Clinical Relevance for the Veteran

SUMMARY OF SCIENTIFIC/TECHNICAL PAPERS IN THIS ISSUE

Normal and Shear Stresses on a Residual Limb in a Prosthetic Socket During Ambulation: Comparison of Finite Element Results with Experimental Measurements. Joan E. Sanders, PhD and Colin H. Daly, PhD *(p. 191)*

Purpose of the Work. The mechanical stress at the interface of the residual limb and prosthetic socket is a cause of skin breakdown in lower-limb amputees. The purpose of this study was to develop and evaluate a computer-based model of the residual limb and socket to predict interface normal stresses and shear stresses on below-knee amputees during ambulation, a potentially useful prosthetic design and fitting tool. **Subjects and Procedures.** To develop the model, data from a single male unilateral amputee subject was used, and the ANSYS® (Swanson Analysis System, Houston, PA) finite element code was employed. **Results.** Results were encouraging in that at some sites the shapes of analytical and experimental interface stress waveforms were similar in that they were double-peaked with some distinct features apparent. However, quantitative comparisons indicate that further model development is needed and suggest that primary attention should be concentrated on more accurate mathematical descriptions of the stump-socket interface region and tissue material properties. **Relevance to Veteran Population.** Being able to predict the sites on a prosthetic socket which might cause shear on the skin when a veteran amputee is walking, could eliminate potential skin breakdown in that area which could prevent the client from being able to continue walking.
Joan E. Sanders, PhD

A Technical Brief: Modelling the Mechanics of Narrowly Contained Soft Tissues: The Effect of Specification of Poisson's Ratio. William M. Vannah, PhD and Dudley S. Childress, PhD *(p. 205)*

Purpose of the Work. The purpose of this study is to demonstrate that the mechanics of soft tissue held in a narrow space (such as a residual limb in a prosthetic socket) are strongly sensitive to small changes in compressibility. **Subjects.** None. **Procedures.** A series of finite element models (having definite limits or boundaries) using differing Poisson's ratios (the ratio of transverse to longitudinal strain in a material under strain) is employed to illustrate the sensitivity effect. **Results.** For the case of a simplified above-knee socket model, changing Poisson's ratio from 0.45 to 0.50, results in a two-fold and five-fold change in the calculated reaction force and tissue stresses, respectively. **Conclusion.** Small changes in Poisson's ratio can strongly affect the results of mechanical analyses of narrowly contained soft tissues, such as a residual limb in a prosthetic socket. **Relevance to Veteran Population.** Relevant examples of narrowly contained soft tissues are those in prosthetic sockets, wheelchair seating, and orthotic footwear. Use of the more accurate analytical technique by researchers may enable us to more clearly understand the mechanics of soft tissue support, leading to fundamentally improved, better fitting, and more comfortable designs in the aforementioned prosthetic sockets, orthotic footwear, and wheelchair seating.
William M. Vannah, PhD

Basic Gait Parameters. Reference Data for Normal Subjects 10-79 Years of Age. Tommy Öberg, MD, PhD; Alek Karsznia, PT, PhD; Kurt Öberg, PhD *(p. 210)*

Purpose of the Work. The basic gait parameters most frequently used are gait speed, step length and step frequency. If such measurements are used for evaluation of pathological gait, the results must be compared with reference data from healthy subjects. The aim of this study was to provide such reference data. **Subjects.** 233 healthy subjects, 116 men and 117 women, 10-79 years of age. **Procedures.** Gait was tested on a 10 m walkway in a gait laboratory. Gait parameters were calculated for the middle 5.5 m, acceleration and deceleration distances were

excluded at the ends. **Results.** Mean, standard deviation, coefficient of variation, 95% confidence intervals and 95% prediction intervals are presented in an appendix. Significant sex differences exist in all gait parameters. In a two-way analysis of variance model there was a statistically significant age variability for gait speed and step length at normal and fast gait, but not for step frequency. In the step length parameter, there was a significant interaction effect of age and sex at normal and fast gait. **Relevance to Veteran Population.** The reference data are considered valid in an indoor laboratory situation. If gait analysis is used for evaluation of gait ability in disabled veterans, and in the disabled community in general, comparison must be made with data from healthy people. This study provides such normative data which makes it easier for the clinician to evaluate what is different about the veteran's gait. The gait evaluation must be done in a gait laboratory to insure validity.
Tommy Öberg, MD, PhD

Characterization of the Dynamic Stress Response of Manual and Powered Wheelchair Frames. J.D. Baldwin, MS and J.G. Thacker, PhD *(p. 224)*

Purpose of the Work. A common thought in random fatigue analysis is that the stress history in a structure matches a consistent statistical assumption. This statistical assumption is known as a stationary narrow band Gaussian random process (SNG). This investigation sought to determine the validity of the SNG assumption for dynamically loaded wheelchairs. **Subjects.** One nondisabled male. **Procedures.** Two folding wheelchairs, one manual, one electrically powered, were instrumented with strain gages near the cross tube pin and operated over four different laboratory terrains. The stresses were computed and statistical hypothesis tests were performed to determine whether the stresses were consistent with the SNG process. **Results.** Summary data for two strain gage locations on each wheelchair suggest that the stress can be considered stationary, but neither narrow-banded nor Gaussian distributed. **Conclusion and Discussion.** These findings indicate that the SNG model for random fatigue testing may not be valid for the wheelchairs and terrains investigated here. These results should caution designers about using the SNG assumption in fatigue analyses. **Relevance to Veteran Population.** The veteran is concerned about how long his wheelchair will last and under what conditions will certain areas fail (such as near the cross pin). Some of the fatigue testing figures being given in laboratories are not valid for certain terrains. The veteran would like to know, before he or she purchases a chair, under what conditions/terrains the chair will or will not hold up.
J.D. Baldwin, MS

Design of a Composite Monocoque Frame Racing Wheelchair. Michael S. MacLeish, MS; Rory A. Cooper, PhD et al. *(p. 233)*

Purpose of the Work. Monocoque shapes may improve the performance of racing wheelchairs. Monocoque is a type of construction in which the outer skin carries all or a major part of the stresses. A monocoque vehicle is one in which the body is integral with the chassis. The purpose of this study was to design a unibody frame racing wheelchair through the use of engineering technology. **Subjects.** One subject was used to represent the racing chair pilot. **Procedures.** A finite element analysis model created with the help of a computer helped point out problems in the design of unibody frame racing wheelchairs. Slight modifications can be made to the model to try different shapes, to see how much weight it could carry, or to use different materials in its construction. **Results.** A prototype was built and tested. While repeated use in racing competitions is still to be done, it has been indicated through this study that the application of engineering technology can improve the design of racing wheelchairs. **Relevance to Veteran Population.** Many veterans participate in and enjoy the sport of wheelchair racing. The sport has been instrumental in promoting the abilities and potential of people with disabilities. Racing wheelchair design has made significant contributions to the improvement of nearly all wheelchairs in use today. By seeking to further improve performance in the racing chairs, wheelchairs designed for daily use may also benefit.
Rory A. Cooper, PhD

The Analysis of Sweat During Soft Tissue Breakdown Following Pressure Ischemia. Adrian Polliack, BS; Richard Taylor, PhD; Dan Bader, PhD *(p. 250)*

Purpose of the Work. This paper examines the nature of sweat by-products collected from soft tissues subjected to mechanical loading for long periods of time. **Procedures.** This loading was produced by 1) external application on the forearm and 2) buttocks support when seated in a wheelchair and sacral support when lying on an examination bed. Sweat pads were attached to the supported tissue areas of a group of able-bodied subjects. After a prescribed period the pads were removed and a quantitative analysis of the biochemical composition of sweat was performed. **Results.** Tissues subjected to pressure, which cut off blood supply to the body part, produced a general increase in concentrations of by-products such as lactate, chloride, ureas and urate, all associated with a decreased sweat rate which are noxious to the body if they are not flushed away. In the refilling of blood to the part when the load was relieved, some of these by-products were washed away. It is proposed that specific biochemical by-products remaining in the area too long may be used as an indicator of soft tissue damage. **Relevance to Veteran Population.** This technique may provide a simple means of identifying veterans and others in the disabled community who are at risk of developing pressure sores by analyzing the sweat content produced at at-risk areas of the body, such as the buttocks and/or sacrum. This is one of the primary reasons why it is important for those people who have lost sensation and motion in parts of their body subjected to mechanical loading to periodically change position (e.g., when sitting in a chair or lying in bed) so as not to keep pressure on any one area of the body for too long a time.

Dan Bader, PhD