body mass index (BMI) between 18.5 to 25, and willing to participate were included. Incontinent females, achieved menopause before >10 years, with the history of cesarean section, multigravida (>2), visible scoliosis, history of low back pain with numeric pain rating value greater than 4, hysterectomy, nulliparous, t value < -1 on bone density scan and with a neurological conditions affecting balance were excluded. A Total of seventy-eight subjects were recruited in this study after screening of 424 subjects. All the subjects were then distributed among three groups Group A (Normal Lordosis), Group B (Hyper Lordosis) and Group C (Hypo Lordosis) based upon their lumbar lordotic angle. Lordotic angle was measured using a lateral view of roentgenogram. Females with angle between 40° to 70° were considered as normal lordosis and put in Group A. Lumbar angle greater than 70° were considered as hyper lordotic and placed in Group B and angle lessor than 40° were put in hypo lordotic group i.e., Group C. Sampling and data collection was done at Indian Spinal Injuries Centre, New Delhi, India. All subjects received a detailed explanation of the safety measures pri or to any procedure and became a part of the study only after signing the consent.

"MYOMED 632X" a myofeedback unit of Enraf Nonius made, was used to record electromyographic (EMG) activity and vaginal pressure. To record EMG activity adhesive carbon electrode with 10 millimeter^2 area and to record intravaginal pressure a vaginal manometer was used. Before placing the electrode, the surface of the skin was cleaned using the alcoholic wipes. Recording electrodes were applied on both side of the rectus and erector spinae muscles and ground electrode were placed at tibial tuberosity. Position of the electrodes were verified by instructing the patient to contract the muscle voluntarily. Before positioning the vaginal probe standardize the volume of bladder, subjects were first asked to void. Each subject was then explained the procedure for placement of vaginal probe and supervised by the experimenter for correct placement in an isolated room.

Each subject was recorded for EMG tonic activity of rectus abdominis, erector spinae and intravaginal pressure during standing still (SS) for 5 Second, maximal coughing (MC) and Valsalva maneuver (VM). Three readings were obtained for each task, with the rest of one minute in between. Mean of all three readings were considered the final value.

Version 20 of the 'Statistical Package for Social Sciences' (SPSS) was used for all the statistical data analysis. The variables were represented as mean ± standard deviation (SD). For the purpose of comparing quantitative variables, a 'one-way analysis of variance' (ANOVA) test and post hoc analysis were used. A 5% probability level i.e., $p < 0.05$, was considered to define statistical significance.

Ethical approvals (reference number ISIC/RP/2017/078 and AUUP/IEC/JULY/2016/3) were received from Indian Spinal Injuries Centre, New Delhi, India and Amity University Uttar Pradesh, Noida, India.

RESULTS & DISCUSSION

Table 1: Demographic Details

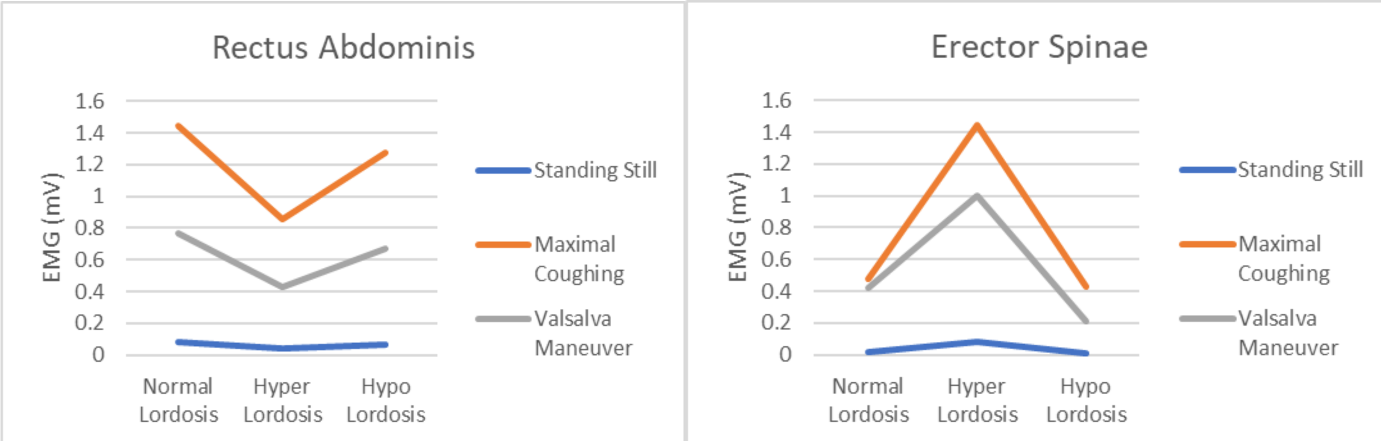
Variable	Mean (n*=78)	Std. Deviation	Std. Error Mean
Age (Years)	51.7179	3.27881	0.37125
Height. (centimeters)	159.4256	5.59804	0.63385
Weight. (Kilograms)	57.0769	6.91604	0.78309
Body Mass Index	22.5254	1.96247	0.22221
*Number of subjects in the study			

Table 1 presents the demographic details of the sample population. All the females included in the study aged between 48 years to 60 years with the mean age of 51.71 ± 3.27. The mean and SD of the three groups shows no significance difference for age, height, weight, and BMI criteria. The baseline data in all the groups had no missing records.

Figure 1 shows the comparison between mean value of

EMG tonic activity of rectus abdominis and erector spinae between three groups during SS, MC and VM.

Figure 1: Present the comparison of EMG tonic activity of rectus abdominis and erector spinae during standing still, maximal coughing and Valsalva maneuver across the three groups



This comparison explains the rectus abdominis and erector spinae activity are found to be higher during maximal coughing across all the three group. The vaginal pressure reflected in figure 2 was also found to be higher during maximal coughing across all three groups. Tonic activity of rectus abdominis and intra vaginal pressure was reduced in hyper and hypo lordosis during MC and VM. While tonic activity of erector spinae was found to increase in hyper lordosis and decrease in hypo lordosis during MC and VM.

Table 2: Between-group analysis (One way ANOVA) of tonic activity of Rectus Abdominis, erector spinae, and Vaginal pressure recorded during standing still, maximal coughing, and Valsalva maneuver among the groups with different lumbar curvature.

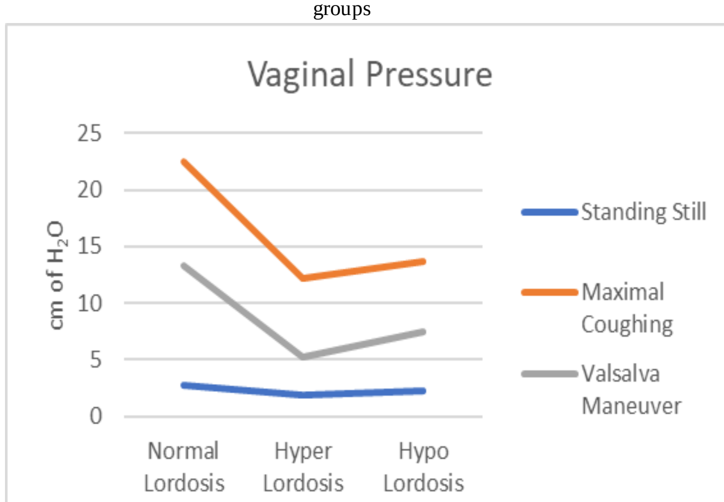
Variable	Mean ± SD (n=26 in each group)			F	Sig.
	Normal lordosis	Hyper Lordosis	Hypo lordosis		
EMG* activity in mV# of Rectus Abdominis during Standing still	0.0800 ± 0.0000	0.0448 ± 0.0057	0.0638 ± 0.0057	365.748	0.000
EMG* activity in mV# of Rectus Abdominis during Maximal coughing	1.4481 ± 0.2402	0.8562 ± 0.0670	1.2769 ± 0.0377	113.753	0.000
EMG* activity in mV# of Rectus Abdominis During Valsalva Maneuver	0.7712 ± 0.0561	0.4315 ± 0.0525	0.6731 ± 0.0340	336.646	0.000
EMG* activity in mV# of Erector Spinae during Standing still	0.0140 ± 0.0000	0.0802 ± 0.0150	0.0085 ± 0.0005	550.897	0.000
EMG* activity in mV# of Erector Spinae during Maximal coughing	0.4781 ± 0.1485	1.4431 ± 0.1701	0.4254 ± 0.0076	501.371	0.000
EMG* activity in mV# of Erector Spinae During Valsalva Maneuver	0.4242 ± 0.0179	1.0004 ± 0.0741	0.2085 ± 0.0078	2225.359	0.000
Vaginal Pressure (cm of H_2O) during Standing Still	2.7269 ± 1.0516	1.9100 ± 0.2039	2.3119 ± 0.6803	8.082	0.001
Vaginal Pressure (cm of H_2O) during Maximal Coughing	22.4423 ± 6.0364	12.2538 ± 3.4373	13.7154 ± 5.3858	30.640	0.000
Vaginal Pressure (cm of H_2O) During Valsalva Maneuver	13.2577 ± 5.1865	5.2692 ± 1.6259	7.5038 ± 3.8936	29.637	0.000
* Electromyography, # Millivolts, n = number of participants in each group, cm = centimetres, SD = Standard Deviation, and H_2O = Water					

Between group analysis (one-way ANOVA) given in table 2 shows the significant ($p<0.05$) difference on rectus abdominis EMG tonic activity across the three different lumbar curvature during all the three tasks i.e., standing still, maximal coughing and Valsalva Maneuver. Significant difference ($p<0.05$) was also observed in the tonic activity of erector spinae muscle and intra vaginal pressure across the three groups during SS, MC and VM.

Paired group comparison between different lumbar curvatures a post hoc analysis is done as presented in table 3. Significant differences ($p<0.05$) were found in the tonic activity of rectus abdominis during SS, MC and VM across all three paired combinations i.e., Group A with Group B, Group B with Group C and Group A with Group C. Difference between Group A and Group C for tonic activity of erector spinae was not significant ($p>0.05$) during SS and MC. Data for intravaginal pressure shows significant difference ($p<0.05$) between Group A and Group B during all three tasks i.e., SS, MC and VM. While non-significant difference was found between Group B and Group C during MC and VM.

In this study, the aim was to find out the effect of different lumbar lordotic angle on trunk muscle activity and pelvic floor function among non-osteoporotic post-menopausal women.

Figure 2: Present the comparison of vaginal pressure recorded during standing still, maximal coughing and Valsalva maneuver across the three groups



The activity of the rectus abdominis was found to be reduced in hyper more than in hypo lordosis during MC and VM. This reduction in the tonic activity can be explained as trunk muscles originate from the pelvic bone and insert to sternum and lower ribs, hence change in the lumbar curvature change the resting length of the muscle and force production during the contraction get effected at altered length of the muscle. This finding is supported by the study which explains how tilting of pelvis can affect the lumbar lordotic angle [19].

Table 3: Between paired group analysis (Post hoc) of tonic activity of rectus abdominis, Erector Spinae, and vaginal pressure during standing still, maximal coughing, and Valsalva maneuver among the groups with different lumbar curvature

Variable	Group Pairing	Mean difference between two groups	Std. Error	Sig.
EMG* activity in mV# of Rectus Abdominis during Standing still	Group A with Group B	0.03515	0.0013	0.000
	Group A with Group C	0.01615	0.0013	0.000
	Group B with Group C	-0.019	0.0013	0.000
EMG* activity in mV# of Rectus Abdominis during Maximal coughing	Group A with Group B	0.59192	0.04039	0.000
	Group A with Group C	0.17115	0.04039	0.000
	Group B with Group C	-0.42077	0.04039	0.000
EMG* activity in mV# of Rectus Abdominis During Valsalva Maneuver	Group A with Group B	0.33962	0.01347	0.000
	Group A with Group C	0.09808	0.01347	0.000
	Group B with Group C	-0.24154	0.01347	0.000
EMG* activity in mV# of Erector Spinae during Standing still	Group A with Group B	-0.06623	0.00241	0.000
	Group A with Group C	0.0055	0.00241	0.064
	Group B with Group C	0.07173	0.00241	0.000
EMG* activity in mV# of Erector Spinae during Maximal coughing	Group A with Group B	-0.965	0.03619	0.000
	Group A with Group C	0.05269	0.03619	0.318
	Group B with Group C	1.01769	0.03619	0.000
EMG* activity in mV# of Erector Spinae During Valsalva Maneuver	Group A with Group B	-0.57615	0.01227	0.000
	Group A with Group C	0.21577	0.01227	0.000
	Group B with Group C	0.79192	0.01227	0.000
Vaginal Pressure (cm of H_2O) during Standing Still	Group A with Group B	0.81696	0.20321	0.000
	Group A with Group C	0.415	0.20321	0.109
	Group B with Group C	-0.40196	0.20321	0.125
Vaginal Pressure (cm of H_2O) during Maximal Coughing	Group A with Group B	10.18846	1.4075	0.000
	Group A with Group C	8.72692	1.4075	0.000
	Group B with Group C	-1.46154	1.4075	0.555
Vaginal Pressure (cm of H_2O) During Valsalva Maneuver	Group A with Group B	7.98846	1.07064	0.000
	Group A with Group C	5.75385	1.07064	0.000
	Group B with Group C	-2.23462	1.07064	0.099

* Electromyography, # Millivolts, Group A = Normal Lordosis, Group B = Hyper Lordosis, Group C = Hypo Lordosis, cm = centimetres, and H_2O = Water

The erector spinae tonic activity was found to be significantly higher in the hyper lordotic individuals as compared to normal lordosis and hypo lordosis during SS, MC and VM. While there was no difference found statistically between normal and hypo lordosis. The higher tonic activity of the erector spinae in hype lordotic females can be understood as in hyper lordotic spine, pelvis goes into anterior tilting which results in the increase in the length of the pelvic floor muscle. Muscle at higher than resting length produces less force. To maintain the continence during the function which raises intra-abdominal pressure, an additional stabilization is being provided by the spinal extensor. This finding of ours is in consistent with the finding of the study who have found out the increase in the erector spinae activity among females using high heels, as high heels results into the hyper lordosis [20].

As shown in figure 2, the vaginal pressure during MC and VM was also found to be reduced among hyper lordotic more than hypo lordotic subjects as compared to the normal lordosis. In hype lordosis as the pelvis tilt anteriorly, less functional force production could be due to change in the alignment of the myofibril of pelvic floor muscle. This change in alignment could be responsible for change in the torque production and hence reduced activity. This finding is contrary with the findings of the study, who found the rise in the pelvic floor muscle activity in hyper lordotic posture willingly attained during experiment by the continent nulliparous young adult females. In this study hyper lordotic posture was attained by the subjects during experiment which do not consider the bodily adaptation due to habitual hyper lordotic posture [21].

In the end, where current literature is available which explain the relationship between abdominal muscles and pelvic floor muscle, our study added the role of lumbar spinal angle in this relationship in the population which mostly get affected due to pelvic floor dysfunction. We did not consider the timing of the pelvic floor muscle and abdominal muscle activation during the functional tasks in this study which can be of future interest as, it may explore the kinetics of the function and adaptation because of habitual posture. We also did not include the socio-economic status of the subjects as, working in squat sitting and sitting on ground is widely practiced among Indian female housewives from low socio-economic background, study of this parameter can also be done in future studies. Studies also explained the therapeutic benefit of the change in mechanics over hormone regulated parameter like HbA1c [22]. Including therapeutic regime to correct spinal curvature can also be studied in future where pelvic functioning is associated with menopausal changes in such patients

CONCLUSION

Based on the finding of present study, it is concluded that change in the habitual lumbar posture may result in the change in the tonic activity of the trunk muscle. This change in the EMG tonic activity was observed in rectus abdominis and erector spinae muscle during the activity which results into the rise in intra-abdominal pressure. It is also concluded the non-osteoporotic post-menopausal women with hyper and hypo lordotic spine produced less intravaginal pressure during maximal coughing and Valsalva maneuver.

Conflict of interest

No conflict of interest.

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