ABSTRACTS OF RECENT LITERATURE

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These abstracts are drawn primarily from the prosthetics and orthotics literature. Selections of articles were made from these journals:

American Journal of Occupational Therapy
Archives of Orthopedic and Traumatic Surgery
Archives of Physical Medicine and Rehabilitation
Journal of Rehabilitation
Journal of Hand Surgery
Journal of Bone and Joint Surgery
Orthotics and Prosthetics
Physical Therapy
Prosthetics and Orthotics International

BALAKRISHNAN A (National Institute of Prosthetic and Orthotic Training, Orissa, India, Pin-754-0100). **Orthosis for Barefoot Walking.** *Prosth Orthot Int* 8: 165, 1984.

Most lower-limb orthoses cannot be used without footwear, even though patients may be required to walk barefoot due to economic circumstances, religious dictates, or comfort. If a shoe with stirrup is detached from the orthosis, the biomechanical function of the brace ankle joint is lost and relative movement will occur between the brace and the body. The modification allows the sole of the foot on the orthotic side to be bare under the heel and forefoot, with a support only under the arch, insuring a level pelvis while standing barefoot. Instead of a shoe, a molded arch support covering the longitudinal and transverse arches is fabricated from polypropylene or epoxy/polyester resin fiberglass laminate. The vertical pieces of a split stirrup are incorporated in the arch support, and the free ends of the stirrup are connected to the ankle joint of the orthosis. The arch support is attached to the foot by D-rings and Velcro fasteners. The orthosis can be used interchangeably: with or without footwear or it can be detached and replaced by a shoe-and-stirrup system. Paraplegics fitted with the orthosis report it to be light, comfortable, easy to don and doff, and easier to walk because of the weight reduction.

BOHLMAN H (Case Western Reserve University, Cleveland, OH). **Treatment of Fractures and Dislocations of the Thoracic and Lumbar Spine.** *J Bone Joint Surg* 67-A: 165–169, 1985.

Classification of fractures is based on stability and neuropathy. Those with a stable fracture have been treated since at least 1953 with 3 months or longer of bed rest, then with external orthoses. Computer-assisted tomography permits measuring the amount of bony intrusion into the spinal canal. Analysis of large numbers of patients at spinal cord injury centers indicates that a patient with complete cord and cauda equina injuries who had not recovered neurological function by 48 hours after injury would continue with complete lesion. The spinal cord ends at the thoracolumbar junction with all lumbar and sacral nerve roots passing by, so that injuries at this level may result in incomplete neuropathy. Emphasis is now placed on continued neural compression by bony fragments. The current shift in management is rapid mobilization by internal fixation, although this has not been shown to increase neurological recovery. Initial mechanical tissue disruption of the cord may be aggravated by motion or compression. Fractures of the 2nd to 10th thoracic vertebrae usually result in severe neuropathy, although fractures are often stable. After 3 to 6 weeks of recumbency, patients may sit in a molded spinal orthosis. Fractures of T_{11} through L_4 with incomplete neurological lesion are often treated with anterior decompression and fusion; the patient is allowed to walk in a molded orthosis within days after surgery. Fractures of the fifth lumbar vertebra with neurological defect are treated with laminectomy and

posterolateral fusion. Many patients with thoracic or lumbar fracture and incomplete neuropathy can recover significantly.

BUNGER C, SOLUND K, AND RASMUSSEN P (County Hospital of Sonderborg, Sonderborg, Denmark). **Early Results After Colles' Fracture: Functional Bracing in Supination Versus Dorsal Plaster Immobilization.** *Arch Orthop Traumat Surg* 103: 251–256, 1984.

One hundred forty-five consecutive patients, primarily women, with Colles' fractures were allocated randomly to dorsal plaster immobilization and to functional bracing in supination. Patients with ipsilateral fractures of the arm or other disabilities were excluded. Undisplaced fractures were treated with 15-cm-wide below-elbow plaster splints with the wrist and forearm in neutral flexion and 25-degree ulnar deviation. Those with displaced fractures (more than 3 mm shortening of radius or dorsal angulation or more than 2 mm of radial dislocation) had the wrist immobilized in 20-degree palmar flexion. Those with unstable fractures with much comminution, severe dorsal angulation, or extensive intra-articular engagement had the forearm in 60-degree pronation. Primary splints were removed after 12 days and replaced by low dorsal splints with the wrist in neutral flexion and deviation for 6 wk. Patients with functional bracing had an above-elbow splint with the forearm in 60-degree supination and the wrist ulnarly deviated 25 degrees and flexed. Splints were replaced after 1 week with a functional brace made of polyvinyl chloride ulnar hinged unit and Hexcelite bandage with a supracondylar extension to prevent pronation and supination, but to allow for elbow flexion and extension from 20 to 100 degrees. The brace allowed full palmar flexion, but limited dorsiflexion to neutral. The brace was removed after 5 weeks. Anatomical results did not differ in the two groups after primary treatment, but during the first 2 weeks of treatment redisplacement occurred in 52 percent of those with plaster and 25 percent of those braced. Bracing accounted for much less dorsal angulation. Functional results did not differ 7 weeks after fracture. Functional bracing provided superior results in the treatment of particularly displaced intra-articular Colles' fractures, probably due to prevention of postreduction displacement.

BURKETT L, KOHRT W, AND BUCHBINDER R (Department of Health and Physical Education, Arizona State University, Tempe, AZ 85287). **Effects of Shoes and Foot Orthotics on VO_2 and Selected Frontal Plane Knee Kinematics.** *Med Sci Sports Exercise* 17: 158–163, 1985.

Twenty-one male runners fitted with orthoses to correct lower-limb problems participated. All wore devices to run pain free. Devices were worn for 6 months to 4 years and were placed in a bilateral symmetrical manner. Most orthoses were polyintrinsic. All subjects experienced resolution of their initial complaint of pain. Prescription was preceded by gait analysis and range-of-motion examination. Plaster casts of both feet were taken, with the subtalar joint neutral and the midtarsal joint loaded. Orthoses were intrinsically posted by angular modification of the casts. All shells were polypropylene and extended to just behind the metatarsal heads. All included a rearfoot post of acrylic or high durometer crepe rubber. Each subject ran at various speeds on a treadmill while barefoot, with shoes, and with shoes plus orthoses. Expired air samples were taken. Subjects were filmed in frontal view with the patella as landmark. Average linear knee displacement for barefoot, shoe, and shoe plus orthosis were not significantly different; however, the average maximum angular displacement of the knee was significantly less when running barefoot, when the average time of support phase was also significantly less. Running in orthoses was significantly more costly than barefoot. Linear displacement results indicated that the lateral movement of the knee was not significantly altered by any of the experimental conditions. Angular displacement was affected. An orthosis controls subtalar motion, reducing the magnitude of lower-leg displacement. If reduction in segment displacement did not occur in the upper leg, the result would be increased angular displacement, as observed in this study. Reduced angular displacement may be attributed to modification of several mechanical variables, such as shock absorption. The observed increase in oxygen cost was due to the added mass of orthosis plus shoe, which is an important factor for competitive runners.

COLE D, DAVIS G, AND TRAUNERO J (Cole Orthotics, Inc., Toledo, OH 43612). **The Toledo Tenodesis Prosthesis: A Case History Utilizing a New Concept in Prosthetics for the Partial Hand Amputee.** *Orthot Prosthet* 38: 13–23, 1984.

For the patient with transmetacarpal amputation, current prosthetic treatment adds unwanted length required by the wrist unit and interferes with the operator's ability to perceive environmental place-

ment of the prosthesis accurately. Traditional prostheses also include a terminal device actuated by shoulder movement, even though the partial hand amputee retains wrist motion for tenodesis action, the method by which prehension of the index and middle fingers and the thumb is achieved through active wrist extension. The Toledo prosthesis is designed so that active wrist extension results in passive flexion of artificial fingers. The index and middle fingers are brought into opposition with the thumb, producing three-jaw chuck grasp. Release is accomplished by flexing the wrist, which results in passive extension of the artificial fingers. Wrist and metacarpophalangeal joints are interconnected by a linkage cable so that wrist motion is directly proportional to finger motion. The linkage also provides the user with pressure-sensory proprioceptive feedback. The prosthesis was fitted to 3-year-old girl who sustained third-degree burns over 80 percent of her body a year prior to fitting. She had bilateral metacarpophalangeal amputation and significant limitations in wrist and elbow motions, as well as multiple skin grafts and other surgical procedures. A jointed laminated socket and forearm shell are fabricated and connected by a wrist hinge on the ulnar side. The socket trimline begins just distal to the wrist on the ulnar aspect and proceeds in an oblique direction to the apex of the thenar eminence. The shell extends across the arm for two-thirds the circumference. The passive hand/finger module is made of fingers from an appropriately sized passive hand that are attached to the socket, casted, and formed of rigid plastic. The metacarpophalangeal articulation, linkage cable, and cosmetic glove are installed. The prosthesis is suspended by compression of the glove on the thenar eminence. The prototype has been used successfully on one child.

Collins K, Oswald P, Burger G, and Nolden J (Center for Rehabilitation, Providence Hospital, Everett, WA). **Customized Adjustable Orthoses: Their Use in Spasticity.** *Arch Phys Med Rehabil* 66: 397–398, 1985.

Customized adjustable orthoses improved and maintained range of motion in severely spastic wrist and ankles of a young woman with closed head injury. The wrists were flexed and the ankles exhibited extensor posture.

The orthoses are made of polyethylene or polypropylene with a Plastazote lining. They are molded over a cast, and are fabricated by drape forming with vacuum for intimate fit. Velcro straps hold the circumferential orthoses in place. The wrist orthosis has an adjustable small Klenzak joint in reverse position. The orthoses have been used on other patients with severely spastic wrist, elbow, and ankle joints. The elbow orthosis has a fracture brace joint.

Custom orthoses position the spastic limb, reducing tone. Adjustments can be done with the limb in the orthosis, preventing loss of motion. They are removable for hygiene and observation, and small adjustments allow slow, comfortable stretch. Also, adjustments are quick. Patients perform in the orthoses, and the orthosis becomes a permanent part of treatment. The orthoses are more expensive initially; however, cost is potentially offset by reduced morbidity from skin breakdown, decreased time in making adjustments or fabricating new devices, and permanence of gains in mobility.

Fernie G R, Griggs G, Bartlett S, and Lunau K (University of Toronto, Toronto, Ontario, Canada). **Shape Sensing for Computer-Aided Below-Knee Prosthetic Socket Design.** *Prosthet Orthot Int* 9: 12–16, 1985.

Two instruments have been developed to aid in the design of sockets. The first task for shape sensing is to capture the standard elements of shapes that have been developed over the years. The computer is programmed with characteristics of shape of a typical modified cast. The second step is a shape-sensing instrument to provide accurate and detailed measurements of the anatomical shape to be fitted.

Measurement involves a laser beam rotated around the limb, so that measurement is completed in 600 milliseconds, thus avoiding problems caused by involuntary movement. Nine cameras provide 72 sets of data at 5-degree intervals around the limb. As the beam rotates, the electronic control circuitry selects cameras that are appropriately positioned. The amputee is seated on a wheeled chair with a panel removed on the side of amputation. The chair is over the center of the shape sensor, and the subject lowers the limb into the sensor. Raw data are smoothed to eliminate spurious data points. The data are then transformed to real cylindrical polar coordinates. The final routine linearly interpolates between data points horizontally and vertically to obtain points on a cylindrical grid, providing for economic data storage, transfer, and display.

The system is modular, calibration procedure allows for reconfiguration without measurements, and the speed of measurement can be increased by increasing the number of light beams projected simultaneously. Resolution of shape-measurement instruments depends on the video-camera selection, object size and shape, number of cameras, number of video frames

analyzed, and software design. Because amputation limbs often swell very rapidly when removed from the socket, current research efforts are directed at determining the optimum conditions for measuring limbs. Presently, the subject wears an elastic stocking suspended by elastic webbing from the seat.

FOLLICK M, AHERN D, LASER-WOLSTON N, ADAMS A, AND MOLLOY A (Miriam Hospital Chronic Pain Research Unit, Providence, RI 02906). **Chronic Pain: Electromechanical Recording Device for Measuring Patients' Activity Patterns.** *Arch Phys Med Rehab* 66: 75–79, 1985.

An electromechanical device was developed to measure directly uptime or downtime of pain patients in their natural environments. The device is composed of a miniature electronic timer, a switching-delay circuit and battery pack, an electromechanical position switch, a belt with carrying cases, and a battery recharger. The position switch responds to changes in the position of the patient; it can be attached to the waist to monitor uptime or to the thigh to monitor downtime. When the switch is tilted beyond 70 degrees from the vertical plane, a steel ball rolls off the switch activator pole and releases the switch. When the switch returns to within 40 degrees of the vertical plane, the ball rolls back to close the switch. The timer case containing the stopwatch timer, switching-delay circuit and batteries is housed in a vinyl pouch attached to a belt. Reliability testing was conducted with two subjects blind to the purpose of the monitor and study. Subjects performed exercises in random sequence. Agreement coefficients were computed for position change and artifact testing at 1.0, indicating the monitor is reliable during uptime and downtime measurement, is resistant to abrupt movement artifact, and is not plane dependent. Concurrent validity of the monitor was also examined with two additional subjects who were videotaped as they exercised. Two observers blind to the study viewed the tapes and timed the duration of the subject in each position. Comparison of the observers' total times revealed agreement within ± 1.0 second for uptime trials and ± 4.0 seconds for downtime trials. Criterion ratings and monitor recordings were significantly correlated for uptime and downtime.

GERSH M AND WOLF S (Saint Luke's Memorial Hospital, Spokane, WA 99210). **Applications of Transcutaneous Electrical Nerve Stimulation in the Management of Patients with Pain: State-of-the-Art Update.** *Phys Ther* 65: 314–336, 1985.

A critical literature review regarding transcutaneous electrical nerve stimulation (TENS) was conducted to determine if more definitive information is available regarding the efficacy of treatment for specific diagnostic categories, current methods of application and their effects on treatment outcomes, and neurophysiological modes of action. One of the most successful application of TENS is for postoperative pain control, including rehabilitation benefits when using TENS to control the postoperative pain of knee surgery. Narcotic use decreased 75 to 100 percent, and recovery of quadriceps strength and knee motion was facilitated. With regard to the efficacy of TENS for chronic low back pain, patients responded better to higher intensity stimulation and obtained decreased benefits from treatment as time progressed. In a double-blind study of patients with chronic low back pain, TENS produced significantly greater improvement than suction-cup massage. Some investigators attempted to predict response to TENS, to identify those more likely to respond favorably to TENS. Older, retired patients with pain of less than 1 year duration, with limited or no surgery, and who used nonnarcotic analgesics were the best candidates. The gate theory has proven to form the basis for contemporary explanations of the neurophysiological mode of TENS action. The concept, developed in 1965, involved large-diameter afferent fiber activation of greater frequency and intensity than smaller-fiber input, activating inhibitory interneurons to presynaptically inhibit transmission centrally from both the noxious and nonnoxious inputs, thus closing the gate. The opposite effect predominates if greater transmission occurred through the smaller-diameter system. Thus, pain perception could be modulated somewhere within the neuraxis if the appropriate stimuli could be delivered and the appropriate neural substrate on which such stimuli might act could be found. The article includes extensive references: 50 are cited in the text, as well as an additional 64 pertaining to pain and TENS, 60 to clinical pain mechanisms, 163 to basic pain mechanisms, 24 to surgical approaches to pain, 59 to acupuncture, 51 to endogenous opiates in humans, 118 to endogenous animal opiates, 22 to serotonergic mechanisms, 48 to opiate antagonists, and 49 to neurotransmitters and other drugs.

GILAD I (Israel Institute of Technology, Haifa, Israel). **Motion Pattern Analysis for Evaluation and Design of a Prosthetic Hook.** *Arch Phys Med Rehabil* 66: 399–402, 1985.

Four below-elbow amputees were fitted with a new design for a terminal device, based on the lyre-shaped

hook. The new hook was designed and manufactured at the Technion-Israel Institute of Technology. Amputees wore body-powered prostheses. Subjects were tested with the standard hook and the new hook on a task board that included 12 objects differing in shape (ball, cube, cylinder, and triangle) and weight and size (small, medium, and large). Performance was filmed and kinesiologic events, motion patterns, motion durations, and temporal relationship between motions were recorded by frame-by-frame analysis. Discriminant analysis was used to assess the contribution of each motion element for its effect on performance time.

The new hook has the basic lyre-shaped fingers with two additional fingers that form a double forceps for better maintaining of multiform and round objects. Adjustable mini-embossments attached to the added fingers, allow safe holding of large balls and provide additional support to irregular objects. The hook provides a close grip for briefcases. The inner surfaces are bonded with roughened rubber to provide friction. Performance was faster with the triangle, cylinder, and ball but not with the cube.

HANNAH R AND COTTRILL S (Medical Engineering Resource Unit, University of British Columbia, Vancouver BC V6H 3N1). **The Canadian Collar: A New Cervical Spine Orthosis.** *Am J Occup Ther* 39: 171–177, 1985.

A new family of orthoses called *tubular orthoses* is under development. The collar has two pieces of pliable, clear polyvinyl chloride tubing that form the upper and lower perimeters of the collar and six, short rigid nylon tubes that provide vertical support. A specially designed T-junction connects the tubing to the short tubes by forming a right-angle union. A performed nylon rod chin, breastplate pieces, and small chin cup provide anterior support. Tubing is cut to length. Three pairs of nylon tubes are symmetrically arranged anteriorly, laterally, and posteriorly. Collar assembly starts by placing components on a work surface. Posterior nylon supports run from C_7 to the occiput. Lateral tubes are half the distance between the clavicle to the angle of the mandible. Anterior tubes provide the desired position of flexion and are connected to the chin support and breastplate. Assembly and fitting takes 30 to 45 minutes. Fifteen orthoses were fitted primarily to elderly, arthritic patients; collars were also provided to a child with juvenile rheumatoid arthritis, and individuals with cerebrovascular accident, amyotrophic lateral sclerosis, osteomyelitis, whiplash injury, and spinal cord injury. Subjective responses were solicited. Three-quarters of the group were considered successful; another 7 percent were partial successes, with compound problems and/or poor motivation. Patients commented that the collar gave coolness and good support. The correct selection of neck-flexion angle markedly influenced the patient's ability to communicate, watch television, type, read, and write. The new orthosis was often used in conjunction with soft collars. Most patients were able to don the collar themselves. For those with asymmetry, the collar was designed with a longer lateral tube on one side. A potential area of application is long-term protection and posture control for high-level spinal cord–injured individuals. The collar accommodates a tracheal respirator tube.

HITTENBERGER D AND PUTZI R (Prosthetics Research Study, Seattle, WA). **A Laminated Ultralight Prosthesis.** *Orthot Prosthet* 39: 41–46, 1985.

Fabrication and prescription criteria for a hollow below-knee prosthesis weighing 1½ to 2 pounds are presented. After fabrication of a socket liner in the usual manner, the socket is laminated of nyglass, fiberglass, and acrylic resin. An Otto Bock Pedilan foot is used because it provides the same function as the SACH foot and weighs less. The foot is attached to a pylon, as is the alignment block. After dynamic alignment, the prosthetist removes the pylon and block, and fills the void between the socket and the foot with rigid polyurethane foam. The exterior is laminated, and once hardened, the shell is split down the back. The posterior shell seam is bonded with fiberglass webbing and acrylic resin. The foam is removed from the socket and the shell is glued to the socket. The prosthesis is filled with sand to keep the shell from collapsing during the second lamination. A secondary socket is laminated using carbon fiber, fiberglass, nyglass and acrylic resin. Once final vacuum lamination is complete, the sand is drained and the foot is attached and painted with Ultra-Dip.

The prosthesis is designed to be durable enough for the geriatric amputee. Adding several layers of carbon and fiberglass around the ankle and calf will make it more durable. Fabrication is more time consuming, although it does not require new equipment. The prosthesis is not recommended for the newer amputee because it lacks adjustment capability.

HOSCHEK J, WEBER U, LADSTATTER P, AND SCHELSKE H J (Orthopadische Universitats-Klinik, D-6300 Giessen, Federal Republic of Germany). **Mathematical Kinematics in Engineering of Endoprostheses: Evaluation of the Results of Gait**

Analysis. *Arch Orthop Traumat Surg* 103: 342–347, 1984.

The object of the study was to measure the passive and dynamic range of motion of the normal knee with motographic stereometric methods and to evaluate the results with mathematical-kinematic analysis to establish error. Miniature lamps were attached to the skin of each volunteer: five lamps on the thigh and five on the lower leg. Lamps blinked at a frequency of 16.6 Hz. Motion of the blinking lamps was photographed with two stereocameras, providing light traces as the volunteer performed knee-bending. The three-dimensional marker coordinates describe the movement of the leg if the markers do not change their relative position during testing. Variation in marker distance is very small for most markers on the recumbent subject. Knee-bending is associated with great displacement of the skin on the thigh. Commercially available knee-joint endoprostheses are kinematically imperfect, resulting in increased wear, fatigue of stabilization parts, and loosening. Modern measuring techniques show that joint motion depends on the demonstration of movement of points on the body surface. By simultaneously measuring different diameters it is possible to perform three-dimensional analysis. Common methods of gait analysis have point inaccuracy of 3-5 mm, which is unacceptable in endoprosthetics. Motography that produces well-defined joint trajectories has minimal error. Soft tissue shifting on the thigh makes it impossible to ascertain joint motion by surface imaging. Mathematical-kinematic methods permit estimating the range of error and explaining the reason for failure.

HUNDERTMARK L (LaGrangeville, NY 12540). **Evaluating the Adult with Cerebral Palsy for Specialized Adaptive Seating.** *Phys Ther* 65: 209-212, 1985.

Adaptive seating may be the most important device for a client who cannot be comfortably, safely, and functionally seated in a commercial wheelchair. Most adults have severe extensor spasticity with severe scoliosis and severe contractures. The client should be evaluated in the sitting position over the side of a mat table. Particular attention must be paid to anterior and posterior pelvic tilt and lateral symmetry. One should note if reflexes or abnormal movement patterns change as the pelvis and trunk are moved in all planes. As the pelvis is tilted anteriorly, righting and equilibrium reactions may result in head and trunk extension and hip and knee flexion. Posterior tilting may trigger hip extension. If the client is tilted back more than 15 degrees, he may curl the trunk into flexion. The initial seating assessment is applied to an adjustable fitting chair, permitting changes in width, depth, height of footboard, armrests, backrest, and the angle of the seat. A standard wheelchair may be adjusted with triple-density cardboard inserts and pieces of foam and wood. The optimal position is 90 degrees horizontal for the seat and 90 degrees vertical for the backrest. Scoliosis requires a back contour of foam. The pelvis should have slight anterior tilt, equal bearing on the ischia, and the iliac crests equally against the backrest, even if the knees drift to the opposite side to assure that the pelvis and trunk are not rotated. The corrected position may be maintained with a wedge-shaped cushion along the abducted thigh. The seat angle may be altered by spacers, and a block moved behind the backrest from bottom to top will vary the trunk angle. The entire unit is tilted by wedging the front casters. The foot support should allow 90 degrees or more of knee flexion; calf panels should not be used to avoid hamstring facilitation. A tilted tray may maintain hands in midline and may have a high inner rim for trunk support.

KAILES J **Watch Your Language, Please!** *J Rehab* 51: 68–69, 1985.

Attitudinal barriers are difficult to overcome and must be dealt with on many levels, including language. People within the disabled community are continually confronted by language that perpetuates negative stereotypes. *Disability* is a medical condition, whereas *handicap* is the cumulative result of the obstacles that disability interposes between an individual and his/her maximum functional level. A disability is thus not always a handicap. *A person with a disability* is preferable to *a disabled person*, for the former connotes that a person is the focus. *Wheelchair user* is preferable to *wheelchair bound or confined*, for one is not bound to a chair. The chair increases the ease and speed of movement. Better to refer to a person who is *non-disabled* than to one who is *normal*, for the latter implies that persons with disabilities are less than normal. *Cripple* and *patient* are other terms perpetuating negative images. Additional dehumanizing, offensive, and unacceptable terms are *she is crippled* (should be, "she has a disability"); "he is arthritic" (should be, *he has arthritis*), *patient* (should be used only when a person is actually being seen or treated by medical personnel). *Afflicted*, *burden*, *defect*, *deformity*, *invalid*, *maimed*, *stricken with*, *sufferer*, and *victim* are other terms to be avoided

because of their negative connotations and tendency to evoke pity.

KREBS D, EDELSTEIN J, AND FISHMAN S (New York University Post-Graduate Medical School, New York, NY). **Reliability of Observational Kinematic Gait Analysis.** *Phys Ther* 65: 1027–1033, 1985.

Videotape recording of 15 wearers of bilateral knee-ankle-foot orthoses were rated by 3 experienced and highly trained physical therapists. The subjects, individuals ranging in age from 60 to 258 months, were each fitted with a pair of plastic-and-metal orthoses and a pair of leather-and-metal braces of similar design. Both types of orthoses were worn at least 2 weeks before videotaping. Recordings were made of frontal and sagittal views of the trunk and lower limbs and close-up frontal views of the feet. The order of braces was independently randomized. All taping was done at the same comfortable cadence for each subject.

Raters participated in four rating sessions. During the first session, seven subjects were rated in their leather-ane-metal orthoses and eight in plastic-and-metal ones. One week later, ratings were conducted for the remaining tapes. Third and fourth sessions were conducted a month later to permit intrarater and interrater analyses. The rating form was derived from widely used forms; it provided for notation of normal, just noticeably abnormal, and very noticeably abnormal scoring during early, mid and late stance, for foot, knee, and hip motions.

Overall, of the 1,080 pairs of observations between sessions for each rater, full intrarater agreement was achieved an average of 742 times and maximum disagreement an average of 35 times. Complete interrater agreement occurred an average of 67.5 percent of the ratings and maximum disagreement on 3 percent of the ratings. The average intrarater standard error represented 4 percent maximum variability and average interrater standard error represented 15.6 maximum. Pearson correlations, analysis of variance, and intraclass correlation coefficents were also computed.

Observational gait analysis is a popular and convenient but only moderately reliable technique for investigating kinematic gait deviations; under nearly ideal conditions, raters achieved less than 7 agreements out of 10 observations.

KLASSON B (Een-Holmgren Ort. AB, Stockholm, Sweden). **Computer-Aided Design, Computer-Aided Manufacture, and Other Computer Aids in Prosthetics and Orthotics.** *Prosthet Orthot Int* 9: 3–11, 1985.

Computer-aided design is the introduction of descriptions of geometrical configurations into computer memories, where they can be displayed and modified. The design process, artwork based on science, covers such activities as generation of ideas, creation of geometrical shapes, calculations, experiments, simulation, and development of manufacturing data. The design approach may be iterative, developed through intuition and modified; the approach may be direct, an analysis of the problem for the direct development of an acceptable solution; or the approach may be a choice from alternatives. Contemporary computer-aided design is much more efficient in modifying designs, amplifying the designer's memory, supporting analytical and logical ability, and doing repetitive routines. The process avoids work duplication, simplifies studying three-dimensional geometries, and facilitates documentation.

Computer-aided manufacture includes preparations for manufacture and the manufacture itself. It can be used without computer-aided design. Computer-aided manufacture can make prosthetic and orthotic fitting reproducible, aiding patient service and research. The resulting device is much less expensive. The three steps in current projects is *1)* to find a way to arrive at an optimal socket shape, *2)* find a rational way to manufacture the socket, and *3)* find a way to modify the socket after fitting it. A system is already a reality through joint efforts between the University of British Columbia and University College, London. The design process takes 10 minutes; numerically controlled carving of a mold takes 10 minutes; socket making in a Rapidform machine takes 30 minutes. Future developments may be combining computer design with a measurement technique that deforms the amputation limb to create the shape of the mold. Education in prosthetics and orthotics must prepare new practitioners for the new technology.

KRITTER A (Waukesha, WI). **Myoelectric Prostheses.** *J Bone Joint Surg* 67*A*: 654–657, 1985.

Myoelectric prostheses, the most exciting improvement in prosthetics, are based on the principle that any limb motion is preceded by muscle currents. In 1936, the first device to appear in which the biological signal controlled a machine was one that measured lethal electric shocks. In 1960 Kobrinski presented the

first series of amputees fitted with electrically driven prostheses. The prosthesis is controlled by the action potential of the muscle membrane that develops secondarily to the excitation of the central nervous system. The force developed by the muscle is linearly proportional to the change in voltage and to the frequency of central stimulation. Any program of muscle action may be represented as a set of pulses sent from the central nervous system to the muscle. The prosthetic hand is usually activated by two electrodes over opposing muscle groups. The electrical potential of the muscle is detected by skin electrodes in the socket of the prosthesis. The potential controls the action of the prosthesis, which is powered by a battery. The most common prosthesis is below-elbow, powered by a 6-volt battery of 225 milliamperes. The adult prosthetic hand is three-pronged with grip varying from 1.5 to 8 kilopounds, a finger opening from 60 to 100 millimeters, and weighing 220 to 500 grams. The socket is usually a Muenster or Northwester fit. No sock is worn.

The Swedish Systemteknik child hand has a 50-millimeter opening and 1.2 kilogram pinch force and has been fitted successfully to 40 preschool children in Sweden. The hand is not suitable for bilateral amputees. Older children are more apt to reject myoelectric prostheses because of fragility, poor function, and heaviness. The most common problems were the cosmetic glove and the batteries. Conversion of older children to a myoelectric hand is very successful.

Adult below-elbow amputees used the myoelectric prosthesis more than a standard one, proving its considerable cosmetic value, except by those working at heavy labor. One-third of adult wearers contend that the myoelectric prosthesis provides tactile feedback.

LEHMANN J, CONDON S, DE LATEUR B, AND SMITH JC (Department of Rehabilitation Medicine, University of Washington, Seattle, WA). **Ankle-Foot Orthoses: Effect on Gait Abnormalities in Tibial Nerve Paralysis.** *Arch Phys Med Rehabil* 66: 212–218, 1985.

Six able-bodied young adults participated in seven ambulation tasks during which limb motions, ground reactive forces, timing of gait events, and step lengths were recorded. Subjects walked normally at normal and slower cadence; subjects had a right tibial nerve block while walking with and without an ankle foot orthosis with anterior stop set at 5-degree dorsiflexion and while walking with the orthosis with stop set at 5-degree plantar flexion.

The orthoses restored step length and speed to levels not significantly different from those observed during normal ambulation. Tibial block had a significant reduction on steplength and speed. Paralysis of the plantar flexors hindered advance of the center of pressure until late stance after weight is transferred to the opposite limb. If the subject allowed the normal forward movement of the center of pressure, the ankle would collapse into maximal dorsiflexion. With the orthosis, the center of pressure was faster to progress. The orthosis with 5-degree plantar flexion at the anterior stop provided the most restoration. Blockage had a significant effect on the magnitude on the dorsiflexion moment; both orthoses improved the values, but they were still significantly less than normal. Heel-off was delayed in the block condition occurring well after the opposite heel-strike. The orthosis with plantar flexion restored timing to normal limits. Knee-flexion moment increased in the block condition; the orthosis with plantar flexion restored the moment to normal limits.

The results suggest that the anterior stop of an ankle foot orthosis can substitute for loss of gastrocnemius-soleus function. A stop set in more than 5-degree plantar flexion would interfere with toe clearance during swing and may produce genu recurvatum.

LEHMANN J, CONDON S, DE LATEUR B, AND SMITH JC (Department of Rehabilitation Medicine, University of Washington, Seattle, WA 98195). **Gait Abnormalities in Tibial Nerve Paralysis: A Biomechanical Study.** *Arch Phys Med Rehabil* 66: 80–85, 1985.

Six healthy young adults were each fitted with a pair of Blucher-style shoes and with markers on the greater trochanter, lateral epicondyle, head of the fibula, lateral melliolu, and head of the fifth metatarsal. Right lower-limb motion, ground reactive forces of the right limb, timing of left and right gait events, and left and right step length were recorded. A 35-mm movie camera recorded motions at 24 frames per second. A Kistler triaxial force plate recorded ground forces' magnitude, direction, and location. Timing was recorded when conductive tape applied to the heels and soles made or broke contact with conductive walkway. Step length was measured from marks made on the walkway as the subject walked. Normal cadence was recorded. After right tibial nerve block and with the aid of a metronome, subjects performed at 80 percent of normal cadence. Step length was reduced bilaterally, and walking speed reduced from 54.0 to 45.1 meters per minute. Reduction in step length was

greater for the left (unblocked) step. Right heeloff occurred at 51 percent of the gait cycle after block, compared with 38 percent without the block. Normally, right heeloff occurred when the vertical force averaged 97 percent of body weight; with the block, vertical force decreased to 40 percent of body weight. Left heelstrike occurred slightly earlier after the block. Midstance was longer than normal (40 percent of cycle vs. 26 percent), and pushoff phase was shorter than normal (12 percent vs. 26 percent). Advancement of the greater trochanter was significantly reduced after the block, although neither the height of the trochanter, nor the knee and ankle angles were altered. To avoid ankle collapse, subjects maintained the ground reactive force line at or behind the ankle until opposite heelstrike. Preventing dorsiflexion is essential to achieve increased supporting limb length at the time of opposite heelstrike to prevent undue lowering of the pelvis.

LOANE T AND KIRBY RL (Department of Medicine, Dalhousie University, Halifax, NS B3H 4K4). **Static Rear Stability of Conventional and Lightweight Variable-Axle-Position Wheelchairs.** *Arch Phys Med Rehabil* 66: 174–176, 1985.

Ten able-bodied subjects, five men and five women, were studied while using a lightweight and a conventional wheelchair. The conventional chair was a collapsible model weighing 22.6 kilograms with swinging detachable footrests, removable desk arms, and 20-cm solid casters. The lightweight model was a titanium, rigid frame sports model weighing 12.3 kg with a one-piece footrests, 10 cm urethan front casters and no armrests. Twenty-one experienced wheelchair users were tested in their own chairs. They included 13 with spinal cord disorder and eight amputees. Each subject sat in the wheelchair on a testing platform in which the pitch was slowly increased. The stability point, the angle at which both front casters lifted off the platform, was measured. Inter- and intraobserver test-retest measurement reliabilities were assessed at 0.97 and 0.974, respectively. The lightweight chair demonstrated significantly less rear stability than the conventional chair, although stability was greatest with the axle in the low posterior position and was worst in the high anterior position. Raising the center of mass by elevating the seat height produced greater rear stability than with the seat in the lower positions. The chair reclined when the seat was lowered, and less rear angulation was required to initiate tipping. Further development of lightweight chairs should include adjustable-height front casters and a wider range of rear-axle settings. Rear stability was tested with the brakes unlocked, unlike in the Veterans Administration study. When wheels are locked, the axis of rotation around which tipping occurs is the contact point of the rear wheels with the ground. When wheels are unlocked, the axis is the rear axle of the chair, which is a more realistic situation. Using live subjects is preferable to using dummies or test loads, as were used in earlier studies.

LOBLEY S, ROGERSON J, CULLEN J, AND FREED M (New England Regional Spinal Cord Injury Center, Boston, MA). **Orthotic Design from the New England Regional Spinal Cord Injury Center.** *Phys Ther* 65: 492–493, 1985.

In 1981 a knee-ankle orthosis was developed that incorporated the superior features of the Craig-Scott orthosis but which eliminated the heavy custom-made shoes and mechanical ankle joint and was lighter, more attractive, and less expensive. The new orthosis consists of an ankle-foot support of 0.25 in stress-relieved polypropylene, bilateral aluminum uprights tripe riveted to the plastic, offset steel drop lock knee joints, an aluminum tibial cuff closed with two Jewett back brace snaps, and a thigh band. The orthosis weighs between 3 and 4 pounds; the patient can wear light shoes, such as athletic shoes with Velcro closure straps.

Ambulation training with the orthosis usually begins 8 weeks after injury. By 6 months after injury, leg size generally stabilizes and further modification of the orthosis is unnecessary. An individual with incomplete lesion may progress from knee-ankle orthoses to ankle-foot orthoses. Over the past 3 years, 22 bilateral and 6 unilateral orthoses have been fabricated without breakage or other malfunction. The orthoses are indicated for individuals with complete injuries below T_6 or those with incomplete injuries who are capable of standing, have circumferential measurements that do not vary more than 1 cm per day, and have full hip range of motion.

MATHIOWETZ V, KASHMAN N, VOLLAND G, WEBER K, DOWE M, AND ROGERS S (Occupational Therapy Program, University of Wisconsin-Milwaukee, Milwaukee, WI 53201). **Grip and Pinch Strength: Normative Date for Adults.** *Arch Phys Med Rehabil* 66: 69–74, 1985.

Strength of 310 men and 318 women, aged 20 to 94 years, was evaluated. Grip was tested with a Jamar dynamometer with the handle set in the same position

for all subjects. The B&L pinch gauge was used to measure tip, key, and palmar pinch. Subjects were seated with the shoulder adducted and neutrally rotated, elbow flexed at 90 degrees, forearm in neutral position, and wrist between 0 and 30 degrees dorsiflexion and between 0 and 15 degrees ulnar deviation. Grip strength peaked withing the 25 to 39 year age group for men and women, then gradually declined. Tip, key, and palmar pinch scores were stable for the 55 to 59 year group before declining gradually. The highest correlations were achieved between right- and left-hand scores for each test, with the right hand stronger even for left-dominant subjects. The only exceptions were higher tip and palmar pinch scores on the left hand for left-dominant women. Average grip strength ranged from a high of 121.8 pounds for men aged 30 to 34 years to a low of 37.6 pounds for women older than 75 years. The strongest tip pinch was 18.7 pounds for men 45 to 49 years old. Highest key pinch was registered by men 25 to 29 years old at 26.7 pounds. Men aged 20 to 24 years registered the strongest palmar pinch at 26.6 pounds. Grip strength is highly correlated with age, whereas age correlates to a low to moderate extent with pinch strength. Data in this study were generally similar to that reported earlier, although improved scores for women may reflect changing sex roles in our society or the use of newer pinch gauges. Data show a curvilinear relationship, with strength peaking for those between 25 and 50 years old and decreasing thereafter.

McPherson J, Becker A, and Franszczak N (University of Wisconsin-Milwaukee, Milwaukee, Wisconsin). **Dynamic Splint to Reduce the Passive Component of Hypertonicity.** *Arch Phys Med Rehabil* 66: 249–252, 1985.

Eight geriatric hemiplegics were matched by age and sex and assigned to two groups. One group wore a dynamic hand splint constructed from an injectable mold plastic. The mold is made in one size and the dorsal forearm surface and finger portion are cut to fit the individual. The splint allows movement in flexion, extension, abduction, and adduction of the fingers and wrist flexion and extension; movement is resisted by 1.35 kg of force toward full wrist and finger extension. The splinted group wore the orthosis for 1 hour 3 days a week. The other group received passive range of motion treatment 3 days a week. The force toward flexion was measured with a spring-weighted scale on all subjects independently.

The dynamic splint reduced the force of wrist flexors, unlike passive range of motion. Data were also compared with results from an earlier study involving static splinting. Dynamic splinting was twice as effective as static splinting and more than three times as effective as passive exercise, probably because the dynamic splint altered the passive viscoelastic force of the muscle by more constant and more forceful resistance to flexion. No rebound, i.e., increased rate of firing of spastic musculature, occurred.

Mueller M and Delitto A (Program in Physical Therapy, Washington University School of Medicine, Saint Louis, MO). **Selective Criteria for Successful Long-Term Prosthetic Use.** *Phys Ther* 65: 1037–1040, 1985.

Questionnaire study of all unilateral below- and above-knee amputees provided with a prosthesis between 1977 and 1982 obtained responses from 56 patients, ranging from 49 to 88 years of age. Telephone responses were augmented by review of the medical record.

Below-knee amputees were much more successful wearers than above-knee amputees. Thirty-seven of 38 below-knee amputees were still wearing the prosthesis daily, compared with only 7 of 18 above-knee amputees. No significant difference exists among above-knee amputees who are or are not wearers, when age, time from prescription, obesity, strength, range of motion, or sex are considered. Two criteria that did show significant difference among above-knee amputees were compliance and medical problems after prosthetic prescription. Compliance was defined as keeping all appointments and following recommendations, and is influenced by motivation. Above-knee amputees with complications such as stroke, pulmonary disease, angina, or contralateral lesions should be prescribed prostheses with great caution. The amputee who is a marginal candidate should be assessed with regard to compliance with the preprosthetic program.

Mustapha NM, Jain SK, Dudley P, and Redhead RG (Limb Fitting Centre, London SW15 5PR, UK). **The Effect of Oxygen Inhalation and Intravenous Naftidrofuryl on the Transcutaneous Partial Oxygen Pressure in Ischaemic Lower Limbs.** *Prosth Orthot Int* 8: 135–138, 1984.

At the central control site (5 cm below the midclavicular line) oxygen produced a significant increase in transcutaneous partial oxygen pressure, whereas there was no change after Naftidrofuryl infusion. At

the 10 cm below-knee site there were significant rises after oxygen inhalation alone, Naftidrofuryl alone, and both combined. The regimen improves the viability of ischemic limbs showing borderline transcutaneous partial oxygen pressure and increases the chances of a successful below-knee amputation. Recordings were made from a control site below the midclavicular point and a site below the knee anteriorly, marking the critical perfusion level in relation to the anterior incision line of the commonly performed below-knee amputation technique. Oxygen inhalation was administered to six young healthy volunteers and six elderly volunteers with no signs of peripheral vascular insufficiency or central cardiopulmonary deficit. Dysvascular patients had inhalation and infusion, then inhalation. Young volunteers showed an average oxygen pressure of 80 mmHg at the control site before inhalation, rising ot 119 mmHg after inhalation; at the below-knee site, they had 92 mmHg prior to inhalation and 129 mmHg afterward. Healthy older volunteers showed a 27 percent rise in pressure at the below-knee site. The 20 dysvascular patients also showed significant rise after inhalation and still higher pressure after infusion and inhalation. The regimen is presented only as a guide; varying clinical conditions will inevitably call for a flexible application to assist clinicians in dealing with borderline ischemia before or immediately after amputation.

PALMER A, WERNER F, MURPHY D, AND GLISSON R (Department of Orthopedics, Upstate Medical Center, Syracuse, NY 13210). **Functional Wrist Motion: A Biomechanical Study.** *J Hand Surg* 10A: 39–46, 1985.

A triaxial electrogoniometer was designed to analyze 10 normal subjects as they performed daily activities. The goniometer was secured with molded Orthoplast hand and radial brackets and Coban tape. To validate the instrument, it was applied with Steinmann pins to the metacarpals and radius of one subject. All subjects were measured as they moved the wrist through flexion and extension and radial and ulnar deviation; they also performed 5 hygienic activities, 8 culinary tasks, and 11 other common activities. In addition, smaller groups of subjects were measured as they executed seven common carpentry tasks, five housekeeping maneuvers, five mechanics' tasks, four secretarial activities, and five surgical skills. The data from the externally fixated goniometer were very similar to that obtained from the pinned instrument, except for marked discrepancy in carpal rotation data. Pin data revealed true carpal rotation ranging from 2.2 degrees when printing a name to 11.8 degrees when opening and closing a jar, which indicated that the wrist has 3 degrees of freedom. Neutral position was placed with the third metacarpal coaxial with the radial shaft and the center of goniometer articulation at the radiocarpal joint. Average maximum wrist motion was 133.3 degrees of sagittal motion and 40.5 degrees frontal motion. For the common tasks, a range of 32.5 degrees of flexion to 58.6 degrees of extension was used, as well as a range of 23.0 degrees of radial deviation to 21.5 degrees of ulnar deviation. Hygienic activities required the greatest range and culinary skills, the least. Carpentry was performed with the wrist extended, as were housekeeping tasks, which also needed radial deviation. Mechanics' activities were done in extension with minimal deviation. Secretarial activities needed minimal wrist motion, except for phoning and folding a letter, which required flexion.

OTIS J, LANE J, AND KROLL M (Hospital for Special Surgery, New York, NY). **Energy Cost During Gait in Osteosarcoma Patients After Resection and Knee Replacement and After Above-the-Knee Amputation.** *J Bone Joint Surg* 67*A*: 606–611, 1985.

Fourteen patients treated for osteogenic sarcoma had en bloc resection and segmental replacement with a knee prosthesis; the mean age was 20.3 ± 2.8 years. Criteria for resection included absence of tumor of the neurovascular bundle, adequate tissue to cover the implant, no pathological fractures or radiotherapy, or infection. Patients had less than 10 percent of knee-extensor strength, 25 percent of flexor strength, and 50 percent of ankle strength. The knee hyperextended 5 degrees during stance and heel rise was absent during the terminal part of stance. The group of amputees had a mean age of 19.7 ± 5.1 years. Performance was compared with a group of normal controls of similar age. No participants used walking aids.

Expired air was collected in a Douglas bag; heart rate was monitored using telemetry. The walkway had 24 lights that flashed sequentally to pace the subjects. Subjects walked at free and 20 percent faster speed for 6 minutes. Average free speed for resection patients and amputees was 87 and 73 percent, respectively, of normal controls. Net oxygen costs for free speed were 138 percent of normal for resection patients and 185 percent for amputees. The patients did not show increased cost at the faster speed, although normal subjects did. Heart rates at free speed for controls, resection patients, and amputees were 96,

118, and 140 beats per minute, respectively. Five resection patients were studied at 6 and 18 months after surgery and showed no changes in speed or cost. Amputees demonstrated significant increase in speed and decrease in energy cost over a 15-month period.

Superior performance of resection patients compared with amputees was compounded by the psychological and cosmetic advantages of the procedure.

PATTERSON P AND SHEA C (College of Education, Texas A&M University, College Station, TX). **Augmented Auditory Information in the Control of Upper-Limb Prostheses.** *Arch Phys Med Rehabil* 66: 243–245, 1985.

Five young men with left above-elbow prosthetic experience were compared with five nonamputees. Subjects were blindfolded and seated in front of a linear track apparatus. The experimenter placed the subject's hand or terminal device, with elbow unit locked, on the cursor and presented the total movement range. The subject moved the cursor from left to right until striking a stop placed at a preselected point. During augmented feedback, cursor movement was accompanied by a tone that increased in intensity and pitch as the distance from the starting point increased. Reproduction movements were undertaken immediately, after a 15-second rest interval, or after a 15-second filled interval of vocal counting backward by three. When recall accuracy was maintained over an unfilled retention interval, but declined after a filled interval, it was assumed that the subject was able to process relevant movement cures. Decreases in recall accuracy after both filled and unfilled retention intervals suggest that the subject was not effective in coding and processing the available cues.

Augmented feedback facilitated immediate recall, with the amputees repositioning more accurately than the normal group. Amputees appeared to process information centrally, unlike nonamputees, who could not, or chose not to, utilize the augmented auditory information. Feedback may aid in training recent amputees in the nonvisual use of their prostheses.

RAJARAM V AND HOLTZ M (Alexian Brothers Medical Center, Elk Grove Village, IL 60007). **Shoulder Forearm Support for the Subluxed Shoulder.** *Arch Phys Med Rehabil* 66: 191–192, 1985.

A shoulder forearm support was devised for patients with painful, flaccid upper-limb with shoulder subluxation. The sling is constructed of Orthoplast, 5 cm webbing, and cotton fabric. The shoulder piece is plastic and is custom fit over the anterior and posterior portions of the involved shoulder and surrounding two-thirds of the length of the humerus. The humeral support is tightened with two Velcro straps and D-rings. Three pieces of nonelastic webbing anchor the shoulder portion. Two pieces, one in front and the other in back, are riveted to the plastic. The third strip of webbing is sewn to the intersection of the other strips and travels across the patient's back (under the contralateral axilla and across the chest) and is pulled through a D-ring anchored on the plastic. The support should maintain the shoulder in adduction and external rotation. The forearm piece is made of cotton, cut to cradle the forearm, elbow, and overlap 5 cm of the distal plastic. The piece should support the elbow firmly at 90 degrees and allow the wrist to rest in a neutral position. Wrist and hand are supported by an adjustable strap that loops over the chest strap of the shoulder portion. The axilla portion of strap is padded with foam encased in stockinette. The sling is used when the involved limb is flaccid, causing the glenoid to face down. The support supports the shoulder, keeping the glenoid facing laterally and up. X rays confirmed the efficacy of the support. The patient wears only the shoulder portion when sitting in a wheelchair with a lapboard, adding the forearm support when ambulating. Fabrication and fitting time is approximately 4 hours and materials cost approximately $35. The support has been used on 20 patients with 90 percent success; however, the sling is cumbersome to don.

RAUSCH R AND KHALILI AA (University of Illinois Hospital, Chicago, IL). **Air Splint in Preprosthetic Rehabilitation of Lower Extremity Amputated Limbs.** *Phys Ther* 65: 912–914, 1985.

Management of postoperative edema is an integral component of preprosthetic rehabilitation to enhance limb maturation and to hasten healing in compliance with diagnostic-related groupings. The material for edema management must apply selective pressure over the limb without restricting distal circulation, should allow inspection and dressing change at the operative site, should promote patient compliance, be comfortable, easily applied, and cosmetically acceptable. Traditional elastic wraps are difficult to apply and must be changed frequently to maintain adequate pressure; the risk of tourniquet effect is present. Shrinkers must be changed frequently and are difficult to suspend. Rigid dressing are difficult to apply and do not allow wound inspection. Unna dressing requires skill in prosthesis fabrication and does not afford easy inspection of the wound. Air splinting provides uniform pressure, allows easy access, and is easy to use. The authors used air splinting on over 100

patients successfully. The splint can be applied immediately after surgery, but is usually applied 2 to 10 days later. Gauze is placed over the wound, and stockinette is drawn over the leg to the proximal thigh to absorb perspiration. The splint zipper is anterior for easy access. The splint is inflated to 25 to 30 mmHg, and remains on continuously, except for inspection and exercise. The bulkiness of the splint makes exercising difficult and is temporarily replaced by elastic wraps. For ambulation a metal cone is applied over the splint, which is inflated to 50 mmHg. Prosthetic fitting usually occurs within 20 days after the air splint is first applied. The splint is self-suspending and lightweight. It decreases the risk of knee-flexion contracture while allowing some knee movement. It is cumbersome, hot, and vulnerable to puncture, and, for the above-knee amputee, does not compress the adductor region and is difficult to suspend.

Reisman M, Burdett R, Simon S, and Norkin C (Irene Walter Johnson Institute of Rehabilitation, Saint Louis, MO). **Elbow Moment and Forces at the Hands During Swing-Through Axillary Crutch Gait.** *Phys Ther* 65: 601–605, 1985.

Ten healthy young women were studied in gait laboratory while performing the swing-through non-weight-bearing gait with the left foot off the ground. They ambulated at a normal speed of 0.73 meters per second, a slow speed of 0.46 meters per second, and a fast speed of 1.12 meters per second. Each subject walked with crutches at 11 conditions: three speeds with crutches set at normal (2 inches below the axilla to a point 12 inches lateral to the midline of the body on line with the shoe tips; the handle was set to provide 30-degree elbow flexion), with crutches longer and shorter than normal, and with the handle set higher and lower. Measurements were taken with a force platform and three movie cameras.

A biomechanical model of crutch walking facilitated calculation of the forces acting on the hands and the moment exerted by the elbow extensors. There was a statistically significant difference between the average force exerted at the hands during slow and normal speed walking, 3.8 percent of body weight. No difference exists amont the average force values as a function of crutch length or handle position. Elbow moment changed little with speed or crutch length, but was affected by handle position; the two higher positions resulted in twice as much moment as the normal or two lower positions.

The shoulder girdle or the stance leg may absorb some energy, thus preventing force changes at the hands; the center of gravity is also kept at a relatively constant level by adjusting the abduction angle of the crutches. The difference in elbow moment occurring with handle changes is caused by increase in the lever-arm distance between the elbow and the action line of the force on the hands; at higher handle positions subjects used much larger elbow-flexion angles. The study confirms that 30 degrees is a suitable elbow-flexion angle.

Robbins F. and Reece T (Massachusetts General Hospital, Boston, MA 02114). **Hand Rehabilitation after Great-Toe Transfer for Thumb Reconstruction.** *Arch Phys Med Rehabil* 66: 109–112, 1985.

Thumb amputation reduces hand function 40 to 50 percent, is generally traumatic, and is unsightly. Properly performed reconstructive surgery such as microvascular great toe transfer, which provides a dexterous, pain-free, and aesthetic digit, is almost always superior to a crude, cumbersome, and insensate prosthesis. Thumb amputation should be near the metacarpophalangeal joint. The toe is disarticulated and the volar plate is shortened to prevent hyperextension. The great toe is a hyperextension joint, whereas the thumb is a flexion joint. The toe angulates laterally 10 to 15 degrees, thus the ipsilateral toe is used for the transfer so it can angulate toward the fingers. Goals of rehabilitation are to prevent web-space contracture, to optimize range of motion, to facilitate normal sensory return, and to maximize strength, coordination, and endurance. Psychological adjustment and vocational adaptation are also important. Initially the patient uses a thermoplastic thumb prosthesis and wears a C-splint at night to maintain the web space. If transfer is elected, the hand is placed in a plaster cast immediately after surgery to control edema. The patient then wears a thermoplastic long opponens splint that holds the thumb in palmar abduction and the wrist in 15 degrees of dorsiflexion. This minimizes tension along the anastomized vessels, nerves, and tendons and protects osteosynthesis at the transplantation site. The splint is worn at all times except during exercise and washing. At 8 weeks posttransfer, the splint is discontinued and new splints are made. A dynamic splint with elastic band traction flexes and extends the interphalangeal joint and promotes gliding of the flexor pollicis longus tendon. Another splint flexes, extends, and abducts the metacarpophalangeal joint. A web spacer is worn at night. Splints are discarded when mobility and strength are sufficient.

Robins R (Royal Cornwall Hospital, Truro, Cornwall, UK). **An Old Cornish Hand.** *J Hand Surg* 9-

B: 199–200, 1984.

The earliest record of an upper-limb prosthesis concerns Marcus Sergius, a Roman general who lost his right hand in the second Punic War and who had an iron replacement. After the invention of gunpowder, the early appliance makers were armorers. The German knight, Gotz von Berlichingen, who lost his hand at the siege of Landshut, Bavaria in 1509 was provided with an iron hand with flexible digits. In 1564 Ambrose Pare quoted exact locksmith's drawings of prostheses that could be set in certain positions and released by the opposite hand, enabling the wearer to hold a shield or bridle. The Cornish hand was an example of this and was probably made in Germany. It was articulated and made of carved and polished wood with metal hinges. It had channels cut in the back, presumably for the fitting of cables. The thumb had a ratchet that allowed it to be set in different positions. A painting of the original owner shows him wearing the hand covered with a glove. The prosthesis remained in the owner's family and is now displayed in the medieval manor house owned by a descendant.

RUBIN G, DIXON M, AND FISCHER E (Veterans Administration Prosthetics Center, New York, NY). **Lower Extremity Amputation Problems: Etiology, Manifestations, and Prevention.** *Orthot Prosth* 39: 47–61, 1985.

A selection of amputation problems may be documented in chart form. Problems are described by etiology, manifestations, and treatment and/or prevention. Surgical problems include overenthusiastic dedication to saving all length, particularly in case of circulatory impairment, short partial foot, excessively long below-knee, and retention of short above-knee limb. Other surgical problems involve deviation from accepted amputation procedures, as tibial crest not bevelled, fibula longer than tibia, quasi-Syme amputation, periosteal stripping, poor placement of suture, poor skin coverage, and inadequate stabilization of Syme pad, as well as nerves not properly treated.

Prosthetic problems include lack of total contact, pressure and shear at the brim, pressure on bowstringing tendons, chocking, valve malfunction, uncured glue or plastic, poor alignment, incorrect socket contour, and low placement of supracondylar wedge. The patient may be the source of problems, such as those related to limb maturation, hyperhidrosis, poor hygiene, weight gain or loss, mental incompetence, improper donning, changing shoes, and acceptance of prosthesis delivery without clinic team checkout. Problems attributable to the nurse and therapist are inadequate gait instruction, neglect of pre- and post-amputation care, and upper-limb neglect. The physician may be involved with problems concerning radiation or chemotherapy or kidney dialysis. The clinic team is responsible for improper selection of components, lack of consideration of contralateral problems or secondary ipsilateral problems, or general health problems. All problems are illustrated.

SEEGER B, CAUDREY D, AND MCALLISTER G (The Regency Park Centre for Young Disabled, Kilkenny, South Australia, Australia). **Skill Evaluator and Trianer for Electrically Operated Devices: An Evaluation of the SET.** *Arch Phys Med Rehabil* 66: 387–390, 1985.

A skill evaluator and trainer device (SET) was developed to select the most appropriate interface for each disabled person, among switches, joysticks and other control interfaces. The SET is easy to operate, portable and versatile. The SET presents stimuli and records the speed and accuracy of responses using various plug-in interfaces. The device weighs 6.5 kg and is housed in an attache case. The stimulus display is an 11×11 matrix of red light-emitting diodes. The subject's task is to manipulate the interface so as to match the position of yellow diodes under his control with the position of red diodes on the display.

A survey of 173 day students at the center indicated that 107 used assistive devices and 54 used at least one electrically operated device, with a total of 136 interfaces, all with at least one two-state (on-off) switch. Seven students used three-state (off-low-high) switches, and 16 used eight-state switches. Forty-four students used potentiometers. A study involving 32 able-bodied children indicated that SET is technically reliable, discriminates between alternative control interfaces, and suits children as young as 6 years. Four subjects with cerebral palsy were tested on such two-state switches as toggle, pneumatic pad, touch-switch, low-pressure-button, pneumatic button and push button. Testing indicated the interfaces that a subject can use; of the ones that are equally easy, subject preference should be the determinant. Eight muscular dystrophics tested wheelchair controls with SET, showing close agreement between SET performance and actual performance in a wheelchair. A manual was prepared for the SET that incorporates response times and number of errors.

SEYMOUR R AND LACEFIELD W (University of Kentucky, Lexington, KY 40536). **Wheelchair Cushion Effect on Pressure and Skin Temperature.** *Arch*

Phys Med Rehabil 66: 103–108, 1985.

Ten able-bodied and ten adults with spinal cord injury participated in the study. Room temperature was controlled and subjects were tested on one cushion per day. Seven commercially available cushions and one experimental cushion were evaluated. Thermilinear components with type 709 surface temperature probes were taped to the skin directly under each ischial tuberosity and under each posterior thigh on the midline, 10 cm distal to the gluteal crease. Temperatures were recorded for 30 min. Simultaneously, pressure was measured by the pressure evaluation pad with a matrix of 144 transducers. Pressures ranged from 74.7 to 89.6 mmHg in the able-bodied group and from 75.2 to 90.1 in the paralyzed group. Temperatures were lowest for the gel (Hydrofloat Pad and Skin Care Pad), water (Hydrofloat Cushion), and air (Bye-Bye Decubiti) cushions. High pressure concentration was recorded most often with Spenco and Tri-pad cushions for the spinal cord–injured group and with Tri-pad in the able-bodied subjects. No cushion rated a perfect score by all subjects, although all paralyzed subjects stated they would purchase a Bye-Bye Decubiti pad. Appearance and purchase were closely related, as were handling and purchase. Pressure in all cushions was more than twice previously reported to result in skin necrosis. Gel cushions had the second- and third-worst pressure readings. Bye-Bye Decubiti cushion had the best pressure reading, whereas Durafoam had the second best and Luxaire, another foam cushion, had the worst reading. The two subject groups differed significantly in mean temperature, with paralytics hotter. Alternating pressure and foam cushions were consistently warmer for both groups. Open-cell foams, if used with porous covers, tend to reduce the complications of heat by limiting moisture accumulation. Air-filled cushions had temperature readings closest to the mean temperature for each group.

SKINNER H AND EFFENEY D (University of California, San Francisco, CA). **Gait Analysis in Amputees.** *Am J Phys Med* 64: 82–89, 1985.

Gait analysis can be employed for those who can ambulate a minimum of 40 feet at a time. Those in wheelchairs or those requiring walking aids are not suitable subjects for gait analysis. Analysis is particularly useful in monitoring the rate of rehabilitation and the effectiveness of therapy. Limited studies have been performed on velocity, cadence, stride length, gait cycle, and single-limb-support time. Zuniga et al. studied gait in 20 above-knee amputees using a foot switch. Single-limb-support times of the prosthesis were briefer than on the contralateral limb. James and Oberg found that forward velocity of 34 traumatic above-knee amputees was reduced because of shorter step length and longer gait cycle; the prosthetic step was longer than the contralateral one. Godfrey et al. found little advantage gained by use of a complicated above-knee prosthesis when subjects walked on flat surfaces. Breakey reported that below-knee subjects had single-limb-support time of 37 percent of the gait cycle for the amputated limb and 43 percent for the normal limb. Waters et al. found that vascular amputees and traumatic above-knee subjects had velocities more than two standard deviations below normal; cadence, stride length, and gait cycle were also abnormal. Kegel et al. found that strengthening exercise increased forward velocity of below-knee amputees, but not to the normal speed. Combining data from various studies reveals that the traumatic above-knee amputee has a mean velocity of 55 meters per minute, cadence of 86 steps per minute, and single-limb-support time difference of 0.13 seconds. Traumatic below-knee amputees walk at 98 steps per minute, with 1.38 meter stride length. Zuniga and Breakey reported that above- and below-knee amputees, respectively, exhibit less flexion of the knee on the prosthetic side. Hershler and Milner noted lack of shock absorption after heel strike on the prosthesis. Suzuki found lower vertical ground reaction force in below-knee amputees than in normal subjects. Effects of prosthetic feet and energy factors were also reviewed.

TESIO L, CIVASCHI P, AND TESSARI L (Instituto di Fisiologia Umana I, Universita di Milano, Milano, Italy). **Motion of the Center of Gravity of the Body in Clinical Evaluation of Gait.** *Am J Phys Med* 64: 57–70, 1985.

Five hemiplegic subjects and 11 individuals with unilateral hip arthritis were studied while walking over a force platform. The method allowed measurement of positive work and power to lift the center of gravity, to accelerate it forward and to maintain its motion in a sagittal plane, the amount of transfer between kinetic and potential energy, height reached by the center of gravity, step length and frequency. From the forward and vertical speed changes during one stride and the average forward speed, a microcomputer calculated immediately the other variables.

Four hemiplegics whose paretic limb was hypertonic lifted the pelvis on the affected side during stance on the normal limb, involving an 0.6–2.9 cm greater lift of the center of gravity during the normal step. The lift

at the end of the normal step means that only a small amount of work is necessary during the pathological step. The one hemiplegic who could flex the paretic limb was not obliged to lift it as a whole during stance on the normal limb. Among all hemiplegics were short stride length, with shortening of the pathological step relative to the normal one and slower cadence.

In the seven arthritics with leg shortening, the center of gravity reached a height 0.4–3 cm lower during stance on the shorter limb; the greater the length discrepancy, the greater the difference between center of gravity heights. A wide range of walking speed was recorded. All had low stride length, possibly a mechanism to decrease the period and amplitude of movement of the affected hip.

Limping is the expression of an asymmetry of center of gravity movement, which involves a greater transfer between kinetic and potential energy of the center of gravity and smaller muscular work to translate the body during the step performed on the affected limb. Escape limp has asymmetry of step length and period. Sickling gait has asymmetrical displacement of body segments. Different motor syndromes may involve similar anomalies of motion of the center of gravity.

VARNAU D, VINNECOUR K, LUTH M, AND COONEY D (American Artificial Limb, Seattle, WA). **The Enhancement of Prosthetics through Xeroradiography.** *Orth Prosth* 39: 14–28, 1985.

Xeroradiography is a dry, photoelectric process for recording x-ray images on paper, which offers great clarity of the bone's boundary lines. Each xeroradiograph can replace two x-ray film pictures, the bone picture, and the soft tissue picture. The image is developed on opaque paper, usually on a blue format. A viewing box is not needed. Unlike the x-ray cassette which is approximately 4 inches from the limb, the xeroradiograph cassette contacts the limb, providing less magnification.

Because the plate is 9½ inches × 13⅝ inches, it is not possible to photograph a long limb on one paper. The image is backwards, i.e., a mirror image of the object. The patient is exposed to greater radiation, depending on the type of x-ray screen, filters, and technique. The local bone dose appears to be as much as nine times that of conventional x-ray film, but is not considered dangerous. With the below-knee amputee, the prosthetist can appreciate the actual length of the tibia, contour of the tibial margin, and thickness of distal soft tissue. The relative position of the inferior border of the patella to the tibial plateau can be seen, enabling optimum placement of the patellar bar. Fibular length and contour of the fibular head are evident. Review of xeroradiographs of 92 adult below-knee amputees indicates that 13 percent have tibias shorter than 3 inches and are PTS candidates because of relative position of the proximal patella to the adductor tubercle. It is impossible to correlate anteroposterior and mediolateral diameter measurements on the xeroradiograph to clinical measurements taken on the patient because the methods used to obtain clinical diameter vary as much as ⅜ inch, the amount of soft tissue thickness varies, and the extent of magnification on xeroradiograph varies between 6 and 14.5 percent.

On 41 percent of the patients, osteophytes were present on the tibia or fibula or both, but generally posed no fitting problems. With regard to the cause of osteophytes, age, amputation etiology, and tibial length were not significant factors. The formation appears grossly similar to heterotopic ossification seen after other resections. Specific instructions for obtaining useful xeroradiographs are provided.

WATERS R, MCNEAL D, FALOON W, AND CLIFFORD B (Rancho Los Amigos Medical Center, Downey, CA). **Functional Electrical Stimulation of the Peroneal Nerve for Hemiplegia.** *J Bone Joint Surg* 67-A: 792–793, 1985.

Between 1971 and 1974, 16 patients who were hemiplegics with foot drop had a neuroelectrical stimulator implanted. The apparatus was composed of an external stimulator and antenna that generated and transmitted a radio frequency signal through the skin, a heel-switch transmitter that triggered the stimulator, and an implanted receiver and bipolar cuff electrode that received the stimulator's signal and converted it to a series of electrical pulses to the motor branches of the peroneal nerve.

Six patients had the implants removed because of inconvenience and difficulty operating the equipment, evidence of progressive neuropathy, late infection, or electrical malfunction. Seven patients continue to use the equipment for an average of 11.6 years. Two patients died from causes unrelated to the implant, and one user developed acute polyneuritis, preventing further use of the implant. Of the seven who derived long-term use, four recovered volitional dorsiflexion and no longer required electrical stimulation. Two continue to use the implant. One patient discontinued the use of the implant but demonstrated increased triceps surae spasticity and will have Achilles tendon lengthening.

Difficulties with the implant include seroma formation about the implant, and inflammation along the lead-wire. A balanced response was obtained at surgery so that the foot dorsiflexed without excessive mediolateral displacement, by placing the electrode around selected branches of the peroneal nerve. Because other invertors such as gastrocnemius and tibials posterior are not innervated by the peroneal nerve and are active in the hemiplegie, four patients required surgical revision to correct foot imbalance. The program was discontinued in 1975 because of difficulty in balancing the foot and gadget intolerance. The group is developing totally implanted multichannel systems.

WOSK J AND VOLOSHIN A (Orthopaedic Clinic, Netania 42281, Israel). **Low Back Pain: Conservative Treatment with Artificial Shock Absorbers.** *Arch Phys Med Rehabil* 66: 145–148, 1985.

Treatment methods for low back pain include bed rest, sedatives, physical therapy, local heat application, local anesthetic injection, pelvic traction, muscle strengthening, and sacroiliac manipulation. Chronic pain is unresponsive to any treatment, and no method prevents future pain attacks. The goal of the new method was to decrease axial repetitive loading exerted on lumbar vertebrae through daily activities, especially walking. Viscoelastic shoe inserts decrease the amplitude of heel-strike shock waves by 40 percent. Inserts with light, flexible sole shoes were prescribed for 254 men and 128 women, most of whom were in the 26 to 45 year age group. Patients with chronic pain with more acute ache, sometimes with radiation and paresthesia also received bed rest and anti-inflammatory therapy. A 54-patient control group discontinued use of the inserts and had bed rest, sedatives, mobilization, exercise, and local paraspinal infiltration with analgesic. Treatment results were evaluated by clinical examination on a four-point subjective scale. After a 1-yr follow-up, nearly 80 percent of patients in all age groups maintained excellent or good results. Elderly patients had only 63 percent improvement. No significant difference existed between those with lesser or greater pain, nor were there any significant sex-linked findings. Patients in the control group had poorer results, with only 44.4 percent reporting good to excellent results. Of a group of 31 truck and tractor operators, half had good to excellent results. They experienced continuous repetitive axial stress in badly cushioned heavy vehicles. Previous studies showed that the shock-absorbing attenuational capacity of the spine in patients with chronic pain was severely reduced. Chronic overloading of the segment elements, especially the discs that are the main axial force shock absorbers, may be responsible for chronic irritation and wear of all vertebral elements. The new treatment produced better results as time passed, compared with conventional methods of treatment.

YOUNG R (Lee Orthopedic Appliances, Memphis, TN 38104). **Special Choparts Prosthesis with Custom-Molded Foot.** *Orthot Prosth* 38: 79–85, 1984.

A special prosthesis was made for a patient with fixed equinovarus and contralateral hemiparesis. The prosthesis needed to be lightweight, thin, contoured to offer stability in the shoe, accommodate the deformity, and be cosmetic. For the custom foot, an impression of the patient's residual limb was taken using the anterior-posterior splint technique and a footboard under partial weightbearing. A positive model was made, the cast modified, and trimlines established for a posteriorly opening, patellar tendon height prosthesis. A PPT foam pad was prepared for the anterior part of the foot. The IPOS-Ipocast System using carbonacryl resin and carbon fiber and fiberglass stockinette added strength without weight or thickness to the socket. The layup consisted of one layer of dacron felt, two layers of Ipocarbon stockinette, and four layers of nylglass stockinette. Two layers of nylglass were laminated over the socket to give it a smooth light-colored finish. A footplate was made to match the patient's shoe. When completed, the prosthesis offered complete contact with the sole of the shoe over its full length, providing a very stable base of support. The foot was integrated into the overall lines of the socket and did not require additional covering to be cosmetically acceptable. The toe area of the foot was modified to have normal appearance and volume. Total weight of the prosthesis including all straps is 2¼ pounds.