In vivo determination of muscle architecture parameters by ultrasonography: applications to the brachialis muscle of normal subjects and persons after stroke

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INTRODUCTION

It is believed that muscle architectural parameters have effects on the muscle's force generating capacity. The pennation angle, fibre length and thickness of the muscle has been described mainly with the data obtained in preserved cadavers or specimen before. However, cadaver data are limited in their usefulness since muscle undergo shrinking during the fixing process.

Ultrasonography can be used to measure the changes of muscle fibre length and pennation angle reliably and non-invasively. It has become possible to describe human muscle architecture in vivo by ultrasound. This study is aim to quantitatively describe the brachialis muscle architecture parameters in rest and muscle contraction condition for normal and subjects after stroke.

METHODS

Brachialis muscle's architecture parameters including pennation angle, muscle fibre length for six unimpaired subjects and six hemiparetic subjects after stroke were measured using ultrasound imaging technology at rest and different levels of muscle contraction. At rest, the measurements for normal subjects were done at elbow positions from 0°–90° flexion with increase of 10° and measurements for pathological subjects were done from 10°-80° since some of them could not extend their arms to full extension. In muscle contraction, the subjects were asked to perform 20%, 40%, 60%, 80% and 100% maximum voluntary contraction(MVC) isometrically at the fixed position of 90° elbow flexion(elbow fully extended called 0° flexion).

RESULTS AND DISCUSSION

Ultrasound measurement of muscle pennation angle and muscle fibre length were comparable with results from cadaver data in literatures. These parameters changed with elbow joint position and muscle contraction activity. The changes in muscle parameters were different between normal and pathological subjects. The finding was that fibre length of pathological subjects change less than normal subjects which may indicate the effects of spasticity.

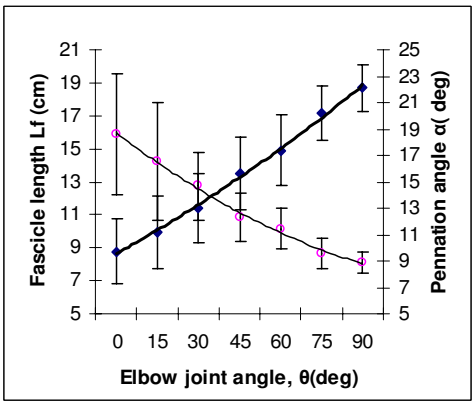

Figure 1: Muscle pennation angle and fibre length change with elbow flexion angle in rest(data from normal subjects)

CONCLUSIONS

This preliminary study finds in vivo ultrasonography could measure muscle architecture parameters and the results are comparable with anatomical data from unimpaired cadavers. Pathological subjects' muscle architecture parameters are different from normal subjects by ultrasonography. The results can be used to study the muscle properties and give useful information for force and tension calculation in the neuromusculoskeletal modelling. Application of in vivo ultrasound study on musculotendon complex is to find the relationship between the force generating of the muscle and muscle's architecture parameters. Other aspect of the applications is to have the musculoskeletal model parameters on specific subject with difference in architecture.

REFERENCES

1. Amis AA, Dowson D, Wright V., 1979. Muscle strengths and musculo-skeletal geometry the upper limb. Eng Med. 8, 41-48.
2. An K.N., Fui F.C., Morrey B.F., Linscheid R.L., Chao E.Y., 1981. Muscles across the elbow joint. J Biomech.14,659-669
3. Winters J.M., Stark L.,1988 Estimated mechanical properties of synergistic muscles involved in movements of a variety of human joints. J Biomech.21,1027-1041
4. Lieber R.L., Jacobson M.D., Fazeli B.M., Abrams R.A., Botte M.J., 1992. Architecture of selected muscles of the arm and forearm: Anatomy and implications for tendon transfer. J.Hand Surgery[AM].17A, 787-798

Table 1: Summary of literature data on brachialis muscle parameters and results of this study

Muscle Parameter Mean.(SD)	**Literature data and results of this study**					
	An et al.,(1981)	Amis et al(1979)	Winters(1988)	Lieber et al.,(1992)	Normal Subjects in this study	Pathological Subjects in this study
Fibre Length(cm)	9.0(2.9)	12.3	9.11	12.1(0.8)	11.75(2.2)	9.1(2.7)
Pennation angle(˚)	---	0	15.0	2(0.6)	15.8(3.5)	15(4.2)