Gait in Pregnant Women – A Review

[1]N.Gowri Priya, [2]S.Sharmili

Assistant Professor/BME
Dr N G P Institute of Technology, Coimbatore.

***Abstract*—Women during pregnancy experience several changes in the body's physiology, morphology, and hormonal system. These changes may affect the balance and body stability and can cause discomfort and pain. The adaptations of the musculoskeletal system due to morphological changes during pregnancy are not fully understood. Few studies clarify the biomechanical changes of gait that occur during pregnancy and in postpartum period. Thus the purpose of this review was to analyze the available evidence on the biomechanical adaptations of gait that occur throughout pregnancy and in postpartum period.**

***IndexTerms*—Pregnancy, Musculoskeletal, Biomechanicaland Morphological.**

I. INTRODUCTION (HEADING 1)

Gait analysis is the systematic study of human motion, using the eye and the brain of observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles. Human gait is a complex and cyclic movement. Gait analysis of human walking can be done either without any technical support, or in combination with complex and expensive equipment. Modern gait analysis is based on the integration of multiple components to derive a complete analysis of gait. These methods may include observation, videotaping, electromyography, kinematics, kinetics and energetics. The results gained from these methods may then be used to determine the treatment course of a subject with gait abnormalities or to document the effects of therapeutically intervention. The study encompasses quantification, (i.e., introduction and analysis of measurable parameters of gaits), as well as about joint kinematics and joint kinetics. For a full understanding of normal gait, it is necessary to know which muscles are active during the different parts of the gait cycle. The following terms are used to identify major events during the gait cycle:

1. Initial contact
2. Opposite toe off
3. Heel rise
4. Opposite initial contact
5. Toe off
6. Feet adjacent
7. Tibia vertical

These seven events subdivide the gait cycle into seven periods, four of which occur in the stance phase, when the foot is on the ground, and three in the swing phase, when the foot is moving forward through the air. The stance phase, which is also called the 'support phase' or 'contact phase', lasts from initial contact to toe off which is shown in the figure 1. It is subdivided into:

1. Loading response
2. Mid-stance
3. Terminal stance
4. Pre-swing.

The swing phase lasts from toe off to the next initial contact. It is subdivided into:

1. Initial swing
2. Mid-swing
3. Terminal swing

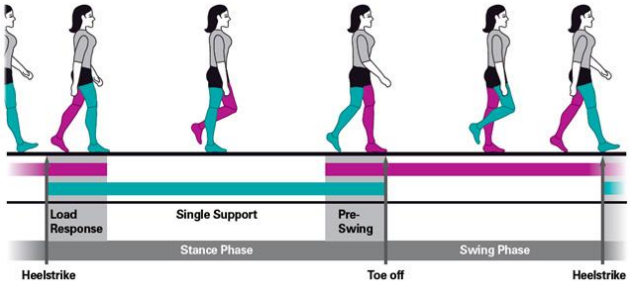

Figure 1: Stance phase and Swing phase

II. Factors and Parameters

Systematic gait analysis is made up of three steps:

1. Structuring of information,
2. Observation of a strict pre-assigned procedure
3. Plan for the interpretation of data.

In examination, the following factors must be taken into account:

1. Kinematics defines the area and the course of time of each joint movement. The hip, knee, and ankle joints are often the focus of investigation in both the sagital plane and frontal.
2. Kinetics provides information about ground reaction forces, and forces which are translated through the body and joints. Moments about joints which occur as a result of body weight can often provide vital information.
3. Dynamic electromyography (EMG) provides information about the activation and intensity of muscle contractions.

The gait analysis is modulated or modified by many factors, and changes in the normal gait pattern can be transient or permanent. The factors can be of various types:

Physical: such as weight, height, physique

Psychological: personality type, emotions

Physiological:anthropometric characteristics, i.e., measurements and proportions of body

Pathological: for example trauma, neurological diseases, musculoskeletal anomalies, psychiatric disorders

Extrinsic: such as terrain, footwear, clothing, cargo

Intrinsic: sex (male or female), weight, height, age, etc.

The parameters taken into account for the gait analysis are as follows:

Step length:thedistancebetweentheposition (e.gheelcontact) of onefootandthenextsimilarposition of theoppositefoot in gait(walking or running).Mayalsoincludeothersupportdevices such as crutches.May be differentforeachfoot.Mayalso be positive,negative('dragging'onefoot so that it neverreachestheother) or zero(whenonefoot is advancedonly to thepositionbesidetheotherfoot).Usually it is measured in meters.

Stride length: Thedistancebetween 2 successiveplacements of thesamefoot,consisting of 2 steplengths.

Cadence:number of stepsperminuteduringnormalgait

Speed: Thetime it takes to walk a specifieddistance,usually 6 m or less.Slowerspeedscorrelatewith an increasedrisk of mortality in geriatricpatients.

Dynamic Base: Side to side distance between the line of the two feet.

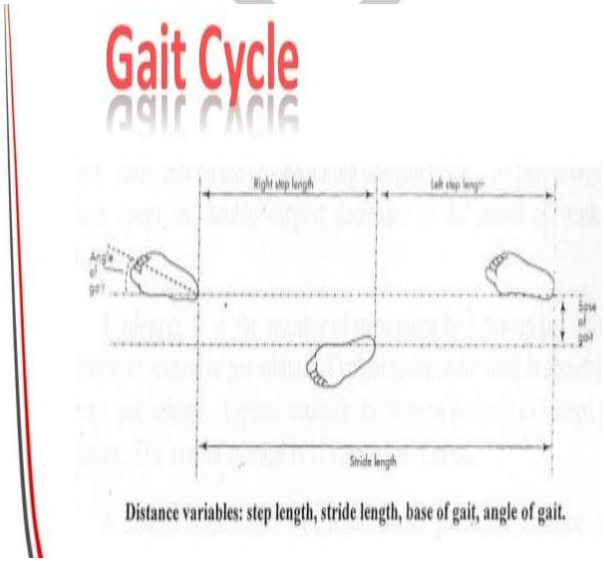

Figure 2: Gait cycle

III. Anatomical and Physiological Changes During Pregnancy

Pregnancy is a period of various physiological and physical adaptations. During this process a lot of biomechanical changes are confronted by the female body. These biomechanical changes, although temporary, lead to debilitating back pain especially in the lumbar area. They may include sway back posture, leg length discrepancy, hormonal changes, stretched and weakened muscles and compression of sciatic nerve.

Uterus: The muscular organ holding the fetus during pregnancy, nourishment of the fetus through the placenta. It is divided into the body (Corpus, and fundus) and the cervix. During pregnancy, the uterus increases in weight from 60 to 1000g. In size, it changes from 6.5 to 32 cm. In a non-pregnant state, the uterus is situated in the pelvic cavity. During pregnancy, it expands into the abdominal cavity. In addition to the growing fetus, uterine expansion is caused by an increase in connective tissue and in the size and number of blood vessels supplying the uterus.

Ligamentous supports: 1) Round ligaments are fibrous cords attaching to the uterus and libiamajora. During pregnancy, they become elongated and hypertrophied. They support the uterus in its move from the pelvic cavity into the abdominal cavity. 2) Broad ligaments are large folds of peritoneum separating the pelvis into the anterior and posterior divisions. The lower portion of the ligament is known as the cardinal ligaments, it attaches the lateral aspect of the uterus to the supra vaginal area of the cervix. 3) Utero sacral ligaments attach the sacrum to the posterior aspect of the cervix to support the cervix.

Respiratory system: During pregnancy, the body is in a state of hyperventilation due to high level of progesterone. Breathing becomes more costal than abdominal. Additionally, most women are mouth breathers during pregnancy. Anatomically the diaphragm is progressively elevated. Possibly because of expansion and elevation of the rib cage. Uterine pressure during the first and second trimesters does not appear to be a factor in this phenomenon.

Musculoskeletal System: Abdominal muscles are stretched to the point of their elastic limit by the end of pregnancy. Hormonal influence on the ligaments is profound producing systemic decrease in ligamentous tensile strength and an increase in mobility of structures supported by ligaments and may predispose the patient to joint injury especially in the weight-bearing joints of the back, pelvis and lower extremities. The pelvic floor muscles must withstand the weight of the uterus, the floor drops as much as 2.5 cm.

Postural changes: During pregnancy, postural changes occur to accommodate for abdominal growth. These changes include forward head, rounded shoulders, increased lumbar lordosis, hyperextended knees, and pronated feet. The center of gravity changes, resulting in changes in balance. Muscular changes are also typical. Often noted alterations include shortened hip flexors, lower back musculature, and pectorals. Abdominal muscles, neck, and upper back muscle groups elongate. This may promote stretch weakness or adaptive shortening.

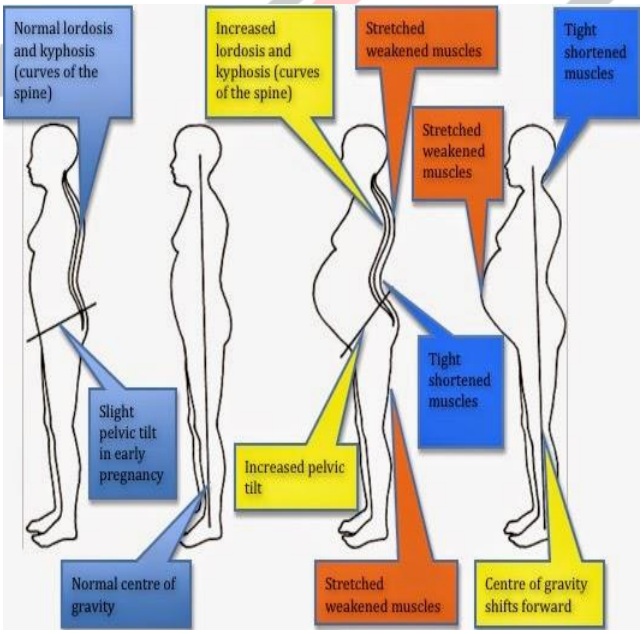

Figure 3: Postural Changes

Bones and joints: There is tendency to decalcification of bones, subluxation of joints due to softening of ligaments by relaxin hormone. It is more marked in sacroiliac joint and symphysis pubis, leading to waddling gait. VII. Hormones: The changes in body posture are observed while walking, standing or performing specific movements (for example landing on the heels after standing on tiptoe) is due to the hormonal changes in different stages of pregnancy. The Women's Pelvic Floor Biomechanics in pregnancy (the whole musculoskeletal system) is influenced by relaxin, which is produced by the placenta, and corpus luteum. They both control the ligamentary apparatus by inhibiting collagen synthesis thatamplifies the activity of collagenase and consequently the ligaments of the pelvic girdle and spine become looser. The loose ligaments and weight of the pregnant uterus increase lumbar lordosis. The whole process results in modifications of movement stereotypes. The modification does not only arise from mechanical principles but in particular form the urgency of seeking a relieving posture.

IV. Joint Kinematics and Joint Kinetics

4.1 Joint Kinematics

The variables of velocity (or speed) and cadence are the kinematic parameters analyzed by the studies included in the review. Most papers reviewed showed changes in kinematic parameters in late pregnancy, specifically, a significant decrease in speed and a significant reduction in the gait cadence.

The joint kinematics of the lower limb shows few changes throughout pregnancy. The angular displacement of the pelvis increases in the anterior tilt of approximately 5 degrees. The joints of the lower limb in the sagittal plane show an increase in hip flexion during stance phase, an increase of knee flexion during the terminal stance phase, a decrease of knee extension, and a decrease of ankle dorsiflexion and plantarflexion. In the frontal plane, Forczekfound a reduction in the amplitude of the unilateral elevation of the pelvis. The hip joint had different results considering the two studies performed: it was found that a peak with greater magnitude in the hip adduction.

4.2 Joint Kinetics

Few studies have evaluated the kinetic parameters of gait during pregnancy. Authors analyzed the joint moments and joint powers with and without normalizing the weight of the women in late pregnancy. Although they found several changes in these parameters without normalization, the authors recommend the analysis with normalization. The analyses performed with normalized data found a significant increase in the hip extensors moment and a significant decrease in the knee extensors moment and in the ankle plantarflexors moment in the sagittal plane. In the frontal plane, there was an increase of the hip abductors moment and in the knee adductors moment.

V. Conclusion

This review suggests that there is a need to examine closely the kinematics of the woman while walking considering the beginning of pregnancy, in order to confirm the influence of morphological changes in the angular motion of the lower limb segments during the course of pregnancy.Very few studies analyzed the kinetics of gait of pregnant women. This review clearly explains about the various parameters that must be taken into consideration during gait of pregnant women.

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