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IN SITU CHONDROCYTE VISCOELASTICITY FOLLOWING STATIC AND DYNAMIC COMPRESSIONS

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INTRODUCTION

Articular Cartilage (AC) is a thin layer of connective tissue covering bony surfaces of joints [1]. AC allows joints to move smoothly during load transmissions, and plays an essential part in the joints overall health [2]. Chondrocytes maintain AC extracellular matrix, the integrity of which depends largely on compressions applied to the tissue. Past studies used strain control protocols to apply static or short term dynamic compressions to AC and observe changes in chondrocyte morphology [1]. However, there is a lack of studies investigating chondrocyte cell behaviour under long-term cyclic compressions at different frequencies. The purpose of this study was to use three different loading protocols in order to see how chondrocyte cell behaviour undergoing static loading compare to cyclic loading at walking and running frequencies.

METHODS

Patellae from New Zealand white rabbits (N=12) were isolated and randomly assigned to one of three loading protocols [2]; (i) static loading with a constant strain level of 10 %, (ii) dynamic sinusoidal loading oscillating at 1 Hz (walking frequency) and an average strain magnitude of 10%, (iii) dynamic sinusoidal loading oscillating at 2 Hz (running frequency) and the same average strain level. Compressive strain was applied for 45 min, followed by 15 min recovery. Cells were stained and tracked by Zeiss laser scanning microscopy during the loading protocol; time points were taken at 5min, 15min, and 30min during loading and at 2min, 5min, and 15min during recovery.

RESULTS

For the loading period, cellular width and depth (perpendicular to the tissue thickness axis) for static loading increased on average by 10%, while cellular height (along the tissue thickness axis) decreased by approximately 20% with respect to the unloaded state (Figure 1a). Similar results were observed for width and depth for dynamic loading at 1 Hz frequency. However, unlike static loading, cellular height did not fully recover to its original state for all of the cells (Figure 1b). For the loading period of dynamic loading at 2 Hz, an increase was observed in cellular depth by approximately 15% along with an average increase in cellular width by 20%, while cellular height was decreased by almost 25% (Figure 1c).

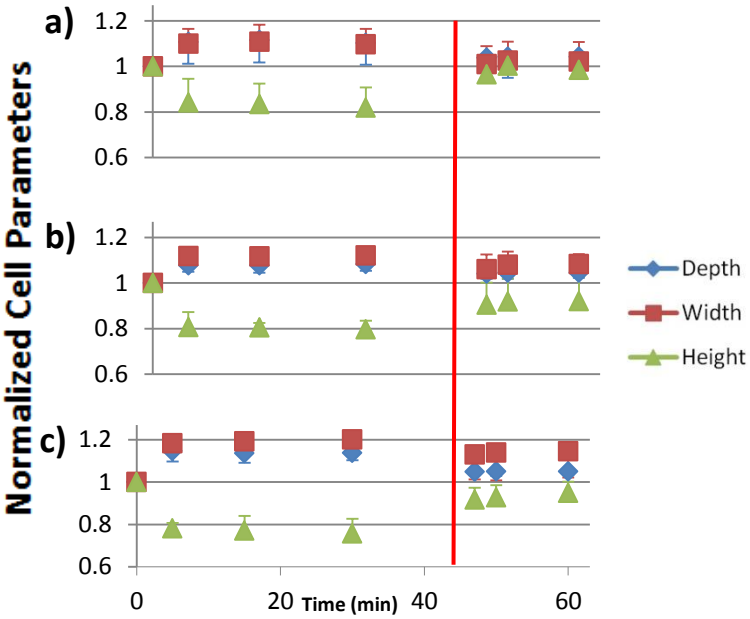

Figure 1: Normalized cell morphologies for (a) static loading (n=51), (b) dynamic loading at 1 Hz (n=35), and (c) dynamic loading at 2 Hz (n=66). Red line separates loading and recovery periods. Mean±1SD

DISCUSSION AND CONCLUSIONS

The lack of variation between static and dynamic compressions at 1 Hz suggests that the cellular mechanical response is similar when an individual walks or stands. The cellular mechanical response for 2 Hz frequency is different from static and 1 Hz loading protocols, thus suggesting that greater changes in cellular morphologies compensate the increase in frequency.

In the future, more studies can be conducted to evaluate how cells respond at the same frequencies but under various strain levels.

REFERENCES

1. Han S, et al. *JBiomech.* **45**:2450-2456,2012.
2. Madden R, et al. *JBiomech.* **46**:554-560, 2013.