ABSTRACTS OF RECENT LITERATURE

By JOAN E. EDELSTEIN, P.T.
Senior Research Scientist
New York University
Post-Graduate Medical School
Prosthetics and Orthotics
New York, NY 10016

Abstracts are drawn primarily from the orthotics and prosthetics literature. Selections of articles were made from these journals:
American Journal of Occupational Therapy
Clinical Prosthetics and Orthotics
Medicine and Science in Sports and Exercise
Orthotics and Prosthetics
Prosthetics and Orthotics International

BEETS C, CLIPPINGER F, HAZARD P, VAUGHN D (University of Virginia Department of Prosthetics and Orthotics, Charlottesville, VA. **Orthoses and the Dynamic Knee: A Basic Overview** *Orthot Prosthet* 39: 33–39, 1985

Arthritis is the most common disturbance of the knee that benefits from the use of an orthosis. The disease may be degenerative arthritis, rheumatoid arthritis, or chondromalacia patellae. Trauma may injure the medical collateral ligament, anterior or posterior cruciate ligament, lateral collateral ligament, or menisci.

Orthoses are described according to their function and design. Elastic orthoses provide minimal stability and patellar control. They may have side bars, pads, or straps. Recurvatum control orthoses are prefabricated of metal, webbing, elastic, and Velcro closures. Ligament supports offer anteroposterior, mediolateral, and rotary control, postoperative protection, and patellar control. The Lerman, Lennox Hill, External Cruciate Ligmanet Orthosis, and Tennessee Rotational Instability Orthosis are examples of ligament supports. Thermoplastic knee immobilization orthosis restricts knee motion. The plastic is bivalved with Velcro closures and a medial supracondylar wedge for suspension. The knee orthosis with suprapatellar suspension provides mediolateral and anteroposterior stability and is made of thermoplastic cuffs with rigid knee joints, Velcro closures, and a latex suprapatellar suspension strap.

Prefabricated orthoses are convenient but do not truly fit anyone. Custom orthoses provide more critical anatomical and mechanical alignment union, especially for definitive use.

A chart indicates which of 9 functions, such as anteroposterior control, are provided by each of 14 orthoses, including Palumbo, Marshall-PAC, Teufel TKS, Swedish knee cage, genucentric, Lerman, Lenox Hill, External Cruciate Ligament, TRIO, Anterson, Iowa, CARS-UBC, Generation II, and Can-AM.

BOLDINGH EJK, VAN PIJKEREN T, WIJKMANS DW (Rijnlands Rehabilitation Centre, Katwijk aan zee, Holland). **A Study on the Value of the Modified KBM Prosthesis Compared with Other Types of Prothesis.** *Prosthet Orthot Int* 9:79–82, 1985.

The modified KBM prosthesis combines the advantages of the PTB prosthesis with those of a prosthesis with thigh corset. The new prosthesis has high "ears" that enclose the femoral condyles. The extensions are flexible enough to allow the amputation limb to pass during donning. The plaster cast for the prothesis is taken with the knee flexed 70 degrees, making the musculature more pronounced and permitting better modeling of plaster in the posterior aspect of the knee. Flexion also relaxes the iliotibial tract, allowing easier palpation of the lateral femoral condyle. As the plaster hardens, the prosthetist pushes the thumbs on the patellar tendon, little fingers behind the knee and the three middle fingers just proximal to the condyles. Over the modified plaster cast a polyethylene foam liner is formed. The plastic socket is then laminated over the liner, with the extensions reinforced with carbon fiber. Finally, an opening is made for the patella in the outer, but not the inner, socket. No wedges are needed. The socket is set in 10 degrees of flexion on a tube frame.

Forty-five amputees who received the modified KBM prosthesis were studied; of these, 37 provided useful answers to questions regarding function, stability, comfort, and appearance. Approximately two-thirds of the respondents had worn a PTB prosthesis and the others had worn one with a thigh corset. Both groups stated the prosthesis was more comfortable and lighter. The former corset wearers also found it easier to don and less damaging to clothing. Respondents also stated that the new

prosthesis looked better. There were no statistically significant differences in function and stability.

CAVANAGH P, KRAM R (Pennsylvania State University, University Park, A 16802). **The Efficiency of Human Movement—A Statement of the Problem.** *Med Sci Sports Exercise* 17:305–308, 1985.

The best introduction to efficiency is to examine oxygen uptake during submaximal running. Equations give representative values for the population mean but disguise large intersubject variation because of biomechanical, physiological, psychological, and biomechanical factors unique to each individual. Muscular efficiency has many definitions. All use gross submaximal oxygen uptake as the denominator, but definition of mechanical work must be resolved. More work is always done to perform a given task than can be measured by an ergometer, such as physiological maintenance work not indicated on the ergometer. In net efficiency, the denominator is the energy expended above that at rest. Work efficiency uses as the denominator energy expended above that used at zero load. The idea of a constant physiological baseline is controversial. Economy, defined as the submaximal oxygen uptake per unit body weight required to perform a given task, has become almost universally accepted as the physiological criterion for efficient performance. The relationship between external work and energy cost can be modified between the muscles and the skeleton and between the human and the ergometer, which does not account for unused force. Many definitions are used for efficiency and economy. "Overall" and "gross efficiency" should be abandoned, as should "net", "delta", and "instantaneous" efficiencies. While not yet practical to measure true effectiveness in humans, an index of effectiveness would be useful for improving performance and equipment. Economy, i.e., submaximal oxygen uptake per unit body weight required to perform a given task, emerges as a term that is conceptually clear and practical for evaluation of endurance activities.

FASO D, STILLS M (3D Orthopedics, Dallas TX 75229) **Passive Mobilization: An Orthotist's Overview.** *Clin Prosthet Orthot* 9: 7–19, 1985.

Over the years clinicians have vacillated between the benefits of rest versus motion in the management of joint disorders. In the 1950's the "movement-is-life" principle found resurgence under the guidance of the Association for Osteosynthesis whose techniques encouraged early mobilization. More recently, others have also advocated early function. When the body is immobilized, heart rate decreases, upright posture is poorly tolerated, nervous response slows, calcium is released by the skeleton, muscles atrophy, and intercellular joint fluid stagnates.

Continuous passive-motion machines are mattress mounted, bed-frame mounted, or single-joint units used primarily for the knee and hip, although units are also made for the ankle and elbow. Features vary from microswitching to torque sensing, mechanical or computerized range setting, 110 volt to battery operated, patient or programmed cycles, and one or variable speeds. Multiple-joint systems require more expertise because of increased options of use but are more cost effective. The authors used five machine designs over a two-year period. Mattress-mounted units mobilize knees and hips; their trays are cumbersome and would not fit patients above or below an average height of 5 feet 10 inches; the limb lacked full extension and flexion. A modification eliminated the tray and used dynamic suspension to achieve full excursion.

Passive mobilization should begin in the recovery room for patients with joint replacements; the unit allows 30–40 degrees of motion initially with rapid increase of range. The units have been used for fractures of the knee, hip, elbow, and ankle; replacements of the knee and hip; and knee sepsis, ligamentous repair, and edema control. They can also be used to mobilize the cervical spine, shoulder, and lumbar spine.

Time minimums in the machine have not been established, thus patients are kept in motion except during meals, therapy, or bathroom use. Four case reports are provided.

GARBER S (The Institute for Rehabilitation and Research, Houston, TX 77030). **Wheelchair Cushions: A Historical Review.** *Am J Occup Ther* 39:453–459, 1985.

Devices that relieve pressure for individuals in wheelchairs have been studied since 1930 when Landis determined mean blood pressure in single capillaries to be 32 mmHg in the arteriolar limb, 20 mmHg in the midcapillary region, and 12 mmHg in the venous limb. A 1958 study of normal subjects on several seat surfaces revealed ischial pressures of more than 300 mmHg on flat padded and unpadded surfaces. A 5 cm foam pad on a flat surface

lowered the pressure to 160 mmHg. A prototype alternating-pressure contour chair reduced pressure to levels in the range of capillary pressure. In 1958, Kosiak defined pressure sores as localized areas of cellular necrosis and that ischemia was a main cause. Sores result from several mechanisms acting systemically. Intense pressure of short duration was as injurious as lower pressure applied longer. One to two hours after pressure was applied was the critical time during which pathological changes occurred. Friction increased susceptibility to ulceration. Ischemic muscle necrosis due to pressure occurs before skin death.

Nonmechanical interventions prevent sore formation and include turning patients, and maintaining cleanliness and good nutrition. Mechanical interventions such as sheepskin, air rings, and foam are used, but no evidence exists that they prevent sores. Various instruments have been used to measure pressure, but they do not give enough objective data on the magnitude and overall distribution of pressure, nor are they practical in the clinical setting. Hundreds of commercially available wheelchair seating devices have been developed which can be categorized as dynamic and static. The former depend on external power to relieve pressure cyclically. Air-filled, flotation, and polymer foam static cushions each have advantages. Cushion prescription is influenced by diagnosis, upper-limb function, posture, time spent in the wheelchair, activities, environmental characteristics, continence, living arrangements, tissue history, body build, wheelchair characteristics, and psychosocial factors.

KREBS D, TASHMAN S (New York University, New York, NY 10016). **Kinematic and Kinetic Comparison of the Conventional and ISNY Above-Knee Socket.** *Clin Prosthet Orthot* 9:28–36, 1985.

A unilateral above-knee amputee, a 36 year-old-man with traumatic amputation 12 years previously, was fitted with two thigh sections atop his exoskeletal prosthesis. The prosthesis has a SACH foot and Mauch hydraulic knee. One socket was a conventional polyester laminate quadrilateral tot-contact suction socket; the other was quadrilateral ISNY, consisting of a flexible thermoplastic socket and a strong frame consisting of a horizontal strut around the quadrilateral brim and a vertical strut along the medial portion of the thigh. Both sockets were identical in size, shape, and alignment. The subject was tested while walking slowly, at normal pace and fast, in randomly assigned order, with rest periods between tests. Kinematic and kinetic data were recorded after the amputee had reached steady-state velocity.

No differences greater than 5 degrees were found in any stance phase kinematics, except for late stance hip rotation at slow speed. Test-retest reliability revealed no more than 3 degrees difference for any given speed between repeated runs in the same socket. The socket design did not differentially affect gait timing, joint motions, or forces. The absence of a rigid lateral wall does not adversely affect dynamic amputation limb or pelvic stability, in the single subject tested. No consistent pattern was found with regard to between-socket comparisons of walking speed, stance duration, or any other temporary variable. Prosthetic stance duration was consistently but slightly longer with the ISNY socket, perhaps indicating greater comfort. The ISNY socket permitted more symmetrical stance durations. Hip abduction in the ISNY socket was relatively invariant over the three walking velocities and more closely approximated previously reported data from normal subjects, than did the subject's hip kinematics while walking with the conventional socket. Kinetic data revealed no mediolateral differences between sockets. The ISNY was loaded more quickly and more forcefully during preferred and fast walking.

The prosthesis was aligned with marked posterior setting of the knee bolt, causing the prosthetic knee to be in hyperextension and keeping the floor reaction vector in front of the knee even during late stance; excessive stability increases the work required for locomotion. The knee was aligned in varus, reflecting appropriate inset of the foot and shank, and causing the pelvic obliquity kinematics and mediolateral kinetics to approximate normal values.

OBERG K (Biomechanics Laboratory, Jonkoping, Sweden). **Swedish Attempts in Using CAD/CAM Principles for Prosthetics and Orthotics.** *Clin Prosthet Orthot* 9:19–23, 1985.

Although CAD/CAM principles were being investigated in the mid-1970's, interest in Sweden was low until a presentation at the 1983 World Congress of the International Society for Prosthetics and Orthotics. The company which provides over 60 percent of prosthetic and orthotic service in Sweden intends to adapt the techniques to its work, beginning with orthopedic shoe service. The second largest company is also following this work, as are other services in Sweden. The College at Jonkoping

is taking an active role in development of the technique with computers, digitizers, image processing equipment, and lasers, experience with digital measuring, computer programming, and biomechanics. The philosophy is that the complete system should be available for each prosthetic and orthotic service shop, the system should require moderate investment, equipment of very high specification able to work to extremely close tolerance should be avoided, and individual three-dimensional shape sensing should be the basis for control of the numerically controlled milling machine. The system's objectives are to develop a system for prosthetics and orthotics as one complete unit based on a microcomputer costing $40,000, and allowing commercially available video imaging to be adapted for shape sensing, and develop a numerically controlled milling machine costing $12,000.

The principal of shape sensing is similar to that developed at West Park Hospital in Toronto. A video recording of a laser-illuminated contour of the limb is taken at increments of 0.01 turn. The videogram is transferred to the computer via the MicroSight image processor. The computer reduces the data to define the limb surface as a set of digital coordinates. The CAD program modifies the shape as specified by the practitioner. A Victor computer is used with an Intel 8088 processor; the monitor has a graphic resolution of 800 × 400 pixels. Commercial milling machines are overspecified for prothetics. The special machine can cut a model of 30 cm in 2 minutes.

PRITHAM O, FILLAUER C, FILLAUER K (Durr-Fillauer Medical, Inc., Chattanooga, TN 37406). **Experience with the Scandinavian Flexible Socket** *Orthot Prosthet* 39:17–32, 1985.

The Scandinavian socket was introduced in 1982 by Ossur Kristinsson at a prosthetics convention in Texas. The technique had already been employed extensively in Sweden. The authors subsequently fitted five patients whose characteristics are summarized; one of the five rejected the new socket. Problems with the suction valve led to the decision that the United States Manufacturing Company's Green Dot Valve was most suitable; the valve has been adapted with a Delrin housing. The socket is similar to the Icelandic, Swedish, New York (ISNY) socket which has been the topic of short-term courses sponsored by New York University.

The socket is indicated for individuals with mature amputation limbs, although minor changes in volume or contour can be accommodated. The benefits are greatest for long amputation limbs; the surface area of the flexible socket not contained in a rigid frame is proportionately less for shorter sockets. The tendency is to extend the brim to allow attachment of a Silesian band or hip joint suspension.

Casting and modifying techniques are conventional because the weight-bearing and femoral stabilization mechanisms are unchanged. Patients' comments indicate the benefits of socket flexibility, enabling the walls to adapt to changes in limb contour during ambulation and sitting. Suction suspension is improved. Proprioception should also be improved. Heat buildup is less in the thin-walled socket. The socket is vacuum formed of polyethylene or Surlyn, the latter being more expensive but clearer and easier to modify. The socket lodges in a supporting structure laminated of carbon fiber, fiberglass, and acrylic resin. Antecedent sockets, such as the Flexi-Cage, Cordo flexible inner socket, and Volkert femoral clasp preceded development of the current version. The socket functions as a receptacle, particularly the innerface, and as a rigid support, the function of the outer surface. In the new socket, the Surlyn socket is the interface, responding to changes in limb contour and volume, and the carbon fiber structure is the structural element. Details of socket and frame fabrication are described and illustrated.

TASHMAN S, HICKS R, JENDRZEJCZYK D (Newington Children's Hospital, Newington, CT 06111). **Evaluation of a Prosthetic Shank with Variable Inertial Properties** *Clin Prosthet Orthot* 9:23–28, 1985.

A prosthetic shank was designed to test two hypotheses: *1*) If the physical properties of the shank section of an above-knee prosthesis with a constant friction knee unit are changed in such a way as to alter the natural swing period, the swing period of the shank during gait is also altered. *2*) If the swing period of the shank is reduced, the natural cadence and walking speed is increased. The study was in response to the well-documented observation that amputees walk slower, probably because the swing of the prosthesis is prolonged. An earlier study demonstrated that adjustments in knee-joint friction did not provide optimum cadence; the swing period of the shank was always close to the natural swing period when the shank was measured off the patient. The design goal of the test shank was to reduce the natural

swing period. The center of mass must be shifted proximally to reduce the period significantly. The completed prosthesis has a moveable mass on the lightweight polyester resin and carbon fiber shank, and an ultralight SACH foot to eliminate shoes and reduce distal weight. The assembly weighed the same as the patient's standard prosthesis.

The effect of changing the position of mass on gait was measured with the aid of an automated video system recording 26 reflective markers placed on the body. The subject walked at normal and fast speed with the weight proximal and distal. At the fast speed, the subject walked 7 percent faster with the mass placed distally, because of faster cadence and longer stride length. At normal speed, shank pendulum time was reduced 8 percent with proximal weight, thus reducing swing asymmetry from 19.5 to 9.1 percent. During fast walking, proximal weighting increased swing phase time 5 percent for the normal limb and reduced time 8 percent for the prosthesis. Proximal weight reduced peak knee flexion at normal and fast speeds. Decreasing the natural swing period of the shank by shifting the center of mass proximally resulted in faster swing phase, and reduced left-right asymmetry, without increase in cadence or walking speed.