

ABSTRACTS OF RECENT LITERATURE

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

Acta Orthopaedica Scandinavica

American Journal of Occupational Therapy

American Journal of Physical Medicine

American Journal of Sports Medicine

Archives of Physical Medicine and Rehabilitation

Clinical Prosthetics and Orthotics

Journal of Biomechanics

Orthotics and Prosthetics

Paraplegia

Physical Therapy

Physiotherapy

Prosthetics and Orthotics International

Scandinavian Journal of Rehabilitation Medicine

ARSENAULT AB, WINTER DA, MARTENIUK RG, ET AL. (School of Rehabilitation, Faculty of Medicine, University of Montreal, Quebec, Canada H3C 3J7). **How Many Strides Are Required for the Analysis of Electromyographic Data in Gait?** *Scand J Rehabil Med* 18:133-135, 1986.

Three strides of electromyographic data provide information as reliable as that obtained from 12 strides. Eight healthy young adults walked on a walkway at self-selected comfortable speeds. Surface electrodes were placed over the soleus, rectus femoris, biceps femoris, vastus medialis, and tibialis anterior. Pressure-sensitive heel switches were placed under each heel. Each subject had 10 gait cycles analyzed. High intrasubject reliability was evident. Very high values of intraclass correlation coefficients were obtained for different combinations of strides and subjects. While increasing the number

of strides and subjects offers higher intraclass correlation coefficients, a minimal amount of data from three subjects offers very highly reliable information because from stride to stride, normal subjects do not vary in an important fashion. An ensemble average of a few strides averages out the step-to-step variability caused by posture control and support by the weightbearing limb.

BERRY DA (Daw Industries, Inc.) **Composite Materials for Orthotics and Prosthetics.** *Orthot Prosthet* 40:35-43, 1987.

Field study and a study project initiated in 1981, combined with established West German fabrication technology, permit development of a rationale for specific application of the composite materials—carbon, Kevlar, and fiberglass. Stress evaluation aids in material choice. Within the socket wall, tension and compression maintain strength, form, and structure; the outer surface bearing tension while the inner wall sustains compression. Material between the inner and outer walls serves as a transition between opposing forces. Distance between the walls is directly proportional to resistances to fracture, fatigue, and failure. At heel strike, compression occurs at the posterior wall with equal tension anteriorly.

A reinforcing composite should be light, strong, flexible to absorb torque, stiff to resist bending and shear, durable to resist fracture, able to resist stress in all planes, cost effective, and easy to apply. Fiberglass is the most common and economical composite. It is the heaviest, but is easy to saturate with resin, as well as being durable and flexible, its fibers being twice as strong under compression as under tension. Kevlar is the lightest, most expen-

sive, and excellent in resisting fracture as well as able to absorb high torque and stress loads. Kevlar is very poor in maintaining structure under load, being five times weaker under tension than under compression—and it is very difficult to saturate with resin. Carbon is almost as light as Kevlar, is very stiff, and holds its shape under stress, having impressive tensile and compressive strength. Stiffness, however, creates brittleness. All the available strength of a composite fiber is displayed only along the length of the fiber, thus the angle of the fibers in relation to the applied stress is important. A blend of carbon-Kevlar provides lightness, stiffness, impact and torque resistance. A blend of carbon-fiberglass resists fracture, is light, and less expensive. A chart displays varying lay-up for a full range of prosthetic components.

Composite materials laminated into orthoses provide lightness, durability, and stiffness in the desired area. The procedure is time-consuming and expensive. Acrylic resins are light, strong thermosets with excellent wetting properties. Various resins are compared.

COSGROVE JL, ALEXANDER MA, KITTS EL, ET AL. (University of Pittsburgh School of Medicine, Pittsburgh, PA 15213). **Late Effects of Poliomyelitis.** *Arch Phys Med Rehabil* 68:4-7, 1987.

One hundred eighty-three adults with previous poliomyelitis had physical examinations and completed a questionnaire that included items pertaining to use of orthoses. Of the group, 84 percent were experiencing late weakness. They contracted poliomyelitis initially at 8.3 years of age, on average, and all were stable neurologically during adulthood. They had a latent period ranging from 15 to 72 years, with a mean of 35 years, in muscles which were clinically affected by the disease previously. About half also noted a weakness in muscles previously considered normal. The most common complaints were decreased endurance and increased difficulty climbing stairs.

Only a sixth of persons with late weakness wore braces, most of which were old, averaging more than 15 years. A fifth had begun to use a cane or crutches. Four percent ceased walking and used a wheelchair. A third of those with late weakness were advised to use braces or have alteration in current orthoses. Some were also advised to use

ambulatory aids. Of the 30 who had scoliosis, only three wore braces and no orthotic changes were suggested.

All patients who had muscle transfer surgery experienced late weakness in the treated limb. Falls were a frequent complaint, many with fractures; however, only a quarter of those with fractures had begun to use bracing or ambulatory aids.

Other indications of late weakness were complications of bulbar involvement. None complained of increased sensitivity to cold or decreased intellectual capacity.

Patients reported that the exercise ritual was religiously followed with the goal of discarding braces. Return to bracing met with almost universal initial resistance; however, with counseling and demonstration, orthotic prescriptions were written. Absence of increase of scoliosis may be attributed to symmetrical decrease in muscle strength.

CRUTS HEP, DE VRIES J, ZILVOLD G, ET AL. (Het Roessingh Rehabilitation Center, Enschede, The Netherlands). **Lower Extremity Amputees with Peripheral Vascular Disease: Graded Exercise Testing and Results of Prosthetic Training.** *Arch Phys Med Rehabil* 68:14-19, 1987.

Graded exercise testing was administered at the start of training for 39 unilateral dysvascular lower-limb amputees, 46 percent of whom had below-knee amputation. Thirty had diabetes, four were hemiparetic, and six had emphysema. Cardiac disorders were evident in 74 percent. Graded exercise testing was performed three weeks after admission for rehabilitation, an average of nine weeks after amputation. A rowing ergometer was used in conjunction with an electrocardiograph and measurements of heart rate and blood pressure. Patients without previous cardiac problems had higher peak workloads and blood pressures; those using beta-blockers had lower blood pressure, and those with atrial fibrillation had higher heart rates.

Eighty-seven percent learned to walk with a prosthesis; those who could not all had progressive vascular disease. At the end of training, those needing walking frames had a mean speed of 6.5 m/min for below-knee, 5.6 m/min for above-knee, and 6.9 m/min for through-knee. Walking speed was significantly higher for crutch walkers, among whom below-knee amputees walked at 24 m/min as com-

pared with the others who had a mean speed of 14 m/min. The average distance walked by those with frames was 42 m, compared with 96 m for crutch walkers; amputation level did not affect distance values significantly. Heart rate was used as a measure for cardiac load during walking and was highly correlated with heart rate at rest. Heart rate responses to exercise testing were comparable to those of nonamputees, and were lower in men and those using beta-blockers. In patients with peak workload of low value, the probability of achieving ambulation without a walking frame is 30 percent; in those with higher workload, above 45 W, the probability is 70 percent. Patients appeared to adapt walking speed and distance to cardiac capacity.

CURTIS KA, McCLANAHAN S, HALL KM, ET AL. (Santa Clara Valley Medical Center, San Jose, CA 95128). **Health, Vocational, and Functional Status in Spinal Cord Injured Athletes and Non-athletes.** *Arch Phys Med Rehabil* 67:862-865, 1986.

Sixty-seven adults with spinal cord injury were interviewed with regard to types of sports participation, medical complications, educational and employment status, rehospitalizations, hours of assistance needed, and financial status. Subjects had injury levels from C6 to L2 and had sustained injury an average of 6.3 years ago. Nearly three-quarters of the group participated in sports at least once weekly, including basketball, swimming, weightlifting, wheelchair tennis, road-racing and jogging, pool/billiards, all-terrain vehicle use, and boating. Nineteen were involved in competitive wheelchair sports.

Most of the group reported medical complications within the past year, particularly urinary tract infection, pressure sores, respiratory infections, severe spasticity, and burns. Approximately a third had been hospitalized last year. A quarter depended on an attendant for daily activities, averaging three hours per week. Half were employed or in school for at least 20 hours per week.

Competitive athletes had higher functional scores, fewer hospitalizations, decubitus ulcers, medical complications or hours of attendant care and more hours of employment, as well as significantly fewer physician visits as compared with nonathletes. Fewer visits may indicate higher self-reliance, or denial of medical complications. Vocational status was not related to hours of sports involvement.

DICKSON TB JR, AND KICHLINE PD (Allentown Sports Medicine Clinic, Allentown, PA 18104). **Functional Management of Stress Fractures in Female Athletes Using a Pneumatic Leg Brace.** *Am J Sports Med* 15:86-89, 1987.

The Air-Stirrup Leg Brace (Aircast, Inc.) was applied to 13 consecutive female athletes, ranging in age from 14 to 40 years, who complained of pain localized to the lower tibia or fibula and increased by physical activity. Ten had X-ray or bone-scan evidence of stress fracture; three had bilateral fracture.

The orthosis is commonly used to control ankle inversion and eversion. It has bilateral rigid plastic supports lined with foam-filled air cells. The cells are preinflated for average needs, but inflation can be altered by blowing into a tube through a self-sealing valve. The cells permit more pressure distally. The brace is fastened by Velcro straps and joined across the sole by a padded strap. The brace is manufactured in two sizes, 20 and 40 cm long. The brace was worn during sports and whenever symptoms were present. All athletes returned immediately to their sport (track, basketball, field hockey, gymnastics), competing at pre-injury level. Eleven became asymptomatic in a month or less. Two cases are reported.

Stress fractures occur as a result of repeated microfractures in the trabeculae that occur faster than the rate of repair. Healing normally occurs if the patient withdraws from sport and is nonweight-bearing. The Air-Stirrup unloads the skeleton enough to permit healing while the patient continues the sport. This may be because of increased hydrostatic pressure of soft tissue, which adds stability to the fracture site. Compression of soft tissue stabilizes the leg and diverts stress from the fracture site. The brace also stabilizes the subtalar joint, preventing severe pronation and thus improving alignment of the leg.

GANDHAVADI B (Department of Physical Medicine and Rehabilitation, Medical College of Wisconsin, Milwaukee, WI 53215). **Porous Removable Rigid Dressing for Complicated Below-Knee Amputation Stumps.** *Arch Phys Med Rehabil* 68:51-53, 1987.

A modified rigid dressing was developed, consisting of a sterile wound dressing, a 3-ply cotton

sock pulled over the residual limb and secured with an elastic belt, and a tapered cotton pad applied over bony prominences and over the medial and lateral sides just below the knee. "Cuttercast" semi-synthetic casting tape was wrapped around the distal thigh. The distal aspect of the amputation limb was wrapped in figure-eight fashion with one to three layers of Cuttercast. After drying approximately 8 minutes, the socket and cotton sock were removed. The margins of the socket were trimmed to midpatella and low enough posteriorly for comfortable knee flexion. The dressing is reapplied over a 3-ply sock. A 1-ply sock is pulled over the dressing and suspended to the thigh Cuttercast by Velcro at the medioposterior aspect of the cuff. Suspension can also be achieved with Hexcelite tape on the thigh or with an inverted "Y" strap and waist belt.

Two case reports illustrate the effectiveness of the porous dressing, which permits good aeration of small open wounds at the amputation scar or elsewhere on the limb. The dressing weighs less than plaster ones.

HEINEMANN AW, MAGIERA-PLANEY R, SCHIRO-GEIST C, ET AL. (Pritzker Institute of Medical Engineering, Illinois Institute of Technology, Chicago, IL). **Mobility for Persons with Spinal Cord Injury: An Evaluation of Two Systems.** *Arch Phys Med Rehabil* 68:90-93, 1987.

Individuals with spinal cord injury were surveyed to assess demographic and mobility information and needs with regard to housing, transportation, psychosocial concerns, and other matters. Respondents were recruited from persons in various settings, actively involved in many pursuits. Ninety-two respondents had injuries at or below the second thoracic vertebra. The mean age was 42 years, and the mean age at injury was 27 years; the mean time since injury was 15 years. Thirty-eight percent were currently employed; current median income from all sources was \$16,000. Although 67 percent had knee-ankle-foot orthoses prescribed, only 26 percent were using them. Reasons cited for stopping brace use included inconvenience, high energy consumption, and pressure sores. Two-thirds had fallen while in braces. Wheelchairs were the sole means of mobility for 87 percent; braces were the only means for 4 percent.

With regard to the needs survey, major concerns

were related to transportation, such as being unable to visit friends' homes because of limited access and using public transportation, as well as difficulty in finding suitable housing. Brace users tended to be younger, with incomplete lesions. Brace use or disuse does not appear to reflect personal and environmental characteristics; life adaptations are independent of the mobility system. Life satisfaction appears related more to availability of transportation, parking, and housing, than to new systems for individual mobility.

Among the other frequently occurring needs were finding handicapped parking filled by persons without handicapped stickers, understanding what had happened to you just after hospitalization, receiving adequate information about sexuality, and dealing with the fear of bowel or bladder accidents.

HOLDEN, JM AND FERNIE GR (West Park Research Department of Surgery, University of Toronto, Toronto, Canada). **Results of the Pilot Phase of a Clinical Evaluation of Computer-Aided Design of Trans-Tibial Prosthesis Sockets.** *Prosthet Orthot Int* 10:142-148, 1986.

Ten below-knee amputees, ranging in age from 54 to 72 years, compared prostheses having computer-aided socket design with their conventional patellar tendon-bearing prostheses. The design system consisted of an interactive IBM PC/XT program with a graphics unit and monitor. Limb measurements entered into the computer were length of both limbs, mediolateral diameter at tibial plateau, anteroposterior diameter at mid-patellar-tendon level and at one-inch intervals below.

The program generated a primary modified shape, which the prosthetist could change with the interactive modification program. The computer disc was then sent to Vancouver so that a numerically controlled milling machine could carve the shape from a solid polyurethane foam plug. The plug was returned to Toronto where a socket was vacuum-molded of acrylic Orthoglas. The socket was trimmed and attached to a temporary pylon with SACH foot. The subjects' conventional sockets were used to create a plaster cast, plaster positive and acrylic socket. Six prosthetists participated; they were paired according to level of experience and attended a two day laboratory course during which a computer-aided design socket was fitted. Subjects were as-

signed randomly to a pair of prosthetists. Each prosthetist made either a conventional or experimental socket. Every effort was made to conceal the origin of the sockets from the subject to eliminate bias. The subject was allowed to choose the preferred socket. Those who could not decide immediately took the prostheses home, fitted with a footstep monitor to measure activity with each. For those who chose the conventional socket, the experimental one was modified on the computer screen leading to a second experimental socket. All sockets were fitted with a one-ply sock, and either hip belt or neoprene sleeve suspension.

Half the subjects preferred the experimental socket on the first or second modification, regardless of prosthetist level of experience. Mean time for making the conventional and first experimental leg were similar, but modifications of the latter were faster.

JAMES KB AND STEIN RB (Department of Physiology, University of Alberta, Edmonton, Canada). **Improved Ankle-Foot System for Above-Knee Amputees.** *Am J Phys Med* 65:301-314, 1986.

Kinematic data were collected from four non-amputees and four above-knee amputees who walked on a treadmill set at level, 16 percent incline and 19 percent decline. Amputees wore a standard single-axis foot and one modified to allow more ankle dorsiflexion and more metatarsophalangeal motion. The dorsiflexion stop was removed and replaced with a rubber pylon used as a spring; various degrees of rigidity were used. The tip of the heel was also shaved, 70 mm being removed. Stainless steel spring strips were stacked to act as a leaf spring to attach the toe to the foot. Amputees were encouraged to adjust the stiffness of ankle and toe motion until satisfied. Plantar flexion in the nonamputee was smaller in magnitude and occurred early in stance phase; however, at late stance, nonamputees exhibited substantial plantar flexion, while amputees had none.

Dorsiflexion for amputees with the standard foot was only 1 degree, but with the modified foot averaged 14 degrees at heel off—exactly matching the nonamputee performance. Dorsiflexion did not vary with change in walking speed or slope of walking surface. Toe motion with both standard and modified prosthetic foot averaged 5 degrees as compared with the normal 17 degrees. Preferred amputee

toe motion is opposite to that provided by such components as the Seattle, Jaipur, and STEN feet, all of which allow more toe motion than the standard single-axis foot. Modified feet did not alter stride length or frequency. The modified foot permitted reduction in vertical motion of the hip which still exceeded normal values, although hip motion in the amputees was more symmetrical. Amputees preferred the modified foot, especially for walking on inclines, although the knee tended to be less stable on declines.

The major problem was on ascending stairs; if the entire foot was not placed on the stair, the ankle would dorsiflex, causing the foot to slip. The added dorsiflexion created a knee flexion moment that could be controlled by selection of the dorsiflexion stop, which should allow 12-15 degrees. Limiting toe motion increased stability.

MCCLELLAND M, ANDREWS BJ, PATRICK JH, ET AL. (Orthotic Research and Locomotor Assessment Unit, Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, England). **Augmentation of the Oswestry Parawalker Orthosis by Means of Surface Electrical Stimulation: Gait Analysis of Three Patients.** *Paraplegia* 25:32-38, 1987.

A hybrid orthosis combines functional electrical stimulation with support provided by the Parawalker orthosis. The Parawalker is the adult version of the hip guidance orthosis designed for children with spina bifida. Unlike a child, however, an adult expends more effort standing and sitting and applies more stress to the hip joint. However, in this case, a two-channel electrical stimulator enables quadriceps to assist in standing and sitting, and allows the hip abductors on the stance side to resist deformation of the orthosis.

Three individuals with complete mid-thoracic spinal cord injury used the system, which requires a wheelchair-mounted support having a hinged telescopic armrest. The subject slides forward on the wheelchair seat, presses the STAND switch to initiate quadriceps stimulation, regulates body weight on the armrests and on the feet, and once upright finds that the spring-loaded bail locks engage automatically. The subject switches off quadriceps stimulation and engages hip motion restraints, and dons elbow crutches. Sitting is accomplished in reverse

sequence with quadriceps stimulation active when knee locks are disengaged. Elbow crutches have push-buttons in the handlegrips so that the stimulator can be operated by the patient's index fingers. Stimulator leads pass through the crutch tube to be connected to the stimulator. Subjects walked along a 20-foot gait laboratory path with and without gluteal stimulation. The path had a Kistler force platform. Quadriceps and gluteal muscles are stimulated during different locomotor activities. With gluteal stimulation, subjects walked faster, with less force on the crutches, thus reducing shoulder muscle fatigue.

McPHEE SD (US Army Command and General Staff College, Fort Leavenworth, KS 66027). **Functional Hand Evaluations: A Review.** *Am J Occup Ther* 41:158-163, 1987.

Nine systems for describing hand function were compared. They include the 1942 McBride classification which describes function according to the parts of the hand involved, intended for workmen's compensation evaluations. Griffiths in 1943 categorized prehension as cylindrical, ball, ring, pincer, and pliers grip. Taylor and Schwartz in 1955 distinguished fist, cylindrical, and hook grasp from lateral, palmar, and tip prehension. Napier in 1956 introduced power, hook, precision, and combination grip. Precision grip was later modified to precision handling. Kapandji defined the digital segments involved during manipulation, with such terms as prehension by subterminolateral opposition. Skerik, Weiss, and Flatt advocated the terms power, lateral, and hook grip, and tip and palmar pinch. The most recent proposal is that of Kamakura and associates who identified 14 basic patterns. All descriptions ignore the dynamic quality of hand function.

Sollerman and Sperling in 1976 developed a coding system with 23 designations for variables associated with grasp, measuring complex variations of object manipulation; the data are generally reserved for research. They claim all hand activities can be divided into eight main types and estimate the percentage of use in daily activities as pulp pinch 20 percent, lateral pinch 20 percent, 5th-finger pinch 15 percent; diagonal volar grip 15 percent; transverse volar grip 14 percent; tripod pinch 10 percent, spherical volar grip 4 percent, and extension grip 2 percent. Bendz advocated describing grip by the

various phases of the procedure, from initial opening to purposeful closing and stabilizing and terminal opening.

Eleven tests of hand function published since 1965 were reviewed. They are those by Carroll; Jebsen, and associates; MacBain; Clawson and associates; Potvin and associates; Smith; Bell and associates; Walker and associates; Wilson; Mathiowetz and associates who devised two different tests. Ninety-one percent of the tests use unilateral tasks, and 55 percent use bilateral ones. Eighty-two percent have objective measures. Most use time as the critical measure of function, an insufficient description of hand function. Tests should use tasks representative of everyday function.

MILLINGTON PJ, ELLINGSEN JM, HAUSWIRTH BE, ET AL. (Clement J. Zablocki Veterans Administration Medical Center, Milwaukee, WI 53193). **Thermoplastic Minerva Body Jacket—A Practical Alternative to Current Methods of Cervical Spine Stabilization.** *Phys Ther* 67:223-225, 1987.

A new cervicothoracic orthosis was developed to offer optimal cervical stabilization, allow early patient mobilization, and overcome difficulties with traditional alternatives such as the halo (which may introduce pin-site infection, cerebrospinal fluid leakage at the pin sites, pin slippage and loosening) and the prefabricated body jacket that is often used with the halo and increases risk of skin breakdown. Plaster jackets are difficult to modify, and if applied in the sitting position, risk loss of optimal cervical positioning; plaster is heavy and hampers hygienic activities. The new orthosis consists of two Polyform sections lined with Polycushion, joined by nylon screws at the neck and by chest straps. A headband joins the anterior and posterior trunk sections. The orthosis may be applied with the patient recumbent. X-rays are taken before and after fabrication to insure proper spinal alignment.

Four patients with cervical injury and one normal subject were fitted with the orthosis. Lateral X-rays were taken at the extremes of flexion and extension. The average intervertebral motion was measured for each segment of the cervical spine. The new orthosis restricted motion virtually as effectively as the halo with plastic body jacket. The thermoplastic orthosis allows the patient to use the shoulders in functional activities and patients may begin a full

mat exercise program with it, for it interferes less with rolling and prone activities than do the halo or plastic Minerva jackets. Cosmetic appearance is better. One half of the orthosis can be removed easily should the patient have cardiac or respiratory emergency. Shaving and washing are accomplished while cervical alignment is maintained.

OLSSON E, OBERG K, RIBBE T (Karolinska Sjukhuset, Stockholm, Sweden). **A Computerized Method for Clinical Gait Analysis of Floor Reaction Forces and Joint Angular Motion.** *Scand J Rehabil Med* 18:93-99, 1986.

The investigators devised a practical method of quantifying time and distance factors in gait, sagittal kinematics of the hips and knees, and vertical ground-reaction forces. The walkway has two parallel measuring platforms so that several steps can be separately analyzed. Each has a force plate with a vertical force transducer, in addition to one sensitive to horizontal fore and aft forces. Walking speed is measured with a stopwatch, later replaced by photocells that trigger the measuring procedure, and the whole system is connected to a computer to calculate time-distance factors and ground reaction forces and motion measurements.

The force transducers were found to be very stable on the vertical plate, but still too unstable on the horizontal measurements. The vertical transducer performed satisfactorily with regard to linearity and hysteresis. Step length measurements were found to be reliable when comparison between computer-generated data and footprint markings were performed. Angular excursions were measured by a self-aligning electrogoniometer set for hip and knee readings. The variables recorded and analyzed include body weight, average velocity, step rate, mean step and stride lengths (right and left and as a percent of leg length), gait cycle durations (including single stance on each leg, double stance), maximum vertical force on each leg, weightbearing areas, and time from heel strike to maximum vertical force on each leg.

ROSE HG, SCHWEITZER P, CHAROENKUL V, ET AL. (Departments of Medicine and Surgery, Veterans Administration Medical Center, Bronx, NY 10468). **Cardiovascular Disease Risk Factors in Combat**

Veterans After Traumatic Leg Amputation. *Arch Phys Med Rehabil* 68:20-23, 1987.

Vietnam War veterans with amputation were randomly selected from Veterans Administration lists and invited to participate in the study. Nineteen bilateral above-knee amputees and 12 unilateral below-elbow amputees had 4 days of inpatient metabolic testing. The groups did not differ according to age at time of amputation or study, race, or years of education. Above-knee amputees were heavier and taller; most had served in the Marine Corps. None had ischemic heart disease as judged by history, electrocardiography, or exercise stress testing. One below-elbow and nine above-knee amputees were hypertensive; none had contributory family histories. Hypertensive lower-limb amputees were significantly fatter, although reported body weights at maturity were identical for those who became obese and hypertensive and those who remained lean. Obese hypertensive lower-limb amputees were markedly hyperinsulinemic; no significant differences existed for serum triglycerides, or cholesterol.

Contrary to previous reports, the high-risk lateral above-knee amputees did not manifest evidence of cardiovascular disease. Risk factors were obtained in that a significant number were hypertensive and obese. Weight gain occurred in the first two postconvalescent years. It is uncertain whether the injury caused weight gain and hypertension, or whether these men would have become obese-hypertensive in any case. Unique in this group, as compared with older hypertensives, was the considerably greater hyperinsulinemia. They depended on arm and upper body musculature for ambulation; arm exercise can be hazardous to nonamputees with underlying heart disease, yet the amputees performed as well as control subjects. It is not yet known whether good performance at young age will be sustained later. Onset of obesity in young adulthood means a prolonged exposure to cardiac risk factors.

RUBIN G, FISCHER E, DIXON M (Veterans Administration Medical Center, New York, NY 10010). **Prescription of Above-Knee and Below-Knee Prosthesis.** *Prosthet Orthot Int* 10:117-124, 1986.

A series of charts match amputation limb characteristics with prosthetic prescriptions derived from the authors' experience. Other factors should also

influence prescription, such as general physical status, individual amputation limb characteristics, and vocational problems; climate, terrain, and cultural factors also affect prescription. The charts do not include advances that are not universally employed, such as the potentially significant flexible and narrow mediolateral above-knee sockets, or the Seattle foot and Mauch ankle, Computer Aided Design-Computer Aided Manufacture, or the Icelandic Roll-on and Pull-on Suction Sockets.

Below-knee amputation is charted according to stump length, modifying factors (unstable knee, occupational considerations, contralateral amputation, hypersensitivity, flexion contracture), prosthesis, suspension, and foot/ankle unit. The SAFE foot is the first choice for the individual with 10 cm or longer limb, together with PTS prosthesis with wedge suspension. Above-knee amputation charts are separated according to active or limited physiological age. For the active amputee with relatively long limb, the preferred prescription includes total suction socket, fluid-controlled knee, either exoskeletal or endoskeletal structural type, and SAFE foot. Prescription for knee disarticulation prosthesis for the amputee with unmodified stump with or without patella and no problems is an end-bearing socket, single-axis hydraulic knee, suspension by soft socket insert for supracondylar suspension, either endo- or exoskeletal type and SAFE foot.

SHEEHAN JCM AND QUIGLEY MJ (Loyola University, Chicago, IL). **The Stat Limb: A Prosthesis for Immediate Postoperative Fitting of AK and BK Amputations.** *Clin Prosthet Orthot* 11:5-10, 1987.

The Stat Limb is a prefabricated supportive structure of high-density polyethylene made in one size, designed to suit both right and left below-knee and above-knee amputation limbs. It is intended to provide all the advantages of a rigid postoperative dressing, as well as early weightbearing. The prosthesis prohibits knee flexion and is very light. After surgery, the wound is covered with a rigid protective dressing made of a gauze dressing over the wound site, covered with a 2-cm layer of cotton from the groin to the distal end, over which a thin layer of fiberglass casting material is applied. Alternatively, plaster may be substituted for the fiberglass; plaster requires 24 hours to dry before the Stat Limb may be applied. The dressing can be applied in less than 8 minutes.

The Stat Limb is cut to the desired leg length, equal to the distance from the sole of sound foot to a few inches short of the top of the rigid dressing, minus half an inch to allow for toe clearance in walking. Six vertical cuts are then made to allow the Stat Limb to form around the rigid dressing. The knee is kept in extension or locked in 2 degrees of hyperextension, allowing the quadriceps, hamstrings, and gastrocnemius to relax reflexly, and reducing pain and associated spasm.

As healing progresses, the rigid dressing is changed for a padded PTB socket made of fiberglass cast material with supracondylar strap or single-axis hinge suspension. Nonslip material should always be worn, because the plastic foot section is very slippery.

More than a thousand Stat Limbs have been used.

STEIN JL and FLOWERS WC (Department of Mechanical Engineering and Applied Mechanics, The University of Michigan, Ann Arbor, MI). **Stance Phase Control of Above-Knee Prostheses: Knee Control versus SACH Foot Design.** *J Biomech* 20:19-28, 1987.

One left unilateral above-knee amputee participated in a series of walking trials. He is 26 years old, sustained amputation at the age of 12, and wears a Mauch SNS knee unit and an Otto Bock SACH foot with soft heel. Data were collected with a Selspot-based gait acquisition system as the amputee used a knee simulator prosthesis, and walked on a forceplate-equipped walkway. Initially, the simulator imitated a conventional prosthesis; subsequent trials were performed with various prosthetic modifications.

The conventional control mode is an angle-dependent nonlinear damper. During single support, the amputee holds the prosthesis against hyperextension stops by hip moment, body placement, and sound leg push-off. After sound heel contact, the amputee imparts energy into the prosthesis which energy is partially dissipated by the knee control unit so that swing phase may be initiated correctly. Stirling is an amputee gait parameter, describing the greater height of the hip on the prosthetic side during stance. Seventeen trials were conducted over a 6-month period. Under conventional knee control, the average knee joint is in full extension 5 percent after prosthetic heel contact and remains extended until

sound heel contact. Under modified echo control of the knee, the prosthetic knee at prosthetic heel contact is in 3 degrees of flexion, then extends to 1 degree of flexion during the first 5 percent of stance, then flexes to reach a maximum of 14 degrees at 33 percent. The knee then extends to within 5 degrees of full extension at sound heel contact. Afterwards, knee motion is identical to the conventional control. The modified control also changed the trajectory of the center of pressure; the echo control caused the knee to flex, thus initiating foot flat sooner. (Hip displacement is presumed to be based on the femur's remaining fixed with respect to socket motion.) Hip trajectories were higher with the experimental knee control. Thus, to generate new hip kinematics requires a change in SACH foot characteristics, inasmuch as the experimental knee control produced kinematics similar to the normal knee.

VILKKI SK (Department of Hand and Microsurgery, Ortyopedic Hospital of the Invalid Foundation, Helsinki, Finland). **Replantation of a Leg in an Adult with 6-Years' Follow-up.** *Acta Orthop Scand* 57:447-449, 1986.

A 24-year old man sustained severance of the leg through the mid-tibial shaft in a circular saw accident. The amputated leg was cooled, and bleeding was controlled with hemostats. He arrived at the hospital 5 hours after the accident. A Kuentscher nail was inserted in the proximal tibia, shortening the bone by 4 cm to facilitate soft tissue repair. The severed leg was attached to the nail. The major veins and arteries were repaired.

After 10 hours of ischemia, circulation was restored. Anastomosis was achieved between the ends of the tibial nerve. Muscles were then sutured and some skin grafting was necessary. The leg was suspended for 3 weeks. The leg and foot were kept in a firm bandage when the patient walked after one month. He used crutches for 3 months without weightbearing. After 6 months he could walk without crutches with a 4-cm shoe lift. Some sensibility returned to the heel after seven months, and ankle mobility was moderately good. The nail was removed after 20 months.

He returned to his previous occupation 11 months after injury. Plantar flexion is now strong, but dorsiflexion remains weak and limited to 10 degrees. Subtalar movement is restricted. Arterial supply is

normal and the patient has no pain. Prerequisites for successful leg replantation are: experienced replantation team, moderately sharp-cut injury, reasonably intact soft tissues, tibial nerve adequately repaired, bone shortening less than 8 cm, and cold-ischemia time less than 12 hours.

WATKINS EM, EDWARDS DE, PATRICK JH (Orthotic Research and Locomotor Assessment Unit, Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, England). **Parawalker Paraplegic Walking.** *Physiotherapy* 73:99-100, 1987.

The Parawalker was developed as an extension of the hip guidance orthosis designed for children. Currently, 160 children use the hip guidance orthosis, and 30 adult traumatic paraplegics with complete lesions between T3 and L2 use the Parawalker. The Parawalker is a custom-made orthosis that requires two to three weeks of inpatient training for satisfactory use. Training starts in the parallel bars and progresses quickly to crutches. Patients maneuver over irregular and sloping surfaces, steps and curbs, and manage a car. Few patients can manage a flight of stairs. All patients walk, but only three walk 1 to 2 km regularly. The gait is reciprocal, with lower energy cost than required by swing-through crutch walking, as indicated by speeds and heart rates. Speed increased an average of 87.3 percent and heart rate decreased 10 beats per minute among children using the Parawalker as compared with their previous traditional orthoses.

Adults who have combined the Parawalker with functional electrical stimulation of the gluteal musculature have decreased the force applied through the crutch by an average of 25 percent.

A small range of clothing has been manufactured to permit easy doff and don and easy access to urinary drainage bags. Patients comment that they feel more socially acceptable standing rather than sitting in a wheelchair, having eye-level contact restored. Quality of life has improved with standing at the bar, playing darts and, for some, doing lengthy walks on rough ground. The upright position aids kidney and bowel function, relieves pressure points, reduces spasticity, and prevents contractures and osteoporosis.

WILSON AB JR, SCHUCH CM, NITSCHKE RO (Department of Orthopedics and Rehabilitation, University of Virginia, Charlottesville, VA 22908). **A Variable Volume Socket for Below-Knee Prostheses.** *Clin Prosthet Orthot* 11:11-19, 1987.

A custom-fitted below-knee socket was designed to enable control of volume equally or selectively between proximal and distal parts of the amputation limb, with normal prosthetic appearance, in a light, durable design. The primary purpose was to design a socket for a preparatory prosthesis, but the current design is suitable for extended periods. The socket consists of a posterior segment held to the rest of the socket by two circumferential straps secured with hose clamps. The two-piece design enables donning and doffing without subjecting the skin to shearing force.

The socket is fabricated with the Fillauer casting procedure in which the anterior portion of the limb is casted first with plaster splints, then the remainder

of the limb is casted. The model is modified in the usual manner. A transparent diagnostic socket should be made and the algination procedure followed. The final socket is made over the positive model which is covered with Pelite over the anterior half. Over the posterior half, 1/8-inch polyethylene or Surlyn is vacuum-formed and trimmed to form a posterior shell extending anteriorly just past the midline to underlap the Pelite by 3/8 to 1/2 inch. Over the posterior panel, rope is glued to form a channel for the volume control straps. The lamination is performed. The socket may be used on the Otto Bock modular endoskeletal unit.

Seven variable-volume sockets have been fitted to six amputees, five of whom used it as their first prosthesis. Subjective response of the amputees and clinic team is positive; in all cases, socket fit was maintained by decreasing socket volume as limb atrophy occurred. The socket remained comfortable. Several additional sockets have been fitted successfully elsewhere.