ABSTRACTS OF RECENT ARTICLES

The following articles have been abstracted by Joan E. Edelstein, R.P.T., who is a Senior Research Scientist, New York University Post-Graduate Medical School, Prosthetics and Orthotics, 317 East 34th Street, New York, N.Y. 10016.

For this issue of the Journal, Joan Edelstein has selected 22 articles for abstraction and two books for review. You will find 22 abstracts which fall into the following general categories:

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American Journal of Physical Medicine 1
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One of the books reviewed in this issue is a guide to the selection and application of controls for assistive devices; the other is a resource manual on seating for children with cerebral palsy. Reviews follow the presentation of abstracts.

Advantages of a Simple Contact Switch for Human Locomotion: Frederick Patterson, Linda Gorman, and Mary Wetzel (Department of Psychology, University of Arizona, Tucson, Arizona) American Journal of Physical Medicine 63:11-17, February 1984.

A simple foot contact switch was designed and tested for several years. The switch excludes the effect upon movement imposed by different footwear, and allows direct comparison of barefoot walking with walking in a shoe. The switch has operated successfully for subjects of many sizes and weights who performed different tasks on a motor-driven treadmill. The switch is made from commercially available foam insole or shoe insert 4 mm thick. Double-thick heel-shaped pads are cut from the insole, then a 1 cm square is cut through the center of each pad. The electrical conduction portion consists of two strips of metallic tape (burglar alarm window foil), each 14 cm long. The strips are secured to the pads with double-sided adhesive tape reinforced with electrical tape, so that the strips are separated by the width of the double pad. The completed switch is held to the foot with elastic adhesive bandage, and is connected to an electronic recording instrument by attaching the free ends of the foil strips to wires fastened to the subject's leg with Velcro.

Time elapsed between heel touchdown and liftoff as measured by the footswitch (and as determined from movie films) was compared with subjects wearing a sandal and then walking with the insole foot switch. Differences in time recordings were attributed to different movements of the feet. One subject touched down with the heel appreciably in advance of the up-thrust ball; the heel and ball moved backward and upward until a lingering liftoff was seen for the toes. Another individual walked in a more flat-footed fashion without toe lingering.

The small size of the insole device permits its use to record contact by other portions of the foot in addition to the heel. The switch eliminates distortion of stance duration timing attributable to conventional shoes.

Amputation Revisited: G. Murdoch (Limb Fitting Centre, Dundee, Scotland) Prosthetics and Orthotics International 8:18-15, April 1984.

In ancient times, amputation usually resulted from gangrene or trauma, sometimes associated with ritual sacrifice, punishment, or ergot poisoning. Today, the car and leprosy are common causes but in Europe and North America most amputations are performed because of vascular disease. Many patients are now rehabilitated, primarily because skin perfusion pressure measurements, Doppler ultrasound, and thermography enable prediction of wound healing. In trauma, all viable tissue should be conserved. Chemotherapy permits amputations through bone affected by osteosarcoma if the site is 10 cm above the most proximal area of bone reaction. Radical local resection and internal prosthetic replacements may obviate some amputations. Congenital absence of the fibula is best treated by foot ablation at 10 months. Ambroise Pare in the sixteenth century was the first to choose a site well above the gangrenous area at a level suitable for fitting with a prosthesis. Today, site selection involves pathology, anatomy at the proposed level, and what prostheses are available.

The preoperative phase should include explanation of

the operation, phantom phenomenon, and the rehabilitation program. Spinal anesthesia ensures no pain for 1-2 hours, with less confusion and fewer problems with hypotension and chest complaints. Celsus in A.D. 25 used a rasp to smooth rough bone margins. Lister's antisepsis paved the way for modern tissue management. The higher the ratio of the base to the length of the flap the better the chance of healing. Muscle stabilization yields better blood supply to the wound. In the Peloponnesian War, the stump was cauterized and covered with tar. Today a rigid cast and controlled environment prevent edema.

Above-knee amputation should be 12-13 cm above the knee, where most adductors have been inserted and the major neurovascular bundles have arrived at their destination. Myoplasty ensures a stump of smooth contours and stable shape. Knee disarticulation with medial and lateral flaps permits true end-bearing, with good proprioception and rotational stability. A posterior flap should be used for below-knee amputation in dysvascular patients. Osteomyoplasty between the tibia and fibula is very satisfactory. Malleolar projections may be removed from the Syme stump, provided the level of amputation is as was described originally. Pirogoff amputation provides excellent end-bearing.

During the middle ages prostheses were mainly intended to conceal the amputation of soldiers on horseback. Modern prostheses are designed with increased understanding of biomechanics.

Joint Forces in the Human Pelvis-Leg Skeleton During Walking: H. Rohrle, R. Scholten, C. Sigolotto, W. Sollbach, and H. Kellner (Dornier GmbH, D-7990 Friedrichshafen 1, West Germany) Journal of Biomechanics 17:409-424, 1984.

Forces in the skeleton during walking are not extremely high, but due to the frequently repeated load cycles there are great demands on the durability of the skeleton and joints. For the calculation of the joint forces, data of the three-dimensional motion of the body need to be obtained without restricting gait. Distribution of forces between foot and ground is to be measured in a sufficiently large number of healthy persons in order to evaluate the joint forces of handicapped subjects. The external forces acting on the leg consist of the components of the foot-ground forces and inertia forces of the thigh, shank, and foot. The calculation model has three degrees of freedom describing the hip, one for the knee, and two for the ankle.

The gait track is 8.1 meters long with a Kistler force plate and moving marks along the sides for speed alignment. A camera tracking system records the motion sequence. The optoelectronic system consisting of 18 Selspot 700 units records the movements of infrared-light-emitting diodes attached to the subjects. Prior to calculation of joint forces, an idealized bone-muscle configuration for a normal person based on anthropometry is needed to provide joint axes, coordinates of joint centers, and muscle origina, directions, and deflecting points. Linear transfer of the muscle idealization to each test person is applied to the thigh, shank, and foot. Weights and centers of gravity of body parts are taken from idealized data and applied to individual subjects. The analysis includes the influence of inertia forces due to the translatory three-dimensional motion of the body parts. Coordinates of the light-emitting diodes and the imaginary joint points are known in the upright position, permitting calculation of the position of the time-dependent joint position.

For determination of muscle and joint forces, the geometrical situation is taken into account, with bones assumed to be rigid. Muscle and inertia forces are calculated based on equilibrium of moments at the joints. Electromyographical measurements permit distinguishing between high and low levels of muscle activity. Gait measurements produce angle-time graphs of time-dependent positions of the skeleton. Inertial and foot-ground forces influence calculation of muscle and joint forces (fast walking increases vertical force up to 30 percent) Since foot-ground force does not pass through the knee and hip, joint forces are much greater than foot-ground force. Joint forces vary linearly with gait velocity, and the load during terminal stance exceeds the values of the prestance.

Leg Exerciser for Training of Paralyzed Muscle by Closed-Loop Control: J. S. Petrofsky, H. H. Heaton III, and C. A. Phillips (National Center for Rehabilitation Engineering, Wright State University, Dayton, Ohio) Medical and Biological Engineering and Computing 22:298-303, July 1984.

A leg trainer was invented for paraplegics and quadriplegics which involves a stimulator controlled by a microcomputer. The stimulator control assembly is built on a single plug-in card for the Apple II microcomputer. Pulses of variable amplitude from the assembly board go to an accessory module placed near the subject. The module has two transistors. The subject sits in a specially designed chair with surface electrodes placed over the muscle group to be stimulated. The electrodes are made of carbon-filled elastomer. The chair contains a leather harness worn around the ankle. The harness is attached to an isometric tension transducer bar through cables and pulleys. Two strain gauges are mounted on the bar. When the muscle is electrically stimulated, the tension can be recorded and is used to determine the maximum isometric strength of the muscle and the workload. Weights can be placed in the apparatus so the leg as it extends lefts the weights. A Precision potentiometer measures leg movement and transmits the measurements to the computer which can sample knee position to see how effective the stimulation was.

The software program has one section which involves measuring the threshold voltage (just enough to make the muscle move), and the voltage that produces maximum contraction. A series of pulse trains is applied to the muscle with increasing amplitude and the strength developed by the muscle is measured. The muscle will develop isometric tension until the maximum isometric tension (or pain) threshold is reached. Once this occurs, the operator

presses an escape button to tell the computer the muscle is developing its maximum isometric strength. The computer uses the maximum strength to set the workload; first no load, then either 25 or 50 percent of maximum. The computer will print the appropriate weight to be added to the trainer to allow the exercise to be performed. After weight is added, the operator cues the computer and the muscle contracts isokinetically. The stimulator causes the muscle to lift the weight through a 60-degree arc over 3 seconds, then slowly to lower the weight.

Submaximal exercise causes strength to return rapidly, but bone size and density are not restored quickly. It is important to examine for stress fractures in osteoporotic bone. Because patients with spinal cord injury lack sensation in the affected limb, it is important that they be checked for burns over the electrode site. Stimulation is restricted to muscles accessible to surface electrodes. Localized hypertrophy could unbalance forces that normally stabilize joints. Therefore monthly radiographs should be taken to rule out bone-spur formation, abnormal joint interspaces, or stress fractures.

Mechanical Effectiveness Studies of Lumbar Spine Orthoses: Alf Nachemson, Albert Schultz, and Gunnar Anderson (Department of Orthopedic Surgery I, Sahlgren Hospital, University of Goteborg, Sweden) Scandanavian Journal of Rehabilitation Medicine, Supplement 9:139-149, 1983.

Four healthy young adults performed six tasks while standing with no orthosis, then with a Camp canvas corset, a Raney flexion jacket, and Boston brace fitted to provide 0, 15, and 30 degrees of lumbar extension. Horizontal loads were applied to a chest harness and vertical loads imposed by having the subjects hold weights in the hand. The subjects resisted weight applications in flexion, extension, right lateral bending, and right twist. Subjects also flexed their hips 30 degrees and held their arms extended forward with "40-N" weights in each hand. Goniometric evaluation was performed to locate the mass center at L3, and linear measurements were taken of the trunk at the L3 level. Twelve bipolar pairs of surface electrodes were placed lateral T8, L1, L3, and L5 vertebrae and over the rectus abdominus and oblique abdominal muscles. Intradiscal pressure was measured by a pressure transducer in a needle tip inserted posterolaterally into the center of the third lumbar disc. Intra-abdominal pressure was measured with a radio transducer swallowed by the subjects.

Intradiscal pressure values with an orthosis were lower in two-thirds of the exercises and higher in the remaining tasks, compared with no-orthosis values. Intra-abdominal pressures were generally low, although no clear trend indicated the effect of the orthosis, nor were there consistent trends as to the effect of orthoses on muscular activity. Linear regression analysis of predicted spinal compression versus measured intradiscal pressure suggested that all orthoses relieved spinal compression approximately equally. Spinal compression relief averaged 7 percent over the 18 tasks, and did not show consistent relationship to task or particular orthosis.

Load distribution is probably determined primarily by segment morphology and soft tissue properties, which are not altered by an orthosis, rather than by intersegmental motions; restriction is important when an orthosis is worn for postoperative stabilization, but seems unrelated to low-back pain. Gross motion restrictions are probably more important to orthosis effectiveness in low-back pain than are intersegmental restrictions. An orthosis sometimes unloads lumbar trunk structures significantly and reduces lumbar spine compression and lumbar erector spinae activity by a third, although orthoses can increase muscular activity. Orthoses did not raise intra-abdominal pressure significantly over the sustained isometric efforts studied. No orthosis seemed clearly superior in mechanical effectiveness.

Assessment of Tissue Viability in Relation to the Selection of Amputation Level: V. A. Spence, P. T. McCollum, W. F. Walker, and G. Murdoch (Ninewells Hospital, Dundee, Scotland) Prosthetics and Orthotics International 8:67-75, August 1984.

Noninvasive ancillary methods to aid in amputation level selection allow estimation of the critical level of ischemia. Presently favored is measurement of segmental limb blood pressures by Doppler ultrasound or plethysmography, although the measurements are unsuitable for estimating the precise level of amputation. Low pressures at the ankle should not exclude below-knee amputation, because local intrinsic regulatory mechanisms can allow adjustments of volume flow in microcirculatory vascular beds. Only methods which measure capillary flow to the skin in potential amputation flaps are useful in site selection.

A microelectrode consisting of a 15-micrometer platinum wire encased in glass of approximately 70 micrometers measures skin oxygen partial pressure. Little difference exists between measurements at normal skin and in the proximal leg skin of patients requiring below-knee amputation, probably because skin has a baseline blood flow much greater than its nutritional demands. Reduced pressure exists in the dorsal foot skin in amputation patients. The procedure is difficult with patients who have ischemic rest pain.

Pressure measurements must be related to meaningful physiological parameters associated with tissue oxygen exchange. Transcutaneous oxygen measurements also reveal good amputation sites.

Measurement of skin blood flow by the rate of removal of a freely diffusible radioisotope such as 133-Xenon injected intradermally is simple, inexpensive, and reproducible. Iodoantipyrine is preferable for use in fatty tissues. A simple method for preparing a stable solution which does not undergo radiolysis has been developed. The clearance method only provides an estimate of blood flow at a single point. Measurements made in the foot are of little use in

determining healing potential.

Thermography provides detailed direct information relating to the circulation through whole areas of skin, although the method lacks necessary quantification. A direct relationship exists between temperature gradients and skin blood flow measurements in the ischemic limb.

The Nonsurgical Management of Odontoid Fractures in Adults: Gwo-Jaw Wang, Kevin Mabie, Richard Whitehill, and Warren Stamp (Department of Orthopaedics and Rehabilitation, University of Virginia Medical Center, Charlottesville, Virginia) Spine 9:229-230, April 1984.

Odontoid fractures account for 10–15 percent of all cervical spine fractures, with earlier a 50–60 percent mortality and now a 5–8 percent mortality. Currently, high nonunion rates complicate management. Twenty-five adult fractures were treated by closed methods during a 5-year period. Four patients had spinal cord dysfunction. Sixteen patients were treated initially with traction, then in halothoracic orthoses to limit atlanto-axial motion. The others had a collar or other brace.

The patient with avulsion fractures at the alar ligament insertion had a halo-vest with ultimate union. Those with fractures extending into axial body had a Philadelphia collar, halo cast, or halo-vest, and all achieved union. Patients with fracture at the junction of the process and body had either halothoracic immobilization or a collar or brace. Forty-two percent had nonunion, with halothoracic immobilization resulting in a lower rate of nonunion. Although displacement did not affect the outcome of fractures at other sites in the odontoid, most of the nonunions occurred in displaced fractures, especially if a collar or brace were used. Only a fifth of nondisplaced fractures treated by halothoracic immobilization resulted in nonunion, and no significant difference exists in the results obtained for displaced fractures treated with halothoracic immobilization versus collars or braces.

Electromyographic Results of Inhibitory Splinting: Virginia Mills (Braintree Hospital, Braintree, Massachusetts) Physical Therapy 64:190-193, February 1984.

Eight subjects with spasticity caused by head trauma or subarachnoid hemorrhage secondary to aneurysm received Orthoplast or plater splints bivalved and lined with Polycushion for total skin contact. The splint positioned the joint within 10 degrees of its full passive range. Ankle plantar flexion, wrist flexion, and elbow flexion were studied by surface electromyography in the nonsplinted resting position and during splint wear. A control contraction was obtained, the subject's best volitional effort at isometrically contracting the spastic muscle against manual resistance for 5 seconds. The limbs were placed in a gravity-eliminated position. A significant increase occurred in the measured goniometric position of the limbs into extension in the splinted condition, but no significant reduction in electromyographic activity was found in the splinted condition, although 7 of the 10 limbs showed decreased activity when splints were worn. Muscle groups accommodated to the elongated position achieved by splinting, evidenced by no change in electrical activity. Splinting is effective in controlling postural defects and deformities without changing muscle activity. Three patients exhibited increased electromyographic activity with splinting, indicating the need to study cases individually.

Sitting Orthosis for Patient with Bilateral Hip Disarticulation: Roman Oryshkevich, Won Heum Jhee, Ronald Wilcox, Delbert Coleman, and Ed Ayyappa (Veterans Administration West Side Medical Center, Chicago, Illinois) Archives of Physical Medicine and Rehabilitation 65: 276-278, May 1984.

A 59-year-old man with right hemiplegia and bilateral hip disarticulation received a sitting prosthesis which enabled him to sit securely in the wheelchair and propel the chair independently. The socket was made of Thermovac 0.6-cm thick and fully lined with 1.3-cm perforated Plastazote. The base of the orthosis was rigid polyurethane foam covered with polyester resin. Beneath the base, plywood provided a light, strong foundation. The base was padded with Kemblo rubber. The orthosis was designed like a bucket, with the patient's weight distributed over a broad area. A front opening proved practical. The patient was placed into the socket and the apron strapped to prevent his falling out. The entire orthosis was strapped to the back of the wheelchair. A window on the apron and corresponding depression at the base accommodated a urinal. Two persons are required to assist the patient into the orthosis. The orthosis also enabled the patient to sit on the floor or in bed.

The Technique of Reciprocal Walking Using the Hip Guidance Orthosis (HGO) with Crutches: P. B. Butler, R. E. Major, and J. H. Patrick (The Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, United Kingdom) Prosthetics and Orthotics International 8:33-38, April 1984.

Walking in complete paraplegia above L1 requires either the swing-through or reciprocal gait; the latter reduces the vertical excursion of the center of mass to provide more efficient walking and can be obtained in long-leg calipers with high energy cost and slow progression. Body brace/calipers restrict flexion/extension. The HGO provides stability and hip control. The orthosis, for children and adults, consists of a rigid body brace to abduct the legs, a pair of hip joints with limited flexion/extension range, stable knees and ankles, shoe plates with rocker soles and a simple fastening arrangement. The body brace is aluminum alloy tubular and channel section with a leather chest

strap. On the buttocks a polypropylene support band is attached directly to the bearing housing. At right crutch strike, lateral movement to the right commences as most weight is transmitted through the right foot. The left crutch is slightly ahead of the left toe pushing down and back to tilt the user to the right to clear the left leg. Forward trunk momentum assisted by the rearward left crutch force moves the right hip over the right stance foot. The HGO provides a reaction force on the right chest wall. Mechanics, muscle action, and orthotic reaction for the remainder of the cycle are described.

Four groups of users are those who are unable to perform competently, those who use a rollator or crutches for three-point contact, those who use crutches for two-point contact, and those who show random crutch use.

A Method for Determining the Mechanical Characteristics of Orthotic Knee Joints: R. P. Scothern and G. R. Johnson Department of Mechanical Engineering, University of Newcastle-upon-Tyne, United Kingdom) Prosthetics and Orthotics International 8:16-20, April 1984

A method of destructive testing by bending about the mediolateral and anteroposterior axes allows measurement of the bending strength of a knee joint side member assembly, and definition of the brittleness of the failure. The angular deflection was compared with the bending moment for a variety of sizes and types of joints, all loaded under a uniform bending moment. Rollers were mounted in pairs on the faces of two pulleys. Equal and opposite torques were then applied to the pulleys. Angular deflection was measured with a Linear Variable Differential Transformer coupled to a pulley. The joint was placed in the test rig with the lock in the center. Load was slowly increased until any part of the assembly fractured, the lock opened, the specimen deflected markedly, or the specimen continued to deflect while the bending moment remained constant. Each joint was tested in flexion, extension, and mediolateral bending in two directions. The elastic region ends at the limit of proportionality, after which the graphed results show plastic permanent deformation. The bending strength was defined as the limit point of proportionality. Ductility/brittleness was measured by the plastic/elastic ratio; the higher the value, the more ductile the failure, and the smaller the chance of injury to the wearer. A ring lock failed when loaded in flexion because of insufficient contact area between the tongue and the ring allowing plastic deformity of both components. A bar lock loaded in flexion failed because of double shear of the hinge pin. A bale lock failed because the locking spring was weak or a large wedge of material was sheared off. Satisfactory failures are associated with ductility in which the first component to fail is not a casting and double-shear failure of loaded pins is avoided.

Potential Problems of Manufacture and Fitting of Polypropylene Ultralightweight Below-Knee Prostheses: P. Covery, D. Jones, J. Hughes, and G. Whitefield (National Centre for Training and Education in Prosthetics and Orthotics, Glasgow, Scotland) Prosthetics and Orthotics International 8:21-28, April 1984.

The ultralightweight prosthesis was developed in 1976 at the Moss Rehabilitation Hospital with a hollow foot and SACH heel wedge. The 1978 version from Rancho Los Amigos Hospital had a hollow-external-keel SACH foot. The primary expectation was that saving weight would minimize energy requirements, but this has not been demonstrated. A clinical evaluation was conducted with a supracondylar socket with a Pe-Lite liner, mated to a hollow calf and a keel bonded to the flexible soleplate of an Otto Bock IS19 foot. A cosmetic cover was fitted. A manual of the manufacturing method is available from the authors.

Prostheses are now manufactured with 4.5-mm-thick sockets to eliminate excessive mediolateral flexibility. Because the keel of a standard SACH foot proved to be too short (upon removal of 4 mm to allow drape of the polypropylene) an external-keel foot is now used. To avoid shrinkage of the mediolateral socket brim, vacuum was reduced to 400 mmHg, the cold water quench was excluded from the manufacturing process, and the calf section was welded to the socket at the patellar bar level rather than around the brim. Additional polyurethane foam is used to compensate for shrinkage when foam is draped with polypropylene. Because temperature and rate of heating are critical, a small sample of polypropylene should be placed in the coolest spot in the oven: when the sample becomes transparent, the plastic is ready to drape. Extruded sheeting of ICI block copolymers to grade GPE 102 with tan additive is used. Securing a permanent bond between the soleplate and the keel remains unsolved. The vertical transfer jig makes foaming the calf section easier and minimizes loss of alignment. Improved technique permits accurate mating of the calf and socket, and also of the keel and soleplate.

The Distal Blood Pressure Predicts Healing of Amputation on the Feet: Per Holstein (Department of Clinical Physiology, Bispebjerg Hospital, Copenhagen, Denmark) Acta Orthopaedica Scandinavica 55:227-233, April 1984.

During a 7-year period, 142 foot amputations were performed in 134 patients. Two-thirds were men, and 80 percent had diabetes. Primary closure was made in only 15 forefoot and 3 digital amputations. Patients with systolic digital blood pressure less than 20 mmHg had a 17 percent healing rate, while 78 percent of those with pressure above 30 mmHg healed. The healing rates in nondiabetic cases equalled those of diabetics. The diabetic legs that failed to heal had a high pressure and invasive infection. Second toe pressure measurements are useful where the first toe is not available. With systolic ankle blood pressure below 50 mmHg, no feet healed, and with pressure above 100

mmHg, 72 percent healed. Healing rates in diabetics equalled that of nondiabetics. Equal healing occurred in forefoot and digital amputations. Ankle pressure may be falsely high because of rigid arterial walls. With perfusion pressure on the forefoot below 20 mmHg, half the patients healed. Ankle pressure is still a valuable predictor because values under 50 mmHg indicate that the limb is seriously threatened. The digital pressure is the best predictor of healing, skin perfusion pressure is valuable in determining the level of major amputation. Pressures below 20 mmHg are very predictive of healing failure in the foot. Healing on the foot requires a higher preoperative perfusion pressure than does major amputation which leads to better circulation of the remaining stump.

The Outrigger Problem in Hand Splinting: Erik Moberg (Department of Hand Surgery, Sahlgrenska Hospital, Gotegorg, Sweden) Scandinavian Journal of Rehabilitation Medicine, Supplement 9:136-138, 1983.

Large outriggers on hand splints sometimes cause the patient to refuse to wear the device. Outriggers tend to hook everywhere, disturbing sleep and dressing. They are also very conspicuous. Outriggers are important to obtain the right angle of pull by the elastics, and are used to reduce the differences in pull between various positions of flexion and extension.

Sufficient length of elastics may also be achieved by use of almost frictionless pulleys which elongate the pathway of the elastics without changing their direction of pull. Pulleys must be built on the rolling principle to compensate for the high friction coefficient in elastics. Disposable hypodermic syringes are a very good material for the pulleys. They are shaped with a hack-saw blade and bonded together with fast acting cyano-acetate glue.

Orthotic Management of Scoliosis in Duchenne Muscular Dystrophy: Barry Seeger, Andrew Sutherland, and Michael Clark (Regency Park Centre for Young Disabled, Kilkenny, Australia) Archives of Physical Medicine and Rehabilitation 65:83-85, February 1984.

The sling seat and back of the conventional wheelchair do little to prevent spinal deformity in muscular dystrophy. Orthotic management relies either on a spinal orthosis or modification of the wheelchair seat and back. The corset is avoided because of risk of pulmonary problems and discomfort. Modifications are sometimes custom-molded total-contact seating systems made by vacuum consolidation. The fabrication process is time-consuming and labor-intensive. Alternatively, a system of modular seating inserts is used.

Twenty-four patients were studied for 3½ years to determine the relative effectiveness of various wheelchair seats and orthoses in preventing spinal deformity. Spinal curvature was measured at 6-month intervals from radiographs. Seats were used for approximately 12 hours a day, and jackets for 7 hours daily. Each child progressed through several types of support. In general, modular seats were used by those with less deformity; children with greater deformity had custom-molded seats and spinal jackets. Children exhibited a significant increase in curvature after age 12, and no increase beyond 18 years. Among boys 14 to 16 years of age, the best results were obtained using a spinal jacket, followed by modular seating, unmodified wheelchairs, and custom-molded seating (the only statistically significant difference was that between the jackets and the custom seats). Spinal support systems failed to keep the youngster's spine straighter for longer. If curvature can be controlled surgically, then the emphasis in wheelchair design can be comfort, appearance, and maximum function.

Assessing the Reliability of Measurements from the Krusen Limb Load Monitor to Analyze Temporal and Loading Characteristics of Normal Gait: Patricia Carey, Steven Wolk, Stuart Binder-Macleod, and Raymand Bain (Emory University School of Medicine, Atlanta, Georgia) Physical Therapy 64:199-203, February 1984.

The Krusen Limb Load Monitor consists of a pressure transducer worn inside a shoe and a control box worn at the waist. Output from the monitor provides auditory feedback as weight exceeding a predetermined threshold is sensed. Interrater and intrarater reliability of four physical therapists' computations of 11 variables from monitor data on 10 healthy subjects was assessed. The monitor was attached to a strip chart recorder. Subjects walked at their natural cadences over a 30-foot walkway. Raters attended a series of practice sessions to gain familiarity with monitor recordings. Subjects displayed significant variability for step measurements of stance time, time from heel strike to peak force at heel strike, time from heel strike to peak force at push off, peak from baseline to heel strike and from baseline to push off. Significant rater variability occurred for stance time and time from heel strike to peak force at heel strike. Other step measurements had significant subject-by-rater variability. Since the largest percentage of total variability was attributed to subject variance, the step measurements were reliable. Subjects also had significant variability in gait measurements of ambulation time, velocity, cadence swing phase durations, and ratio of unilateral weightbearing. Rater variability was significant for average swing phase duration.

Interrater and intrarater reliability was very dependable for individual step time and force variables and overall gait variables of ambulation time, velocity, and cadence. Improvement in instructions for determining average swing time and ratio may insure greater accuracy.

The Clinical Engineering/Health Care Mismatch: Its Effect on Personnel Management: L. Fennigkoh (Saint Luke's Hospital, Milwaukee, Wisconsin) Medical and Biological Engineering and Computing 22:113-114, March 1984.

Personnel management is especially stress-inducing within hospital-based clinical engineering departments, where thing-oriented people (such as engineers) are expected to function in a people-oriented system. Job differentiation is necessary if specialists, such as clinical engineers, are to perform effectively, while job integration is required for the hospital to function as an organization with coordination among specialists. An antagonistic, inverse, relationship exists between job differentiation and integration, so that the more two specialists differ in patterns of behavior, the more difficult it is to integrate them. Clinical engineering's lack of acceptance as a profession is due, in part, to the high degree of differentiation that exists between it and the rest of health care — because clinical engineers are uniquely attracted to things rather than to people. Achieving integration, while a management paradox, is possible only through good communication channels. Engineers must improve communication skills by becoming involved in local engineering organizations, teaching, presenting technical papers, consulting, subscribing to people-oriented publications and being willing to take mental risks. Engineers relate upward to the hospital administrator, downward to technicians, and laterally to other department heads. The ability to get along with people, rather than technical skills, is perceived by hospital administrators as the clinical engineer's most important quality.

Prosthetic Alignment: Effect on Gait of Persons with Below-Knee Amputations: R. E. Hannah, J. B. Morrison, and A. E. Chapman (University of British Columbia, Shaughnessy Hospital, Vancouver, British Columbia, Canada) Archives of Physical Medicine and Rehabilitation 65:159-162, April 1984.

Five men with below-knee amputations walked on adjustable prostheses. They wore plastic laminate patellar tendon-bearing-type sockets with solid-ankle cushion-heel feet. Alignment devices were Winnipeg wedge disc alignment units or four-screw temporary alignment jigs. Electrogoniometers were attached bilaterally at the hips and knees. A knee measuring module was attached to the prosthesis pylon to record rotations about three mutually orthogonal axes. Subjects were fitted at least 3 weeks prior to the measurement session. Optimum alignment was established using standard clinical techniques. Gait recording was made as the amputee walked along a 10-meter walkway on a free time walk.

The objective of data analysis was to determine whether maximum symmetry of lower limb kinematic variables coincided with optimum prosthetic alignment. Indices of symmetry were developed for time and frequency. Changes in pylon lengths resulted in the least number of asymmetries, and sagittal foot realignment resulted in the largest number. Knee valgus-varus motion and hip flexion-extension motion times were most frequently affected by alignment changes. Least affected were hip and knee transverse plane motions. Although the relationship of kinematic variable symmetry to optimal prosthetic alignment has been delineated, the current method requires large alignment changes to elicit changes in symmetry which achieve statistical significance. It is therefore important to differentiate between detection rate and significance when assessing the effectiveness of the asymmetry indices.

Lateral Electrical Surface Stimulation as an Alternative to Bracing in the Treatment of Idiopathic Scoliosis: Lynn Eckerson and Jens Axelgaard (Rancho Los Amigos Rehabilitation Engineering Center, Downey, California) Physical Therapy 64:483-490, April 1984.

Idiopathic scoliosis comprises approximately 75 percent of all scoliosis in the United States. One of the most common treatments for progressive curves between 20 and 45 degrees has been the Milwaukee brace worn 23 hours daily until the patient nears skeletal maturity. Although the brace can halt progression, problems complicate its use. Wearers cannot participate in sports and experience clothing wear, pressure sores, difficulty working at a desk because of the chin piece, and negative psychological changes. Braces entail significant initial cost and must be replaced as the child grows. Low-profile braces, such as the Boston brace, eliminate some but not all problems.

Electrical stimulation for mild to moderate curves was first attempted in 1974 with intermuscular electrodes in the paraspinal muscles. Following animal studies, patient selection criteria were developed that required that the curve be idiopathic, progressive, between 20 and 45 degrees, and in a patient having at least 1 year of growth remaining. The protocol for subjects includes initial assessment, then stimulation with the Scolitron for single curves, and for double curves, use of a special dual-channel stimulator. Stimulators deliver trains of 25 rectangular constant-current pulses per second, 6 seconds on and 6 seconds off, transmitted through carbon-rubber electrodes. Patients kept a diary regarding the time and amplitude of stimulation, and a compliance meter located in the Scolitron was also used. Electrodes were placed on the midaxillary line lateral to the apical rib or vertebra on the convex side of the curvature. Palpation of spinal movement of all curves is necessary before selecting final electrode position and polarity. Amplitude and treatment time are increased gradually to allow for sensory accommodation and to avoid muscle soreness. Stimulation continued until skeletal maturity was reached, without a weaning period. Of 57 patients who used the treatment for 6 to 42 months, 12 had been braced prior to electrical stimulation. Total compliance was reported in those who had worn braces, and 90 percent of those who had no prior brace

were compliant. Few had difficulty sleeping with the stimulation. Proper electrode placement presented no problem to 93 percent.

Pathologic Gait Diagnosis with Computer-Averaged Electromyographic Profiles: David Winter (Department of Kinesiology, University of Waterloo, Waterloo, Ontario, Canada) Archives of Physical Medicine and Rehabilitation 65:393-398, July 1984.

A suitably chosen analog electromyographic signal can represent the pattern of muscle activity more meaningfully than the common practice of noting only the on and off times of each muscle, because the phasic patterns do not include the threshold for turn-on and turn-off. The new technique records five muscles and one footswitch signal, using a biotelemetry system, electromyographic processor, and computer. The signals were processed to produce a linear envelope (full-wave rectifier followed by a second order low-pass filter with a cutoff at 3 Hz). Each subject was tracked with a television camera mounted on a cart that followed the individual on a 10-meter walkway. The linear envelope and footswitch signals were converted at 250 samples per second by computer. Time averaging of each recording over each stride was accomplished by normalizing each stride to 100 percent and then averaging each stride at each 2 percent interval over the stride. The mean electromyographic signal in microvolts (ensemble average) was plotted to form curves for each subject. Using time averaging, the intersubject averages for 11 able-bodied persons walking at their natural cadences were obtained. Work is ongoing to expand the muscular curves to 15 from the lower limb.

Cerebral palsied children were assessed in the same manner and their curves compared with those of able-bodied subjects to provide a rapid and objective technique to assess each muscle's pattern of activity and identify periods in the gait cycle when abnormalities occur. Future developments include defining changes related to cadence, for it is incorrect to compare a slow-walking patient with able-bodied persons who walk considerably faster. Speed-related profiles are needed on each muscle. Efforts are also required to devise techniques to account for intersubject variability among normal profiles due to measurement and biologic differences.

Wheelchair Mountaineering: Julie Madorsky and David Kiley (Casa Colina Hospital for Rehabilitative Medicine, Pomona, California) Archives of Physical Medicine and Rehabilitation 65:490-492, August 1984.

A 28-year-old director of therapeutic recreation with incomplete L1 paraplegia was part of a six-man team of wheelchair-bound individuals that climbed to the summit of an 8751-foot mountain in 2 days during rain and thunderstorms. The director used a lightweight aluminum Quadra wheelchair equipped with 24-inch wheels. Three-inch pneumatic tires with deep tread provided strong grip on the gravel trail. Eight-inch-wide inflatable front tires were used. A compartment under the seat stored gear. Padding inside the trousers seat protected the buttocks and leather gloves reduced hand blisters. No able-bodied person gave assistance during the climb, although park rangers patrolled the trail. The final day was spent climbing a 35 to 45 degree slope by crawling and clawing their way up, pulling the chair by a rope clenched in the mouth. After determining that the descent would be too treacherous, they were rescued by helicopters from the summit. The leader developed a 4.5 × 4 cm superificial sacral abrasion and a 2 x 2 cm skin breakdown over the Achilles tendon, both of which healed within a few days. Wheelchair mountaineering is a form of exercise, endurance, and survival training which can be a valuable tool in the physical and emotional rehabilitation of selected individuals. Referral to self-help groups, such as Paraplegics on Independent Nature Trails, deserves serious consideration.

Energy Expenditure of Paraplegic Patients Standing and Walking with Two Knee-Ankle-Foot Orthoses: Kurt Merkel, Neil Miller, Philip Westbrook, and John Merritt (Mayo Clinic and Mayo Foundation, Rochester, Minnesota) Archives of Physical Medicine and Rehabilitation 65: 121-124, March 1984.

Eight subjects with complete motor paraplegia participated in the study, wearing Scott-Craig and single-stopped knee-ankle-foot orthoses. Lesion levels ranged from C7 to T12. Six subjects regularly used Scott-Craig orthoses and two wore single-stopped ones. Data was collected as subjects sat, stood, walked with a walker, and walked with crutches with trainer versions of each type of orthosis. Energy expenditure was essentially the same during standing and walking with either type. With Scott-Craig orthoses, velocity was 8.8 meters per minute compared with 6.3 with a single-stopped orthoses, indicating the Scott-Craig devices to be more energy-efficient. Crutch ambulation with Scott-Craig devices cost patients 25 percent less energy, and they achieve 34 percent greater energy efficiency, although velocity was not appreciably greater. The anterior ankle stop in the Scott-Craig orthoses substitutes for the action of the gastrocnemius-soleus muscle to reduce the vertical amplitude of the center of gravity during ambulation. The ankle bar provides mediolateral stability to reduce the amplitude of the center of gravity in the horizontal plane. As compared with able-bodied individuals, paraplegic subjects wearing Scott-Craig orthoses expend 5 times more energy with crutches and 8.8 times more with a walker. Those with single-stopped orthoses use 7.7 times more energy with crutches and 12.8 times more with a walker.