

Reliability analysis: force displacement curve at different loading rate of the amputated foot

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Abstract. The aim of our study was to assess the measurement reproducibility of the amputated defrosted foot compression test data at different loading rate. The foot specimen used for testing was from a female. Compressive tests were done on a 25 kN force Tinius Olsen H25K-T testing machine. Defrosted foot specimen was repeatedly loaded at a different rate 25 mm/min, 50 mm/min, 100 mm/min and 500 mm/min. The Intraclass Correlation Coefficient was calculated to assess the measurement reliability of foot force-displacement curves at each loading rate. The measures of foot displacement taken from the repeated compression test had a very high level of agreement at each compression rate.

Keywords: measurement reproducibility, force-displacement curve, foot, compression test.

Introduction

Development of a realistic physics-based human foot model requires the use of empirical data on the mechanical behavior of the foot arch, foot bones, cartilages, plantar ligaments and fascia and heel pads under the action of external forces. To investigate the mechanical properties of foot many authors use the cadaver feet [1–5]. During testing the specimens are loaded repeatedly and it is not clear yet how force displacement curve at different loading rate of the amputated defrosted unfixed foot changes with the increasing number of repetitions. The goal of our study was to assess the measurement reproducibility of the amputated defrosted foot compression test data at different loading rates.

Methods

The specimen was a right foot with normal longitudinal arch from a female. The right limb was amputated due to irreparable vascular disease. At the time of surgical procedure the age of the donor was 64 years; body weight and height were 69 kg and 1.68 m respectively. The foot was disarticulated at the ankle with preservation of all soft tissues. The specimen was evaluated for clinical and radiographic normality by orthopedic surgeons prior to testing. The foot was sealed in double plastic bags and stored in a freezer maintained at -20°C . It was thawed at room temperature for 24 hours before testing. The National Bioethics Committee reviewed and approved the study protocol.

Compressive tests were done on a 25 kN force Tinius Olsen H25K-T testing machine. The foot was put on the machine so that talus would be in the pressing center. Before the formal trial, the specimen was three times preconditioned to 1000N. Defrosted foot specimen was repeatedly loaded at a different rates 25 mm/min (ten times), 50 mm/min (ten times), 100 mm/min (ten times) and 500 mm/min (four times). The maximum loading 1000N was achieved. There was an interval of 2 minutes between each compression. Before the next loading the foot was put on the machine in new stable position. During compressions the Tinius Olsen H25K-T testing machine indicated the values of displacement (mm) and force (N).

The Intraclass Correlation Coefficient (ICC) was calculated to assess the measurement reliability of foot force-displacement curves at each loading rate.

Results

The measured force-displacement curves taken from the repeated compression tests had a very high level of agreement (Fig. 1). The high values of the Intraclass Correlation Coefficients (25 mm/min ICC = 0.995, $p < 0.000$; 50 mm/min ICC = 0.998, $p < 0.000$; 100 mm/min ICC = 0.999, $p < 0.000$; 500 mm/min ICC = 0.996, $p < 0.000$) showed that the force displacement curves within each loading rate were almost exactly the same.

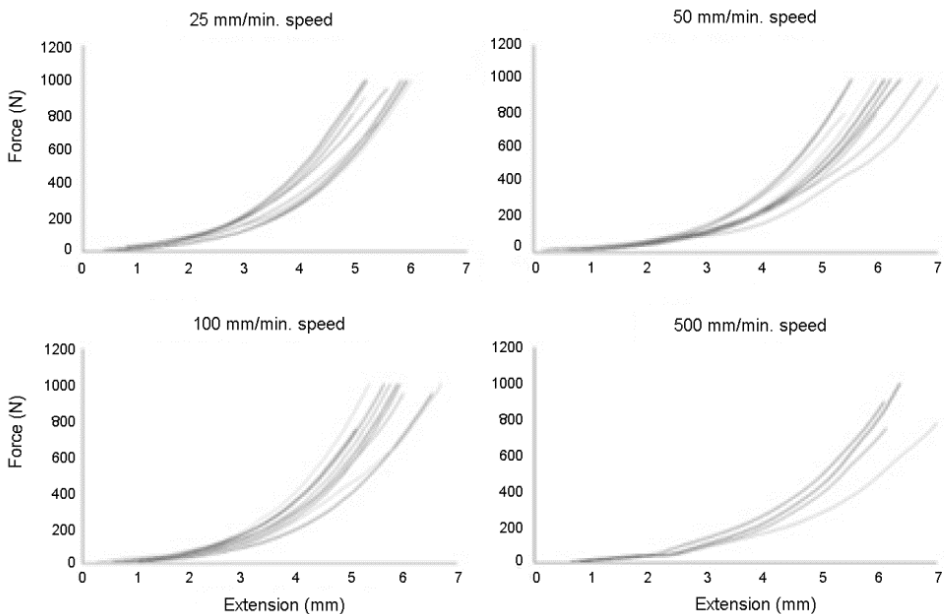


Fig. 1. Force displacement curves at different loading rate of the foot specimen

Discussion

The measurement reliability plays a very important role when the measurement is repeated for the same cadaveric specimen (in an artificial experimental situation). The studies showed that testing feet at room temperature after frozen storage gives the same results as testing fresh and warm feet [6]. The question if the number of loading repetitions has influence on the findings could not be answered. Our data gave a possibility to calculate Intraclass Correlation Coefficients and to assess the measurement reliability of the force-displacement curves of the foot at different loading rates. The findings showed that the number of loading repetitions of the amputated defrosted feet doesn't have influence on compression test data.

Conclusions

We conclude that cadaveric defrosted foot repeatedly loaded during compression test demonstrated very good force displacement curve reliability. This finding was showed at different loading rates.

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