HOW MUCH DO THE HIP ABDUCTORS CONTRIBUTE TO THE GAIT STABILITY FOR AMPUTEE WITH A PROSTHESIS?

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INTRODUCTION

The appropriate abduction torque by hip abductor muscle is essential to the balance and stability control of frontal plane stability of pelvis during walking. Without adequate abduction torque on the stance limb, above-knee amputees tend to lean trunk toward the amputated side during single-limb support in the frontal plane. The aim of the present study was to analyze the role of hip abductors which control the gait stability at walking speeds using 3-D musculoskeletal dynamic models for amputees by the inverse dynamic analysis.

METHODS

Ten transfemoral amputees with lower-limb prosthesis and ten healthy subjects were involved and gait analysis was performed by motion analyzer. Subjects were instructed to walk at three speeds at which they felt fast, most comfortable, and slow. Using SIMM, we made the musculoskeletal model for stump using anthropometric data which were obtained from computed tomography and MRI. After consultation with clinicians and references, the insertion points of muscles related to hip motion were redefined. Four primary abductors-the gluteus medius (GMed), the gluteus minimus (GMin), tensor fasciae Latae(TFL) and two secondary abductors-the piriformis (PF) and the satorius (SAT) were considered in this study. Next, we made the 4-bar linkage prosthetic model scaled to the stump model. (Figure 1) The dynamic equation of motion for amputee and normal subject was derived using SD/FAST and an inverse dynamics simulation was produced by Dynamics Pipeline. We adapted the muscle parameters of normal subjects to those of amputees through the sensitivity analysis referred to the comparative results from isokinetic and isometric test using dynamometer (Biodex) and also to the help of clinicians.

RESULTS AND DISCUSSION

During single-limb support period in the frontal plane, the pelvic obliquity of right legs of normal was 3~8 degrees greater than those of amputated leg of amputees which showed the negative sign of obliquity for amputees meaning that they tend to lean trunk toward amputated leg.

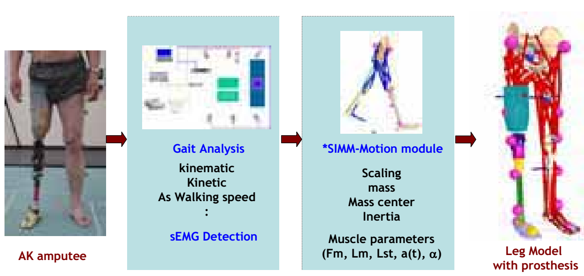

Figure 1 The configuration of experiment and simulation

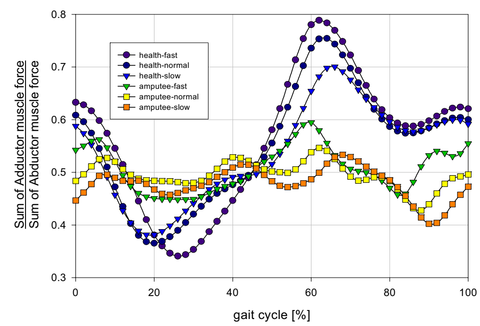

Figure 2: Comparison of the ratio of the sum of adductor muscle force with that of abductor muscle force

The muscle force of GMin is 11% (about 80N) and that of GMed is 20% (about 100N) over bodyweight(BW) less than those of the normal. The force of TFL and SAT is not different in pattern and scale. But that of PF is 39% of BW (about 390N) less than normal. The sum of adductor and abductor muscle force was less than that of normal at swing phase and at stance phase respectively. In view of the ratio of the sum of adductor muscle force to that of abductor muscle force, the weakened abductor during stance phase and the weakened adductor during swing phase were observed in contrast to normal subjects. And as walking speed increases, the force of abductor and adductor is vertically increased and decreased for normal gait. But for amputee gait they are shifted back as walking speed increases. (Figure 2)

CONCLUSIONS

From musculoskeletal model for normal and amputee gait as walking speed increased, weaken abductor results in excessive adduction in the frontal plane and then inadequate valgus torque was generated. The PF, GMin and GMed in order were significantly weak ($p<0.05$). The abductor and adductor forces are vertically increased and decreased for normal gait but shift-back for amputee gait as the walking speed increase. By dynamic modeling of musculoskeletal motion during gait, it was found that the magnitude or pattern of muscle forces and moments was different between amputees and normal subjects in three dimensional planes.

REFERENCES

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