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Biomechanical Perspectives on the Urinary Bladder: Insights from the Hydrostatic Skeleton Concept

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Abstract : Introduction: The urinary bladder undergoes repeated strain during its working cycle, suggesting the presence of an efficient support system, force transmission, and mechanical amplification. The concept of a "hydrostatic skeleton" (HS) could contribute to our understanding of the functional relationships among bladder constituents. Methods: A multidisciplinary literature review was conducted to identify key features of the HS and to gather evidence supporting its applicability in urinary bladder biomechanics. The collected evidence was synthesized to propose a framework for understanding the potential hydrostatic properties of the urinary bladder based on existing knowledge and HS principles. Results: Our analysis revealed similarities in biomechanical features between living fluid-filled structures and the urinary bladder. These similarities include the geodesic arrangement of fibres, the role of enclosed fluid (urine) in force transmission, prestress as a determinant of stiffness, and the ability to maintain shape integrity during various activities. From a biomechanical perspective, urine may be considered an essential component of the bladder. The hydrostatic skeleton, with its autonomy and flexibility, may provide insights for researchers involved in bladder engineering. Discussion: The concept of a hydrostatic skeleton offers a holistic perspective for understanding bladder function by considering multiple mechanical factors as a single structure with emergent properties. Incorporating viewpoints from various fields on HS can help identify how this concept applies to live fluid-filled structures or organs and reveal its broader relevance to biological systems, both natural and artificial. Conclusion: The hydrostatic skeleton (HS) design principle can be applied to the urinary bladder. Understanding the bladder as a structure with HS can be instrumental in biomechanical modelling and engineering. Further research is required to fully elucidate the cellular and molecular mechanisms underlying HS in the bladder.

Keywords : hydrostatic skeleton, urinary bladder morphology, shape integrity, prestress, biomechanical modelling
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