State-of-the-Art Research in Lower-Limb Prosthetic Biomechanics-Socket Interface

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Background: Scientific studies have been conducted to quantify attributes that may be important in the creation of more functional and comfortable lower-limb prostheses. The prosthesis socket, a human machine interface, has to be designed properly to achieve satisfactory load transmission, stability, and efficient control for mobility. The biomechanical understanding of the interaction between prosthetic socket and the residual limb is fundamental to such goals.
Objectives: The purpose of this paper is to review the recent research literature on socket biomechanics, including socket pressure measurement, friction-related phenomena and associated properties, computational modeling, and limb tissue responses to external mechanical loads and other physical conditions at the interface.
Criteria for selecting studies for this review:
Types of studies: Studies on prosthetic biomechanics
Types of participants: Persons with lower limb amputation
Types of interventions and outcome measures:

- Socket pressure measurements: A variety of transducers have been developed for socket pressure measurements. They can be classified, based on their operation principle, as fluid-filled sensors (10-12), pneumatic sensors (13-15), diaphragm deflection
- strain gauge (16-25), cantilever/beam strain gauge (26-28), and printed circuit sheet sensors (29-34), as reviewed by Sanders (35) and Silver-Thorn and colleagues (36).
- Friction-related phenomena and associated properties, such as shear stress, frictional properties of skin, slippage. Radiography (55-59) and ultrasound (60,61) techniques have been used to investigate the skeletal movements within transtibial sockets and transfemoral sockets
- Computational modeling for residuum tissue stress/strain analysis to provide quantitative information on the load transfer between the socket and the residual limb for the purpose of optimal socket design and objective evaluation of the fit. Tissue responses to external mechanical loads and other physical conditions at the prosthetic interface.

Search strategy for identification of studies: NA
Conclusion: There is no doubt that improved biomechanical understanding has advanced the science of socket fitting. However, the most recent advances in the understanding of stresses experienced at the residual limb have not yet led to enough clinical consensus that could fundamentally alter clinical practice. Efforts should be made to systematically identify the major discrepancies. Further research should be directed to address the critical controversies and the associated technical challenges. Developments should be guided to offer clinicians the quantification and visualization of the interaction between the residual limb and the prosthetic socket. An understanding of comfort and optimal load transfer as patterns of socket interface stress could culminate in socket design expert systems.