DEVELOPMENT OF MUSCLE FORCE ESTIMATION SYSTEM FROM KINEMATIC DATA

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INTRODUCTION

Since insufficient muscle forces are considered that people cannot perform some activities related to roles of the muscle, muscle force have been considered as an important parameter in clinic. Many methods have been introduced to estimate muscle force indirectly [1,2]. They, however, need motion data captured from 3-dimensional (3D) motion analysis system, that is, they are not possible in real-time without 3D motion analysis sytem. In this study, we developed a system for estimating muscle force from kinematic data in real-time.

METHODS

A normal was required to rise and lower his feet for 5 times. During the experiments, motion analysis was performed with 3D motion analysis system, EMG measurement system, and goniometers. EMG signals were obtained on gastrocnemius medialis (GCM) and tibialis anterior (TA). Goniometers were attached on around knee joint and ankle joint.

To find relationship between joint angles and muscle lengths, cubic regression analysis was performed using SPSS 12.0 after muscle lengths were obtained from commercial software SIMM (Musculographics, U.S.A.) including musculoskeletal model [3].

Muscle model used in this study was designed by Zajac [2]. The model has advantages of cheaper computational cost than other models and easiness implementation. Estimation of muscle forces was conducted using home-made software written in C# language.

To validate developed system, analysis of correlation coefficient (r) and significance of the correlation (p) were performed between muscle lengths and muscle forces from SIMM and those from developed system.

RESULTS AND DISCUSSION

Joint angles calculated from marker data and those of goniometers were similar in pattern (Figure 1). The good correlation was observed in knee joint angle ($r = 0.879$, $p < 0.01$) and ankle joint angle ($r = 0.922$, $p < 0.01$).

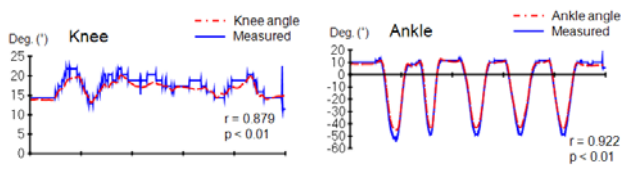

Figure 1: Comparison of joint angles between values calculated from marker and those of goniometers

Muscle lengths obtained from SIMM and those of joint angles were similar in pattern (Figure 2). The good correlation was observed in selected muscles (GCM: $r = 0.874$, TA: $r = 0.907$). The correlations were significant in all above muscles at a $p < 0.01$ level.

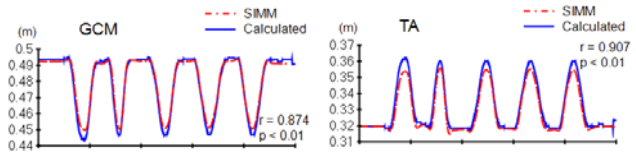

Figure 2: Comparison of muscle lengths between values obtained from SIMM and those of developed system

Muscle forces obtained from SIMM and those of home-made software had good correlations in selected muscles (GCM: 0.913, TA: 0.733; Figure 3). The significance of correlations was lower than 0.01 in all above muscles.

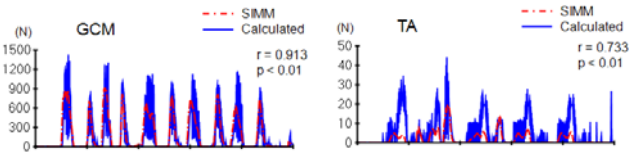

Figure 3: Comparison of muscle forces between values obtained from SIMM and those of developed system

CONCLUSIONS

In this study, muscle force estimation system was developed to apply in real-time. Muscle length was calculated from joint angle and muscle force was estimated from calculated muscle length. The results had good correlation with those of commercial software including musculoskeletal model at least. Results of this study, which were reasonable, would be helpful for clinician or researcher to determine patient's task ability and to understand motion.

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