SUBWOOFER AS A VIBRATION LOADING DEVICE TO INTENSIFY THE OSTEOGENIC DIFFERENTIATION OF ADIPOSE STEM CELLS

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Introduction

The current methods of regenerative medicine are often insufficient to treat patients with severe bone defects. Tissue-engineered bone grafts could offer a relevant solution for the purpose, though currently used methods are still insufficient. Lately the advantages of providing the cultured cells with their natural environment -like mechanical stimulation have been recognized. We constructed a specially designed amplifier-driven subwoofer to stimulate human adipose stem cells in vitro with high-magnitude high-frequency (HMHF) vibration loading. With the inexpensive stimulation method we were able to find vibration loading -specific cell responses in increased osteogenic differentiation and in inhibited adipogenesis (Tirkkonen et al. 2011).

Methods

A commercial subwoofer was used as the vertically vibrating platform of the stimulator. An attachment system of five cell culture dishes and an accelerometer was constructed on the cone and a home-made controller drove the element with an amplified AC-signal. The vibration magnitude of 3 *G* peak accelerations were produced with load application frequencies of 50 and 100 Hz using modulated square wave. The accelerometer measured the vertical accelerations. It had a direct feedback to the controller, which provided the vibration magnitude adjustment. During stimulation experiments the stimulator performed in both open-loop and closed-loop modes. The daily stimulation procedures consisted of three hours of vibration loading with a stimulation pattern of 1 s vibration and 1 s of rest.

Results

The designed stimulator was simple and easy to use. The 3 *G* peak accelerations were produced and maintained the most accurately at the 50 Hz vibration frequency of the closed-loop mode. The stimulation neither affected cell viability nor number, when significantly increased ALP activity and significantly higher collagen production were observed in the osteogenic medium at 14 day. In addition, mineralized areas were found only in the vibrated samples. The vibration loading also inhibited adipogenic differentiation. The cell responses to mechanical stimulation were higher with the 100 Hz vibration frequency when compared to the 50 Hz vibration frequency.

Discussion

The simple working principle of the subwoofer was capable of producing continuously accelerated linear motion. The amplifier-subwoofer system performed surprisingly accurately as a HMHF vibration loading device, regardless of the mechanically complex extra mass added on the cone and the demanding vibration loading parameters. An essential benefit of the device was that it was efficient enough to stimulate high number of cultured cells simultaneously. Also, the real-time controlled vibration magnitude adjustment of the closed-loop mode enabled more accurate maintenance of the desired vibration amplitude when compared to the simple open-loop mode. As a conclusion, the stimulation method provided us with encouraging findings related to the benefits of utilizing the mechanical stimulation as a stem cell differentiator.

References

Tirkkonen et al, J R Soc Interface, 8:1736-1747.