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DETERMINE THE FORCES IN THE MUSCLES OF THE LEG AND FOOT WHILE MOVING HELP MODELING AND TESTING

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Abstract

In this paper, a four-segment musculoskeletal model of the floor and legs is created in AnyBody in which are considered all the muscles and ligaments of the leg and foot. To obtain input this dynamic problem (ground reaction force and path components in the foot during walking) on subjects with normal foot motion analysis and force plate testing has been done. To solve the model and determine the muscle forces is used of the two criteria min-max optimization and fifth order polynomial. For validation, Electromyography testing has been done on the subject. The review results be determined that the min-max optimization criteria than fifth order polynomial optimization criteria estimates closer approximation to the actual muscle activity estimates. Modeling with both criteria min-max and fifth order polynomial, in the anterior tibia muscle activation patterns are weaker than other.

Keywords: musculoskeletal model, Force, Foot.

1. Introduction

The leg is final part of the chain of motion keeps the body with the distribution of gravitational forces and inertia. Ankles and foot will play a significant role in maintaining the balance and the establishment of compliance with uneven surfaces as catchy beats and provides the steps necessary to start, operate [1]. In the 1960s, researchers are modeling human motion. It includes exercise and movements that are repeated in daily activities [2]. The knowledge obtained from the modeling can be done in the proper exercise movements according to individual circumstances can be used to increase performance or in medical research, such as the treatment of motor disorders and improve the use of electrical stimulation of the muscles utilize fabrication orthotics. Analysis of data on the performance of the motor can extend the normal foot during walking. These data can be used to select the appropriate equipment to control improper functioning or disability; joint experts help [3]. The muscle force can be determined by doctors in the muscles that can withstand a maximum force, would help. These results can be useful in REHABILITATION.

Various models have been used to analyze clinical ankle and foot plantar in most of them are considered as a rigid body and just flexion and extension to consider it. However the proportion of single-segment model for the purposes of the study are not very good feet and with little trust in this regard to make, there are very few multi-segment model presented. Fuller [4], two-segment foot model can be used to develop treatments of pathology. Saraswat [5], studied the, three-segment musculoskeletal foot Model to gait analysis. Salathe [6], Using the eight-segment foot model for the role of muscles, tendons and ligaments while walking and displayed affect different parts of the leg of forces muscles and tendons. Although multi-segment models are preferred to single-segment But recognizing the errors of individual anatomy and the use of physical markers and is not inevitable and could provide potentially be a significant error in the results of these models. Therefore, all the models presented for the feet, the error caused by the proximity of markers that are inevitable in any case, in these experiments, not cleared[7]. Another view of the existing model to be two-dimensional and three-dimensional models can be divided into two categories.

Considering that the aim of this paper is the amount activity of leg muscles during walking, three segment model of the right foot has been used. This model consists of four links: forefoot, hind foot and hallux plus a portion of the tibia, which are considered as a single rigid body. Figure (1) overview of the model used is shown. This model can be used to spread knowledge Chndbkhshy foot model for pathological purposes utilize foot.

Figure 1: Overview of the model used

2. Methods of testing and simulation

In this study to determine the muscle forces first using data obtained from subject to the walking foot with normal arches and without a history of certain diseases, especially in the field of orthopedic diseases in a cycle, ground reaction forces and trajectories in space systems with the installation of 10 markers (Figure 2) on bone with force and motion analysis testing simultaneous testing has been set. Then three components of the force and the three components of the torque exerted on the foot from force plate and the interval separating the two components center of pressure and the data were converted to the number of 100. For validation of the results of modeling, electromyography test while walking from four muscles gastrecnemius, proneus langus, soleus and tibialis anterior involved in walking from subject was performed (Figure 3).

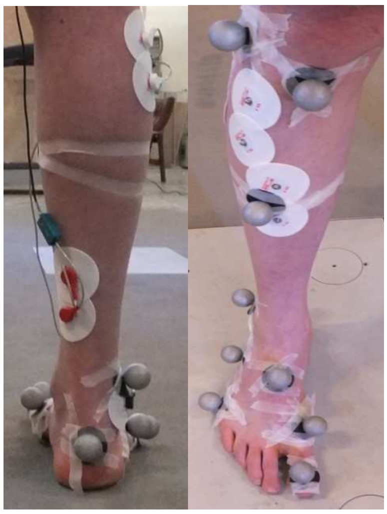

Figure 2: The junction markers on the subject's foot

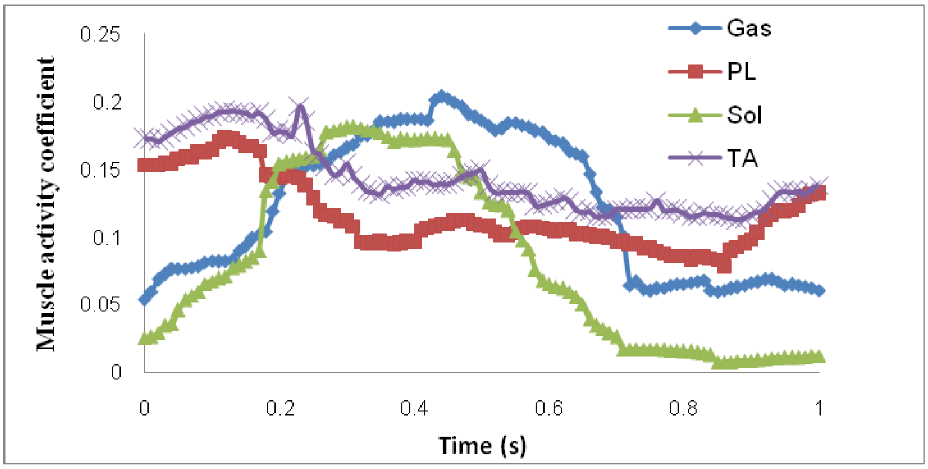

Figure 3: Electromyography activity coefficient obtained during tests of walking activity

Then four-foot segment consists of four links: forefoot, hind foot and hallux plus a portion of the tibia which are considered as a single rigid body along with all the muscles and ligaments from joints that are considered in the model pass in AnyBody software has been modeling. For each degree of freedom system, the contract incentive or be constrained by the adverbial, otherwise it will not solve the kinematic and cause undetermined. Since the four-segment model is defined and each segment has six degrees of freedom in space, the total number of degrees of freedom for the system is 24 =4×6 and the provisions governing the issue from number of degrees of freedom is reduced. The model has three revolute joint each have only one degree of freedom (the five adverbs). Therefore constrained number is 15=3×5 and the number of degrees of freedom of systems is equal to the difference between these two the amount 9. Of this value, three degrees of freedom joint (Figure 4) and the other six will be to determine the position in space of the whole system.

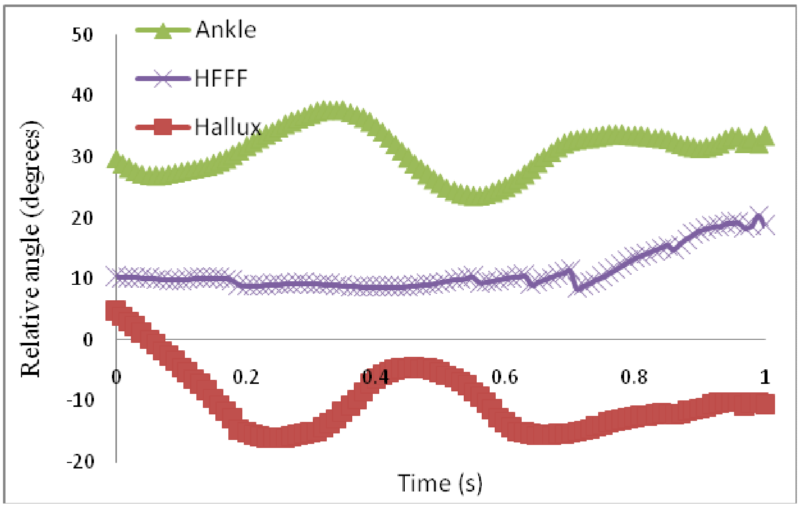

Figure 4: The relative angles of the three joints ankles, HFFF and hallux

After completion of the model, D'Alembert dynamic equilibrium equations are written for each segment. After writing the equations, the number of unknowns is greater than the number of information and compelled to find the best physical solution it should be considered as an optimization problem therefore, in this study after create the model and applied external forces and torques on it and consider other constraints optimization Problem using two criteria five degree polynomial and min-max in AnyBody software is resolved and required results including muscle and ligament force, muscle activity coefficient, diagram of location, velocity and acceleration specified points is obtained (Figure 5).

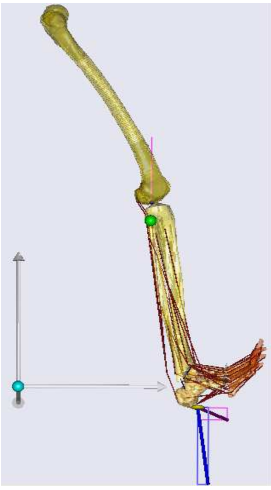

Figure 5: Overview of the model and the external forces and torques acting on it

3. Results

To assess the accuracy of the modeling results compared with the results of the Electromyography experiment has been done. To this typical activity coefficients of four major muscles of leg in electromyography in both experiments and modeling (in each of the two optimization criteria) were compared. Figure (6) coefficients derived from experiments and modeling activities to grade 5 polynomial method is presented. As can be seen in Figures, soleus muscle activity coefficients in both experiments and modeling are a very good compatible. Gastrecnemius muscle activation patterns in the two modes is also a similarity, although the EMG activity level is a little more. The results of the modeling to estimate proneus langus and tibialis muscle activity is not very satisfactory. In Figure (7) coefficients derived from experiments and modeling activities using min-max optimization criterion is given. As can be seen in the tibialis anterior muscle, EMG results are more compatible with estimates from the min-max criterion and muscle gastrecnemius estimates of the minmax criterion is considerably more accurate than the method of fifth order polynomial, while the muscle proneus langus the opposite is true. Comparing the diagrams (6) and (7) we find that using both criteria optimization, models made in estimating muscle tibialis anterior and proneus langus activity, is weak.

4. Conclusion

In this paper, a four-segment musculoskeletal model of the lower leg and the floor is created in the AnyBody in which all the muscles and ligaments of the leg and foot are considered. To obtain this dynamic problem input (ground reaction force and the foot path components while walking), have been done force plate and motion analysis tests on subjects with normal foot. To solve the model and determine the muscle forces have been used polynomials of degree 5 and min-max optimization criteria. By study results was determined that min-max optimization criterion to measure the degree 5 polynomial optimization estimates muscle force whit better approximation.

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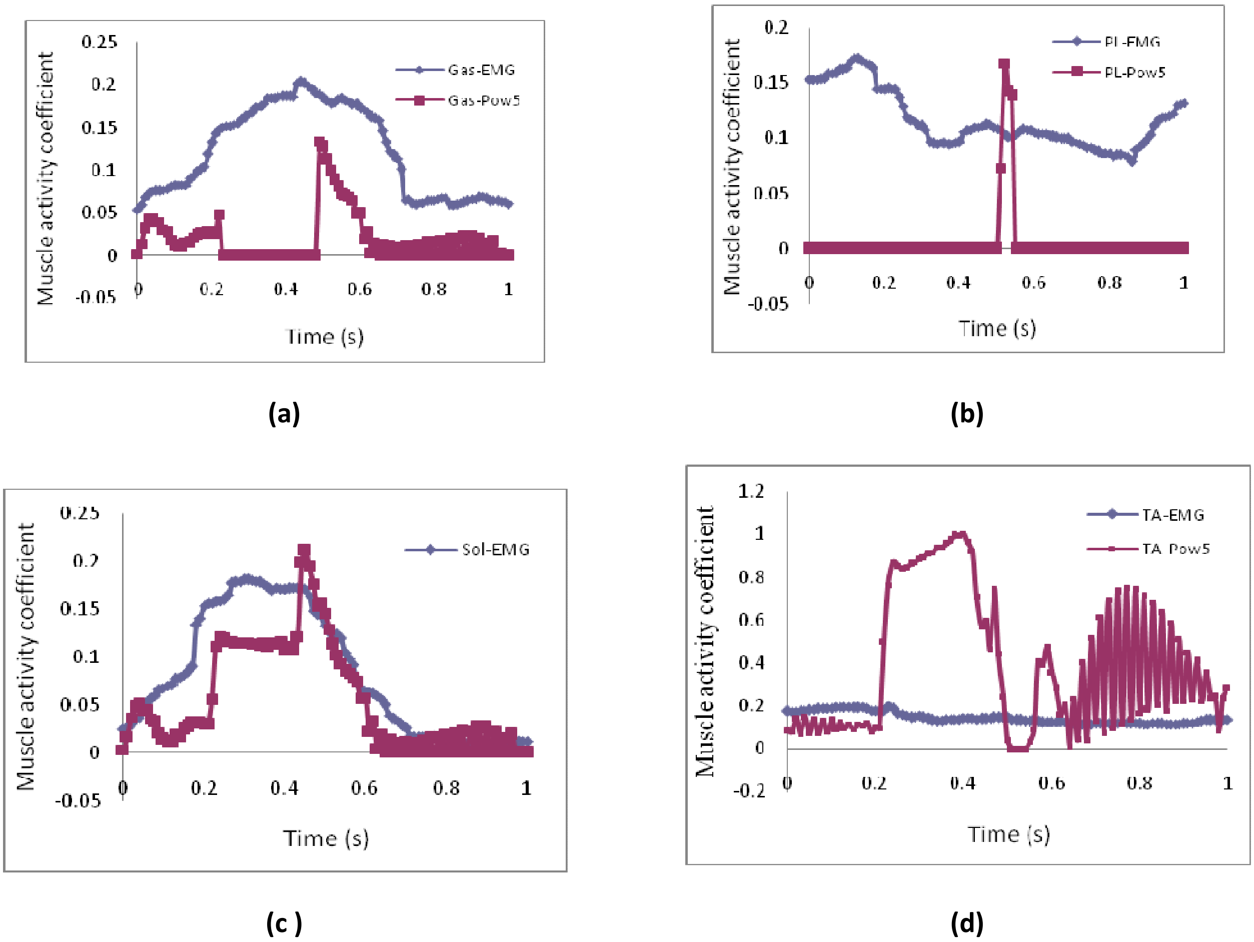
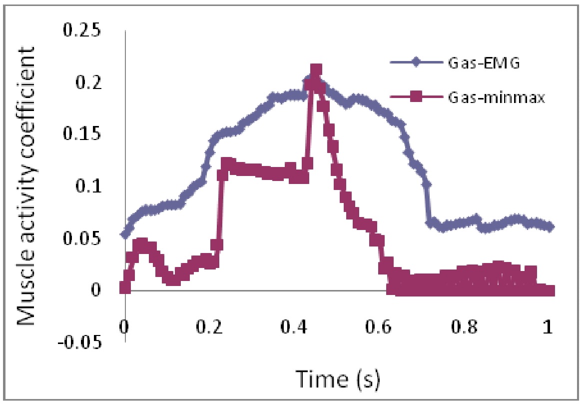
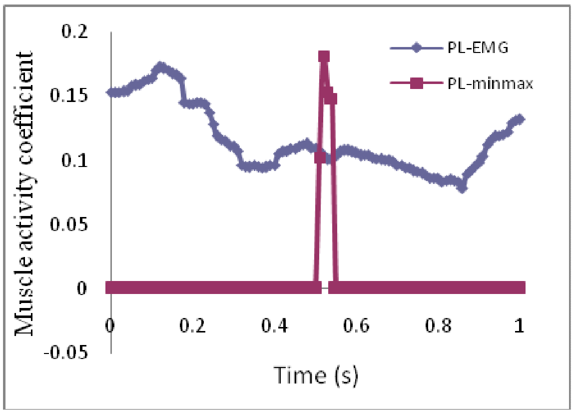


Figure 6: Coefficients derived from experiments and modelling activities using polynomials of degree 5. Respectively, Muscle activity coefficients;
a) Gastrecnemius b) Proneus Langus c) Soleus d) Tibialis Anterior



(a)



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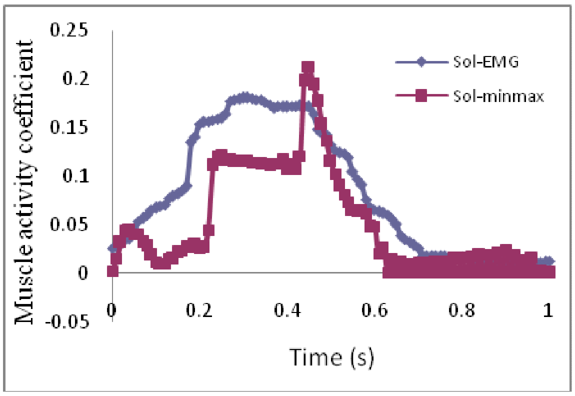

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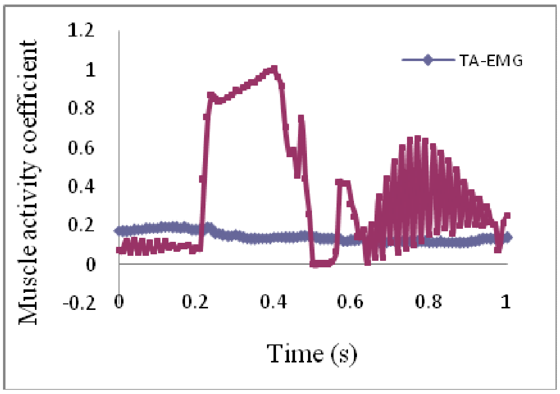

(d)

Figure 7: coefficients derived from experiments and modelling activities using minmax. Respectively, Muscle activity coefficients;
a) Gastrecnemius b) Proneus Langus c) Soleus d) Tibialis Anterior