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REVIEW ARTICLE **OPENACCESS**

Elucidation of changes in endurance and fatigue parameters of trunk musculature in asymptomatic individuals having Pelvic asymmetry

Karisharma chawla*[1], ZainyKhan[2], M.EjazHussain[3], NitinDhar[4]
*[1] SGT University, Gurugram
[2]Jamia Millia Islmia University, NewDelhi,
[3]SGTUniversity,Gurugram
[4]Amity University, Noida
***Corresponding Author E.mail:** karishama_fphy@sgtuniversity.org,

ABSTRACT
Pelvis is the core centre of the body which is responsible for any asymmetry occurring above or below its level. Any deviation in the normal alignment of pelvis can lead to discrepancies in the muscular length and activation patterns. In this study we have talked about the changes that can take place in the limb length as well as the endurance and fatigue parameters of the muscles around the pelvis. Endurance can be measured efficiently by the method of "Time to fatigue" measurement. Whereas, fatigue can be measured by EMG analysis. The role of these de-arrangements in Low backache is also evident. The purpose of this study is to analyse the pattern of changes in context muscular fatigue and endurance that takes place in the musculature due to asymmetries in the alignment of pelvis.
Key words:-*Pelvic Asymmetry, Electromyography, Fatigue, Endurance, Limb length discrepancy*

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INTRODUCTION

The pelvic girdle has been a source of mystery for many health practitioners since ages, yet amongst some them is a long-held belief that its asymmetry plays a significant role in low back pain [16]. Pelvic asymmetry is often seen as a dysfunction of Sacro-illiac joint in which there is a mal-positioning of one side of pelvis with respect to the other [29]. The prevalence of asymmetry and leg length inequality in asymptomatic population was found to be 8%, majorly demonstrating anterior pelvic tilt [26]. Bailey and Beckwith, 1937 published a study on sacral tilt frequency and this data was related to contralateral or ipsilateral leg shortening. They have been thought to be the first who extended a line on the sacral base to intersect perpendicular lines drawn up from the femoral heads, this helps in difference between the sacral base inclination and inclination of the femoral head can be assessed in the frontal plane. Another study done by Krawiec *et al* in 2003 on asymptomatic collegiate athletes, in which they found that 95% of population demonstrated some degree of static innominate asymmetry out of which 73% demonstrated right innominate anterior rotation dysfunction. Also, they found unequal leg lengths in which 68% showed slightly longer left leg.

If we talk about asymmetries it should be taken into consideration that there is always versatility in types of asymmetries that can occur, among those Tilt, Shift, Upslip are the three main types of asymmetries [27, 28]. Tilt is rotation of the innominate anteriorly or posteriorly in sagittal plane and transverse axis. Upslip is the Elevation of the pelvis in Frontal plane. Shift is the movement of the innominate anteriorly and posteriorly in sagittal axis. In work done by Timgren et al in 2006, they found that from the total of 150 patient's pelvic asymmetry was present in 130 (87%) patients which results into disparity in illiac crest levels, as observed by palpation [29]. Pelvic asymmetry was also found perpetually related to with modification in the spine and apparent leg length [7]. In another study by L.Herrington [10] studied the prevalence of sagital plane innominate tilting in an asymptomatic population and he found that males and females had 85% and 75% of anterior pelvic tilt respectively whereas, only 7% of females and 6% of males had a posterior tilt and neutral was found in 18% of females and 9% of males. To study and analyse the pattern of changes in context muscular fatigue and endurance that takes place in the musculature due to asymmetries in the alignment of pelvis.

ETIOLOGY

The common causes of pelvis asymmetry could be carrying bag on one side, sitting or standing for long hours putting more pressure on one side, crossing one leg over the other in high sitting, arm and leg dominance (Hee Soon Woo et al, 2015)A study was done by Motmans et al in 2006 on EMG activity of Erector spinae and Rectus abdominus while a person carries bag on right side of shoulder the muscles on the contralateral side to the weight that is the left side showed the highest activity. In 2017 Wohn-wee Lee found one side carrying bag significantly increases the activity of both the muscles leading to early fatigue. Likewise, Cross leg sitting was also evaluated by Jung-Hoon Lee et al in 2010, where they saw a significant increase in the gluteal pressure and posterior pelvic tilt on the ipsilateral side and anterior pelvic tilt of the contra-lateral side. They concluded that repeated cross-leg sitting may lead to pelvic asymmetry followed by a study by Hee Soon Woo et al in 2015 where they saw increase in pelvic obliquity after 1 hour of cross leg sitting.

Myokinematics

To understand the misalignment syndrome properly, it is important to understand the functional sling systems and others muscles around the bony pelvis which gets involved in malalignment (Liz et al, 2010). The sling system or also known as "stabilizers of pelvic unit" comprise oblique sling systems and longitudinal sling system as described firstly by vleemings et al in 1995. Posterior sling system is further divided into two subparts, first being the superficial posterior comprising latissimus dorsi connected to contralateral gluteus maximus through thoracolumbar fascia lower logitudnal part connects gluteus maximus to illio-tibial band. The deep posterior comprises of ipsilateral erector spinae connected to contralateral illiocoastalis. Then comes the anterior sling system of which upper part has external oblique of iplilateral side connected to internal oblique of contralateral side. Last but not the least in the lateral sling having Quadratus Lumborum (QL) above and same side Gluteus Medius, Minimus and Tensor Fascia Latae (Ganesh et al, 2014)

Julie et al in 2012 has very well described the mechanics responsible for the asymmetry. They describes anterior pelvic rotation as anterior innominate struck which takes place when anteriorly there is tightness of psoas major and weakness of rectus abdominus, at the same time posteriorly, there is tightness of erector spinae and weakness of hamstrings muscles. In the same way Liz et al in 2010 explained posterior innominate struck occurs when anteriorly, there is weak psoas major and tight rectus abdominus, posteriorly there is weak erector spinae and tight hamstrings. In cases where there is upslip of one side of innominate, like in cases of right innominate upslip struck, on the right side the quadratus lumborum will be tight and gluteal muscles will be weak. Crewe et al in 2013 explained that in some cases the upslip is accompanied by rotation of the pelvis as well, for example in case of right innominate upslip and anterior rotation stuck, cranially there will be weak rectus abdominus followed by tight quadratus lumborum and erector spinae whereas caudally there will be tight illio-psoas muscle followed by weak gluteals and hamstrings.

Quadratus lumborum is a muscle that is activated while doing flexion, extension, side bending but maximum activity is seen during isometric side support postures (McGill et al, 1996). It works as a stabilizer because of its anatomy as it connects each transverse process to the pelvis and rib cage which facilitates a bilateral buttressing for the vertebrae (Mc Gill, 2000). Analyzing the activation pattern of the deep muscles as well as the surface musculature demonstrated that the QL was the muscle most satisfactorily activated by the motor control system to provide stability in bending movement, although the abdominals play an important role in stabilization of posture, the QL was more active in the upright posture when the bending moments are absent but when the risk of buckling from compression is high (Mc gill et al,1996). The erector spinae, made up of the longissimus and the iliocostalis spread the length of the spine from the sacral to the thoracic region (Karl Daggfeldt, 2000). In consistent stabalisation of the spine leads to shortening of the spinal erector muscle which ultimately leads to anterior pelvic tilting (Punjabi et al,1992). QL and Erector muscles are a part of suprapelvic muscles, their hypertonicity can result in pelvic torsion or lateral rotation in an unloaded state. This hypertonicity can result in pelvic asymmetry through upsliding or tilting which eventually causes functional LLD. (Cooperstein R,2000) (Knutson G,2000).

Measurements of Functional limb length discrepancy and pelvic asymmetry

A structural LLD (SLLD) defined as LLD that occurs because changes in the length of bone whereas, Functional LLD (FLLD) defined as those that occurs a result of altered mechanics of the lower limb or spine (Burke et al,2002).In a consecutive case study carried out in 2004 on 421 patients with lower back pain Juhn et al found majorly subjects had a significant Limb length impairment (LLI), and in most the dominant side was found to have a shorter leg. Taking 5-mm cut-off for LLI, the most common pattern of Pelvic asymmetry is seen as a complete upslip on one side and the rarest being the contra lateral sacral tilting and un-levelling of opposite sides. Garry Knuston did an extensive research on relation between pelvic asymmetry and functional LLD through his various studies. In one of his studies in 2005 he explains that when a person is standing the action of quadratus lumborum will depend on the stabilization of the spine or pelvis. If it is stabilized then the quadratus lumborum will act primarily to laterally flex and extend the spine, it will have a cephal pull through its attachment on the posterior aspect of hemi-pelvis. Now, if the subject attains unloaded posture in supine or prone position, the hypertonicity of quadratus is liberated from the body weight and now the muscle can pull the pelvis in cranial direction causing leg length alignment asymmetry at the foot. In 2002 he also correlated supine LLA with back pain through a questionnaire based study having sensitivity of 87%, specificity of 84%, and positive predictive value of 73% in recurrent back pain. He found subjects having LLA reported more pain when compared to subjects having no LLA.

Various methods can be used to measure LLD such as Tape measure, Standing blocks, scanogram, teleoroentogram, CT scanogram and MRI scanogram. The reliability for non-radiographic methods are held to be little less because of difficulty in palpation and differences in girth measurements but out of the two non-radiographic methods available tape methods seems to be more reliable and less-cumbersome for measuring apparent LLD (Sabarwal et al, 2008)

For measuring the limb length difference the best method is to carry out the measurements with the help of tape method (Gary A. Knutson,2005). It is safe, non-invasive, has no radiation exposure, cheap, and easy. It has high interater-reliability (ICC, 0.88) but low reliability when compared to radiographic method (ICC, 0.75) (Beattie et al,1990). This may be due to difference in intra-tester bony palpation and limb girth measurement (Potter et al, 1985). We need certain measurements which increases the reliability of these methods using some mathematical formulas.

As we know movement in sacro-illiac joint (SIJ) has always been a topic of interest to a lot of researchers, there has been a long held belief that there is no movement available at SIJ. But recent studies quote that a mean of 2.5° of innominate rotation in conjuction with a mean of 0.7 mm of translation is possible at SIJ [27, 28]. There are various methods available for palpation such as visual method, visual manual palpatory method, inclinometers, PALM meter [4].

Palpation and testing methods for ASIS, PSIS, Pubic tubercle, Ischial tuberosity, Forward bending test(Sensitivity: 0.17; Specificity: 0.79), Gillet test (Sensitivity: 0.08; Specificity: 0.93), Supine long sitting test (Sensitivity: 0.08; Specificity: 0.93) were very well explained by Ganesh et al in 2014. PALM is a pelvic leveling device which is a combination of a caliper and an inclinometer with ICCs for inter-rater reliability of 0.65 in the frontal plane and 0.89 in the sagittal plane, and intra-rater reliability coefficients of 0.84 (frontal plane) and 0.98 (sagittal plane) [23]. To increase the intra-rater reliability certain mathematical formulas are available. The first formula was given by David A. Egan et al in 2013. They worked on finding out the asymmetry ratio which was calculated by taking sum of the ratio height difference and width difference between PSIS and ASIS respectively. Another set of formulas were given by Rafael Gnat, Maciej Bialy in 2015. They divided the dysfunction to occur in two planes, sagittal or frontal plane. For measuring the dysfunction in the Frontal plane he measured the angles between the PSIS and ASIS. For measuring the asymmetry in the sagittal plane they measured the angle between the PSIS and ASIS on right side and left side respectively. Einas Al-Eisa [4] in 2013 studied a relationship between the lateral pelvic tilting and sitting pressure. They predominantly took the subjects with lateral pelvic tilting asymmetry in frontal plane and excluded the subjects with sagittal plane deformity. For assessing the patients they used the formula given by David A. Egan. Intrarater reliability was found to be excellent (ICC > 0.9) and good interrater reliability (ICC > 0.8) [25] .

Endurance and Fatigue

J. H. Van Dien defined endurance as time until exhaustion. Muscular endurance can be defined as an ability of a muscle to exert force against resistance over time [3]. Fatigue can be defined as the phase where the subject is not able to hold the position anymore or the point of exhaustion (Gary A. Knutson, 2005). Time to Fatigue is defined as the time taken until the Fatigue was set in shown by increase in RMS value with respect to time for all muscles, which signifies the development of muscle fatigue [21].

Longer endurance times were seen in women as compared to men for the extensor exercise. For quadratus lumborum, men were shown to have more endurance in the side bridge exercise (McGill et al, 1996). In a study knuston et al in 2005, he found there was significant difference in the time until fatigue in group having limb length asymmetry and the group that did not have any asymmetry. The Fatigue timings were found to be reduced on the side of shortening for both erector spinae as well as quadratus lumborum muscles.

Electromyographic studies

Allison et al in 2002 [1] described the change in the power spectrum of a muscle as the muscle reaches its fatigue point. This change is carried forward by the surface electrodes placed on the skin. Physiologically, the frequency shift has been attributed to changes in some factors such as changes in conduction velocity, modification in intra-muscular pH, alteration in the recruitment and synchronization of the motor units and the fibre type. Fatigue results in decrease in the frequency of the (Electromyography) EMG signal, commonly delineated as a diminution of the mean power or median frequency parameters of the EMG power spectrum. The integrated EMG signals of the patients having lower back pain were substantially higher than for the control subjects during endurance isometric trunk extension contraction for Erector Spinae muscle [30]. Another study was conducted by Cardozo in 2001 on the erector spinae muscle where they investigated the electromyographic fatigue threshold of the erector spinae muscle. The test was conducted with 45 degree hip flexion and the subject was asked to perform repeated isometric contractions at different percentage values. The fatigue was greatest the earliest achieved with the threshold value of 70%.

For analyzing fatigue in a muscle using isometric contraction Median frequency current is thought to be the ideal parameter. Mannion et al in 2011 used the MFC for plotting the Normalized Frequency Curve to analyse fatigue of back extensor muscle. This parameter was used in 2014, by Motriz, Rio Claro who worked on the extensor muscle endurance testing during EMG. He used the bearing Sorenson method for endurance testing. From the EMG MFC values NMF slope was obtained. They found that although the different extensor muscles showed variance in frequency domain but they did not show any difference in the time domain.

Maximal deoxygenation was seen at 100 % iering-Sørensen muscle endurance test time, and was found to decrease to about 15 % from the resting value [3].

McGill in 1996 did a study where it was seen the Quadratus Lumborum was highly active with MVC of 54% during isometric side support postures where the body is held horizontally almost parallel to the floor while the subjects support themselves on one elbow on the floor with both feet together.

CONCLUSION

Pelvic asymmetry may lead to development of functional limb length discrepancy which can be well identified by the measurements by Egan et al. Any discrepancies in the pelvic alignment in turn leads to changes in the activation pattern of the trunk musculature specially Quadratus lumborum and erector spinae majorly responsible for the stability of the spine. Deficient stability in the spine and reduced endurance of these muscle play a major role in the etiology of the development of Low-back ache in General population.

CONFLICT OF INTEREST

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