

OBJECTIVE DIFFERENTIATION BETWEEN THE ADULT DIABETIC FOOT AND THE NORMAL ADULT FOOT USING PASSIVE TORQUE vs RANGE-OF-MOTION MEASUREMENT OF THE FOOT/ANKLE COMPLEX

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INTRODUCTION

The study has been performed on normal subjects and diabetics patients at the University of Texas Medical Branch (UTMB) and affiliated hospitals. In an earlier study, the inter- and intra-rater reliability of this device designed to measure the passive mechanical properties of the foot-ankle complex was ascertained [Hume, et al.]. On a regular basis the foot and ankle endure a tremendous amount of stress. In the injured or diseased foot, these forces can result in severe complications, such as the Charcot arthropathy in diabetic patients. In this example, the insensibility of the diabetic foot predisposes patients to exacerbate breakdown of the foot and ankle with irregular walking which would normally be prevented by pain.

The goal in the treatment of the diabetic foot and other pathology of the feet is to protect it from harmful forces and pressures and to allow for protective ambulating. With this in mind, the objective of this research is to provide a more in-depth understanding of the passive viscoelastic properties of the foot/ankle complex with the prospects of improving diagnosis and treatment. The hypothesis of this study is that the mechanical parameters derived from passive TROM curves will be significantly different between normal and diabetic adults.

METHODS

The TROM device is a transducer system based on a prototype developed in our lab that is manually rotated through plantar and dorsiflexion. The device and method of application are described in [Hume, et al.]. The device is a single degree-of-freedom hinge connected to molded thermoplastic splints which are strapped to the calf and foot. With the patient in a relaxed, sitting position in a recliner chair, the device is passively rotated at a slow rate (a metronome is used at 40 beats per minute) during a 50 second data acquisition period. A cantilever beam strain gauge provides the torque signal and a precision single-turn potentiometer provides plantarflexion-dorsiflexion angle to a two-channel portable pc data acquisition system.

Parameters determined from the TROM curve are maximum ROM (ROM 1 in the figure [next page]), normal or functional ROM (ROM 2 in the figure), the hysteresis area proportional to the energy absorbed in the loading/unloading cycle, dorsiflexion stiffness (Slope 1, Tangent a1), working ROM stiffness (Slope 2, Tangent a3), and plantarflexion stiffness (Slope 3, Tangent a2). All parameters are automatically calculated using a Basic language program as a macro in Microsoft Excel.

RESULTS AND DISCUSSION

The results are shown in Table. 1 with t-test statistics (Microsoft Excel). The study included 49 normal and 27 diabetic adult feet. For a probability level of 0.01 there was a significant difference between the AREA, and both dorsi- and plantar-flexion stiffnesses. Neither ROM nor the normal ROM stiffness ($\tan a_3$) differed between the normal and diabetic populations. This leaves a summarized conclusion that adult diabetic feet absorb more energy during cyclic motion (thus must dissipate more energy per cycle) and are stiffer in the terminal regions (where muscle-tendon-ligament properties prevail) than normal adult feet. Future work includes measurement of patients with other foot-ankle problems, correlation of these results with other parameters of clinical interest, and development of a three degree-of-freedom device in order to measure the passive properties for the foot in internal-external and inversion-eversion rotation as well as plantarflexion-dorsiflexion.

	Normal		Diabetic		t-stat.
	Avg.	S.D.	Avg.	S.D.	P
ROM 1	59.17	12.25	60.02	10.57	0.76
ROM 2	43.31	8.93	42.27	7.74	0.61
AREA	81.04	30.66	103.69	31.41	< 0.01
Slope 1	0.43	0.16	0.59	0.19	< 0.01
Slope 2	0.077	0.05	0.076	0.039	0.95
Slope 3	0.33	0.13	0.50	0.15	< 0.01

Table 1. Results for Normal and Diabetic subjects with t-statistics.

REFERENCES

Hume et al, "Analysis of TROM for the Passive Viscoelastic Properties of the Foot/Ankle Complex," Abstracts, 18th Annual Meeting, HSEMB, Univ. Hilton Hotel, Houston TX, 10-11 Feb, 2000, p124.

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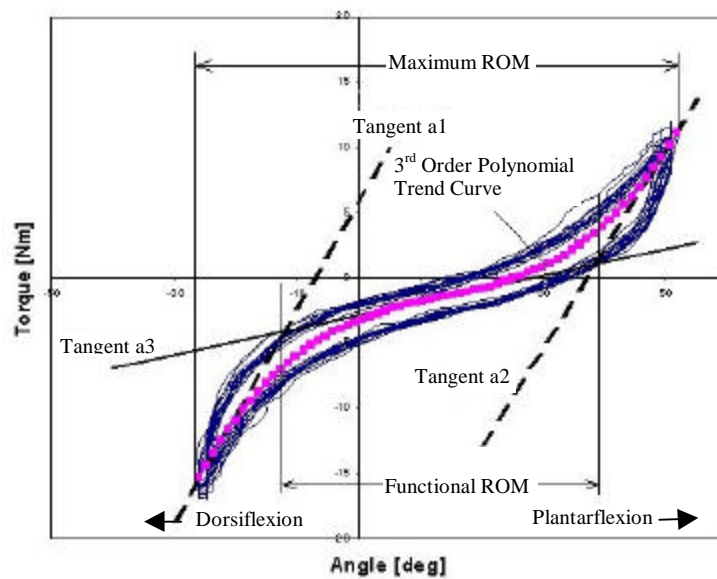


Figure. A typical TROM curve for a normal adult foot.