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Important Characteristics of the Trans-Femoral Residual Limb to Consider When Designing Prosthetic Sockets

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Background：The socket shape and compression value of a prosthesis are determined empirically based on information such as the dimensions, amount of remaining soft tissue, and hardness of the residual limb. Appropriate compression allows the residual limb to bear weight and makes the socket comfortable. Various approaches have been used for evaluating prosthetic sockets, but there is currently no established method for quantifying prosthetic socket fitting.

Aim：This study aimed to determine the necessary characteristics for determining compression value by evaluating residual-limb elasticity and tissue distribution to develop a quantitative socket design.

Methods：Five transfemoral amputees without complaints about their residual limbs were included in this study. Already-fitted ischial ramus containment sockets were used. Measurements were made with (donning) and without a socket (doffing). Magnetic resonance imaging of the residual limb and tissue shape was performed, on which tissue shape and area (bone, muscle, fat, and skin) measurements were based. Donning-induced changes in tissue area were calculated. An indentation test was conducted to measure the elasticity of the residual limb. Elasticity distribution was measured at 32 points for each limb, while tissue distribution was measured on the entire residual limb.

Results：Weak correlations were found between compression value and elasticity and between compression value and soft-tissue area. A principal components analysis performed with elasticity and soft-tissue area as components showed that the principal components were 45° from the components axis. A strong correlation was found between compression value and second principal component scores.

Discussion & Conclusion：Those results showed that compression values were determined by certain variables that were in turn determined by stiffness and soft-tissue volume.
In this study, the relationships between compression and soft-tissue volume and between compression and stiffness of the residual limb were shown quantitatively.
Additionally, the results suggested that muscle volume affected the compression value.