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Abstract

Development of parametric unit cells for the elasticity modulation of 3D-printed midsoles

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Parametric unit-cell structures have great potential for 3D-printing of shoe soles. Since different areas of the foot are subjected to varying pressure, various material properties are required across the sole to improve plantar pressure distribution in cases such as diabetes-related complications [5]. Modifying the stiffness of the entire sole is often not ideal [1, 6]. The advantage of 3D-printed lattice structures with individually adjustable strength has already been confirmed [1-4]. A common approach to achieving different material properties is using different infill densities which can lead to mechanical discontinuities between zones [2]. The preferable option is the use of continuous unit-cell structure lattices.

For additive manufacturing of lattice structures with individually adjustable compression behavior, parametric variations of unit cells were developed. Each developed strut-based structure was assembled into 3x3 lattices and 3D-printed with thermoplastic polyurethane (Stratasys TPU 92A Black, Stratasys Ltd., USA) to enable mechanical testing. The structures were parameterized in their strut thickness and curvature.

After acquiring the compressive stress-strain curves of the structures in compression tests, the Young's moduli and maximum stress values at defined strain levels were determined. The geometric properties of the structures can be tailored, enabling a wide range of Young's moduli. The relationship between the geometric properties and the compression properties of the structures was modeled by polynomial fitting using the least squares method. This allows the creation of 3D-printed midsoles that can be adapted to individual plantar pressures in different areas of the sole. The structure with the widest range achieves values for the Young's modulus from (0.72 ± 0.04) MPa to (13.93 ± 0.18) MPa.

AUTHOR'S STATEMENT

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