Mechanical behavior of Muscles during flexion and extension of lower limb on variable age group by using BRG.LifeMod

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Abstract— **The main objective of this paper is to find out the muscle which plays a major role during flexion and extension on models of different age groups and the extent of mechanical deformation which takes place in the muscles of lower limb with the help of BRG.Life Mod software which works in ADAM's environment. The muscles moment is obtained with the help of inverse and forward dynamics simulation of human model that shows us which muscle is active during flexion and extension and how much moment (torque) that muscle is exerting, which causes muscle deformation. According to Hill's mechanical model of muscle, it consists of three elements: one contractile element attached in series with an elastic element and both of these attached in parallel to an elastic element. During muscles contraction and expansion the deformation of muscles takes place and during one complete gait cycle it regains its original shape and size due to its viscoelastic nature. The deformation in the muscles is obtained by finding the change in the length of muscles during extended flexion and extension in complete gait cycle on different age group models. After conducting the simulation on models of different age group, it is observed that deformation in the muscles of lower limb is maximum obtained in Rectus femoris which is one of the four quadriceps muscles of the human body, the others being Vastus medialis, Vastus intermedius, and Vastus lateralis. On the basis of our experiment the conclusion is made that Rectus femoris plays a major role in regulating knee flexion and extension.**

Keywords— **Flexion & Extension, Hill Muscle Model, Gait cycle.**

I. INTRODUCTION

Muscles provide two kinds of forces, active and passive, which compose a muscles total force. Though actin and myosin "ratching" mechanism muscles will provide the
active force while with the help of non contractile element the muscle will provide passive forces, muscles are called as parallel elastic element that contributes to its passive forces. In 1922 A.V. Hill(Hill 1970) first noted that activated muscles produce more force when held isometrically (at a length fixed) then when they shorten.
Muscles co-ordinate muscle joints motion by generating forces that causes reaction forces throughout the body [1].

The motion of walking in human being is divided in to two phases swing phase and support phase. The swing phase is the behavior that the foot leaves the ground surface and the leg swing forward. The support phase is the behavior that the foot stays in the contact with the ground surface and the body is supported by leg [2] as shown in Fig. 2,3,4,5. In this paper the activity of the muscle rectus femoris of lower limb is observed during walking motion of human body of different age in inverse dynamics [3]. The change in the length of rectus femoris is find out during the normal Gait cycle of human being and compared with other muscle activity which helps in finding the strain in particular muscle. The amount of rectus femoris activity is related to walking speed [4] as it plays a crucial role in knee flexion and extension during the Gait cycle of human being [5,6,7,8]. For rectus femoris, the relative work contribution done in knee extension was 21% in jumping and 31% in sprinting[9].The paper's main focus is given to plot the length v/s time graph of muscle during the gait cycle.

II. MECHANICAL MUSCLE MODELHILL'S MODE

The Hill model is composed of three elements: two of which are arranged in series which, in turn, are in parallel with the third element. The contractile element is freely extendable when at rest, but capable of shortening when activated by an electrical stimuli. The contractile element is connected to an elastic serial element.

The serial element accounts for the muscle elasticity during isometric (constant muscle length) force conditions. The muscle elasticity during isometric contraction is due in a large part to the elasticity of the cross-bridges in the muscle [Fung 93]. These two elements are then joined in parallel with another elastic element used to account for the elasticity of the muscle at rest. The parallel element accounts for the inter-muscular connective tissues surrounding the muscle fibers [5].Force-Length PropertiesThe properties of the three elements in the Hill model which are responsible for force generation are defined in terms of force-length properties and force-velocity properties. The force-length property is based on isometric muscle contraction, that is, the force generated within the muscle as the length of the muscle remains constant. During an isometric contraction, the series element lengthens while the contractile element shortens [10]. The lengthening of the serial element must be equal to the shortening of the contractile element for the overall length of the muscle to remain unchanged. As the serial element lengthens, the parallel element no longer remains slack and develops tension in a non-linear manner. The total force developed within the muscle is then the sum of the forces in both the active and passive muscle tissue. An example of the force-length curve common to skeletal muscles is shown in Fig.1.

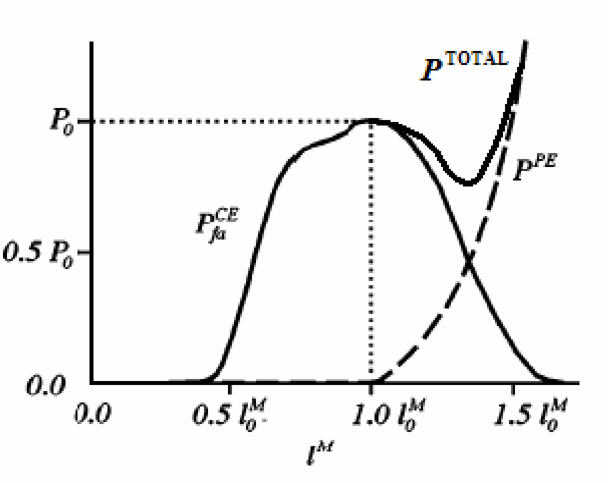

Fig. 1: Force-length property of muscle a) fully activated force length properties

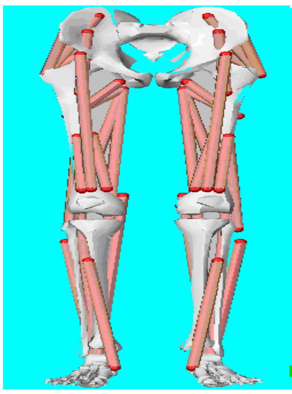

Fig. 2 Lower body model with muscle

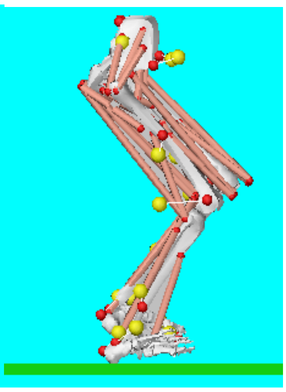

Fig. 3 Initial Swing Phase

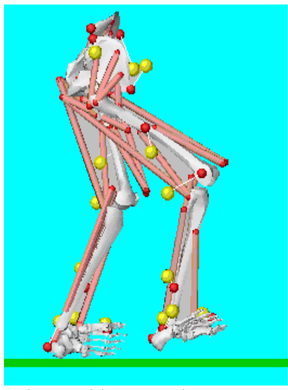

Fig. 4 Mid stance Phase

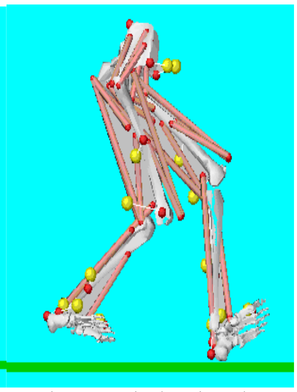

Fig.5 Terminal Swing Phase

III. Method

Model is generated in BRG LifeMod of lower limb, It will generates the groups of main muscle which are responsible for the control of large motions of body segment in humans, in case flexion, extension LifeMOD assigns muscle tissue properties, which include the maximum allowable stress in each muscle and the physiological cross-sectional area (pCSA), from its database which is obtained from various in vivo experiment on various subjects. Each muscle contains a contractile element in series with a spring–damper element, storing the input motion and effectively 'training' the muscles to reproduce the necessary force to recreate the desired motion.[12]. Age , height and region of the model is assign in the LifeMOD then according it will generate the model of lower limb then the formation of joint will takes place which is followed with the attachment of muscles. In the end the simulation is run for 9 sec and then the change in the length of the muscles during flexion and extension is obtained which is represented in Fig. 6. The EMG were taken of rectus femoris were taken of a subject during gait cycle[12] as shown in Fig. 7 which reflects activity of rectus femoris during flexion & extension.

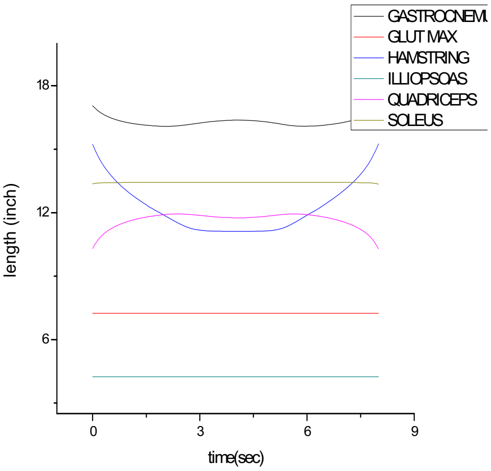

Fig 6 Mechanical behavior of muscles during Flexion & Extension

IV. Results

From the graphs as shown in Figure 6 & 7 we can obtain the activity of different muscles during flexion and extension of different muscles during the Gait cycle. As we can observe that Hamstring muscle shows more deviation during flexion & extension (Fig. 6). In figure 7 the enhance activity of the rectus femoris is shown during flexion and extension through EMG.

V. Conclusion

From the above it is conclude that during the flexion and extension of lower limb the deformation of muscles will occur and as the gait cycle proceeds and the activity of the Hamstring and the rectus femoris is enhanced. The models of different age group with abnormalities in their gait should be simulated in LifeMod and then the results will be compared with the in vivo experimental data.

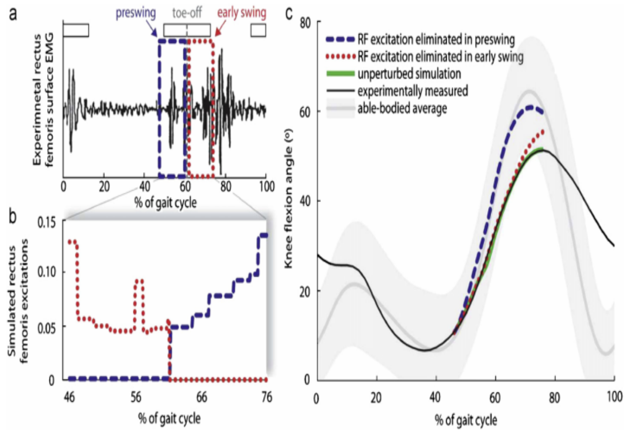

Fig.7 [11].Example of methods used to determine increase in peak knee flexion when rectus femoris activity was eliminated during preswing and separately during early swing. (a) Rectus femoris surface EMG of a subject with stiff-knee gait was recorded over an entire gait cycle. Normal rectus femoris EMG timing is indicated by horizontal white bars (Bleck, 1987). Toe-off is indicated by a vertical dashed line at 61% of the gait cycle. Two time periods were selected for analysis: early swing (i.e., period from toe-off to peak knee flexion) and preswing (i.e., period before toe-off equal in duration to early swing). (b) Two simulation experiments were conducted by eliminating rectus femoris activity during preswing (dashed line) and separately during early swing (dotted line) to determine the muscle's effect on peak knee flexion. (c) Simulated changes in knee flexion angles were different when rectus femoris activity was eliminated during preswing (dashed line) or early swing (dotted line). The unperturbed simulation (thick solid line) and experimentally measured (thin solid line) knee angles are shown for comparison. Normal knee flexion (shaded line) and two standard deviations of the normal curve (shaded region) are shown as well.

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