EFFECTIVENESS OF LOW-COST THERMOELECTRICALLY COOLED TISSUE CLAMP FOR *IN VITRO* CYCLIC LOADING AND LOAD-TO-FAILURE TESTING

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INTRODUCTION

During biomechanical load testing on cadaver specimens, linkage of an actuator to either muscle or tendon has always been a concern [1,2]. To overcome this problem, many different techniques have been advocated such as using 'cryo-jaws'. Those devices require liquid CO^2, liquid nitrogen or dry ice. This gives rise to a certain complexity of setup as well as many manipulations during testing to prevent thawing of tissues, rendering those procedures cumbersome and impractical for long-term cyclic loading experiments. The aim of this study is to describe and evaluate the effectiveness of a simple custom-made thermoelectrically cooled freeze clamp to transmit loads without tissue slippage.

METHODS

A custom-made freeze clamp was designed by modifying a TEC VGA waterblock (MCW50-T, Swiftech, Lakewood,CA) (Figure 1b). The effectiveness of the clamp was tested on 10 canine *quadriceps femoris* myo-tendinous junctions. Tibias were secured in metal cylinders with cross-pins and embedded in a polyester resin. The distal end of the cylinder was then screwed in a receptor fixed to a 15 kN load cell. The distal end of the *quadriceps femoris* was inserted in the freeze clamp such that the inferior end of the clamp was within 15 mm of the proximal pole of the patella. A heavy gauge steel cable attached to the clamp was then hung by a pneumatic grip linked to a servo-controlled hydraulic testing machine (Figure 1a).

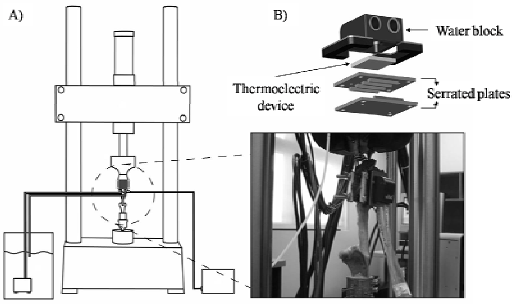

Figure 1: Illustration of the experimental setup (A) and exploded view of the custom-made freeze clamp (B).

Specimens were randomly assigned to the dynamic cycling group (n=5) or the failure group (n=5). Before testing, a 5 N pretension was applied to straighten the patellar tendon and distance between the clamp and the patella (DCP) was measured in millimeters by 2 of the authors (MOK and AL) using a ruler. Each specimen was preconditioned with 200 cycles. After preconditioning, DCP was measured at a 5 N load and the specimen was visually inspected for sign of apparent slippage within the clamp (indentation marks). Specimens assigned to dynamic testing were then submitted to 1800 cycles of 1Hz sinusoidal loading from 100 N to 1200 N. After dynamic cycling, DCP was again measured. Specimens were then brought to failure at a rate of 1 mm/s. In the failure group, the specimens were brought to failure at a rate of 1 mm/s immediately following preconditioning. After failure, DCP was measured when disruption occurred elsewhere than between the clamp and the patella. During preconditioning and failure testing, load and displacement were recorded at 10 Hz whereas a frequency of 20 Hz was used during dynamic testing using a 15 kN load cell and a LVDT respectively.

RESULTS AND DISCUSSION

Distance between the clamp and the patella (DCP) increased by a mean of 1.8±1.3 mm after preconditioning without apparent slippage within the clamp. All specimens of the dynamic cycling group withstood loading without sign of failure of the muscle-tendon-bone complex. DCP increased by a mean of 1.3±1.6 mm after dynamic cycling without apparent slippage within the clamp. All 10 specimens were brought to failure with a peak load at failure ranging from 2050 N to 4840 N with an average of 3340±840 N. Mean peak load of specimens from the dynamic cycling group was 3410±1070 N compared to 3270±650 N for the failure group. No statistically significant difference was found ($p=0.80$, two-tailed Student's t-test). Specimens were observed post failure and the prints of the clamp's indentation were clearly seen. No case of slippage was noted.

CONCLUSIONS

The realization of this study allowed us to demonstrate that this clamp can withstand considerable loads without sign of failure and could be used successfully in both quasi-static load-to-failure experiment and dynamic cyclic loading for an extended period of time**.** Therefore, results obtained suggest that the use of a TEC freeze clamps is an excellent alternative to liquid nitrogen, liquid CO_2 or dry ice freeze clamps for biomechanical testing.

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REFERENCES

1. Riemersa DJ, et al., *J Biomech*. **15** :619-620,1982.
2. Cheung JT, et al., *Med Eng Phys.* **28**:379-382, 2006