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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – I – Advanced Rehabilitation Engineering – SBMA5301

UNIT I – INTRODUCTION

Rehabilitation engineering is the use of engineering science and principles to

1) Develop technological solutions and devices to assist individuals with disabilities,

2) Aid the recovery of physical and cognitive functions lost because of disease or injury.

Rehabilitation engineers design and build devices and systems to meet a wide range of needs that can assist individuals with mobility, communication, hearing, vision, and cognition. These tools help people with day-to-day activities and tasks related to employment, independent living, and education.

Rehabilitation engineering may involve relatively simple observations of how workers perform tasks, and then making accommodations to eliminate further injuries and discomfort. On the other end of the spectrum, more complex rehabilitation engineering is the design of sophisticated brain computer interfaces that allow a severely disabled individual to operate computers, and other assistive devices simply by thinking about the task they want to perform.

Rehabilitation engineers also develop and improve rehabilitation methods used by individuals to regain functions lost due to disease or injury, such as limb (arm and or leg) mobility following a stroke or a joint replacement.

What types of assistive devices have been developed through rehabilitation engineering?

The following are examples of the many types of assistive devices.

- ✓ Wheelchairs; scooters; and prosthetic devices, such as artificial limbs that provide mobility for people with physical disabilities that affect movement.
- ✓ Kitchen implements with large, cushioned grips to help people with weakness or arthritis in their hands with everyday living tasks.
- ✓ Automatic page-turners, book holders, and adapted pencil grips, that allow participation in educational activities in school and at home.
- ✓ Medication dispensers with alarms that can help people remember to take their medicine on time.
- ✓ Specially engineered computer programs that provide voice recognition to help people with sensory impairments use computer technology.

How can future rehabilitation engineering research improve the quality of life for individuals?

Ongoing research in rehabilitation engineering involves the design and development of new, innovative assistive devices. An important research area focuses on the development of new technologies and techniques for improved therapies that help people regain physical or cognitive functions lost because of disease or injury. For example:

- Rehabilitation robotics that involves the use of robots as therapy aids instead of solely as assistive devices. Intelligent rehabilitation robotics aids mobility training in individuals suffering from impaired movement, such as following a stroke.
- Virtual rehabilitation, which uses virtual reality simulation exercises for physical and cognitive rehabilitation. Compared to conventional therapies, virtual rehabilitation can offer several advantages. It is entertaining and motivates patients. It provides objective measures such as range of motion or game scores that can be stored on the computer operating the simulation. The virtual exercises can be performed at home by a patient and monitored by a therapist over the Internet (known as tele-rehabilitation), which offers convenience as well as reduced costs.
- Improved prosthetics, such as smarter artificial legs. This is an area where researchers continue to make advances in design and function to better mimic natural limb movement and user intent.
- Increasingly sophisticated use of computers as the interface between the user and various devices to enable severely impaired individuals increased independence and integration into the community. For example, brain computer interfaces that use the brain's electrical impulses to allow individuals to learn to move a computer cursor or a robotic arm that can reach and grab items.
- Development of new technologies to analyze human motion, to better understand the electrophysiology of muscle and brain activity, and to more accurately monitor human functions. These technologies will continue to drive innovation in assistive devices and rehabilitation strategies.

What are NIBIB-funded researchers developing in the area of rehabilitation engineering?

Promising research currently supported by NIBIB includes a wide range of approaches and technological development. Several examples are described below.

Wireless Tongue Drive System for Paralyzed Patients: NIBIB-funded researchers are developing an assistive technology called the Tongue Drive System (TDS). The core TDS technology exploits the fact that even individuals with severe paralysis that impairs limb movement, breathing, and speech can still move their tongue. Simple tongue movements send commands to the computer allowing users to steer their wheelchairs, operate their computers, and generally control their environment in an independent fashion.

Neurostimulation in Individuals with Spinal Cord Injury (SCI) for Recovery of Voluntary Control of Standing and Movement, and Involuntary Control of Blood Pressure, Bladder and Sexual Function: Through the NIBIB Rehabilitation Engineering program, researchers are developing the next generation of high density electrode arrays for stimulation of the spinal cord. The first patient received a current generation electrical stimulator implant in his lower back. The electrical stimulation and locomotor training resulted in the ability to stand independently for several minutes, some voluntary leg control, and regained blood pressure control, bladder, bowel, and sexual function. Three more patients have received this treatment and had similar results.

Smart Environment Technologies: As the population ages, increasing numbers of Americans are unable to live independently. NIBIB-funded researchers are working on creating smart environments that aid with home health monitoring and intervention allowing individuals with health issues to remain safely at home. For example, researchers are analyzing the needs and limitations of Alzheimer's patients to develop automated and reminder-based technologies that can be integrated into the home to help with everyday tasks.

Artificial Hands Capable of Complex Movements and Sensation: Persons with hand amputations expect modern hand prostheses to function like intact hands. Current state-of-the-art prosthetic hands simply control two movements "open" and "close." As a result, NIBIB researchers are developing new artificial hand systems that would perform complex hand motions based on measurements of the residual electrical signals from the remaining muscles of an amputee's forearm. Signals from the muscles (in one project) and nerves (from another project) have the potential to result in much finer control of the fingers in the artificial hand. In addition, one of the teams is working on capturing the sense of touch, so in the future the users will be able to also "feel" what they are holding with their artificial hand.

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Assistive technology is an umbrella term that includes assistive, adaptive, and rehabilitative devices for people with disabilities and also includes the process used in selecting, locating, and using them. Assistive technology promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to, or changing methods of interacting with, the technology needed to accomplish such tasks.

Assistive technology refers to "any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities", while adaptive technology covers items that are specifically designed for persons with disabilities and would seldom be used by non-disabled persons. In other words, "assistive technology is any object or system that increases or maintains the capabilities of people with disabilities," while adaptive technology is "any object or system that is specifically designed for the purpose of increasing or maintaining the capabilities of people with disabilities

Wheel chairs

Wheelchairs are devices that can be manually propelled or electrically propelled and that include a seating system and are designed to be a substitute for the normal mobility that most people enjoy. Wheelchairs and other mobility devices allow people to perform mobility related activities of daily living which include feeding, toileting, dressing grooming and bathing. The devices comes in a number of variations where they can be propelled either by hand or by motors where the occupant uses electrical controls to manage motors and seating control actuators through a joystick, sip-and-puff control, or other input devices. Often there are handles behind the seat for someone else to do the pushing or input devices for caregivers. Wheelchairs are used by people for whom walking is difficult or impossible due to illness, injury, or disability. People with both sitting and walking disability often need to use a wheelchair or walker.

Patient transfer devices

Patient transfer devices generally allow patients with impaired mobility to be moved by caregivers between beds, wheelchairs, commodes, toilets, chairs, stretchers, shower benches, automobiles, swimming pools, and other patient support systems (i.e., radiology, surgical, or examining tables). The most common devices are Patient lifts (for vertical transfer), Transfer benches, stretcher or convertible chairs (for lateral, supine transfer), sit-to-stand lifts (for moving patients from one seated position to another i.e., from wheelchairs to commodes), air bearing inflatable mattresses (for supine transfer i.e., transfer from a gurney to an operating room table), and sliding boards (usually used for transfer from a bed to a wheelchair). Highly dependent patients who cannot assist their caregiver in moving them often require a Patient lift (a floor or ceiling-suspended sling lift) which though invented in 1955 and in common use since the early 1960s is still considered the state-of-the-art transfer device by OSHA and the American Nursing Association.

Walker

A walker or walking frame or Rollator is a tool for disabled people who need additional support to maintain balance or stability while walking. It consists of a frame that is about waist high, approximately twelve inches deep and slightly wider than the user. Walkers are also available in other sizes, such as for children, or for heavy people. Modern walkers are height-adjustable. The front two legs of the walker may or may not have wheels attached depending on the strength and abilities of the person using it. It is also common to see caster wheels or glides on the back legs of a walker with wheels on the front

Assistive technology in sport is an area of technology design that is growing. Assistive technology is the array of new devices created to enable sports enthusiasts who have disabilities to play. Assistive technology may be used in adaptive sports, where an existing sport is modified to enable players with a disability to participate; or, assistive technology may be used to invent completely new sports with athletes with disabilities exclusively in mind.

An increasing number of people with disabilities are participating in sports, leading to the development of new assistive technology. Assistive technology devices can be simple, or "low-tech", or they may use highly advanced technology, with some even using computers. Assistive technology for sports may also be simple, or advanced.

LEVELS OF PREVENTION

Preventive healthcare (alternately preventive medicine or prophylaxis) consists of measures taken for disease prevention, as opposed to disease treatment. Just as health encompasses a variety of physical and mental states, so do disease and disability, which are affected by environmental factors, genetic predisposition, disease agents, and lifestyle choices. Health, disease, and disability are dynamic processes which begin before individuals realize they are affected. Disease prevention relies on anticipatory actions that can be categorized as primal, primary, secondary, and tertiary prevention.

Each year, millions of people die of preventable deaths. A 2004 study showed that about half of all deaths in the United States in 2000 were due to preventable behaviors and exposures. Leading causes included cardiovascular disease, chronic respiratory disease, unintentional injuries, diabetes, and certain infectious diseases. This same study estimates that 400,000 people die each year in the United States due to poor diet and a sedentary lifestyle. According to estimates made by the World Health Organization (WHO), about 55 million people died worldwide in 2011, two thirds of this group from non-communicable diseases, including cancer, diabetes, and chronic cardiovascular and lung diseases. This is an increase from the year 2000, during which 60% of deaths were attributed to these diseases. Preventive healthcare is especially important given the worldwide rise in prevalence of chronic diseases and deaths from these diseases.

There are many methods for prevention of disease. It is recommended that adults and children aim to visit their doctor for regular check-ups, even if they feel healthy, to perform disease screening, identify risk factors for disease, discuss tips for a healthy and balanced lifestyle, stay up to date with immunizations and boosters, and maintain a good relationship with a healthcare provider. Some common disease screenings include checking for hypertension (high blood pressure), hyperglycemia (high blood sugar, a risk factor for diabetes mellitus), hypercholesterolemia (high blood cholesterol), screening for colon cancer, depression, HIV and other common types of sexually transmitted disease such as chlamydia, syphilis, and gonorrhea, mammography (to screen for breast cancer), colorectal cancer screening, a pap test (to check for cervical cancer), and screening for osteoporosis. Genetic testing can also be performed to screen for mutations that cause genetic disorders or predisposition to certain diseases such as breast or ovarian cancer. However, these measures are not affordable for every individual and the cost effectiveness of preventive healthcare is still a topic of debate.

Primary prevention aims to prevent disease or injury before it ever occurs. This is done by preventing exposures to hazards that cause disease or injury, altering unhealthy or unsafe behaviours that can lead to disease or injury, and increasing resistance to disease or injury should exposure occur. Examples include:

- legislation and enforcement to ban or control the use of hazardous products (e.g. asbestos) or to mandate safe and healthy practices (e.g. use of seatbelts and bike helmets)
- education about healthy and safe habits (e.g. eating well, exercising regularly, not smoking)
- immunization against infectious diseases.

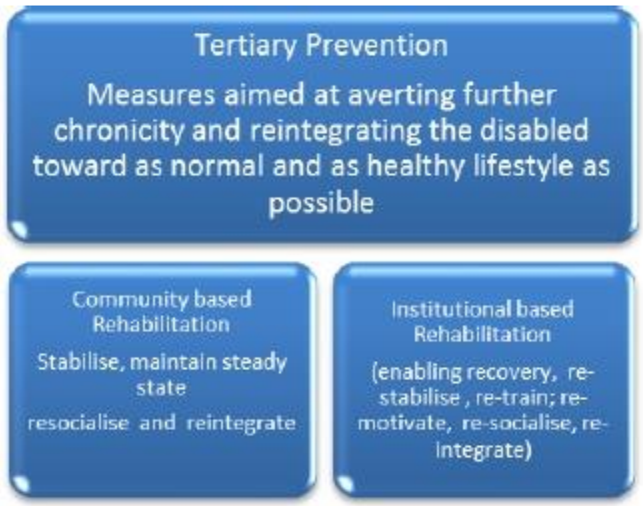
Secondary prevention aims to reduce the impact of a disease or injury that has already occurred. This is done by detecting and treating disease or injury as soon as possible to halt or slow its progress, encouraging personal strategies to prevent reinjury or recurrence, and implementing programs to return people to their original health and function to prevent long-term problems. Examples include:

- regular exams and screening tests to detect disease in its earliest stages (e.g. mammograms to detect breast cancer)
- daily, low-dose aspirins and/or diet and exercise programs to prevent further heart attacks or strokes
- Suitably modified work so injured or ill workers can return safely to their jobs.

Tertiary prevention aims to soften the impact of an ongoing illness or injury that has lasting effects. This is done by helping people manage long-term, often-complex health problems and injuries (e.g. chronic diseases, permanent impairments) in order to improve as much as possible their ability to function, their quality of life and their life expectancy.

Examples include:

- cardiac or stroke rehabilitation programs, chronic disease management programs (e.g. for diabetes, arthritis, depression, etc.)
- support groups that allow members to share strategies for living well
- vocational rehabilitation programs to retrain workers for new jobs when they have recovered as much as possible.



Functional Diagnosis

Modern medicine has evolved in a way that has focused on labeling. Often times because of convenience, many practitioners may even resort to simply using diagnosis codes designed for billing purposes. As a result, such terms as "runner's knee" and "chronic pain syndrome" creep up in many clinical notes and consultations and become the patient's label. These terms relate a vague story about the real diagnosis. A "functional diagnosis" is one that is more comprehensive and centered around biomechanics and disease, relating the two into a more conceptual definition.

Here is a great example: A 25 year old professional football player presented to our clinical office for a consultation regarding his "chronic ankle pain." He was told that he had a bone spur on his tibia that needed to be shaved down to relieve pain. A functional evaluation of his ankle, however, told a much different story. A closer look at the bone spur showed that it was in fact providing some stability in this area of the ankle. The real problem was the lack of overall stability in the ankle, which was demonstrated by the fact that he had significant tears in the major ligaments of the ankle. Dynamic ultrasound testing demonstrated that these ligaments were unable to provide stability to the joint. The bone spur, therefore, was actually critical to his overall function. Removing it might provide relief, but would undoubtedly lead to significantly more instability and possibly worse pain. Our recommendation was to address the ligament deterioration and ankle mechanics using a regenerative and rehabilitation approach prior to dealing with the bone spur. The functional diagnosis might be: "Chronic ankle instability related to ligament injury manifested by boney changes and pain." This definition gives us the framework to build a treatment plan; one that addresses instability and pain with the goal of restoring proper function.

The goal of the "functional diagnosis" is to establish a connection between disease and movement, providing a more holistic framework to design interventions around. For this reason, we must focus on providing an accurate and comprehensive diagnosis before any recommendations can be made. This takes time, effort, experience and communication.

RRPC “Cardiology” offers a wide spectrum of current highly informative diagnostic tools used in cardiovascular patients.

Electrocardiography (ECG) is a mandatory investigation method of heart. ECG gives evidence of the frequency and regularity of heart rhythm, presence of arrhythmias, and efficiency/deficiency of heart muscle (myocardial) circulation.

ECG Holter monitoring is a method of ECG daily registration using a special device, i.e. registration that is worn by the patient during 22-24 h, being on outpatient treatment. The method allows for a in-depth assessment of arrhythmias and establishment of myocardial ischemic events.

24-hour Blood Pressure Monitoring is a method of blood pressure daily registration using automated computerized tonometer. The investigation is performed during daily activities and helps to define the presence/absence of arterial hypertension, and the relevance of therapies being used.

Bicycle ergometry exercise test or Treadmill test implies that electrocardiographic data are recorded in patients during physical exercise (walking on treadmill). The examination both establishes patient’s exercise tolerance, and detects exercise-induced changes taking place in cardiovascular system. Exercise tests are generally used to define exercise-induced heart diseases and heart rhythm disturbances and to assess results obtained from angioplasty or CABG surgery. The main advantage of bicycle ergometry exercise test (treadmill test) is that it imitates daily activities.

Epidemiology is the study and analysis of the patterns, causes, and effects of health and disease conditions in defined populations. It is the cornerstone of public health, and shapes policy decisions and evidence-based practice by identifying risk factors for disease and targets for preventive healthcare. Epidemiologists help with study design, collection, and statistical analysis of data, amend interpretation and dissemination of results (including peer review and occasional systematic review). Epidemiology has helped develop methodology used in clinical research, public health studies, and, to a lesser extent, basic research in the biological sciences

DIAGNOSIS OF DISABILITY

Learning disabilities are often identified when a child begins to attend school. Educators may use a process called "response to intervention" (RTI) to help identify children with learning disabilities. Specialized testing is required to make a clear diagnosis, however.

RTI

RTI usually involves the following:

- Monitoring all students' progress closely to identify possible learning problems
- Providing a child identified as having problems with help on different levels, or tiers
- Moving this youngster through the tiers as appropriate, increasing educational assistance if the child does not show progress

Students who are struggling in school can also have individual evaluations. An evaluation can[2]:

- Identify whether a child has a learning disability
- Determine a child's eligibility under federal law for special education services
- Help construct an individualized education plan (IEP) that outlines supports for a youngster who qualifies for special education services
- Establish a benchmark for measuring the child's educational progress

A full evaluation for a learning disability includes the following

- A medical examination, including a neurological exam, to identify or rule out other possible causes of the child's difficulties, including emotional disorders, intellectual and developmental disabilities, and brain diseases
- Exploration of the youngster's developmental, social, and school performance
- A discussion of family history
- Academic achievement testing and psychological assessment

Usually, several specialists work as a team to perform an evaluation. The team may include a psychologist, special education expert, and speech-language pathologist (SLP). Many schools also have reading specialists on staff who can help diagnosis a reading disability.

Role of School Psychologists

School psychologists are trained in both education and psychology. They can help to identify students with learning disabilities and can diagnose the learning disability. They can also help the student with the disability, parents, and teachers come up with plans that improve learning.

Role of SLPs

All SLPs are trained in diagnosing and treating speech- and language-related disorders. A SLP can provide a complete language evaluation as well as an assessment of the child's ability to organize his or her thoughts and possessions. The SLP may evaluate various age-appropriate learning-related skills in the child, such as understanding directions, manipulating sounds, and reading and writing.

Preventive Rehabilitation

The Section of Preventive Cardiology & Rehabilitation offers services to patients with cardiovascular disease and those who have a high risk of developing it. Individualized programs are designed to reduce risk factors and prevent disease from getting worse. Our team includes specialists from many areas to offer nutritional services, prescriptive exercise programs, stress testing, cardiovascular disease risk-reduction programs and a peripheral vascular rehabilitation program.

Patients benefit from five specialized programs:

Preventive Cardiology Program

Cardiac Rehabilitation Program

Preventive Cardiology Nutrition Program

Women's Cardiovascular Center

These programs help patients make lifestyle changes and determine the best medical treatment plan to:

Prevent cardiovascular disease/keep disease from getting worse

Reduce the risk of heart attack or stroke

Reduce the need for surgery

Improve your quality of life by reducing symptoms

The Cardiac Health Improvement and Rehabilitation Program were founded in 1985. The program helps promote health and wellness for patients with cardiac and vascular disease while they are in hospital, during their recovery and throughout their lives.

MEDICAL REHABILITATION

Physical medicine and rehabilitation (PM&R), also referred to as physiatry, is a medical specialty concerned with diagnosis, evaluation, and management of persons of all ages with physical and/or cognitive impairment and disability. This specialty involves diagnosis and treatment of patients with painful or functionally limiting conditions, the management of comorbidities and co-impairments, diagnostic and therapeutic injection procedures, electrodiagnostic medicine, and emphasis on prevention of complications of disability from secondary conditions.

Physiatrists are trained in the rehabilitation of neurologic disorders, and in the diagnosis and management of impairments of the musculoskeletal (including sports and occupational aspects) and other organ systems, and the long-term management of patients with disabling conditions. Physiatrists provide leadership to multidisciplinary teams concerned with maximal restoration or development of physical, psychological, social, occupational and vocational functions in persons whose abilities have been limited by disease, trauma, congenital disorders or pain to enable people to achieve their maximum functional abilities.

TELE REHABILITATION:

Telerehabilitation is the delivery of rehabilitation services over telecommunication networks and the internet. Most types of services fall into two categories: clinical assessment (the patient's functional abilities in his or her environment), and clinical therapy. Some fields of rehabilitation practice that have explored telerehabilitation are: neuropsychology, speech-language pathology, audiology, occupational therapy, and physical therapy. Telerehabilitation can deliver therapy to people who cannot travel to a clinic because the patient has a disability or because of travel time. Telerehabilitation also allows experts in rehabilitation to engage in a clinical consultation at a distance.

Most telerehabilitation is highly visual. As of 2006 the most commonly used modalities are via webcams, videoconferencing, phone lines, videophones and webpages containing rich Internet applications. The visual nature of telerehabilitation technology limits the types of rehabilitation services that can be provided. It is most widely used forneuropsychological rehabilitation; fitting of rehabilitation equipment such as wheelchairs, braces or artificial limbs; and in speech-language pathology. Rich internet applications for neuropsychological rehabilitation (aka cognitive rehabilitation) of cognitive impairment (from many etiologies) was first introduced in 2001. This endeavor has recently (2006) expanded as a teletherapy application for cognitive skills enhancement programs for school children. Tele-audiology (hearing assessments) is a growing application. As of 2006, telerehabilitation in the practice of occupational therapy and physical therapy are very limited, perhaps because these two disciplines are more “hands on”.

Two important areas of telerehabilitation research are (1) demonstrating equivalence of assessment and therapy to in-person assessment and therapy, and (2) building new data collection systems to digitize information that a therapist can use in practice. Ground-breaking research in telehaptics (the sense of touch) and virtual reality may broaden the scope of telerehabilitation practice, in the future.

In the United States, the National Institute on Disability and Rehabilitation Research's (NIDRR) [1] supports research and the development of telerehabilitation. NIDRR's grantees include the "Rehabilitation Engineering and Research Center" (RERC) at the University of Pittsburgh, the Rehabilitation Institute of Chicago, the State University of New York at Buffalo, and the National Rehabilitation Hospital in Washington DC. Other federal funders of research are the Veterans Administration, the Health Services Research Administration in the US Department of Health and Human Services, and the Department of Defense. Outside the United States, excellent research is conducted in Australia and Europe.

As of 2006, only a few health insurers in the United States will reimburse for telerehabilitation services. If the research shows that tele-assessments and tele-therapy are equivalent to clinical encounters, it is more likely that insurers and Medicare will cover telerehabilitation services.

History

In 1999, D.M. Angaran published “Telemedicine and Telepharmacy: Current Status and Future Implications” in the American Journal of Health-System Pharmacy. He provided a comprehensive history of telecommunications, the internet and telemedicine since the 1950s. The Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) spearheaded the technology in the United States during the Vietnam War and the space program; both agencies continue to fund advances in telemedicine.

Three early adopters of telemedicine were state penitentiary systems, rural health care systems, and the radiology profession. Telemedicine makes business sense for the states because they do not have to pay for security escorts to have a prisoner receive care outside the prison.

Rural telemedicine in the United States is heavily subsidized through federal agency grants for telecommunications operations. Most of this funding comes through the Health Services Research Administration and the Department of Commerce. Some state universities have obtained state funding to operate tele-clinics in rural areas. As of 2006, few (if any) of these programs are known to financially break-even, mostly because the Medicare program for people over age 65 (the largest payer) is very restrictive about paying for telehealth.

In contrast, the Veterans Administration is relatively active in using telemedicine for people with disabilities. There are several programs that provide annual physical exams or monitoring and consultation for veterans with spinal cord injuries. Similarly, some state Medicaid programs (for poor people and people with disabilities) have pilot programs using telecommunications to connect rural practitioners with subspecialty therapists. A few school districts in Oklahoma and Hawaii offer school-based rehabilitation therapy using therapy assistants who are directed by a remote therapist. The National Rehabilitation Hospital in Washington DC and Sister Kenny Rehabilitation Institute in Minneapolis provided assessment and evaluations to patients living in Guam and American Samoa. Cases included post-stroke, post-polio, autism, and wheel-chair fitting.

An argument can be made that "telerehabilitation" began in 1998 when NIDRR funded the first RERC on tele-rehabilitation. It was awarded to a consortium of biomedical engineering departments at the National Rehabilitation Hospital and The Catholic University of America, both located in Washington, DC; the Sister Kenny Rehabilitation Institute in Minnesota; and the East Carolina University in North Carolina. Some of this early research work, and its motivation, is reviewed in Winters (2002). The State of Science Conference held in 2002 convened most of military and civilian clinicians, engineers, and government officials interested in using telecommunications as a modality for rehabilitation assessment and therapy; a summary is provided in Rosen, Winters & Lauderdale (2002). The conference was attended by the incoming president of the American Telemedicine Association (ATA). This led to an invitation by ATA to the conference attendees to form a special interest group on telerehabilitation. NIDRR funded the second 5-year RERC on telerehabilitation in 2004, awarding it to the University of Pittsburgh. This RERC was renewed in 2010.

In 2001, O. Bracy, a neuropsychologist, introduced the first web based, rich internet application, for the telerehabilitation presentation of cognitive rehabilitation therapy. This system first provides the subscriber clinician with an economical means of treating their own patients over the internet. Secondly, the system then provides, directly to the patient, the therapy prescription set up and controlled by the member clinician. All applications and response data are transported via the internet in real time. The patient can login to do their therapy from home, the library or anywhere they have access to an internet computer. In 2006, this system formed the basis of a new system designed as a cognitive skills enhancement program for school children. Individual children or whole classrooms can participate in this program over the internet.

In 2006, M.J. McCue and S.E. Palsbo published an article in the Journal of Telemedicine and Telecare that explored how telemedicine can become a profitable business for hospitals. They argue that telerehabilitation should be expanded so that people with disabilities and people in pain (perhaps after hip-replacement surgery or people with arthritis) can get the rehabilitative therapy they need. It is unethical to limit paymente for telerehabilitation services only to patients in rural areas.

Research in telerehabilitation is in its infancy, with only a handful of equivalence trials. As of 2006, most peer-reviewed research in telemedicine are case reports of pilot programs or new equipment. Rehabilitation researchers need to conduct many more controlled experiments and present the evidence to clinicians (and payers) that telerehabilitation is clinically effective. The discipline of speech-language pathology is far head of occupational therapy and physical therapy in demonstrating equivalence over various types of telecommunications equipment.

Technologies

Plain old telephone service (POTS) with videophones/Phones in telerehabilitation

There are several types of connections used with real time exchanges. Plain old telephone service (POTS) uses standard analog telephone lines. Videophones are used with POTS lines and include a camera, display screen, and telephone. Videophones use telephone lines that are available in most homes, so are easy to set up; however small display screens make them problematic for individuals with vision problems. This can be solved by using a large screen or television as a screen.

1. Videotelephony/Videotelephony in telerehabilitation

   The use of improved quality video-assisted telecommunication devices, such as videoconferencing, webcams and telepresence to assist in treatments.

2. Virtual reality/Virtual reality in telerehabilitation

   Virtual reality in telerehabilitation is one of the newest tools available in that area. This computer technology allows the development of three-dimensional virtual environments.

3. Motion technology/Motion technology in telerehabilitation
4. Web-based approaches/Web-based approaches in telerehabilitation

   Applications that run over the internet, just as if they were installed in your computer (called Rich Internet Applications), represent a new direction in software development. A person subscribes to the website rather than purchase the software. Any updates or changes to the software system are instantly available to all subscribers. The applications can be accessed from any location where one has access to an internet connected computer. Likewise, a patient's data is accessible from where ever the therapist is located. Neither the application nor the patient's data is tied to one computer.

5. Sensors and body monitoring/Sensors and body monitoring in telerehabilitation
6. Haptic technology/Haptic technology in telerehabilitation
7. Artificial intelligence/Artificial intelligence in telerehabilitation
8. Wireless technology/Wireless technology in telerehabilitation
9. PDAs/PDA in telerehabilitation
10. Mobile telephony/Mobile telephony in telerehabilitation
11. Electronic medical records/Electronic medical record telerehabilitation
12. Mobile apps/Mobile apps telerehabilitation

1. Review of telerehabilitation research on clinical populations
2. Professional to professional (clinic to clinic applications)
3. Telehealth – Information access
4. Clinical approaches
    1. Assessment
    2. Monitoring
    3. Intervention
    4. Telesupervision (of licensed assistants)
    5. Telementoring
    6. Tele-education
    7. Telementoring

Speech-language pathology

The clinical services provided by speech-language pathology readily lend themselves to telerehabilitation applications due to the emphasis on auditory and visual communicative interaction between the client and the clinician. As a result, the number of telerehabilitation applications in speech-language pathology tend to outnumber those in other allied health professions. To date, applications have been developed to assess and/or treat acquired adult speech and language disorders, stuttering, voice disorders, speech disorders in children, and swallowing dysfunction. The technology involved in these applications has ranged from the simple telephone (Plain Old Telephone System – POTS) to the use of dedicated Internet-based videoconferencing systems.

Early applications to assess and treat acquired adult speech and language disorders involved the use of the telephone to treat patients with aphasia and motor speech disorders (Vaughan, 1976, Wertz, et al., 1987), a computer controlled video laserdisc over the telephone and a closed-circuit television system to assess speech and language disorders (Wertz et al., 1987), and a satellite-based videoconferencing system to assess patients in rural areas (Duffy, Werven & Aronson, 1997). More recent applications have involved the use of sophisticated Internet-based videoconferencing systems with dedicated software which enable the assessment of language disorders (Georgeadis, Brennan, Barker, & Baron, 2004, Brennan, Georgeadis, Baron & Barker, 2004) and the assessment and treatment of motor speech disorders (Hill, Theodoros, Russell, Cahill, Ward, Clark, 2006; Theodoros, Constantinescu, Russell, Ward, Wilson & Wootton, in press) following brain impairment and Parkinson's disease. Collectively, these studies have revealed positive treatment outcomes, while assessment and diagnoses have been found to be comparable to face-to-face evaluations.

The treatment of stuttering has been adapted to a telerehabilitation environment with notable success. Two Australian studies (Harrison, Wilson & Onslow, 1999; Wilson, Onslow & Lincoln, 2004) involving the distance delivery of the Lidcombe program to children who stutter have utilized the telephone in conjunction with offline video recordings to successfully treat several children. Overall, the parents and children responded positively to the program delivered at a distant. Using a high speed videoconferencing system link, Sicotte, Lehoux, Fortier-Blanc and

Leblanc (2003) assessed and treated six children and adolescents with a positive reduction in the frequency of dysfluency that was maintained six months later. In addition, a videoconferencing platform has been used successfully to provide follow-up treatment to an adult who had previously received intensive therapy (Kully, 200).

Reports of telerehabilitation applications in paediatric speech and language disorders are sparse. A recent Australian pilot study has investigated the feasibility of an Internet-based assessment of speech disorder in six children (Waite, Cahill, Theodoros, Russell, Busuttin, in press). High levels of agreement between the online and face-to-face clinicians for single-word articulation, speech intelligibility, and oro-motor tasks were obtained suggesting that the Internet-based protocol had the potential to be a reliable method for assessing paediatric speech disorders.

Voice therapy across a variety of types of voice disorders has been shown to be effectively delivered via a telerehabilitation application. Mashima et al. (2003) using PC based videoconferencing and speech analysis software compared 23 patients treated online with 28 persons treated face-to-face. The authors reported positive post treatment results with no significant difference in measures between the traditional and videoconferencing group, suggesting that the majority of traditional voice therapy techniques can be applied to distance treatment.

Although obvious limitations exist, telerehabilitation applications for the assessment of swallowing function have also been used with success. Lalor, Brown and Cranfield (2000) were able to obtain an initial assessment of the nature and extent of swallowing dysfunction in an adult via a videoconferencing link although a more complete evaluation was restricted due to the inability to physically determine the degree of laryngeal movement. A more sophisticated telerehabilitation application for the assessment of swallowing was developed by Perlman and Witthawaskul (2002) who described the use of real-time videofluoroscopic examination via the Internet. This system enabled the capture and display of images in real-time with only a three to five second delay.

There continues to be a need for ongoing research to develop and validate the use of telerehabilitation applications in speech-language pathology in a greater number and variety of adult and paediatric communication and swallowing disorders.edit

Disciplines and therapies

Speech-language pathology

1. Audiology
2. Physical therapy
3. Occupational therapy
4. Psychology
5. Nursing
6. Social work
7. Rehabilitation counseling/Vocational rehabilitation

STANDARDS AND TRAINING REQUIREMENTS

Telerehabilitation standards

1. Reimbursement policies/Reimbursement in telerehabilitation
2. Legislative activities/Legislative activities in telerehabilitation
3. Ethics and privacy issues/Ethics and privacy issues in telerehabilitation
4. Clinical and technology training issues

VOCATIONAL REHABILITATION

Vocational rehabilitation is a process which enables persons with functional, psychological, developmental, cognitive and emotional impairments or health disabilities to overcome barriers to accessing, maintaining or returning to employment or other useful occupation.

Vocational rehabilitation can require input from a range of health care professionals and other non-medical disciplines such as disability employment advisers and career counselors. Techniques used can include:

- assessment, appraisal, program evaluation and research.
- goal setting and intervention planning.
- provision of health advice and promotion, in support of returning to work.
- support for self-management of health conditions.
- making adjustments to the medical and psychological impact of a disability.
- case management, referral, and service co-ordination.
- psychosocial interventions.
- career counseling, job analysis, job development, and placement services.
- functional and work capacity evaluations.

Vocational rehabilitation practitioners are often governed by standards of practice. In the United Kingdom these are produced by the Vocational Rehabilitation Association.

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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – II – Advanced Rehabilitation Engineering – SBMA5301

UNIT II – ERGONOMICS & REHABILITATION

INTRODUCTION TO ERGONOMICS

Ergonomics derives from two Greek words: ergon, meaning work, and nomoi, meaning natural laws, to create a word that means the science of work and a person's relationship to that work.

Human factors and **Ergonomics** (HF&E) is a multidisciplinary field incorporating contributions from psychology, engineering, industrial design, graphic design, statistics, operations research and anthropometry. In essence it is the study of designing equipment and devices that fit the human body and its cognitive abilities.

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

The International Ergonomics Association has adopted this technical definition: ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

HF&E is employed to fulfill the goals of health and safety and productivity. It is relevant in the design of such things as safe furniture and easy-to-use interfaces to machines and equipment. Proper ergonomic design is necessary to prevent repetitive strain injuries and other musculoskeletal disorders, which can develop over time and can lead to long-term disability.
Human factors and ergonomics is concerned with the 'fit' between the user, equipment and their environments. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, functions, information and the environment suit each user.

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system. Practitioners of ergonomics, ergonomists, contribute to the planning, design and evaluation of tasks, jobs, products, organizations, environments and systems in order to make them compatible with the needs, abilities and limitations of People.

Domains of Specialization

Derived from the Greek ergon (work) and nomos (laws) to denote the science of work, ergonomics is a systems-oriented discipline, which now applies to all aspects of human activity.
Practicing ergonomists must have a broad understanding of the full scope of the discipline, taking into account the physical, cognitive, social, organizational, environmental and other relevant factors. Ergonomists often work in particular economic sectors or application domains.
These application domains are not mutually exclusive and they evolve constantly. New ones are created; old ones take on new perspectives. Within the discipline, domains of specialization

represent deeper competencies in specific human attributes or characteristics of human interaction:

- **Physical Ergonomics**

  Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. The relevant topics include working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety and health.

- **Cognitive Ergonomics**

  Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. The relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design.

- **Organizational Ergonomics**

  Organizational ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes. The relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, organizational culture, virtual organizations, telework, and quality management.

Environmental ergonomics is concerned with human interaction with the environment. The physical environment is characterized by: climate, temperature, pressure, vibration, light.

GENERAL ERGONOMIC PROGRAM MANAGEMENT

This section describes the necessary elements of USC's Ergonomics Program:

1. Management Leadership
2. Risk Assessment and Prioritization
3. Hazard Prevention and Control
4. Information Sharing
5. Reporting Procedures/Medical Management
6. Process Management
7. Training

Management Leadership

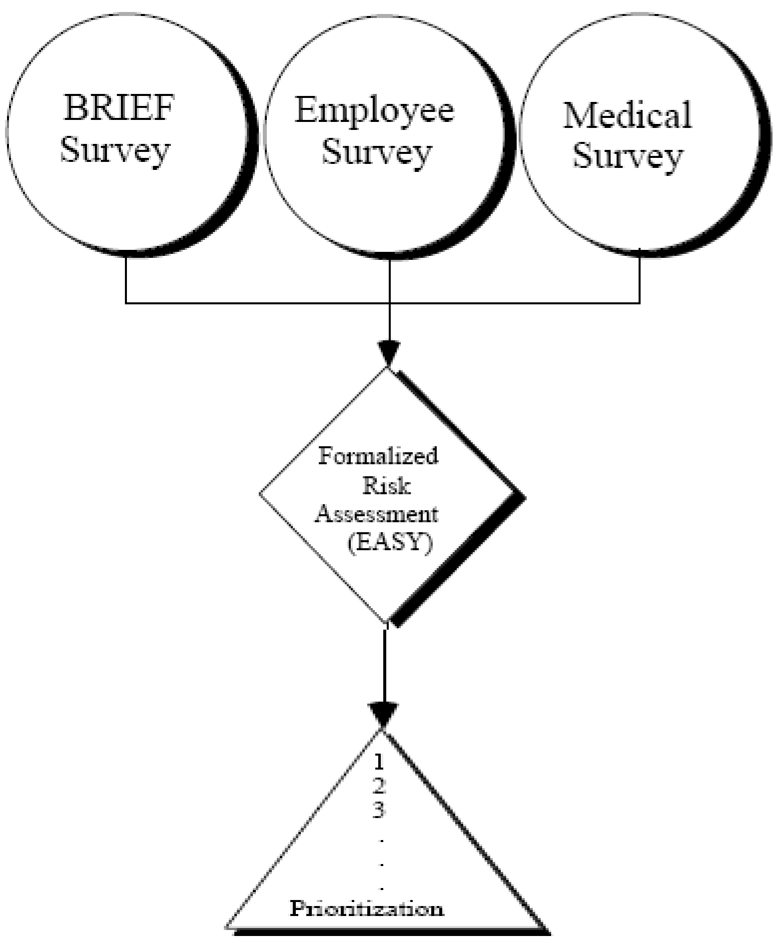
Business Affairs will set ergonomics improvement priorities based on employee risk exposure and operational initiatives. The EH&S Director will lead the Ergonomics program and utilize a team consisting of the following as applicable based on USC's functional make-up:

- Safety Staff
- Safety Assessors

Risk Assessment and Prioritization

The EASYTM method will be used as the worksite analysis tool. The EASYTM method (see diagram below) identifies and ranks operations by degree of RMI hazard. This is accomplished through a summary that integrates the BRIEFTM risk assessment tool (see diagram below) with injury/illness data and employee feedback into a systematic process. The highest priority operations, based on the EASYTM rankings, should be selected first for solution implementation.

RMI Risk Prioritization Easy Method



Hazard Prevention and Control

Ergonomic hazards identified, as high priority with an EASYTM score of 5 or above will be corrected using one or more of the following methods:

- Engineering controls

• Work practices controls
• Administrative controls

All high priority job/tasks will have corrective action plans written after the completion of the ergonomic assessment. Simple solutions, defined as low cost opportunities for ergonomic improvements, will be implemented within three months of the assessment. Complex solutions, defined as opportunities for ergonomic improvements that are highcost or require significant engineering involvement, will be implemented within a time frame determined by the Ergonomic Team.

Ergonomic Assessors will be utilized to resolve specific ergonomic challenges. These will consist of employees, operators and supervisors from the area for simple solutions. For those job/tasks requiring significant capital or engineering involvement, the Ergonomics Steering Team will include trained Engineers/Technical Staff and area managers. H&S Professionals or engineers/technical staff trained in this function will review any changed, designed, or purchased equipment. Ergonomics/Process Improvements and Ergonomics Design Templates will be utilized as guides for designing/modifying equipment and workstation designs and set-ups to resolve ergonomic challenges. Control measures will be planned, evaluated, and implemented for identified RMI hazards. Progress will be tracked to ensure that established plans are fulfilled.

Information Sharing

The **Ergonomic Assessors** will communicate effective controls to high-risk job/tasks to **Ergonomics Process Owner**. An ergonomics-tracking database will be created to track the ergonomic risk assessments completed for office and non-office assessments.
Information recommended to be in the database is the following:

1. Job Name
2. Department
3. Job Tasks
4. EASY Data
5. Number of Employees Involved
6. Frequency the task in completed
    a. Daily
    b. Weekly
    c. Monthly
    d. Semi-annually
    e. Annually

7. Ergonomic Risk Factors
8. Employee Discomfort Data and Comments
9. Injury Data
10. Injury Cost Data
11. Injury Lost Work Day Data
12. Safety Risk Factors

13. Personal Protective Equipment
14. Recommendations
15. Follow-up

Reporting Procedures/Medical Management

All **employees** who report RMIs will have access to prompt and effective medical management, including access to health care professionals for evaluation, treatment, and follow up. When possible, employees will be assigned to jobs that meet work restrictions recommended by health care providers.

- Any employee who experiences a RMI is required to immediately report the injury to his/her supervisor and then seek medical attention at the Faculty Staff Clinic (UPC) or the Ambulatory Health Care Center (HSC)

- The supervisor must complete the "SUPERVISOR'S REPORT OF INJURY" form and return it to the Workers' Compensation Office within 24 hours of the injury

- The Workers' Compensation Office will monitor the employee throughout the recovery period and will ensure that appropriate treatment/rehabilitation is provided in order for the worker to return to work as soon as possible

- Workers' Compensation will provide timely notification of suspected RMI incidents to EHS

Process Management

The **Director** will monitor the effectiveness of the ergonomics program and controls with a formal review at least every three years. This monitoring will include:

- Measures to assess the functioning of program activities.
- Measures to quantitatively assess the success of the program and specific controls that have been implemented.

The **Ergonomics Process Owner** will develop a plan annually that formalizes measurable goals and defined resources for USC's ergonomics program. The **Ergonomics Process Owner** will periodically monitor the following key activities with performance checked against metrics:

- Ergonomics team activities.
- Implementation of improvement projects.
- Training plans.
- Evaluations of changed, designed, or purchased equipment.

Training

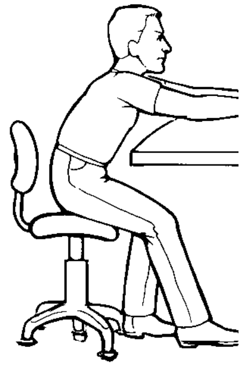
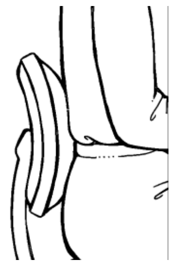
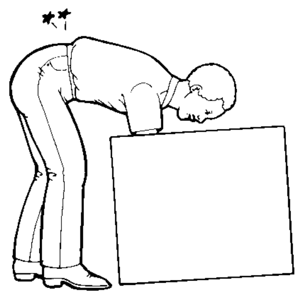
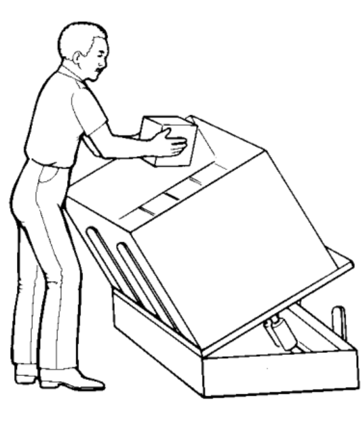
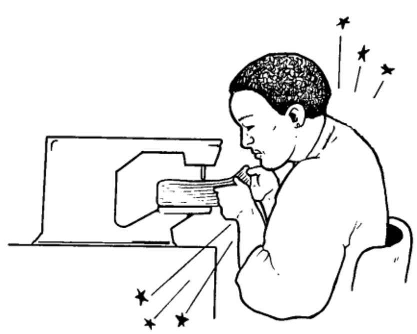
Training will be provided to employees diagnosed by a physician with a repetitive motion injury (RMI), employees performing an identical job, work process, or operation as the individual diagnosed with an RMI, as well as any individual requesting training or concerned about the ergonomic safety of their work environment. The Ergonomic Safety training course will introduce the concept of ergonomics, explain why an ergonomics program is necessary, provide an overview of the USC Ergonomic Program, identify the exposures which have been associated with RMIs, emphasize the importance of reporting symptoms and injuries to a supervisor, and provide methods to minimize RMIs.
Communications will be provided to managers, supervisors and employees in the role they will play in the program, such as recognition of RMIs and importance of early reporting.

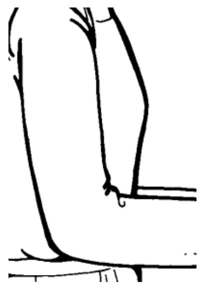
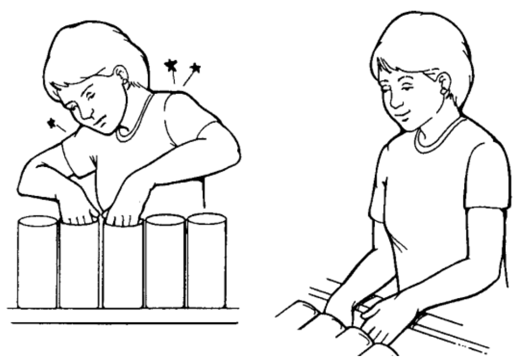
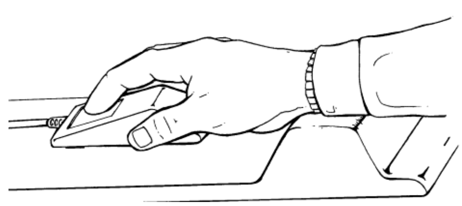
10 Principles of Ergonomics

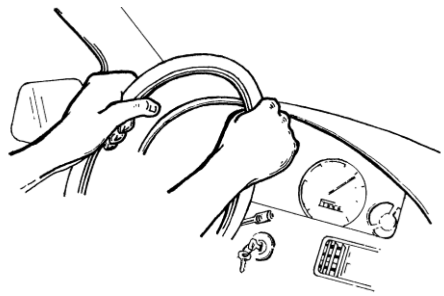
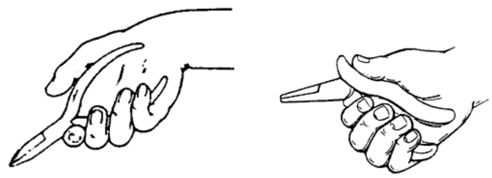
Principle 1 Work in Neutral Postures

Your posture provides a good starting point for evaluating the tasks that you do. The best positions in which to work are those that keep the body "in neutral."

Maintain the "S-curve" of the spine Your spinal column is shaped more or less like an "S."	
It is important to maintain the natural S-curve of the back, whether sitting or standing. The most important part of this "S" is in the lower back, which means that it is good to keep a slight "sway back," When standing, putting one foot up on a footrest helps to keep the spinal column in proper alignment.	

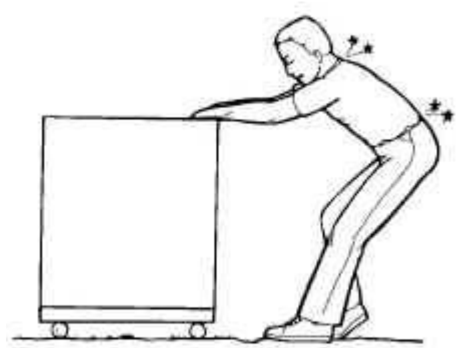
Working for long periods with your back in a "C-curve" can place strain on your back. Good lumbar support is often helpful to maintain the proper curve in the small of your back.	 
The "Inverted V-curve" creates an even greater strain on your back. Even without lifting a load, bending over like this creates a great deal of pressure on the spine. One common improvement is to use a lifter or tilter. Or there may be other ways of making improvements depending upon the situation.	 
Keep the neck aligned The neck bones are part of the spinal column and thus are subject to the same requirements of maintaining the S-curve. Prolonged twisted and bent postures of the neck can be as stressful as its equivalent for the lower back. The best way to make changes is usually to adjust	

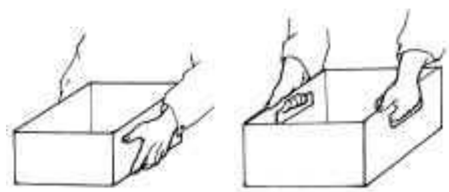
equipment so that your neck is in its neutral posture.	
Keeps elbows at sides The neutral posture for your arms is to keep you elbows at your sides and your shoulders relaxed. This is pretty obvious once you think about it, but we don't always do it.	
Here's an example of changing a workstation to get the arms in neutral. In the illustration at the left, the product is too high, and the employee is hunching her shoulders and winging out her elbows. In the right-hand illustration, the product has been reoriented and the shoulders and elbows drop to their relaxed position.	
Keep Wrists in Neutral There are several good ways to think about wrist posture. One way is to keep the hand in the same plane as the forearm, as this person is doing here by using a wrist rest along with the computer mouse.	

A slightly more accurate approach is to keep your hands more or less like they would be when you hold the steering wheel of your car at the 10 and 2 o'clock position — slightly in and slightly forward.	
Here's an example of how this principle applies to tool design. Working continuously with the pliers as shown in the left-hand picture can create a lot of stress on the wrist. By using pliers with an angled grip, however, the wrist stays in its neutral posture.	

Principle 2 Reduce Excessive Force

Excessive force on your joints can create a potential for fatigue and injury. In practical terms, the action item is for you to identify specific instances of excessive force and think of ways to make improvements.

For example, pulling a heavy cart might create excessive force for your back. To make improvements it might help to make sure the floor is in good repair, that the wheels on the cart are sufficiently large, and that there are good grips on the cart. Or a power tugger might be needed.	

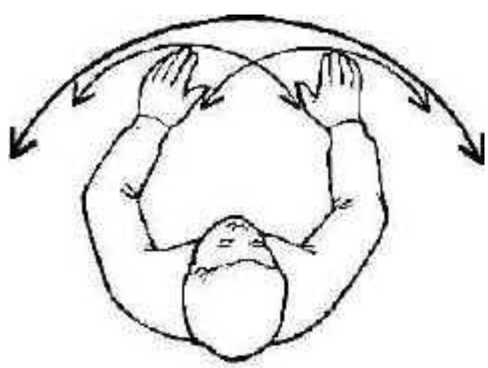
<table>
<tr><td>Or another example of reducing force is to use a hoist for lifting heavy objects, like this vacuum hoist in the drawing.</td><td></td></tr>
<tr><td>Another kind of example is having handholds on boxes or carrying totes. Having the handhold reduces the exertion your hands need to carry the same amount of weight.</td><td></td></tr>
<tr><td colspan="2">Point:

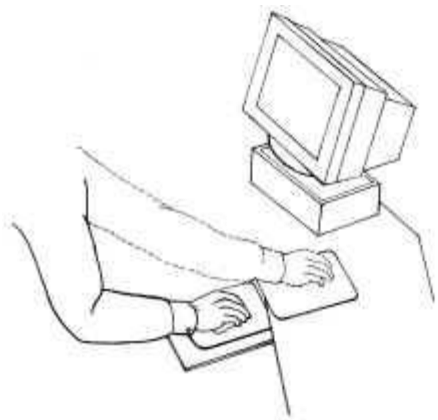
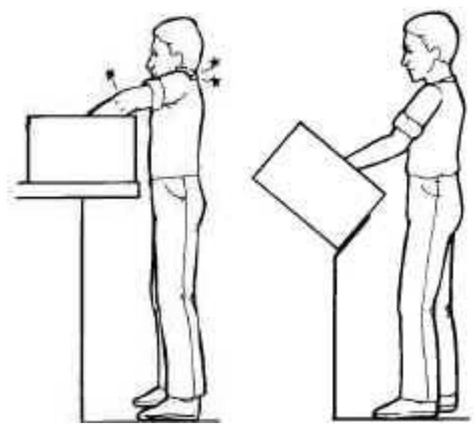
There are thousands of other examples and the field of ergonomics includes much information on conditions that affect force. The basic point is to recognize activities that require excessive force, then think of any way you can to reduce that force.</td></tr>
</table>

Principle 3 Keep Everything in Easy Reach

The next principle deals with keeping things within easy reach. In many ways, this principle is redundant with posture, but it helps to evaluate a task from this specific perspective.

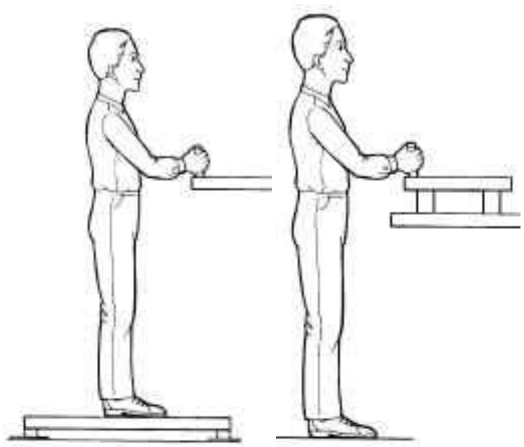
<table>
<tr><td>Reach Envelope

One concept is to think about the "reach envelope." This is the semi-circle that your arms make as you reach out. Things that you use frequently should ideally be within the reach envelope of your full arm. Things that you use extremely frequently should be within the reach envelope of your forearms.</td><td></td></tr>
</table>

Much of the time, problems with reach are simply matters of rearranging your work area and moving things closer to you. This is not exactly a hard concept to grasp; what is difficult is having the presence of mind to notice and change the location of things that you reach for a lot. Often it is a matter of habit — you are unaware that you continually reach for something that could be easily moved closer.	
Or sometimes, the work surface is just too big, causing you to reach across to get something. One option is just to get a smaller surface. Another option is to make a cutout — this way your reaches are cut, but you still have plenty of space for things.	
Or another common problem is reaching into boxes. A good way to fix this is to tilt the box. Once again, there are thousands of other examples of ways to reduce long reaches. The point is for you to think about when you make long reaches, then figure out how to reduce that reach.	

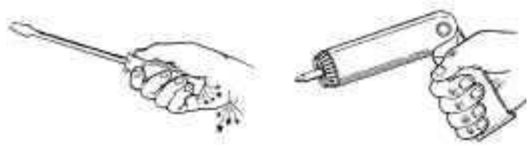
Principle 4 Work at Proper Heights

Working at the right height is also a way to make things easier.

Do most work at elbow height A good rule of thumb is that most work should be done at about elbow height, whether sitting or standing. A real common example is working with a computer keyboard. But, there are many other types of tasks where the rule applies.	
Exceptions to the Rule There are exceptions to this rule, however. Heavier work is often best done lower than elbow height. Precision work or visually intense work is often best done at heights above the elbow.	
Sometimes you can adjust heights by extending the legs to a work tables or cutting them down. Or you can either put a work platform on top of the table (to raise the work up) or stand on a platform (to raise YOU up). Or to be a little more complicated, there are ways to make stands and work tables instantaneously adjustable with hand cranks or pushbutton controls.	

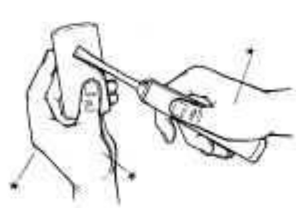
Principle 5 - Reduce Excessive Motions

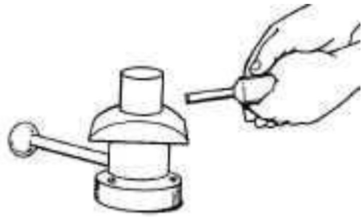
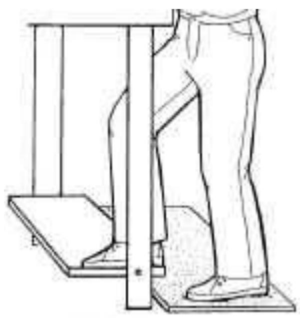
The next principle to think about is the number of motions you make throughout a day, whether with your fingers, your wrists, your arms, or your back.

One of the simplest ways to reduce manual repetitions is to use power tools whenever possible.	
Another approach is to change layouts of equipment to eliminate motions. In the example here, the box is moved closer and tilted, so that you can slide the products in, rather than having to pick them up each time.	
Or sometimes there are uneven surfaces or lips that are in the way. By changing these, you can eliminate motions. As always, there are more examples, but you should be getting the idea.	

Principle 6 Minimize Fatigue and Static Load

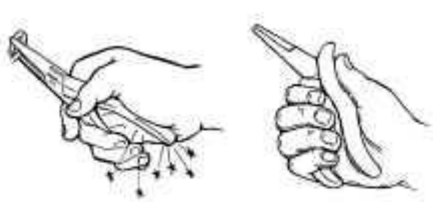
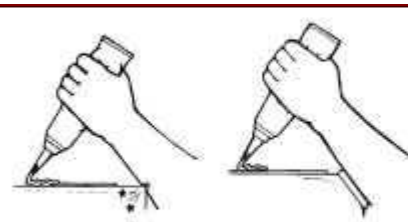
Holding the same position for a period of time is known as static load. It creates fatigue and discomfort and can interfere with work.

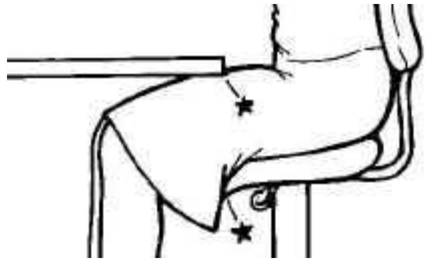
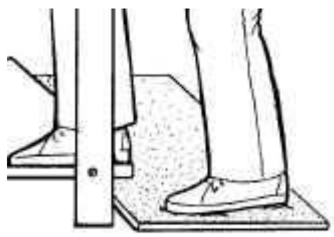
A good example of static load that everyone has experienced is writer's cramp. You do not need to hold onto a pencil very hard, just for long periods. Your muscles tire after a time and begin to hurt.	
In the workplace, having to hold parts and tools continually is an example of static load. In this case, using a fixture	

eliminates the need to hold onto the part.	
Having to hold your arms overhead for a few minutes is another classic example of static load, this time affecting the shoulder muscles. Sometimes you can change the orientation of the work area to prevent this, or sometimes you can add extenders to the tools.	
Having to stand for a long time creates a static load on your legs. Simply having a footrest can permit you to reposition your legs and make it easier to stand. We’re going come back to this point later.	

Principle 7 - Minimize Pressure Points

Another thing to watch out for is excessive pressure points, sometimes called "contact stress."

A good example of this is squeezing hard onto a tool, like a pair of pliers. Adding a cushioned grip and contouring the handles to fit your hand makes this problem better.	
Leaning your forearms against the hard edge of a work table creates a pressure point. Rounding out the edge and padding it usually helps.	

We've all had to sit on chairs that had cushioning and so understand almost everything we need to know about pressure points. A particularly vulnerable spot is behind your knees, which happens if your chair is too high or when you dangle your legs. Another pressure point that can happen when you sit is between your thigh and the bottom of a table.	
A slightly more subtle kind of pressure point occurs when you stand on a hard surface, like concrete. Your heels and feet can begin to hurt and your whole legs can begin to tire. The answer is anti-fatigue matting or sometimes using special insoles in your shoes. Like the other basic principles that we've covered so far, pressure points are things that you can look for in your work areas to see if there are ways to make improvements.	

Principle 8 - Provide Clearance

Having enough clearance is a concept that is easy to relate to.

Work areas need to be set up so that you have sufficient room for your head, your knees, and your feet. You obviously don't want to have to bump into things all the time, or have to work in contorted postures, or reach because there is no space for your knees or feet.	

Being able to see is another version of this principle. Equipment should be built and tasks should be set up so that nothing blocks your view.	

Principle 9 - Move, Exercise, and Stretch

To be healthy the human body needs to be exercised and stretched.

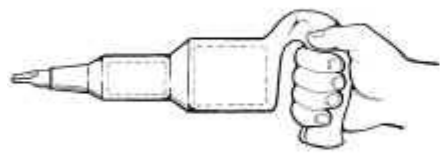
You should not conclude after reading all the preceding information about reducing repetition, force, and awkward postures, that you're best off just lying around pushing buttons. Muscles need to be loaded and your heart rate needs periodic elevation.	
Depending upon the type of work you do, different exercises on the job can be helpful. • If you have a physically demanding job, you may find it helpful to stretch and warm up before any strenuous activity. • If you have a sedentary job, you may want to take a quick "energy break" every so often to do a few stretches.	

If you sit for long periods, you need to shift postures: • Adjust the seat up and down throughout the day. • Move, stretch, and change positions often.	
It actually would be ideal if you could alternate between sitting and standing throughout the day. For some tasks, such as customer service, desks are available that move up and down for this purpose (this is not new; Thomas Jefferson built a desk like this for himself).	

Principle 10 - Maintain a Comfortable Environment

This principle is more or less a catch-all that can mean different things depending upon the nature of the types of operations that you do.

Lighting and Glare One common problem is lighting. In the computerized office, lighting has become a big issue, because the highly polished computer screen reflects every stray bit of light around.	

But many other types of tasks can be affected by poor lighting, too. Concerns include glare, working in your own shadow, and just plain insufficient light. One good way to solve lighting problems is by using task lighting; that is, having a small light right at your work that you can orient and adjust to fit your needs.	
Vibration Vibration is another common problem that can benefit from evaluation. As an example, vibrating tools can be dampened.	

Note: The above principles all address physical issues, those items that people are most interested in currently. Two additional "principles" are:

11. Make displays and controls understandable

12. Improve work organization

These last two "principles" are in fact huge topics that in themselves can be summarized in a series of principles.

REHABILITATION TEAM

Your interdisciplinary rehabilitation team, which includes highly trained and experienced specialists in this field, will work closely with you to advance your recovery, provide the skills and strategies to encourage your independence, and offer you and your family support and encouragement every step of the way.

Each specialist plays a significant role in the rehabilitation process:

The **Case Manager** serves as the primary contact for the patient and family. His or her role on the team is to direct the patient's rehabilitation and coordinate with everyone involved in the patient's care. The case manager also provides ongoing communication with the patient, family, attending and consulting physicians, referral sources and insurance companies. In addition, he or she helps patients and families access needed services, and prepare for identify available resources for the return home.

Physiatrists are the main medical doctor on the rehabilitation team. A physiatrist is either an M.D. (Medical Doctor) or D.O. (Doctor of Osteopathic Medicine) with a specialty in physical medicine and rehabilitation. The physiatrist assesses patients at admission to rehabilitation and directs the patient's medical care, monitoring the course of rehabilitation to help the patient attain optimal function. Your physiatrist stays in contact with your other physicians to address special issues and keep them updated on your rehabilitation progress. The physiatrist makes contact with all patients daily and meets with families as needed during the rehabilitation stay.

Nurses and nursing assistants provide the patient with 24-hour-a-day nursing care. Our nurses have specialized training in rehabilitation and provide the patient's daily medical care, support and education. They encourage patients to use techniques learned in therapy. Unlike in other nursing units, rehabilitation nurses encourage patients to do as much of their own care as functionally possible, since the goal is to teach independence and challenge each patient to achieve their maximum potential.

Neuropsychologists are clinical psychologists who specialize in studying brain behavior relationships. Neuropsychologists have extensive training in the anatomy, physiology, and pathology of the nervous system. Their role on the rehabilitation treatment team is to address psychological needs and concerns, helping patients and families adjust to changes in their life. They offer assessment, treatment, and consultation and education.

Physical Therapists and Physical Therapy Assistants provide assessments, treatment and therapy programs to help patients gain greater mobility, muscle strength and performance, and joint motion and balance. They also work with patients to improve their ability to perform daily activities. Treatment often includes walking, transfers (moving from bed to chair, for example), balance, therapeutic exercise, and cardiovascular endurance training. They recommend and provide training on any assistive devices to improve mobility, such as crutches, canes, walkers, wheelchairs and artificial limbs or braces.

Occupational Therapists and Occupational Therapy Assistants work with patients to regain, develop, and build skills that are important for independent functioning, health, well-being and security. Treatment focuses on helping individuals regain greater independence with activities for daily living, often referred to as ADLs. These may include eating, dressing, and personal care. Your occupational therapists may use a variety of activities and tools to improve your strength, movements and motor skills. They will provide training on adaptive techniques or devices as needed, such as one-handed techniques, reachers, dressing aids or environmental modifications. They also will help simulate your home environment or real life situations as part of your therapy.

Speech Therapists (also referred to as Speech-Language Pathologists) evaluate speech and language, memory, problem-solving, hearing and swallowing skills in order to develop a treatment plan for improving problems related to a patient's injury or illness. Treatment may focus on expressive language (talking, naming, writing), receptive language (understanding and reading), swallowing, and/or diet recommendations,

SSM Rehabilitation Hospital's holistic team approach includes **Pastoral Care.** Members of the Pastoral Care staff can help patients and families address their hopes and fears in facing recovery and the hard work of rehabilitation, as well as the unique spiritual and emotional needs in reaching their goals. They can help patients and families discover value amidst the personal and physical changes from their injury or illness. Pastoral Care chaplains are available to visit, listen, comfort, and address any spiritual needs, whatever the denomination or preference. They can also help in contact a patient's faith communities or church, and encourage ministers of all faiths to visit at any time during the patient's stay.

Dietitians supervise methods of feeding and caloric needs, and monitor feeding tolerance to assure patients receive adequate nutrition.

Speech and Language Pathologist

Works with patients who have difficulties in understanding what they hear or read and/or expressing their ideas through speech and writing. The SLP also assesses patients who have dysphagia (swallowing problems) and helps them to eat and drink safely in the most natural way.

Social Worker

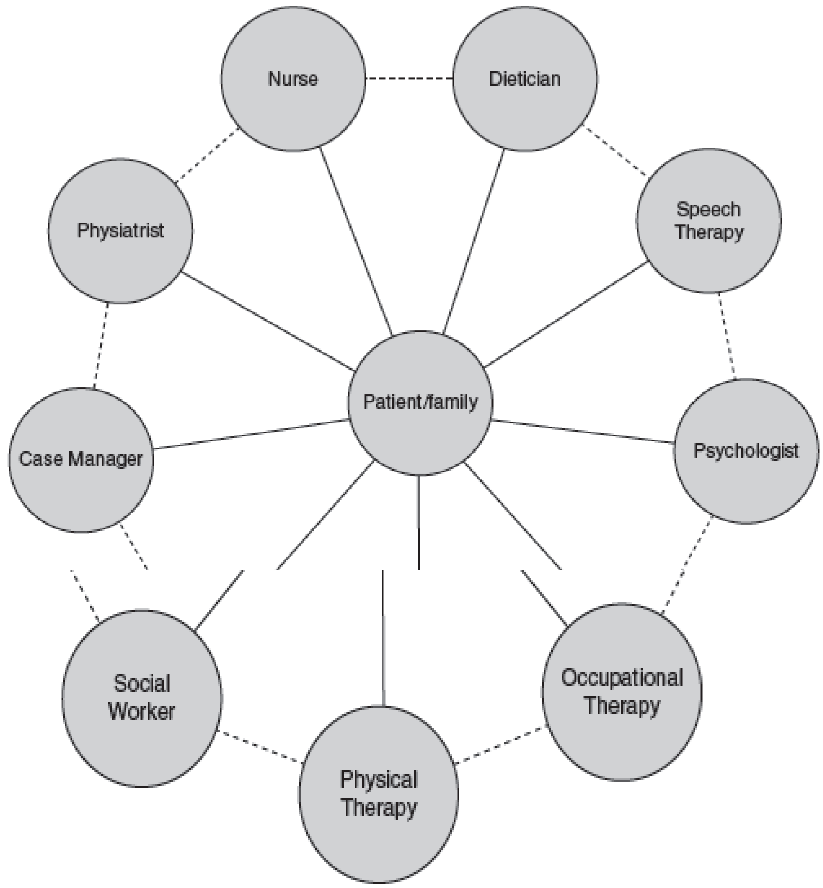
Provides support and counseling as needed for the patient and their family, and facilitates a safe and effective discharge plan.

Rehabilitation Assistant

Works under the supervision of the Physiotherapist and/or Occupational Therapist to provide individual or group therapy programs.

Respiratory Therapist

Evaluates treats and cares for patients with breathing disorders.



Interdisciplinary model.

Discipline	Primary Role in the Team	Examples of Collaboration With Other Team Members
Physiatrist	Responsible for physical medicine and rehabilitation management of patient's care.	Often leads the team. Orders assessment and ongoing treatment in collaboration with team.
Staff nurse	Coordinates and provides day-to-day patient care. Educates patient/family regarding medical and health issues as well as skills needed to provide safe health care (i.e., catheterization skills, bowel programs, skin maintenance/wound management). Patient advocate.	Supports and coaches patients to practice newly learned skills. Cues them as needed. Provides feedback to therapists re: patient ability to follow through with skill and if there are cognitive, behavioral, or physical changes during the day that are impacting patient's ability to consistently perform on unit.
Physical therapist (PT)	Maximizes patient function by working with patients to improve gross motor skills. Focuses on mobility, including ambulation, balance, W/C skills, Provides modalities for pain management.	PT and OT work together to develop strength, balance, and teaching skills needed for ADLs. Patient works on W/C transfers, whereas OT incorporates what PT has taught patient to practice toilet transfers, and instructs patient on clothing management, personal hygiene.
Occupational therapist (OT)	Assist patient gain maximal function in areas of ADLs.	OT and PT collaborate to assist patient to become functional with all components of skills/ADLs.

Speech-language pathologist (SLP)	Evaluates and treats cognition, communication, swallowing disorders, and hearing deficits.	Communicates with team regarding patient communication needs, how to cue patient when learning an activity, impact of cognitive deficits on ability to learn and retain information. Communicates with team regarding feeding and swallowing disorders and works with physicians, nurses, and dieticians about appropriate food and liquid consistencies, compensatory strategies to maintain safe swallow.
Therapeutic recreation (TR)	Assists patients to reenter their community and helps patients adapt so they can enjoy leisure activities.	Incorporates what patient has learned from other disciplines to assist patient with community reentry and leisure activities in preparation for patient discharge.
Respiratory therapist (RT)	Evaluates and treats a patient's breathing, including assist of ventilation as needed.	Supports maintenance of respiratory status and prevention of complications related to inactivity. Works with PT to increase tolerance for increased mobility.
Neuropsychologist	Evaluates cognitive and behavior status, assists in the adjustment to illness/disability. Provides support to patient and family as they come to grips with issues related to illness/disability.	Works with team regarding cognitive and behavioral needs of patients, developing appropriate plans of care related to cognitive and behavioral management.
Case manager	Coordinates implementation of treatment plan, communicates insurance benefit information to patient/families and the team. Advocates for services. Acts as liaison between patient, hospital, and payer. Provides updated information to insurance companies. Coordinates optimal use of available benefits.	Coordinates team to look at patient days, status of insurance to assist in planning for discharge, and to keep members mindful of time allotted to accomplish goals
Advanced practice nurse (CNS /nurse practitioner)	Conducts comprehensive assessment. Integrates education, research, and consultation into clinical practice	Collaborates with nursing peers, interdisciplinary team, including physician, regarding evidenced-based practice. Integrates education, research and consultation into clinical practice.
Chaplains	Supports patients in their spiritual/religious practices. Provides encouragement and support.	Guides team to provide support while coping with illness/disability, consistent with patient's faith/beliefs.
Vocational services	Evaluates impact of illness/injury on vocation. Assists patients with adaptations to return to present vocation or retraining/education.	Communicates status of patient's vocational needs. Works with therapists to develop, adapt, or improve skills required for return to work or school.

FES Systems

Functional Electrical Stimulation (FES) can help in regaining functional movements in numerous paralyzed humans. FES activates innervated but paralyzed muscles, by using an electronic stimulator to deliver trains of pulses to neuromuscular structures. The basic phenomenon of the stimulation is a contraction of muscle due to the controlled delivery of electric charge to neuromuscular structures. FES systems can restore (1) goal-oriented (hand and arm) movements, and (2) cyclic (walking and standing) movements.

Restoration of Hand Functions

The objective of an upper extremity assistive system is directed toward establishing independence to the user. Efforts in developing upper extremity FES systems were targeted toward individuals with diminished, but preserved, shoulder and elbow functions, with lack of wrist control and grasping ability. There have been several designs of FES systems. These systems can be divided among the source of control signals to trigger or regulate the stimulation pattern: shoulder control, voice control, respiratory control ,joystick control , and position transducers or trigger . The division can be made based upon the method to which patterned electrical stimulation is delivered: one to three channel surface electrode systems, multichannel surface stimulation system, multichannel percutaneous systems with intramuscular electrodes , and fully implanted systems with epimysial electrodes . Only a small number of FES grasping systems has been used outside the laboratory. The first grasping system used to provide prehension and release used a splint with a spring for closure and electrical stimulation of the thumb extensor for release. This attempt was unsuccessful mostly because of the state-of-the-art technology used, but also because of muscle fatigue and erratic contractile response. Rudel et al., following the work of Vodovnik suggested the use of a simple two-channel stimulation system and a position transducer (sliding potentiometer). The shift of the potentiometer forward from its neutral position causes opening by stimulating the dorsal side of the forearm; a shift backward causes closing of the hand by stimulating the volar side of the forearm The follow-up of initial FES system use was systematically continued in Japan. The development of implantable cuff electrodes to be used for sensing contact, slippage, and pressure opens a new prospective in controlling grasping devices, and the Center for Sensory Motor
Interactions in Aalborg, Denmark is pursuing a series of experiments combining their sensing technique with the fully implantable CWRU system.

Bionic glove for restoration of grasping in persons with tetraplegia used for multicentre trials. The upper panel shows electrodes, stimulator, and the glove, while the bottom panel shows the glove mounted.

Restoration of standing and walking

The application of FES to the restoration of gait was first investigated systematically in Ljubljana, Slovenia Currently, FES for gait rehabilitation is used in a clinical setting in several rehabilitation centers and there is a growing trend for the design of devices for home use. A multichannel system with a minimum of four channels of FES is required for ambulation of a patient with a complete motor lesion of lower extremities and preserved balance and upper body motor control Appropriate bilateral stimulation of the quadriceps muscles locks the knees during standing. Stimulating the common peroneal nerve on the ipsilateral side, while switching off the quadriceps stimulation on that side, produces a flexion of the leg. This flexion, combined with adequate movement of the upper body and use of the upper extremities for support, allows ground clearance and is considered the swing phase of the gait cycle. Hand or foot switches can provide the flexion–extension alternation needed for a slow forward or backward progression. Sufficient arm strength must be available to provide balance in parallel bars (clinical application), and with a rolling walker or crutches (daily use of FES). Multichannel percutaneous systems for gait restoration were suggested. The main advantage of these systems is the plausibility to activate many different muscle groups. A very similar preprogrammed.

Stimulation pattern to the one in a human with no motor disorders is delivered to ankle, knee, and hip joints, as well as to paraspinal muscles. The experience of the Cleveland research team suggested that 48 channels are required for a complete SCI walking system to achieve a reasonable walking pattern, but they recently changed their stimulation strategy and included some external bracing. Fine-wire intramuscular electrodes are cathodes positioned close to the motor point within selected muscles. Knee extensors (rectus femoris, vastus medialis, vastus lateralis, vastus intermedius), hip flexors (sartorius, tensor fasciae latae, gracilis, iliopsoas), hip extensors (semimembranosus, gluteus maximus), hip abductors (gluteus medius), ankle dorsiflexors (tibialis anterior, peroneus longus), ankle plantar flexors (gastrocnemius

lateralis and medialis, plantaris and soleus), and paraspinal muscles are selected for activation.

A surface electrode is used as a common anode. Interleaved pulses are delivered with a multichannel, battery-operated, portable stimulator. The hand controller allows the selection of gait activity. These systems were limited to the clinical environment. A multichannel totally implanted FES system was proposed and tested in a few subjects. This system uses a 16-channel implantable stimulator attached to the epineurium electrodes. Femoral and gluteal nerves were stimulated for hip and knee extension. The so-called “round-about” stimulation was applied in which four electrodes were located around the nerve and stimulated intermittently. This stimulation method reduces muscle fatigue. The development of the stimulation technology is providing new hope for patients and researchers alike. Two new techniques are especially important: (1) application of remotely controlled wireless microstimulators and (2) so-called “stimulator for all seasons General statements about FES systems indicate that it is suitable for subjects with preserved peripheral neuromuscular structures, moderate spasticity, without joint contractures and limited osteoporosis. Subjects should be able to control their balance and upper body posture using the upper extremities for assistance (parallel bars, walker, crutches, etc.). Subjects with pathologies that affect the heart, lungs, or circulation should be treated with extreme care, and often they should not be included in an FES walking program. A satisfactory mental and emotional condition is extremely important because an FES treatment requires a certain degree of intelligence and understanding of the technical side of the system. High motivation and good cooperation with medical staff is a significant aspect for the efficacy of FES. Surface stimulation may be applied only in subjects with limited sensation because it activates pain receptors. Subjects suitable for FES can include those with head and spinal cord injuries, cerebral paralysis, multiple sclerosis, and different types of myelitis and others.

The final current drawback to FES ambulation is the excessive energy cost while walking. FES walking should be described as a sequence of static states; long stance phase (several seconds) followed by brisk flexion movement and short step, followed by the same movement at the contralateral side. Dynamic walking is a necessary development which will introduce better use of inertial and gravity forces, and reduce energy rate and cost, increase the walking distance, and increase the speed of progression in parallel with decreased fatigue of muscles because the muscles will not be stimulated for long periods.

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SCHOOL OF BIO & CHEMICAL ENGINEERING

DEPARTMENT OF BIOMEDICAL ENGINEERING

UNIT – III – Advanced Rehabilitation Engineering – SBMA5301

UNIT III – ORTHOTICS & PROSTHETICS

Orthotics in Rehabilitation

Introduction

The use of orthotic intervention in rehabilitation spans the history of humans, from the first crude fracture splint made from sticks in the forest, to the sophisticated modern dynamic orthoses fabricated from hybrid materials. Many of the principles have remained the same through time; however, the new materials and structural designs, and breadth of application to a greater number of medical conditions have contributed to the expansive utilization of orthotic intervention. The use of orthotics can be found in almost every aspect of rehabilitation today. With the appreciation and understanding of terminology, materials, generic designs, and the application of orthotics, clinicians can enhance the delivery of healthcare to their clients.

Terminology

The terminology related to medical appliances is fairly straightforward. The prefix "ortho" means to "straighten or correct," with the suffix "tic" referring to the "systematic pursuit of".

The term orthosis refers to an exoskeletal appliance applied to a body part, and has replaced the traditional term, "bracing." A brace is considered to be an appliance that allows movement at the joint, whereas a splint does not allow movement at a joint.

Through the years, the term "splint" has been used, especially in the area of hand therapy, to mean a short-term orthosis and splints have been described as both static and dynamic. As a result, the terms orthosis, brace, and splint have become interchangeable across many allied health professions.

The orthotist is the person who designs, fabricates, and repairs the orthotic appliance, however, physical and occupational therapists, as will as physicians, may fabricate low temperature thermoplastic.

The American Academy of Orthopaedic Surgeons and the American Orthotic and Prosthetic Association developed a standard of nomenclature devices. The acronyms used for the generic are listed in table 1. Orthotics are named by the joints they encompass. Thus, foot orthoses (FO) are appliances applied to the foot and are placed inside or outside the shoe.

Table 1: Orthotic acronyms

LL orthoses:			
FO	Foot orthosis	AFO	Ankle-Foot orthosis
KO	Knee orthosis	KAFO	Knee-Ankle-Foot orthosis
HO	Hip orthosis	HKAFO	Hip-Knee-Ankle-Foot orthosis
		RGO	Reciprocal Gait orthosis
Spinal orthoses			
CO	Cervical orthosis	CTO	Cervical-Thoracic orthosis
TO	Thoracic orthosis	CTLSO	CervicoThoraciclumbosacral orthosis
SO	Sacral orthosis		Thoraciclumbosacral orthosis
SIO	Sacroiliac orthosis	TLSO	Lumbosacral orthosis
		LSO	
UL orthoses			
HdO	Hand orthosis	WHO	Wrist-Hand orthosis
WO	Wrist orthosis	EWHO	Elbow-Wrist-Hand orthosis
EO	Elbow orthosis	SEO	Shoulder-Elbow orthosis
SO	Shoulder orthosis	SEWHO	Shoulder-Elbow-Wrist-Hand orthosis

Biomechanical principles of orthotic design

- The biomechanical principles of orthotic design assist in promoting control, correction, stabilization, or dynamic movement.

- All orthotic designs are based on three relatively simple principles: (1) pressure.

  (2) equilibrium

  (3) the lever arm principle.

- These considerations include and are not limited to:
  - the forces at the interface between the orthotic materials and the skin,
  - the degrees-of-freedom of each joint,
  - the number of joint segments,
  - the neuromuscular control of a segment, including strength and tone,
  - the material selected for orthotic fabrication,
  - the activity level of the client.

- The following principles provide the foundation for all orthotic design keeping in mind that the more complicated the orthotic application, the more confounded the various principles become.

1. **The pressure principle**

It states that: ***Pressure is equal to the total force per unit area.***

Clinically, what this means is that the greater the area of a pad or the plastic shell of an orthosis, the less force will be placed on the skin. Therefore, any material that creates a force against the skin should be of a dimension to minimize the forces on the tissues.

$$P = \frac{\text{force}}{\text{Area of application}}$$

2. **The equilibrium principle**

It states that: ***The sum of the forces and the bending moments created must be equal to zero.***

The practical application is best explained by the most commonly used loading system in orthotics, the three-point pressure system (Fig. 1). The three-point pressure or loading system occurs when three forces are applied to a segment in such a way that a single primary force is applied between two additional counterforces with the sum of all three forces equaling zero. The primary force is of a magnitude and located at a point where movement is either inhibited or facilitated, depending on the functional design of the orthosis.

3. The lever arm principle

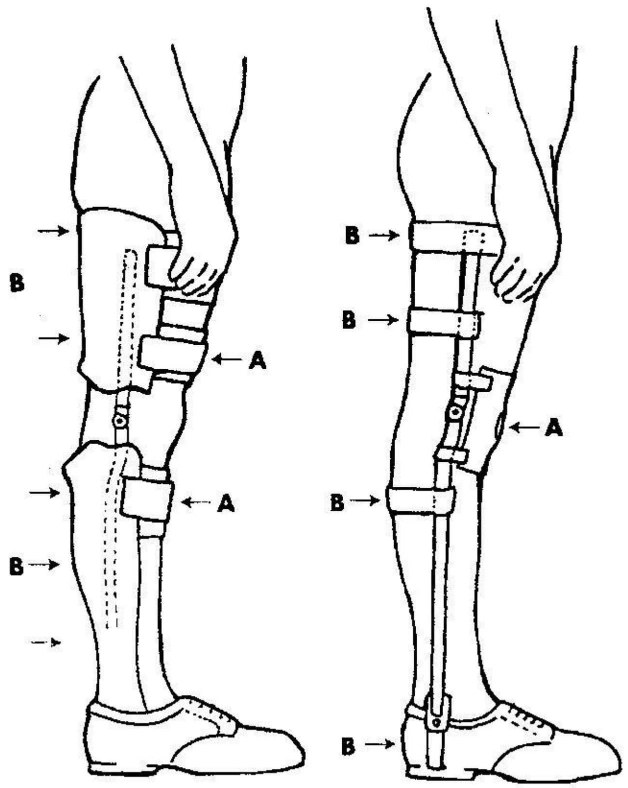
It states that: **The farther the point of force from the joint, the greater the moment arm and the smaller the magnitude of force required to produce a given torque at the joint.**

This is why most orthoses are designed with long metal bars or plastic shells that are the length of an adjacent segment. The greater the length of the supporting orthotic structure, the greater the moment or torque that can be placed on the joint or unstable segment. Collectively, these three principles rarely, if ever, act independently of each other. Ideally, when designing or evaluating an orthotic appliance, the clinician should check that

(1) There is adequate padding covering the greatest area possible for comfort;

(2) The total forces acting on the involved segment is equal to zero or there is equal pressure throughout the orthosis and no areas of irritation to the skin;

(3) The length of the orthosis is suitable to provide an adequate force to create the desired effect and to avoid increased transmission of shear forces against the anatomic tissues.



FIGURE

The three-point pressure system. **A,** The primary force. **B,** The counterforce application. The sum of all forces will equal zero.

Figure 1: Three point pressure system

Orthotic Considerations

- The goal of orthotic fitting is to meet the functional requirements of the client with minimal restriction.
- To meet this goal, the rehabilitation team must evaluate each client individually without preconceived ideas of routine orthotic prescription based purely on the diagnosis.

- It must be determined whether the appliance will be:
    - a temporary device to protect or assist the client until further restorative therapies have been progressed, or
    - a permanent orthosis fabricated for long-term use.

The functional considerations for an orthoses typically include one or more of the following.

1- **Alignment:** the correction of a deformity or maintenance of a body segment.

Clinical examples:

a) Musculoskeletal considerations

i. Milwaukee brace for scoliosis

ii. Dynamic splint to prevent scar shortening in clients with burns

b) Neurologic considerations

i. Tone reducing AFOs in patient with cerebral palsy

ii. CTLSO to prevent motion of the cervical region

2- **Movement:** a joint requires assistance with motion or resistance to excessive motion.

Clinical examples:

A. Assistance with joint motion

a) Musculoskeletal considerations

AFO with dorsiflexion assist for dorsiflexor weakness

b) Neurologic considerations

RGO assist clients with spinal cord injury with ambulation

B. **Resistance of joint motion**

a) Musculoskeletal considerations

i. Shoe insert for a patient with foot deformity.

ii. Finger splints for arthritic hands

b) Neurologic considerations

i. Swedish knee cage for unstable knee

ii. Arm sling for neurologic shoulder

3- **Weight-bearing:** to reduce axial loading and reduce the forces placed on a joint.

Clinical examples:

a) Musculoskeletal considerations

Shoe insert with metatarsal pad for a diabetic patient with foot deformity.

b) Neurologic considerations

Heel wedge for the pronated foot of a child with cerebral palsy

4- **Protection:** support or protect a segment against further injury or pain.

Clinical samples:

a) Musculoskeletal considerations

Functional knee brace

b) Neurologic considerations

Cock-up splints post spinal cord injury

Contraindications for orthotic application:

(1) The orthosis cannot provide the required amount of motion,

(2) When greater stabilization is required than can be provided,

(3) The orthosis actually limits function, and the client is more functional without the appliance, and

(4) Abnormal pressures from the orthosis would result in injury to the skin and other tissues.

Materials:

The client is fitted with an orthotic appliance that is both functional and, in most cases, cosmetically acceptable. Selecting the appropriate material characteristics for the fabrication of an orthotic device requires careful consideration of a number of factors:

1. **Strength:** the maximum external load that can be sustained by a material.
2. **Stiffness:** the amount of bending or compression that occurs under stress. Clinically, when greater support is required, a stiffer material is used; when a more dynamic orthosis is desired, a more flexible material is used.
3. **Durability** (fatigue resistance): the ability of a material to withstand repeated cycles of loading and unloading. Selection of a material for orthotic appliances is frequently based on the ability of the material to withstand the day-to-day stresses of each individual client.

4. **Density:** the material's weight per unit volume. Generally, the greater the volume or thicker a material the more rigid and more durable it will be, however, this usually increases the overall weight of the finished orthosis.

5. **Corrosion resistance:** the vulnerability of the material to chemical degradation. Most materials will exhibit corrosion over time, metals will rust and plastics will become brittle. Contact with human perspiration and environmental elements such as dirt, temperatures, and water accelerate the wearing effect on materials. Knowing the client's daily environment can assist in material selection.
6. **Ease of fabrication:** The equipments needed for fabrication of orthoses

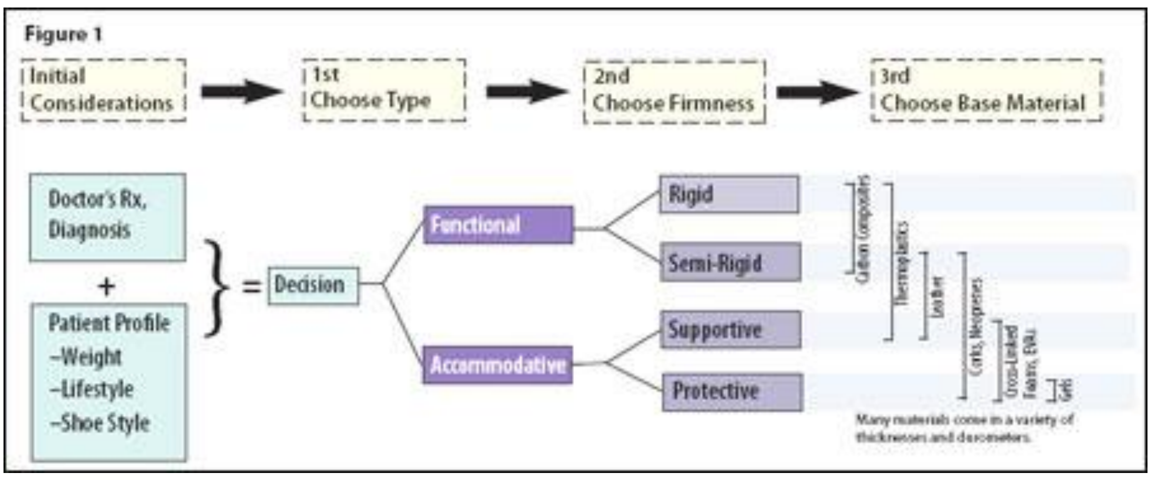


Fig. 2 The equipments needed for fabrication of orthoses

Orthotic Base Materials

Thermoplastics

Materials that soften when heated and harden when cooled. There are several groups of plastics used in the orthotic industry, and they are sold in many different thicknesses, strengths, and colors.

Polypropylene

A plastic with a low specific gravity and high stiffness. This combination of light weight and high strength makes it ideal for manufacturing rigid foot orthotics although any notch or groove on the finished shell can create a stress point that may eventually crack.

Subortholen Family

Officially known as high-molecular-weight, high-density polyethylene (HMW-HDPE), Subortholen is a wax-like, inert, flexible, and tough polymer. These characteristics ensure a high melt strength and deep draw without thinning. It is also easily cold-formed; i.e., hammered, allowing for adjustments after the heating and vacuum process.

Acrylic

Rohadur, Polydur, and Plexidur are some of the more common trade names for this class of material. Made from methyl methacrylate polymers, these were among the first of the man-made (synthetic) materials used for rigid orthotics. They were prone to cracking. The search for alternatives took on urgency when it was discovered that the Rohadur production process was carcinogenic.

Composite Carbon Fibers

Combining acrylic plastic with carbon fibers creates a rigid sheet material. Known by various trade names such as Carboplast, Graphite, and the TL-series, the "carbons" are good for thin, functional orthotics. They are a little more difficult to work with, requiring a higher softening temperature, faster vacuuming, and complete accuracy during the "pull," as they do not re-work easily.

Cork

This natural material can be combined with rubber binders to create an excellent thermo-formable sheet. Thermocork comes in many weights and thicknesses and vacuums well to provide a firm but forgiving orthotic, which is easily adjusted with a sanding wheel.

Leather

This was the original material used for "arch supports." Shoemakers took sole leather and wet-molded it to casts. These devices typically had high medial flanges to support the midfoot, and relatively low heel cups. Leather laminates are still used today when patients want good support but cannot tolerate firmer plastics. Their bulk and weight usually necessitates an extra-depth shoe, work boot, or sneaker.

Polyethylene Foams

This is a very broad category of materials that are in widespread use. Cross-linked polyethylenes (CL-PE) include the trade names Plastazote®, Pelite, Aliplast®, Dermaplast®, XPE, and

Nickelplast™. These closed-cell foams are ideal for total-contact, pressure-reducing orthotics although some are subject to compression with continued wear.

Ethyl-vinyl cetates (EVAs), crepes/neoprenes, and more recently silicones are other groups of man-made materials that are ideal for making accommodative foot molds.

INTRODUCTION

Modern orthotic devices play a vital role in the field of orthopaedic and neurological rehabilitation. These devices improve function, restrict or enforce motion, or support a body segment and are an integral part of the life of persons with disability.

Definition

An **Orthosis** is a mechanical device fitted to the body to maintain it in an anatomical or functional position.

Functional Classification

Supportive It stabilises the joints and supports the body in its anatomical position, e.g. calipers, gaiters.

Functional It stabilises the joint and also makes up for a lost function, e.g. foot drop splint in common peroneal nerve palsy or dynamic cock-up splints in wrist drop.

Corrective to correct deformities, e.g. Club foot boot in congenital talipes equino varus.

Protective To protect a part of the body during its healing, e.g. rigid four post-collar for fracture cervical vertebrae.

Prevent substitution of function In a full length caliper, substitution of hip flexors by abductors or adductors of hip and other similar trick movements are prevented.

Orthoses which strengthen certain groups of muscles, e.g. Tenodesis splint

Relief of pain, e.g. Lumbosacral corset supports the lower back, preventing painful movement.

Prevent weight bearing A weight relieving orthosis, prescribed for conditions like fracture calcaneum will take weight away from the injured site into proximal site like the patellar tendon bearing area.

Regional Classification

They are classified according to the anatomical area fitted with the orthosis.

1. Cervical Orthosis
2. Head-Cervical Orthosis (HCO)
3. Head-Cervical-Thoracic Orthosis (HCTO)
4. Sacral Orthosis
5. Lumbo-sacral Orthosis (LSO)
6. Thoraco lumbo-sacral Orthosis (TLSO)
7. Upper Extremity Orthosis
   a. Shoulder and Arm Orthosis
   b. Elbow Orthosis
   c. Wrist Orthosis
   d. Hand Orthosis
8. Lower Extremity Orthosis
   a. Foot Orthoses (FO)
   b. Ankle-Foot Orthoses (AFO)
   c. Knee-Ankle Foot Orthoses (KAFO)
   d. Hip-Knee-Ankle-Foot Orthoses (HKAFO)

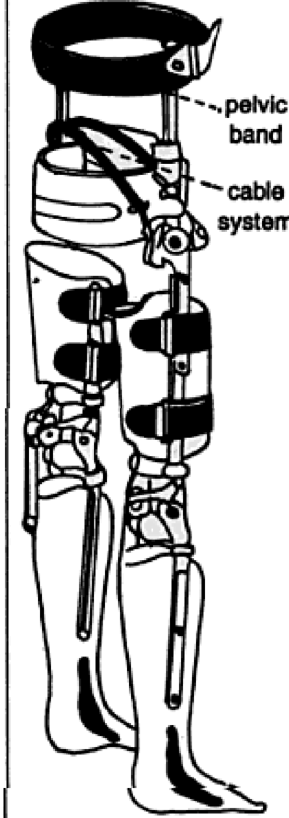


Fig. 7.1: Reciprocating gait orthosis

Orthosis Serving Specialised Functions

1. **Swedish knee cage:** It is a knee orthosis that is used to control minor or moderate genu recurvatum.
2. **Paediatric orthosis:** *Standing Frame:* Used for a toddler with spina bifida or a T12 neurosegmental level lesion or a child with cerebral palsy.
3. **Parapodium (Swivel Orthosis):** It is used for leg length discrepancy and has a wide abdominal support pad to assist in upright posture.
4. **Reciprocating gait orthosis (RGO)** These are bilateral hip, knee, ankle, foot orthosis to provide contralateral hip extension with ipsilateral hip flexion. When one hip flexes, the contralateral hip extends.
5. **Twister:** It is prescribed for lack of control of internal or external rotation or torsion of lower limb.
6. **Orthosis used for hand injuries, flexors and extensor tendon injuries,** e.g. dynamic orthosis – volar and dorsal wrist splints.

7. **Orthosis used for nerve injury:**
   a. ***Radial nerve injury*** – A radial nerve glove is given with the wrist held in extended position or a wrist drop splint is given.
   b. ***Ulnar nerve injury*** – Splints that maintain the flexion of metacarpo-phalangeal joints and extension at interphalangeal joint with a lumbrical bar, e.g. knuckle duster splint.
   c. ***Median nerve injury*** – Splints is put to the thumb in an abducted, opposed position. (Opponens Splint).
8. **Orthosis used for inflammation of joints and tendons:** Static thumb spica orthosis with the proximal interphalangeal joint kept free.
9. **Orthosis used for burns:** Splinting done to hold the hand is neutral position and prevent stiffening of the metacarpophalangeal joints in an extended position.
10. **Orthosis used in rheumatoid arthritis:** Static three point proximal interphalangeal orthosis for Boutonniere deformity.
11. **Orthoses used for stroke and brain injury** In stroke, large arm slings to prevent subluxation of the shoulder.

GENERAL PRINCIPLES OF ORTHOSIS

1. **Use of forces**
   Orthoses utilise forces to limit or assist movements for example.
   a. Rigid material spanning a joint prevents motion, e.g. posterior tube splint.
   b. A spring in a joint is stressed by one motion and then recoils to assist, the opposite desired motion.
      e.g. leaf spring orthosis
2. **Limitation of movement:** Limiting motion may reduce pain.
3. **Correcting a mobile deformity:** A flexible deformity may be corrected by an orthosis. Corrective force must be balanced by proximal and distal counter forces (three point force systems).
4. **Fixed deformity:** If the fixed deformity is accommodated by an orthosis, it will prevent the progression of the deformity.
5. **Adjustability:** Orthotic adjustability is indicated for children to accommodate their growth and for patients with progressive or resolving disorders.
6. **Maintenance and cleaning:** The orthosis should be simple to maintain and clean
7. **Application:** The design should be simple for easy donning and doffing. The more complicated the gadget the less likely it is to be accepted for permanent use.
8. *Sensation:* An orthotic device does not provide sensation; in fact it often covers skin areas and decreases sensory feedback. Proprioception should be preserved where possible.

9. **Gravity:** Gravity plays an important role in upper limb orthosis, especially in those joints where the heaviest movement masses are present. For example, a Rolyan shoulder cuff can be used in hemiplegia to prevent subluxation of the shoulder, which is the largest joint prone for the deleterious effects of gravity.
10. **Comfort:** The orthosis should be comfortable. Pressure should be distributed over the largest area possible.
11. **Utility:** The orthoses must be useful and serve a real purpose. A well-functioning opposite extremity is a major deterrent to the use of an upper extremity orthosis as most activities of daily living can be performed with the good hand. If the orthosis does not add significance to their function, the patients typically discontinue its use.
12. **Cosmesis:** Cosmesis is important especially in hand orthosis. A functional but unsightly orthosis is often rejected if the patient values appearance over function.

Principle of Jordan (Fig. 7.2)

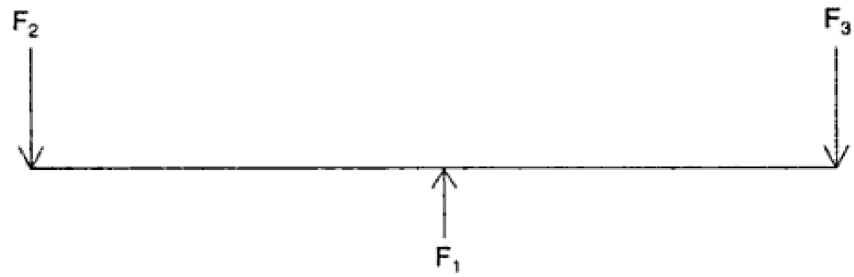
The basic mechanical principle of orthotic correction is the "**Three Point System of Jordan.**" This system applies corrective or assistive forces, which are implemented at the surface of the orthosis through the skin and are transmitted to the underlying soft tissues and bones.

To remain stable, the body has to have one point of pressure opposed by two equal points of counter pressure in such a way that $F_1 = F_2 + F_3$.

The corrective force is directed toward the angulation or deformed area to be corrected, and other two counter forces are applied distal and proximal to the corrective force. The greater the distance between the force and the counter forces, the less the counter force required.

Contraindications to Orthoses

1. Skin infections.
2. When the muscle power is very much affected by the weight of the orthoses.
3. In case of severe deformity which cannot be accommodated in the orthosis.
4. If it limits movements at other normal joints.
5. Where the orthosis interferes grossly with clothing or limits ones style of living.
6. Lack of motivation or other psychological problems.
7. Very young or old patients.



$$F_1 = F_2 + F_3$$

Fig. 7.2: Principle of Jordan

Biomechanics of Orthosis

There are four different ways in which an orthosis may modify the system of external forces and moments acting across a joint.

The four patterns are:

1. Control of rotational moments across a joint
2. Control of translational forces around a joint
3. Control of axial forces around a joint
4. Control of line of action of ground reaction force and involves modifying the point of application and line of action of the ground reaction force during either static or dynamic weight bearing.

TYPES OF ORTHOTICS

Spinal orthotics

A spinal orthotic device (commonly referred to simply as an orthotic or an orthosis) is an external apparatus that is applied to the body to limit the motion of, correct deformity in, reduce axial loading on, or improve the function of a particular spinal segment of the body

Spinomed

A Spinomed is a prefabricated spinal orthosis consisting of a padded rigid posterior framework with several Velcro straps and a corset-type abdominal section. The rigid posterior section can be contoured to follow the alignment of the forward bending spine.

The purpose of a Spinomed is to control thoracic kyphosis, reducing the strain in a painful spine. It is designed to reduce angulation of the upper thoracic spine secondary to:

- Osteoporosis or other osteopenic changes in bone
- inflammatory conditions such as Rheumatoid Arthritis
- numerous multi-level compression-type fractures

Its accessible design allows the wearer to apply and remove it without difficulty. Application is easily accomplished, even if the wearer has severely arthritic fingers with loss of dexterous function.

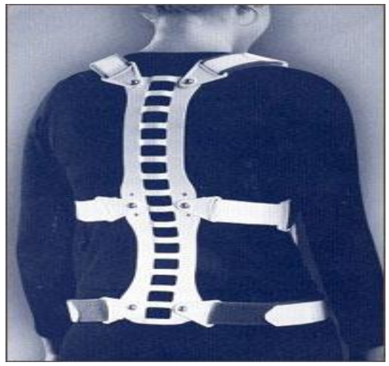


Fig. 3 Spinal orthosis

Jewett

A Jewett is a type of spinal Orthosis that stabilizes the upper thoracic to the lower lumbar spine. It is a dynamic Orthosis which places the spine into hyperextension in an effort to offload the anterior aspect of one or more vertebral bodies.

Utilizing three points of pressure, the Jewett is diamond-shaped in appearance with pads at the sternum and lower abdomen. Additionally, there is a padded posterior strap which completes the hyperextension force.

It is appropriate for anterior wedge-shaped compression fractures of the vertebral body. Multi-level compression fractures may be treated with the Jewett brace, while more complex burst-type fractures are typically treated with a TLSO.

Cervical Orthoses (CO) (http://hubrxonline.net)

Several drawbacks to CO use have been noted, as follows :

- The soft-tissue structures around the neck (eg, blood vessels, esophagus, trachea) limit the application of aggressive external force.
- The high level of mobility at all segments of the cervical spine makes it difficult to restrict motion.
- Cervical orthoses offer no control for the head or thorax; therefore, motion restriction is minimal. (Cervical orthoses serve as a kinesthetic reminder to limit neck movement.)

Appropriate precautions associated with orthotic use should be observed. It should be kept in mind that the long-term use of orthoses has been associated with decreased muscle function and dependency.

The soft collar is a common, lightweight orthotic device made of polyurethane foam rubber with a stockinette cover; Velcro closure straps are used for easy donning and doffing. Patients find the collar comfortable to wear, but it is easily soiled with long-term use.

Indications for the use of a soft collar include the following benefits for the patient:

- Warmth
- Psychological comfort
- Head support when acute neck pain occurs
- Relief from minor muscle spasm associated with spondylolysis
- Relief from cervical strain

The soft collar provides some motion limitations for the patient, including the following:

- Full flexion and extension are limited by 5-15%.
- Full lateral bending is limited by 5-10%.
- Full rotation is limited by 10-17%.

Hard cervical collars are similar in shape to soft collars but are made of Plastizote, a rigid polyethylene material. Hard collars are ring-shaped with padding; some of these have an adjustable height, providing patients with a better fit. Velcro straps are used for easy donning and doffing. With regard to long-term use, hard collars, which cost approximately $60, are more durable than soft collars.

Several problems can be alleviated with the use of a hard collar. Indications for the orthosis include the following:

- Head support when acute neck pain occurs
- Relief of minor muscle spasm associated with spondylosis
- Psychological comfort
- Interim stability and protection during halo application

Motion restrictions associated with the hard collar include the following:

- Full flexion and extension are limited by 20-25%.
- The hard collar is less effective in restricting rotation and lateral bending.
- It is better than a soft collar in motion restriction.

Halo (http://cpo.biz)

The halo is a device for treatment of unstable cervical and upper thoracic fractures and dislocations from C1 to T3. The halo provides greater motion restriction than any other cervical orthosis. The halo ring is made of graphite or metal, with pin fixation on the frontal and parietal-occipital areas of the skull. Development of lightweight composite material led to the design of radiolucent rings that are compatible with magnetic resonance imaging (MRI). The halo ring attaches to the vest anteriorly and posteriorly via 4 upright bars.

The halo vest has shoulder and underarm straps for tightening; it is usually made of rigid polyethylene and extends down to the umbilicus. Restriction in cervical motion depends on the fit of the halo vest. An improper fit can allow 31% of normal spine motion; compressive and distractive force can occur with variable fit of the vest.

Motion restrictions:

- Flexion and extension are limited by 90-96%
- Lateral bending is limited by 92-96%.
- Rotation is limited by 98-99%

Halo (http://www.cascadeorthotics.com/html/halo.html)

The Halo cervical Orthosis is an external fixation spinal Orthosis that provides the greatest level of stabilization to the head and cervical spine. It involves the semi-permanent fixation of a graphite ring to the head with Titanium skull pins. Through a group of carbon fiber rods attached to a plastic sheepskin-lined vest, the head and cervical spine are maintained in a stable and optimally-aligned position.

This Orthosis is utilized to treat unstable cervical spinal fractures and often is an addendum to cervical spinal surgery to maintain position until fusion occurs or further surgical stabilization is performed.

The Halo Orthosis is often utilized for complex cervical fractures that do not avail themselves to surgical stabilization or in situations where surgical intervention is contraindicated.

Typically, patient care with a Halo is much more involved than with other types of cervical Orthoses. As the Halo is a complicated mechanical Orthosis, the patient will be required to make numerous follow-up visits to ensure that the torque setting of the screws and the alignment remain appropriate throughout the duration of care.

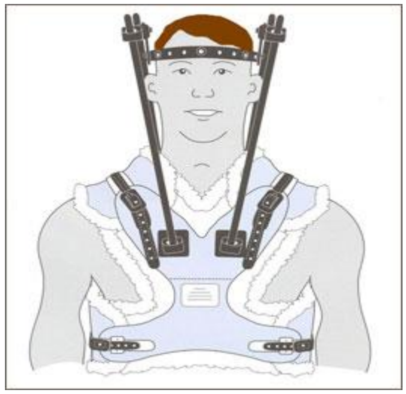


Fig. 4 – Halo cervical orthoses

Soft Collar

Cervical orthoses (COs) support the occiput and chin in order to decrease range of motion (ROM) from C2-C5. A thoracic extension can be added to increase motion restriction and treat C6-T2 injuries. COs generally are used to support stable spine conditions, and are listed below from least to most supportive.

The soft collar is a common, lightweight orthotic device made of polyurethane foam rubber with a stockinette cover; Velcro closure straps are used for easy donning and doffing. Patients find the collar comfortable to wear, but it is easily soiled with long-term use.

Motion Restrictions

Flexionand extension are limited by 5-15%

Lateral bending is limited by 5-10%

Rotation is limited by 10-17%

Indications

Head support when acute neck pain occurs

Relief from minor muscle spasm associated with spondylosis

Relief from cervical strain

Contraindications

Unstable fracture

Neural Involvement

The **Philadelphia collar** is a semirigid CO with a 2-piece system of Plastizote foam. Plastic struts on the anterior and posterior sides are used for support. The upper portion of the orthosis supports the lower jaw and occiput, while the lower portion covers the upper thoracic region. The Philadelphia collar comes in various sizes and is comfortable to wear, improving patient compliance. Velcro straps are used for easy donning and doffing. An anterior hole for a tracheostomy is available.

A semi-rigid CO, the **Miami J collar** is another commonly used cervical orthosis. The device consists of a 2-piece system made of polyethylene, with a soft, washable lining. The anterior piece has a tracheostomy opening similar to that in the Philadelphia collar. Velcro straps are used for easy donning and doffing. A thoracic extension can be added to increase support and treat C6-T2 injuries. Available in various sizes, the Miami J collar can be heated and molded to a contoured fit.

Motion restrictions:

• Flexion and extension are limited by 55-75%.

• Rotation is limited by 70%.

• Lateral bending is limited by 60%.

Lumbosacral Orthosis (LSO)

Knight Brace It is a short spinal brace consisting of a pelvic band and a thoracic band joined by two posterior and two lateral metal uprights which, provide considerably more rigidity than a corset.

Boston Brace The Boston brace is an example of modular orthosis that provides varying control and is useful for the treatment of scoliosis. It is made up of semirigid plastic and supports the lower trunk by controlling all lumbosacral motion.

Conditions Used

1. Low back pain.
2. Spondylolisthesis.
3. Intervertebral disc diseases.

Uses

1. The orthosis reminds the wearer to avoid abrupt motion.
2. Motion control is achieved by means of various three-point force systems — support for the spine is also by abdominal pressure.

Lumbosacral Corset

These are very common, and routinely used. Lumbosacral corsets may vary in rigidity based on the amount and type of metal stays included. Longer length corsets generally are used for more extensive spinal mechanical disability. A

corset may have vertical reinforcements or a rigid posterior plate, but no rigid horizontal bands. They are made of leather or canvas and contain elastic straps with Velcro fastening for a close fit, and available off the shelf in various sizes (28" to 42" waist circumference).

Conditions Used

Many painful low back conditions associated with:

1. Osteoporosis
2. Lumbar spondylosis
3. Malignancy
4. Postural back pain
5. Spondylolisthesis
6. Lumbosacral strain
7. Sciatica.

Uses

1. This is used in reducing pain by avoiding movement.
2. This orthosis also used in reducing contraction of the erector spinae and consequently compression of intervertebral discs.

Sacral Orthosis

1. Sacral orthosis are the least restrictive spinal orthosis. They provide control of the pelvis as a supportive base for the rest of the spinal column.

Uses

a. Healing pelvic fractures.
b. Helps in relieving sacro-iliac pain (sacroileitis).

Sacro-iliac Corset : It is a prefabricated cloth device that can be adjusted anteriorly, posteriorly or laterally with laces or hooks. Its superior borders lie at the level of the iliac crest. Inferiorly its anterior border lies 0.5 to 1 inch above the pubic symphysis and its posterior border extends to the gluteal fold.

Uses

This orthosis is thought to act by elevation of intra-abdominal pressure and stabilisation of the sacro-iliac joint and pubic symphysis.

1. Lumbosacral Orthoses

1.1. Chairback brace

The chairback brace, shown below, is a short, rigid lumbosacral orthosis (LSO) with 2 posterior uprights that have thoracic and pelvic bands. The abdominal apron has straps in front for adjustment in order to increase intracavitary pressure. The thoracic band is located 1 inch below the inferior angle of the scapula. The thoracic band extends laterally to the midaxillary line, and the pelvic band extends laterally to the midtrochanteric line. Place the pelvic band as low as possible without interfering with sitting comfort. Position the posterior uprights over the paraspinal muscles. Uprights can be made from metal or plastic. The brace uses a 3-point pressure system and can be

custom molded to improve the fit for each patient.

Indications for the use of a chairback brace include the following:

- Unloading of the intervertebral disks and the transmission of pressure to soft-tissue areas
- Relief of low back pain (LBP)
- Immobilization after lumbar laminectomy
- Kinesthetic reminder to the patient following surgery

Motion restrictions associated with the chairback brace include the following:

- Limits flexion and extension at the L1-L4 level
- Minimally limits rotation
- Limits lateral bending by 45% in the thoracolumbar spine

1.2. Chairback Ortho-Mold brace

The chairback Ortho-Mold brace is similar to the chairback brace, but it has a rigid plastic back piece custom-molded to the patient. The plastic back can be inserted into the canvas-and-elastic corset.

1.3. Williams brace

The Williams brace is a short LSO with an anterior elastic apron to allow for forward flexion. Lateral uprights attach to the thoracic band, and oblique bars are used to connect the pelvic band to the lateral uprights. The abdominal apron is laced to the lateral uprights. The brace limits extension and lateral trunk movement but allows forward flexion.

The brace is indicated for the treatment of spondylolysis and spondylolisthesis, being used to provide motion restriction during extension. The device is contraindicated in spinal compression fractures.

Motion restrictions of the Williams brace include the following:

- Limits extension
- Limits side bending at the terminal ends only

1.4. MacAusland brace

The MacAusland brace is an LSO that limits only flexion and extension. This brace has 2 posterior uprights but no lateral uprights. The 3 anteriorly directed straps connect with the abdominal apron to provide increased support. Motion restrictions include limitation of flexion and extension at the L1-L4 level.

1.5. Standard lumbosacral orthotic corset

The standard lumbosacral orthotic corset has metal bars within the cloth material posteriorly that can be removed and adjusted to fit the patient. The anterior abdominal apron has pull-up laces in the back that are used to tighten the orthosis. The abdominal apron can come with a Velcro closure for easy donning and doffing. The corset, which increases intracavitary pressure, has a lightweight design and is comfortable to wear. Anteriorly, the brace covers the area between the xiphoid process and the pubic symphysis. Posteriorly, it covers the area between the lower scapula and the gluteal fold.

Indications for the use of a standard lumbosacral orthotic corset include the following:

- Treatment of LBP
- Immobilization after lumbar laminectomy

Motion restrictions associated with the corset include the limitation of flexion and extension.

1.6. Rigid LSO

The rigid LSO, shown below, is a custom-made orthosis that is molded over the iliac crest for an improved fit. Plastic anterior and posterior shells overlap for a tight fit. Velcro closure in the front is designed for easy donning and doffing. Multiple holes can be made for aeration to help decrease moisture and limit skin maceration. The rigid LSO can be trimmed easily to make adjustments for patient comfort, and it may be used in the shower if necessary.

Fig. 6 - Custom-molded, plastic lumbosacral orthosis (LSO).

Indications for the use of a rigid LSO brace include the following:

- Postsurgical lumbar immobilization
- Treatment of lumbar compression fractures

Motion restrictions provided by the rigid LSO brace include the following:

- Limits flexion and extension
- Limits some rotation and side bending

1.7. Rigid LSO with hip spica

A rigid LSO with hip spica uses a thigh piece on the symptomatic side and extends to 5 cm above the patella. The hip is held in 20° of flexion to allow sitting and walking. After the orthosis is applied, some patients require a cane for ambulation. Indications for immobilization with the rigid LSO with hip spica include the following:

- Lumbar instability at L3-S1
- Lumbosacral fusion with anchoring to the sacrum - Postoperative

Motion restrictions associated with the rigid LSO with hip spica include the following:

- Limits flexion and extension
- Limits some rotation and side bending

New brace designs for LSOs include strapping systems that pull the brace inward and up, improving the hydrostatic effect in order to relieve pressure on the lumbar spine. The better fit helps limit migration. Some low-profile designs take pressure off the hip and rib area, which, in turn, improves patient compliance. Low-profile braces fit more easily under clothing. These braces can treat areas from L3-S1.

Some spinal braces have an interchangeable back with an open center or a flat back design for postoperative patients. The same brace can be interchanged with a back that has an indentation to fit the lordotic curvature of the lumbar spine for pain management purposes. Braces with interchangeable parts allow an LSO to be converted into a TLSO with a large back support and an attachment for a sternal extension to prevent unwanted flexion. The sternal extension has straps that attach to the LSO.

Thoraco-Lumbar-Sacral Orthosis (TLSO)

Jewett Orthosis This is an anterior hyperextension orthosis which has an anterior rectangular frame exerting pressure over the pubis and upper thorax with the fulcrum being maintained by a thoracic strap attached to the sides of the frame.

Conditions Used

1. Vertebral compression fracture
2. Intervertebral disc diseases
3. Non-operative and postoperative immobilization of spine.

Uses

1. Flexion, extension and lateral flexion of the thoracolumbar spine are restricted.

Thoracolumbosacral Orthosis (TLSO)

A TLSO is a rigid spinal Orthosis that spans the thoracic, lumbar and sacral spine. It is used to provide post-traumatic and post-surgical stabilization. A custom-made, rigid TLSO provides the maximum amount of exterior stabilization to the thoracic and lumbar parts of the spine.

The effective range of stabilization is from T5 – L4. An extension to the head with a cervical superstructure or to the leg with a hip joint and thigh cuff can increase the effective range of the TLSO through the entire length of the spine.

It is often custom-made from polyethylene plastic with a soft interface for patient comfort and can be either made in one piece with a single opening or in two pieces with lateral openings. The latter design is referred to as a clam-shell style. Of all the different designs the clam-shell is the easiest to apply. A custom-made TLSO is usually fabricated from a plaster of Paris cast or from digital scanning technology.

It is often used to provide non-operative management of:

- burst-type fractures
- multi-level compression fractures
- Chance-type fractures
- complex multi-planar fractures

Other indications include restriction of mobility for pain relief due to:

- Osteomyelitis
- Discitis
- multi-level lesion for metastatic disease
- Scoliosis
- Scheuermann's kyphosis
- Ankylosing Spondylitis

The TLSO may also be used post-operatively to limit mobility of a region to enhance bony fusion. The duration of wear is typically up to 3 months depending on the treatment requirements of the Spine Surgeon.

Thoraco-Lumbo-Sacral-Orthosis (TLSO)

The most common form of a TLSO brace is called the "Boston brace", and it may be referred to as an "underarm" brace. This brace is fitted to the child's body and custom molded from plastic. It works by applying three-point pressure to the curvature to prevent its progression. It can be worn under clothing and is typically not noticeable. The TLSO brace is usually worn 23 hours a day, and it can be taken off to swim, play sports or participate in gym class during the day.This type of brace is usually prescribed for curves in the lumbar or thoraco-lumbar part of the spine.

Cervico-Thoraco-Lumbo-Sacral-Orthosis (known as a Milwaukee brace)

The Milwaukee brace is similar to the TLSO described above, but also includes a neck ring held in place by vertical bars attached to the body of the brace.

It is usually worn 23 hours a day, and can be taken off to swim, play sports or participate in gym class during the day.

This type of brace is often prescribed for curves in the thoracic spine.

Milwaukee brace (hubrxonline.net)

The Milwaukee Brace is commonly used for high thoracic (mid-back) curves. It extends from the neck to the pelvis and consists of a specially contoured plastic pelvic girdle and a neck ring connected by metal bars in the front and the back of the brace. The metal bars help extend the length of the torso and the neck ring keeps the head centered over the pelvis. Pressure pads, strategically placed according to the patient's curve pattern, are attached to the metal bars with straps.

The Milwaukee Brace was the first modern brace designed for the treatment of scoliosis. Developed by Drs. Walter Blount and Albert Schmidt of the Medical College of Wisconsin and Milwaukee's Children's Hospital in 1945, its design has been tweaked through the years until reaching its current design around 1975. Today, the brace is used less frequently now that more form-fitting plastic braces have been developed; however, it's still prescribed for some types of curves that are located very high in the spine.

The Milwaukee brace is a CTLSO that was originally designed by Blount and Schmidt to help maintain postoperative correction in patients with scoliosis secondary to polio. The brace is designed to stimulate corrective forces in the patient. When the patient has been fitted properly with a brace, the trunk muscles are in constant use; therefore, disuse atrophy does not occur. The brace has an open design, with constant force provided by the plastic pelvic mold. The pelvic portion helps reduce lordosis, derotates the spine, and corrects frontal deformity.

The uprights have localized pads that apply transverse force, which is effective for small curves. The main corrective force is the thoracic pad, which attaches to the 2 posterior uprights and to 1 anterior upright. Discomfort from the thoracic pad creates a righting response to an upright posture. In contrast to the thoracic pads, the lumbar pads play a passive role.

The uprights are perpendicular to the pelvic section, so any leg-length discrepancy should be corrected to level the pelvis. The neck ring is another corrective force and is designed to give longitudinal traction. Jaw deformity is a potential complication of the use of the neck ring. The throat mold, instead of a mandibular mold, allows the use of distractive force without the development of jaw deformity.

As a child grows, the brace length can be adjusted. In addition, pads can be changed to compensate for spinal growth. The brace needs to be changed if pelvic size increases. Average cost of this brace is approximately $2100-$2300.

Indications for the use of a Milwaukee brace include the following:

- Patients with a Risser score of I-II, as well as a curve that is greater than 20-30° and that progresses by 5° over 1 year
- Curves of 30-40°, but not curves of less than 20°.

Curves of 20-30°, with no year-over-year progression, require observation every 4-6 months. The Milwaukee brace is used for curves in which the apex is above T7.

The Milwaukee brace's duration of use is determined by the following criteria:

- Daily use ranges from 16-23 hours per day.
- Treatment should continue until the patient is at Risser stage IV or V.
- If the curve is greater than 30°, consider continued use of the brace for 1-2 years after maturity, because a curve of this magnitude is at risk of progression.

Problems that are associated with the use of a Milwaukee brace include the following:

- Jaw deformity
- Pain
- Skin breakdown
- Unsightly appearance
- Difficulty with mobility
- Difficulty with transfers
- Increased energy expenditure with ambulation

Failure to correct deformity can be caused by any of the following:

- Poor patient compliance
- Improper fit
- Curves below T7

3. Charleston Bending Brace

This type of brace is also called a "nighttime" brace because it is only worn while sleeping. A Charleston back brace is molded to the patient while they are bent to the side, and thus applies more pressure and bends the child against the curve. This pressure improves the corrective action of the brace. This type of brace is worn only at night while the child is asleep. Patients can go to school and participate in sports normally without their friends even knowing they have scoliosis and wear a brace, avoiding any potential negative stigma.

Many studies have shown that the Charleston Night time brace is as effective as the above-described 23-hour-a-day brace wear.

Curves must be in the 20 to 40 degree range and the apex of the curve needs to be below the level of the shoulder blade for the Charleston brace to be effective.

4. Boston brace

There are a variety of TLSO braces, but the one most commonly used to treat scoliosis is the "Boston Brace." TLSO braces are often called "low-profile" or "underarm" braces. They are not as large or bulky as the Milwaukee Brace (see below), and their plastic components are custom-molded to fit the patient's body.

The Boston Brace extends from below the breast to the beginning of the pelvic area in the front and from below the shoulder blades to the tail bone in the back. This type of brace works by applying three-point pressure to the curve to prevent its progression. It forces the lumbar area to flex, which pushes in the abdomen and flattens the posterior lumbar curve. Strategically placed pads place pressure on the curve, and "relief voids" are located opposite the areas of pressure.

Developed in the early 1970s by Dr. John Hall and Mr. William Miller of The Boston Children's Hospital, the Boston Brace is typically prescribed for curves in the lumbar (low-back) or thoraco-lumbar (mid- to low-back) sections of the spine.

The Boston brace is a prefabricated, symmetric, thoracolumbar-pelvic mold with built-in lumbar flexion, that can be worn under clothes. Lumbar flexion is achieved through posterior flattening of the brace and extension of the mold distally to the buttock. Braces with superstructures have a curve apex above T7. Curves with an apex at or below T7 do not require superstructures to immobilize cervical spine movement. Unlike the Milwaukee brace, the Boston brace cannot be adjusted if the patient grows in height. Both braces need to be changed if pelvic size increases. The average cost of the Boston brace is approximately $2000.

Indications for the use of a Boston brace include the following:

- A curve of 20-25° with 10° progression over 1 year
- A curve of 25-30° with 5° progression over 1 year
- Skeletally immature patients with a curve of 30° or greater

FUNCTIONAL ELECTRICAL STIMULATION (FES)

The concept of FES was introduced by Liberson and co-workers to control foot drop during the swing phase in hemiplegic patients. The theory is based on the survival of the motor neuron in UMN lesions such as hemiplegia. Such stimulation is done to obtain a functional movement, such as picking up objects or walking. Multichannel stimulators are being used for paraplegics in research laboratories, to simulate walking. The emphasis today is on miniaturization and portability.

A typical functional stimulator consists of:

1. Stimulator
2. Leads
3. Electrodes which may be superficial or implanted.

A miniature electrical stimulator producing currents between 90 and 200 mA, of pulse duration between 20 and 300 microseconds, and voltage between 50 to 120 V is fitted to the patient. It must be lightweight and portable.

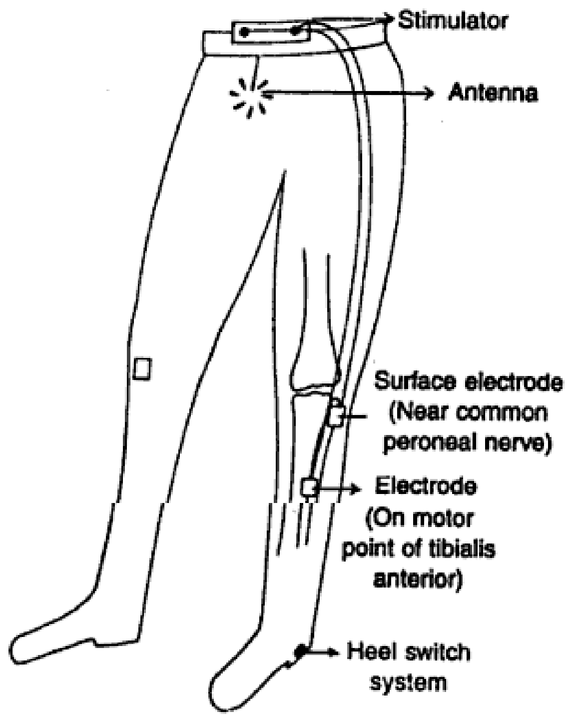


Fig. 7.8: Functional electrical stimulation

A power pack which powers the stimulator is worn on a waist belt and in the typical peroneal stimulator, one skin electrode is applied to the common peroneal nerve below the fibular head on the affected side, while the inactive electrode is applied to the leg at the motor point of the tibialis anterior. A heel switch is incorporated in the shoe that turns ***on*** the stimulator when the heel leaves the ground and turns it ***off*** on heel strike. Thus at heel off the tibialis anterior and other dorsiflexors are stimulated, affording clearance, and at heel strike the stimulation is switched off, allowing the foot to become plantigrade.

Sometimes electrodes are surgically implanted instead of being placed directly on the skin. This eliminates the need for wires passing all over the affected site.

When an implanted electrode is used, it must be placed directly on the nerve with a flexible wire lead connected to a subcutaneously implanted receiver located over the antero-medial aspect of the thigh. There is an antenna located over the implanted receiver, responding to signals from a transmitter incorporated into the shoe. Phasing of the stimulation during the gait cycle is controlled by the heel switch. The power pack for the stimulator and transmitter is worn at the waist.

Criteria

The selection of patients who can use the FES has to be done very carefully:

1. Such patients should be able to walk independently at a speed more than 25 m/min without an orthosis, and have good balance and saving reactions.
2. The major gait problem should be foot drop, without equinus contracture.
3. Proprioception should also be intact.
4. The regular use of a FES system could result in an increase in the strength of foot dorsiflexors in the long-term, and may improve the gait pattern through re-education and over a period the patient *may reach a stage where he may no longer need it.*

This principle is also used to major hip and thigh muscle groups in patients with spinal cord injuries for muscle strengthening, maintaining standing posture and ambulation.

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UNIT IV

NEUROPROSTHETICS

Neuroprosthetics (**neural prosthetics**) is a discipline related to neuroscience and biomedical engineering concerned with developing neural prostheses. They are sometimes contrasted with a brain–computer interface, which connects the brain to a computer rather than a device meant to replace missing biological functionality.

Neural prostheses are a series of devices that can substitute a motor, sensory or cognitive modality that might have been damaged as a result of an injury or a disease. Cochlear implants provide an example of such devices. These devices substitute the functions performed by the ear drum and stapes while simulating the frequency analysis performed in the cochlea. A microphone on an external unit gathers the sound and processes it; the processed signal is then transferred to an implanted unit that stimulates the auditory nerve through a microelectrode array. Through the replacement or augmentation of damaged senses, these devices intend to improve the quality of life for those with disabilities.

These implantable devices are also commonly used in animal experimentation as a tool to aid neuroscientists in developing a greater understanding of the brain and its functioning. By wirelessly monitoring the brain's electrical signals sent out by electrodes implanted in the subject's brain, the subject can be studied without the device affecting the results.

Accurately probing and recording the electrical signals in the brain would help better understand the relationship among a local population of neurons that are responsible for a specific function.

Neural implants are designed to be as small as possible in order to be to minimally invasive, particularly in areas surrounding the brain, eyes or cochlea. These implants typically communicate with their prosthetic counterparts wirelessly. Additionally, power is currently received through wireless power transmission through the skin. The tissue surrounding the implant is usually highly sensitive to temperature rise, meaning that power consumption must be minimal in order to prevent tissue damage

Visual Prosthetics

A visual prosthesis can create a sense of image by electrically stimulating neurons in the visual system.

A camera would wirelessly transmit to an implant; the implant would map the image across an array of electrodes. The array of electrodes has to effectively stimulate 600-1000 locations, stimulating these optic neurons in the retina thus will create an image.

The stimulation can also be done anywhere along the optic signal's path way. The optical nerve can be stimulated in order to create an image, or the visual cortex can be stimulated, although clinical tests have proven most successful for retinal implants.

A visual prosthesis system consists of an external (or implantable) imaging system which acquires and processes the video.

Power and data will be transmitted to the implant wirelessly by the external unit. The implant uses the received power/data to convert the digital data to an analog output which will be delivered to the nerve via micro electrodes.

Photoreceptors are the specialized neurons that convert photons into electrical signals. They are part of the retina, a multilayer neural structure about 200 um thick that lines the back of the eye. The processed signal is sent to the brain through the optical nerve. If any part of this pathway is damaged blindness can occur.

Blindness can result from damage to the optical pathway (cornea, aqueous humor, crystalline lens, and vitreous). This can happen as a result of accident or disease. T

he two most common retinal degenerative diseases that result in blindness secondary to photoreceptor loss is age related macular degeneration (AMD) and retinitis pigmentosa (RP).

The first clinical trial of a permanently implanted retinal prosthesis was a device with a passive microphotodiode array with 3500 elements.

In 2002, Second Sight Medical Products, Inc. (Sylmar, CA) began a trial with a prototype epiretinal implant with 16 electrodes.

The microphotodiodes serve to modulate current pulses based on the amount of light incident on the photo diode.

The requirements for a high resolution retinal prosthesis should follow from the needs and desires of blind individuals who will benefit from the device. Interactions with these patients indicate that mobility without a cane; face recognition and reading are the main necessary enabling capabilities.

The results and implications of fully functional visual prostheses are exciting. However, the challenges are grave. In order for a good quality image to be mapped in the retina a high number of micro-scale electrode arrays are needed. Also, the image quality is dependent on how much information can be sent over the wireless link. Also this high amount of information must be received and processed by the implant without much power dissipation which can damage the tissue. The size of the implant is also of great concern. Any implant would be preferred to be minimally invasive.

Auditory prosthetics

Cochlear implants (CIs), auditory brain stem implants (ABIs), and auditory midbrain implants (AMIs) are the three main categories for auditory prostheses.

CI electrode arrays are implanted in the cochlea, ABI electrode arrays stimulate the cochlear nucleus complex in the lower brain stem, and AMIs stimulates auditory neurons in the inferior colliculus.

Cochlear implants have been very successful among these three categories. Today the Advanced Bionics Corporation, the Cochlear Corporation and the Med-El Corporation are the major commercial providers of cochlea implants.
In contrast to traditional hearing aids that amplify sound and send it through the external ear, cochlear implants acquire and process the sound and convert it into electrical energy for subsequent delivery to the auditory nerve.
The microphone of the CI system receives sound from the external environment and sends it to processor. The processor digitizes the sound and filters it into separate frequency bands that are sent to the appropriate tonotonic region in the cochlea that approximately corresponds to those frequencies.
Improved performance in cochlea implants not only depends on understanding the physical and biophysical limitations of implant stimulation but also on an understanding of the brain's pattern processing requirements.

Modern signal processing represents the most important speech information while also providing the brain the pattern recognition information that it needs.

Pattern recognition in the brain is more effective than algorithmic preprocessing at identifying important features in speech.

A combination of engineering, signal processing, biophysics, and cognitive neuroscience was necessary to produce the right balance of technology to maximize the performance of auditory prosthesis.

Cochlear implants have been also used to allow acquiring of spoken language development in congenitally deaf children, with remarkable success in early implantations (before 2–4 years of life have been reached). There have been about 80.000 children implanted worldwide.

Motor prosthetics

Devices which support the function of autonomous nervous system include the implant for bladder control. In the somatic nervous system attempts to aid conscious control of movement includes Functional electrical stimulation and the lumbar anterior root stimulator.

Bladder control implants

Where a spinal cord lesion leads to paraplegia, patients have difficulty emptying their bladders and this can cause infection. From 1969 onwards Brindley developed the sacral anterior root stimulator, with successful human trials from the early 1980s onwards. This device is implanted over the sacral anterior root ganglia of the spinal cord; controlled by an external transmitter, it delivers intermittent stimulation which improves bladder emptying.

Motor prosthetics for conscious control of movement

Researchers are currently investigating and building motor neuroprosthetics that will help restore movement and the ability to communicate with the outside world to persons with motor disabilities such as tetraplegia or amyotrophic lateral sclerosis.

Research has found that the striatum plays a crucial role in motor sensory learning. This was demonstrated by an experiment in which lab rats' firing rates of the striatum was recorded at higher rates after performing a task consecutively.

To capture electrical signals from the brain, scientists have developed microelectrode arrays smaller than a square centimeter that can be implanted in the skull to record electrical activity, transducing recorded information through a thin cable.

After decades of research in monkeys, neuroscientists have been able to decode neuronal signals into movements.

COCHLEAR IMPLANTS

Cochlear implant (**CI**) is a surgically implanted electronic device that provides a sense of sound to a person who is profoundly deaf or severely hard of hearing in both ears.

Cochlear implants bypass the normal hearing process; they have a microphone and some electronics that reside outside the skin, generally behind the ear, which transmits a signal to an array of electrodes placed in the cochlea, which stimulate the cochlear nerve.

The procedure in which the device is implanted is usually done under general anesthesia.

People may experience problems with dizziness and balance for up to a few months after the procedure; these problems generally resolve, but for people over 70, they tend not to.

Evidence is of low to moderate quality that when CIs are implanted in both ears at the same time, they improve hearing in noisy places for people with severe loss of hearing but other measures are mixed.

Implanting the CIs sequentially instead of simultaneously makes things worse or causes no change. There is some evidence that implanting CIs to improve hearing, may also improve tinnitus but there is some risk that it may cause people who never had tinnitus to get it.

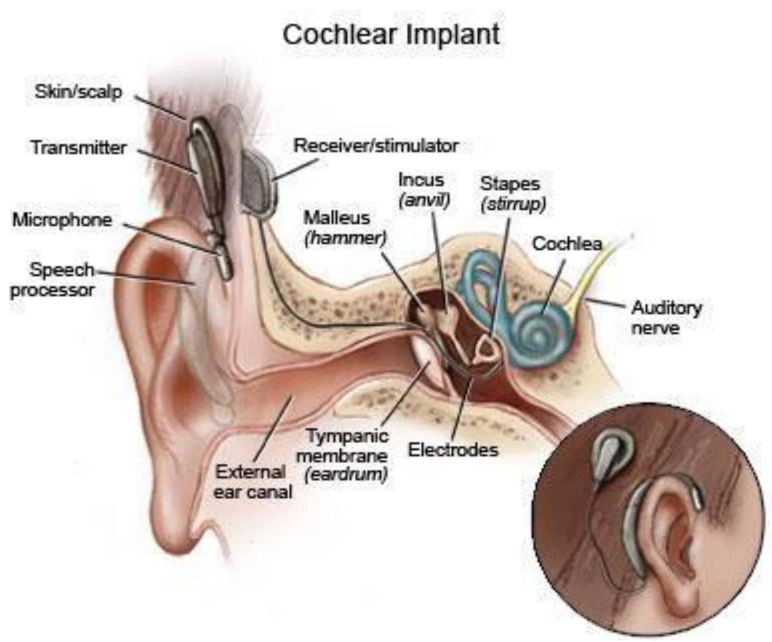
Cochlear implant (**CI**) has the following

components: External

- one or more microphones that pick up sound from the environment
- a speech processor which selectively filters sound to prioritize audible speech
- a transmitter that sends power and the processed sound signals across the skin to the internal device by electromagnetic induction,

Internal:

- a receiver/stimulator, which receive signals from the speech processor and converts them into electric impulses.
- an electrode array embedded in the cochlea



An **auditory brainstem implant** (ABI) is a surgically implanted electronic device that provides a sense of sound to a person who is profoundly deaf, due to retrocochlear hearing impairment (due to illness or injury damaging the cochlea or auditory nerve, and so precluding the use of a cochlear implant).

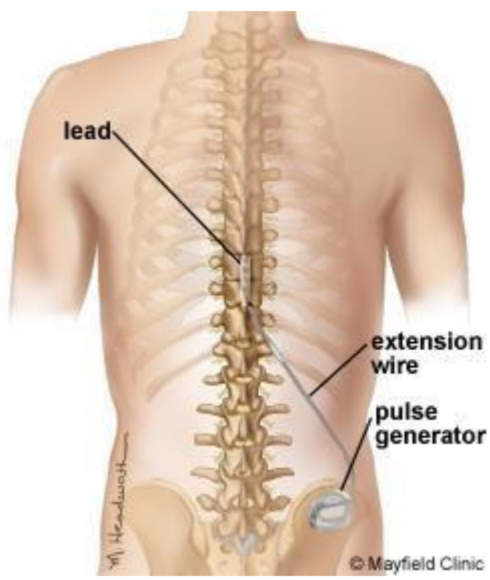
The auditory brainstem implant uses technology similar to that of the cochlear implant, but instead of electrical stimulation being used to stimulate the cochlea, it is used to stimulate the brainstem of the recipient

Spinal cord stimulator

Spinal cord stimulation uses low voltage stimulation to the spine to block the feeling of pain. A small device implanted in the body transmits an electrical current to the spinal cord. When turned on, the stimulation feels like a mild tingling in the area where pain is felt. It helps patients better manage symptoms and potentially decrease use of pain medications. It may be an option if you have chronic leg or arm pain, and have not found relief with other therapies.

What is a spinal cord stimulator?

A spinal cord stimulator (SCS), also known as a dorsal column stimulator, is a device surgically placed under your skin to send a mild electric current to your spinal cord. A small wire carries the current from a pulse generator to the nerve fibers of the spinal cord. When turned on, the stimulation feels like a mild tingling in the area where pain is felt. Your pain is reduced because the electrical current interrupts the pain signal from reaching your brain.



Stimulation does not eliminate the source of pain, it simply interferes with the signal to the brain, and so the amount of pain relief varies for each person. Also, some patients find the tingling sensation unpleasant. For these reasons trial stimulation is performed before the device is permanently implanted. The goal for spinal cord stimulation is a 50-70% reduction in pain. However, even a small amount of pain reduction can be significant if it helps you to perform your daily activities with less pain and reduces the amount of pain medication you take. Stimulation does not work for everyone. If unsuccessful, the implant can be removed and does not damage the spinal cord or nerves.

There are many types of stimulation systems. The most common is an internal pulse generator with a battery. A SCS system consists of

- An implantable pulse generator with battery that creates electrical pulses.
- A lead with a number of electrodes (4-16) that delivers electrical pulses to the spinal cord.
- An extension wire that connects the pulse generator to the lead.
- A hand-held remote control that turns the pulse generator on and off and adjusts the pulses.

The battery inside the pulse generator delivers low voltage and needs to be surgically replaced every 2 to 5 years if it is a standard battery. Rechargeable battery systems may last up to 10 years, depending on usage. Your doctor will select the best type of system for you during the trial stimulation.

The pulse generator is programmable by the doctor and has three settings:

1. Frequency (rate): number of times stimulation is delivered per second.
2. Pulse width: determines size of area stimulation will cover.
3. Pulse amplitude: determines threshold of perception to pain

What happens during surgery?

There are two parts to the procedure: placement of the lead in the epidural space of the spinal cord and placement of the pulse generator in the buttock or abdomen. There are five main steps of the procedure, which generally takes 3 to 4 hours.

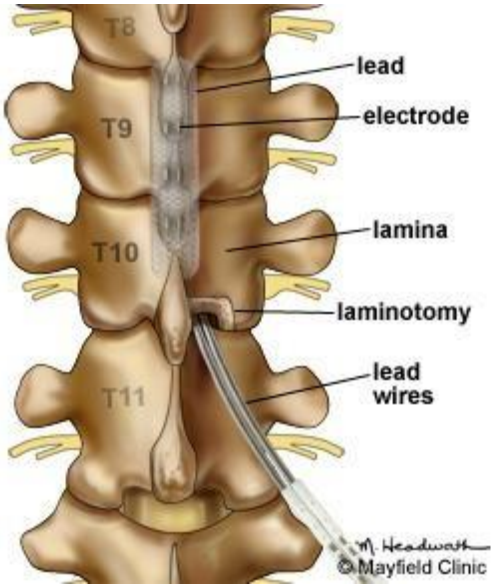
Step 1: prepare the patient

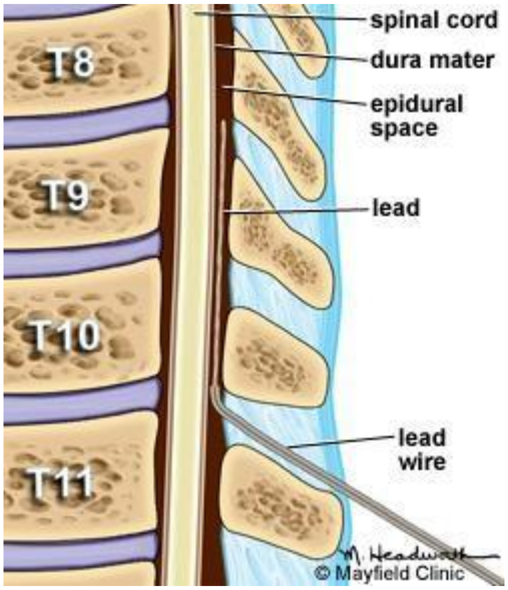
You are placed lying on your side or on your stomach on the operative table. The team will work with you to make sure you are comfortable before you are given light sedation. Next, the areas of your back and stomach are shaved and prepped where the leads and the generator are to be placed. Local anesthetic will be injected where incisions are to be made to prevent pain during the procedure.

Step 2: place the leads

Placement of the surgical leads is performed with the aid of fluoroscopy (a type of X-ray). A small skin incision is made in the middle of your back. The bony arch of the vertebra is exposed. A portion of the lamina is removed (laminectomy) to allow room to place the leads.

The leads are placed in the epidural space above the spinal cord and secured with sutures. Your surgeon will decide how many leads and the number of electrodes on the lead to implant. Your surgeon will decide how many leads and the number of electrodes on the lead to implant.





Step 3: test stimulation

You will be awakened so that you can help the doctor determine how well the stimulation covers your pain pattern without feeling any pain or discomfort from the lead implantation itself. Several stimulation settings will be tried and the surgeon will ask you to describe the location of any tingling you feel. These settings will be used to program the pulse generator at the end of surgery, so your feedback during this part of the surgery is important for providing you the best pain relief. In some cases, if the leads implanted during the trial are positioned perfectly, there is no need to reposition or insert new leads.

Step 4. Tunnel the extension wire

Once the leads are in place, sedation is again given. An extension wire is passed under the skin from the spine, around your torso to the abdomen or buttock where the generator will be implanted.

Step 5. Place the pulse generator

A 4 to 6 inch skin incision is made below the waistline. The surgeon creates a pocket for the generator between the skin and muscle layers. The extension wire is attached to the pulse generator. The generator is then correctly positioned under the skin and sutured to the thick fascia layer overlying the muscles.

Step 6. Close the incisions

The two incisions are closed with sutures or staples and a dressing is applied.

SACRAL ANTERIOR ROOT STIMULATOR

The Brindley procedure consists of a stimulator for sacral anterior-root stimulation and a rhizotomy of the dorsal sacral roots to abolish neurogenic detrusor overactivity.

Stimulation of the sacral anterior roots enables micturition, defecation. This overview discusses the technique, selection of patients and clinical results of the Brindley procedure.

The Brindley procedure is suitable for a selected group of patients with complete spinal cord injury. Overall, the Brindley procedure shows good clinical results and improves quality of life. However, to remain a valuable treatment option for the future, the technique needs some adequate changes to enable analysis of the implanted parts, to improve revision techniques of the implanted parts, and to abolish the sacral dorsal rhizotomy.

The Brindley system is composed of an external and implanted part. The implanted part consists of electrodes, connecting cables, and a receiver block.

Patients have to position an external stimulating device on the skin over the implanted receiver to evoke stimuli. The receiver does not have a battery. Electrical stimuli are evoked by radiofrequency waves.

With the availability of separate stimulation of the sacral levels and various stimulation settings, it is possible to set various stimulation programs to optimize micturition, defecation, and penile erections.

A tripolar electrode cuff is used for intradural stimulation of the sacral anterior roots. A three-channel implant is composed of two books.

The upper book contains three parallel slots for S3 (one slot) and S2 roots (two slots at one channel), and the lower contains one slot for S4 roots.

Each slot contains one cathode in the centre and an anode at each of the two ends to avoid stimulation of tissue structures outside the slot. The two-channel implant allows stimulation of two root levels or sets of root levels.

The four-channel implant has the same configuration as the three-channel implant but allows independent stimulation of four sets of roots. The choice for the number of channels depends on the number of different rootlet combinations that have to be stimulated. Each channel is connected to the subcutaneous receiver block by a silicone-coated cable.

Extradural electrodes are used in patients in whom intradural electrodes could not be placed due to, for example, arachnoiditis or a previous intradural electrode implantation that failed.

Some centres prefer to use extradural electrodes primarily for nearly all patients. The extradural implant has three helical electrodes at its end, which are also configured with a cathode between two anodes.

The Brindley procedure generally shows good clinical results for restoration of function in spinal cord injury patients with multiple organ dysfunction, including bladder, bowel, and erectile dysfunction.

Moreover, the Brindley procedure improves quality of life. However, it is not a procedure that is easy to apply in clinical practice. Firstly, not every patient is suited for the procedure and the success depends on selection of appropriate patients.

Prerequisites are a complete spinal cord lesion since neurostimulation can cause pain in incomplete spinal cord lesions, an intact sacral motor neuron pathway enabling stimulation of the bladder, and a detrusor muscle that is capable to contract on stimulation.

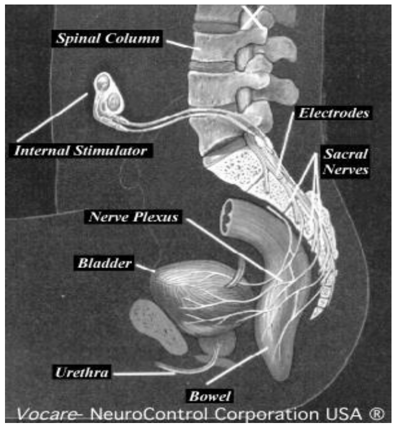
Secondly, a dorsal rhizotomy and implantation of a Brindley stimulator is complex and not a routine procedure for urologists and should be reserved for specialized centres.

Thirdly, the technique is also prone to failures, including the external and implanted components. Analysis of the external components is easy to apply.

This can be explained by national legislation with respect to certain aspects of the surgical procedure for revision of the implant, like burning the insulation of the implanted electrode cables.

This excludes these patients from the thorough analysis of the implanted components and revision surgery to restore function of their stimulator.

They accept the dysfunction of the stimulator more frequently because they remain continent due to their dorsal rhizotomy in combination with controlled emptying of their bladder and bowels.



BRAIN-COMPUTER INTERFACE

Brain-computer interfaces (BCIs) acquire brain signals, analyze them, and translate them into commands that are relayed to output devices that carry out desired actions.

BCIs do not use normal neuromuscular output pathways.

The main goal of BCI is to replace or restore useful function to people disabled by neuromuscular disorders such as amyotrophic lateral sclerosis, cerebral palsy, stroke, or spinal cord injury.

From initial demonstrations of electroencephalography-based spelling and single-neuron-based device control, researchers have gone on to use electroencephalographic, intracortical, electrocorticographic, and other brain signals for increasingly complex control of cursors, robotic arms, prostheses, wheelchairs, and other devices.

Brain-computer interfaces may also prove useful for rehabilitation after stroke and for other disorders.

In the future, they might augment the performance of surgeons or other medical professionals. Brain-computer interface technology is the focus of a rapidly growing research and development enterprise that is greatly exciting scientists, engineers, clinicians, and the public in general.

Its future achievements will depend on advances in 3 crucial areas. Brain-computer interfaces need signal-acquisition hardware that is convenient, portable, safe, and able to function in all environments.

Brain-computer interface systems need to be validated in long-term studies of real-world use by people with severe disabilities, and effective and viable models for their widespreaddissemination must be implemented. Finally, the day-to-day and moment-to-moment reliability of BCI performance must be improved so that it approaches the reliability of natural muscle- based function.

A BCI is a computer-based system that acquires brain signals, analyzes them, and translates them into commands that are relayed to an output device to carry out a desired action.

Thus, BCIs do not use the brain's normal output pathways of peripheral nerves and muscles.

This definition strictly limits the term *BCI* to systems that measure and use signals produced by the central nervous system (CNS). Thus, for example, a voice-activated or muscle-activated communication system is not a BCI.

Furthermore, an electroencephalogram (EEG) machine alone is not a BCI because it only records brain signals but does not generate an output that acts on the user's environment. It is a misconception that BCIs are mind-reading devices.

Brain-computer interfaces do not read minds in the sense of extracting information from unsuspecting or unwilling users but enable users to act on the world by using brain signals rather than muscles.

The purpose of a BCI is to detect and quantify features of brain signals that indicate the user's intentions and to translate these features in real time into device commands that accomplish the user's intent. To achieve this, a BCI system consists of 4 sequential components:

(1) Signal acquisition, (2) feature extraction, (3) feature translation, and (4) device output.

These 4 components are controlled by an operating protocol that defines the onset and timing of operation, the details of signal processing, the nature of the device commands, and the oversight of performanc

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UNIT V

COMMUNICATION SYSTEMS AND MOBILITY AIDS

Assistive technology is an umbrella term that includes assistive, adaptive, and rehabilitative devices for people with disabilities and also includes the process used in selecting, locating, and using them.

Assistive technology promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to, or changing methods of interacting with, the technology needed to accomplish such tasks.

Assistive technology refers to "any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities", while adaptive technology covers items that are specifically designed for persons with disabilities and would seldom be used by non- disabled persons.

In other words, "assistive technology is any object or system that increases or maintains the capabilities of people with disabilities," while adaptive technology is "any object or system that is specifically designed for the purpose of increasing or maintaining the capabilities of people with disabilities."

MOBILITY IMPAIRMENTS

Wheelchairs

Wheelchairs are devices that can be manually propelled or electrically propelled and that include a seating system and are designed to be a substitute for the normal mobility that most people enjoy.

Wheelchairs and other mobility devices allow people to perform mobility related activities of daily living which include feeding, toileting, dressing grooming and bathing.

The devices comes in a number of variations where they can be propelled either by hand or by motors where the occupant uses electrical controls to manage motors and seating control actuators through a joystick, sip-and-puff control, or other input devices.

Often there are handles behind the seat for someone else to do the pushing or input devices for caregivers.

Wheelchairs are used by people for whom walking is difficult or impossible due to illness, injury, or disability. People with both sitting and walking disability often need to use a wheelchair or walker.

Transfer devices

Patient transfer devices generally allow patients with impaired mobility to be moved by caregivers between beds, wheelchairs, commodes, toilets, chairs, stretchers, shower benches, automobiles, swimming pools, and other patient support systems (i.e., radiology, surgical, or examining tables).

The most common devices are Patient lifts (for vertical transfer), Transfer benches, stretcher or convertible chairs (for lateral, supine transfer), sit-to-stand lifts (for moving patients from one seated position to another i.e., from wheelchairs to commodes), air bearing inflatable mattresses (for supine transfer i.e., transfer from a gurney to an operating room table), and sliding boards (usually used for transfer from a bed to a wheelchair).

Walkers

A walker or walking frame is a tool for disabled people who need additional support to maintain balance or stability while walking.

It consists of a frame that is about waist high, approximately twelve inches deep and slightly wider than the user.

Walkers are also available in other sizes, such as for children or for heavy people. Modern walkers are height-adjustable. The front two legs of the walker may or may not have wheels attached depending on the strength and abilities of the person using it. It is also common to see caster wheels or glides on the back legs of a walker with wheels on the front.

Conventional Hearing aids - Hearing aid types differ in their technology or circuitry. In the early days, hearing aid technology involved vacuum tubes and large, heavy batteries. Today, microchips, computerization, and digitized sound processing are used in hearing aid design.

Digital programmable hearing aids have all the features of analog programmable aids but use digitized sound processing (DSP) to convert sound waves into digital signals. A computer chip in the aid analyzes the signals to determine whether the sound is noise or speech. It then makes modifications to provide a clear, amplified, distortion-free signal.

Digital hearing aids are usually self-adjusting. The digital processing allows for more flexibility in programming the aid. In this way, the sound it transmits matches your specific pattern of hearing loss.

This digital technology is the most expensive, but it offers many advantages. Key benefits include:

- improvement in programmability
- greater precision in fitting
- management of loudness discomfort
- control of acoustic feedback (whistling sounds)
- noise reduction

Some aids can store several programs. As your listening environment changes, you can change the hearing aid settings. This is usually done by pushing a button on the hearing aid or by using a remote control to switch channels. The aid can be reprogrammed by the audiologist if your hearing or hearing needs change.

These aids are more expensive than conventional analog hearing aids. However, they generally have a longer life span and may provide better hearing for you in different listening situations.

Conventional analog hearing aids are designed with a particular frequency response based on your audiogram. The audiologist tells the manufacturer what settings to install. Although there are some adjustments, the aid essentially amplifies all sounds (speech and noise) in the same way. This technology is the least expensive, and it can be appropriate for many different types of hearing loss.

Analog programmable hearing aids have a microchip that allows the audiologist to program the aid for different listening environments. Example environments include quiet conversation in your home, noisy situations like a restaurant, or large areas like a theater. The programming settings depend on your individual hearing loss profile, speech understanding, and range of tolerance for loud

A **rollator** (or walker with wheels) is useful for those who wish to mobilise but can't physically lift a static walker. The majority of rollators are either three or four wheeled and have hand lever brakes. The four wheeled version offers more stability to the user than its three wheeled counterpart.

Some come with the option of accessories such as baskets and bags which make them useful for carrying items when out shopping. A seated rollator is a good idea for those who like to stop and take regular breathers when out walking.

If you're choosing a rollator to use indoors, measure doorways to ensure that the rollator will fit through. Most rollators can be folded away for ease of storage and for transportation.

Rollators are not recommended for those with balance problems.

A **mobility aid** is a device designed to assist walking or otherwise improve the mobility of people with mobility impairment.

There are various walking aids which can help people with impaired ability to walk and wheelchairs or mobility scooters for more severe disability or longer journeys which would otherwise be undertaken on foot. For people who are blind or visually impaired the white cane and guide dog have a long history of use. Other aids can help with mobility or transfer within a building or where there are changes of level.

Traditionally the phrase "mobility aid" has applied mainly to low technology mechanical devices. It refers to those devices whose use enables a freedom of movement similar to that of unassisted walking or standing up from a chair.

Technical advances can be expected to increase the scope of these devices considerably, for example by use of sensors and audio or tactile feedback

Walking aids include assistive canes (commonly referred to as walking sticks), crutches, and walkers. As appropriate to the needs of the individual user, these devices help to maintain upright ambulation by providing any or all of: improved stability, reduced lower-limb loading and generating movement.

Improved stability

By providing additional points of contact the walking aid provides both additional support and a wider range of stable centre of gravity positioning.

Reduced lower-limb loading

By directing load through the arms and the walking aid, lower impact and static forces are transmitted through the affected limbs.

Generating Movement

The walking aid and arms can substitute for the muscles and joints of the spine, pelvis and/or legs in the generation of dynamic forces during walking.

Cane

The cane or walking stick is the simplest form of walking aid. It is held in the hand and transmits loads to the floor through a shaft. The load which can be applied through a cane is transmitted through the user's hands and wrists and limited by these.

Crutches

A crutch also transmits loads to the ground through a shaft, but has two points of contact with the arm, at the hand and either below the elbow or below the armpit. This allows significantly greater loads to be exerted through a crutch in comparison with a cane.

Canes, crutches, and forearm crutch combinations

Devices on the market today include a number of combinations for canes, crutches, and forearm crutches. These crutches have bands that encircle the upper arms and handles for the patient to hold and rest their hands to support the body weight. The Forearm crutch typically gives a user the support of the cane but with additional forearm support to assist in mobility. The forearm portion helps increase balance, lateral stability and also reduces the load on the wrist.

Walkers

A walker (also known as a Zimmer frame) is the most stable walking aid and consists of a freestanding metal framework with three or more points of contact which the user places in front of them and then grips during movement. The points of contact may be either fixed rubber ferrules as with crutches and canes, or wheels, or a combination of both. Wheeled walkers are also known as rollators

A walker cane hybrid was introduced in 2012 designed to bridge the gap between a cane and a walker. The hybrid has two legs which provide lateral (side-to-side) support which a cane does not. It can be used with two hands in front of the user, similar to a walker, and provides an increased level of support compared with a cane. It can be adjusted for use with either one or two hands, at the front and at the side, as well as a stair climbing assistant. The hybrid is not designed to replace a walker which normally has four legs and provides 4-way support using both hands.

Gait trainers

Another device to assist walking that has entered the market in recent years is the gait trainer. This is a mobility aid that is more supportive than the standard walker. It typically offers support that assists weight-bearing and balance. The accessories or product parts that attach to the product frame provide unweighting support and postural alignment to enable walking practice.

Seated walking scooter

The Walk Aid Scooter allows a user with normal balance and foot, knee or hip conditions to unload the lower extremities. The two-wheeled scooter has a bicycle-type seat and handlebars, and is manually propelled with one or both feet. This walking aid scooter provides more support than a cane and is lighter, less bulky and easier to propel than a wheelchair.

Wheelchairs and scooters

Wheelchairs and mobility scooters substitute for walking by providing a wheeled device on which the user sits. Wheelchairs may be either manually propelled (by the user or by an aide) or electrically powered (commonly known as a "power chair"). Mobility scooters are electrically powered, as are motorized wheelchairs. Wheelchairs and Scooters are normally recommended for any individual due to significant mobility/balance impairment.

Stairlifts and similar devices

A stairlift is a mechanical device for lifting people and wheelchairs up and down stairs. Sometimes special purpose lifts are provided elsewhere to facilitate access for the disabled. A wheelchair lift is specifically designed to carry the user and the wheelchair. This can either be through floor or utilizing the staircase.

Walking sticks are devices used by people who have difficulty in walking. They are very useful to those who have had a temporary injury or wound and find it difficult to walk on their own or by those who have had a permanent disability and need a support at all times. They are also preferred by a lot of elders who find it reassuring to walk with the help of a walking stick.

There are several models available including the simple single cane, foldable sticks, 3 legged or tripod sticks, 4 legged or quadripod sticks, sticks with a seat attached etc. This article will discuss in detail about a quadripod walking stick and its advantages.

Fast Cure is a leading brand of manufacturers of user friendly walking sticks, wheel chairs etc. and are well known for their ergonomically designs products. The Fast Cure Adjustable Stick with 4 Leg -model FS932 is a popular model of theirs.

The following are its properties:

- 4 legged base for extra strength and balance
- Strong Aluminium body
- Adjustable height for better comfort
- Better grasping handle

When compared to a single cane, the below are the advantages of a 4 legged cane

1. Better control on all surfaces

Since it is 4 legged, it stands strong on all possible surfaces. A single legged cane might be slippery or be uncomfortable to carry

2. Better balance

These quadripods offer better balance as they prevent swaying while moving, thereby preventing further damage to affected parts of the body

3. Free standing

They can stand independently as they have four strong base legs. A cane needs to be rested horizontally or held at all times

4. Adjustable height

The height of the stick plays a very important role in the rehabilitation process. A cane that is too high can cause pain in the hands and wrist while one that is too short for one's height can cause pain in the spine, legs and back. This will add to one's physical conditions delaying the process of healing. Fast Cure adjustable walking stick can be increased or decreased in height and suits almost everyone

5. Wider base

A wider base ensures better stability. The weight of the person is evenly distributed throughout the four legs. This will perfectly balance the person's steps giving greater support when compared to other models

Using a walking stick the right way is more important than one thinks. Using it without reading the instructions or without the guidance of a trained doctor/instructor will cause discomfort and pain. It will deteriorate the existing medical condition and cause further damage to muscles, tissues, joints and bones. First time users are advised to consult their doctors before choosing a walking cane and get their help in adjusting the position of walking before using them independently.

Trusting a walking stick and letting go of the fear of moving around is the first step to healing. Hence it is better to buy a brand that promises and delivers safety and comfort. Fast Cure adjustable Walking stick with 4 legs is a good choice for first time users.

A **crutch** is a mobility aid that transfers weight from the legs to the upper body. It is often used for people who cannot use their legs to support their weight, for reasons ranging from short-term injuries to lifelong disabilities.

There are several types of crutches:

Forearm

> A type of crutch with a cuff at the top to go around the forearm, also known as the **Lofstrand crutch**. It is the type most commonly used in Europe. A forearm crutch is used by inserting the arm into a cuff and holding the grip. The cuff, typically made of plastic or metal, can be a half-circle or a full circle with a V-type opening in the front allowing the forearm to slip out in case of a fall.

Underarm or axilla

> It is used by placing the pad against the ribcage beneath the armpit and holding the grip, which is below and parallel to the pad.

Platform

> These are less common and used by those with poor hand grip due to arthritis, cerebral palsy, or other conditions. The arm rests on a horizontal platform and is strapped in place.

The hand rests on a grip which, if properly designed, can be angled appropriately depending on the user's disability.

Leg Support

These non-traditional crutches are useful for users with an injury or disability affecting one lower leg only. They function by strapping the affected leg into a support frame that simultaneously holds the lower leg clear of the ground while transferring the load from the ground to the user's knee or thigh. This style of crutch has the advantage of not using the hands or arms while walking. A claimed benefit is that upper thigh atrophy is also reduced because the affected leg remains in use. Unlike other crutch designs these designs are unusable for pelvic, hip or thigh injuries and in some cases for knee injuries also.

Walking sticks or canes serve an identical purpose to crutches, but are held only in the hand and have a limited load bearing capability because of this.

Information on use

Several different gait patterns are possible, and the user chooses which one to use depending on the reason the crutches are needed. For example, a person with a non-weight bearing injury generally performs a "swing-to" gait: lifting the affected leg, the user places both crutches in front of him, and then swings his uninjured leg to meet the crutches. Other gaits are used when both legs are equally affected by some disability, or when the injured leg is partially weight bearing.

With underarm crutches, sometimes a towel or some kind of soft cover is needed to prevent or reduce armpit injury. A condition known as *crutch paralysis*, or *crutch palsy* can arise from pressure on nerves in the armpit, or axilla. Specifically, "the brachial plexus in the axilla is often damaged from the pressure of a crutch. In these cases the radial is the nerve most frequently implicated; the ulnar nerve suffers next in frequency."

Alternative devices

The knee scooter and the wheelchair are possible alternatives for patients who cannot use or do not like crutches. These wheeled devices introduce an additional limitation, however, since they cannot negotiate stairs.

Materials

1. Wood
2. Metal alloys (most often Steel, Aluminium alloys, Titanium alloys)
3. Carbon or glass fiber reinforced composites
4. Thermoplastic
5. Carbon fiber reinforced polymer

A **wheelchair** is a chair with wheels. The device comes in variations allowing either manual propulsion by the seated occupant turning the rear wheels by hand, or electric propulsion by motors. There are often handles behind the seat to allow it to be pushed by another person.

Wheelchairs are used by people for whom walking is difficult or impossible due to illness, injury, or disability. People who have difficulty sitting and walking often make use of a wheelbench

Types

A basic manual wheelchair incorporates a seat, foot rests and four wheels: two caster wheels at the front and two large wheels at the back. The two larger wheels in the back usually have handrims; two metal or plastic circles approximately 3/4" thick. The handrims have a diameter normally only slightly smaller than the wheels they are attached to. Most wheelchairs have two push handles at the top of the back to allow for manual propulsion by a second person.

Other varieties of wheelchair are often variations on this basic design, but can be highly customised for the user's needs. Such customisations may encompass the seat dimensions, height, seat angle (also called seat dump or squeeze), footrests, leg rests, front caster outriggers, adjustable backrests and controls.

Everyday manual wheelchairs come in two major designs—folding or rigid. The rigid chairs, which are increasingly preferred by active users, have permanently welded joints and many fewer moving parts. This reduces the energy required to push the chair by eliminating many points where the chair would flex as it moves. Welding the joints also reduces the overall weight of the chair. Rigid chairs typically feature instant-release rear wheels and backrests that fold down flat, allowing the user to dismantle the chair quickly for storage in a car.

Many rigid models are now made with ultralight materials such as aircraft aluminium and titanium. One major manufacturer, Tilite, builds only ultralights. Another innovation in rigid chair design is the installation of polymer shock absorbers, such as Frog Legs, which cushion the bumps over which the chair rolls. These shock absorbers may be added to the front wheels or to the rear wheels, or both. Rigid chairs also have the option for their rear wheels to have a camber. Wheels can have a camber, or tilt, which angles the tops of the wheels in toward the chair. This allows for better propulsion by the user which is desired by long-term users. Sport wheelchairs have large camber angles to improve stability.

Various optional accessories are available, such as anti-tip bars or wheels, safety belts, adjustable backrests, tilt and/or recline features, extra support for limbs or neck, mounts or carrying devices for crutches, walkers or oxygen tanks, drink holders, and clothing protectors.

Transport wheelchairs are usually light, folding chairs with four small wheels. These chairs are designed to be pushed by a caregiver to provide mobility for patients outside the home or more common medical settings.

Experiments have also been made with unusual variant wheels, like the omniwheel or the mecanum wheel. These allow for a broader spectrum of movement.

Manually propelled

Manual wheelchairs are those that require human power to move them. Many manual wheelchairs can be folded for storage, or placement into a vehicle, although modern wheelchairs are just as likely to be rigid framed.

Manual or self-propelled wheelchairs are propelled by the occupant, usually by turning the large rear wheels, from 20–24 inches (51–61 cm) in average diameter, and resembling bicycle wheels. The user moves the chair by pushing on the handrims, which are made of circular tubing attached to the outside of the large wheels. The handrims have a diameter that is slightly less than that of the rear wheels. Skilled users can control speed and turning and often learn to balance the chair on its rear wheels—do a wheelie. The wheelie is not just for show—a rider who can control the chair in this manner can climb and descend curbs and move over small obstacles.

Foot propulsion of the wheelchair by the occupant is also common for patients who have limited hand movement capabilities or simply do not wish to use their hands for propulsion. Foot propulsion also allows patients to exercise their legs to increase blood flow and limit further disability.

One-arm drive enables a user to guide and propel a wheelchair from one side. Two handrims, one smaller than the other, are located on one side of the chair, left or right. On most models the outer, or smaller rim, is connected to the opposite wheel by a folding axle. When both handrims are grasped together, the chair may be propelled forward or backward in a straight line. When either handrim is moved independently, the chair will turn left or right in response to the handrim used. Some chairs are also configured to allow the occupant to propel using one or both feet instead of using the rims.

Light weight and high cost are related in the manual wheelchairs market. At the low-cost end, heavy, tubular steel chairs with sling seats and little adaptability dominate. Users may be temporarily disabled, or using such a chair as a loaner, or simply unable to afford better. Heavy unmodified manual chairs are common as "loaners" at large facilities such as airports, amusement parks and shopping centers. In a higher price range, and more commonly used by persons with long-term disabilities, are major manufacturer lightweight chairs with more options. The high end of the market contains ultra-light models, extensive seating options and accessories, all-terrain features, and so forth. Reclining wheelchairs have handbrake-like controls attached to the push handles or posts supporting the backrest which, when pressed by the caregiver, allow the backrest to recline from is normal upright position (at 90 degrees) to varying angles up to 180 degrees.

Transport wheelchairs

Attendant-propelled chairs (or transport wheelchairs) are designed to be propelled by an attendant using the handles, and thus the back wheels are rimless and often smaller. These chairs are often used as 'transfer chairs' to move a patient when a better alternative is unavailable, possibly within a hospital, as a temporary option, or in areas where a user's standard chair is unavailable. These chairs are commonly seen in airports. Special airplane transfer chairs are available on most airlines, designed to fit narrow airplane aisles and transfer wheelchair-using passengers to and from their seats on the plane.

Electric-powered

An electric-powered wheelchair is a wheelchair that is moved via the means of an electric motor and navigational controls which is usually a small joystick mounted on the armrest, rather than manual power. For users who cannot manage a manual joystick, headswitches, chin-operated joysticks, sip-and-puff or other specialist controls may allow independent operation of the wheelchair.

Wheelbase chairs are wheeled platforms with specially molded seating systems interfaced with them for users with a more complicated posture. A molded seating system involves taking a cast of a person's best achievable seated position and then either carving the shape from memory foam or forming a plastic mesh around it. This seat is then covered, framed, and attached to a wheelbase.

Other variants

A dynamic tilt wheelchair has seating surfaces which can be tilted to various angles. It was developed by an orthotist, Hugh Barclay, who worked with disabled children and observed that postural deformities such as scoliosis could be supported or partially corrected by allowing the wheelchair user to relax in a tilted position. Invented in Kingston, Ontario, Canada, in the early 1980s, the dynamic tilt wheelchair type is now manufactured by a number of companies and used all around the world. This revolutionary adaptation of wheelchair design provides individuals with very complex health needs the opportunity for increased mobility.

A Standing wheelchair is one that supports the user in a nearly standing position. They can be used as both a wheelchair and a standing frame, allowing the user to sit or stand in the wheelchair as they wish. They often go from sitting to standing with a hydraulic pump or electric-powered assist. Some options are provided with a manual propel model and power stand, while others have full power, tilt, recline and variations of power stand functions available as a rehabilitative medical device. The benefits of such a device include, but are not limited to: aiding independence and productivity, raising self-esteem and psychological well-being, heightening social status, extending access, relief of pressure, reduction of pressure sores, improved functional reach, improved respiration, reduced occurrence of UTI, improved flexibility, help in maintaining bone mineral density, improved passive range motion, reduction in abnormal muscle tone and spasticity, and skeletal deformities.

A bariatric wheelchair is one designed to support larger weights; most standard chairs are designed to support no more than 250 lb (113 kg) on average.

Pediatric wheelchairs are another available subset of wheelchairs. *Hemi wheelchairs* have lower seats which are designed for easy foot propulsion. The decreased seat height also allows them to be used by children and shorter individuals.

A knee scooter is a related device which may be substituted for a wheelchair when an injury has occurred to only one leg, below the knee. The patient rests the injured leg on the scooter, grasps the handlebars, and pushes with the uninjured leg.

A power-assisted wheelchair is a recent development that uses the frame & seating of a typical manual chair while replacing the standard rear wheels with wheels that have small battery- powered motors in the hubs. A floating rim design senses the pressure applied by the users push & activates the motors proportionately. This results in the convenience, small size & light- weight of a manual chair while providing motorised assistance for rough/uneven terrain & steep slopes that would otherwise be difficult or impossible to navigate, especially by those with limited upper-body function.

Smart wheel chair

A smart wheelchair is any motorized platform with a chair designed to assist a user with a physical disability, where an artificial control system augments or replaces user control. Its purpose is to reduce or eliminate the user's task of driving a motorized wheelchair. Usually, a smart wheelchair is controlled by a computer, has a suite of sensors and applies techniques in mobile robotics, but this is not necessary. The interface may consist of a conventional wheelchair joystick, or it may be a "sip-and-puff" device or a touch-sensitive display connected to a computer. This is different from a conventional motorized or electric wheelchair, in which the user exerts manual control over motor speed and direction via a joystick or other switch- or potentiometer-based device, without intervention by the wheelchair's control system.

Smart wheelchairs are designed for a variety of user types. Some platforms are designed for users with cognitive impairments, such as dementia, where these typically apply collision-avoidance techniques to ensure that users do not accidentally select a drive command that results in a collision. Other platforms focus on users living with severe motor disabilities, such as cerebral palsy, or with quadriplegia, and the role of the smart wheelchair is to interpret small muscular activations as high-level commands and execute them. Such platforms typically employ techniques from artificial intelligence, such as path-planning.

Manual wheelchairs can be very basic or can be designed with highly advanced, specialized features. Manual wheelchairs are divided into four basic categories; folding, rigid, positioning and sports wheelchairs.

- offer a high level of adjustability, and can accept all types of seating systems, footrests and arms
- designed for portability and are effective for travel and storage
- choice of either steel or aluminum construction
- footrests are removable, as well as arms and wheels on some models
- a great choice for the more dependent user who does not need maximum efficiency in propulsion
- they are generally heavier than rigid chairs due to folding cross-braces

Rigid Wheelchairs

- eliminates the flex associated with a folding manual wheelchair and offers a higher level of performance
- lighter weight - can be made with steel, aluminum or even titanium
- footrests can be fixed or removable but the frame itself is fixed which means the wheels must be removed and the back folded down to allow for transport in a typical vehicle
- wide range of seating systems available
- the choice of the full-time independent user due to their high efficiency

Positioning Wheelchairs

- commonly known as tilt wheelchairs, they address specific needs no other wheelchair style can do effectively
- pressure reduction - allows for frequent changes in position reducing the occurrence of pressure sores
- positioning - users with a kyphosis (forward curve in the upper spine) constantly face the floor when seated upright but can see better when tilted back
- support - minimizes the need for many restraints and extra supports

Sports Wheelchairs

- similar to rigid wheelchairs, but have features that make them more effective for playing sports
- added features such as optional wheel camber angles and offensive/defensive

wings, to full-out racing machines
- can be specialized for basketball, quad rugby, tennis, track, marathon and more
- hand cycle can be added to an existing chair or purchased as part of a stand-alone chair

CRITERIA for STANDARD WHEELCHAIR

1. The member has a mobility limitation that significantly impairs their ability to participate in one or more mobility-related activities of daily living (MRADLs)

A mobility limitation is one that:

- Prevents the member from accomplishing an MRADL entirely; or
- Places the member at reasonably determined heightened risk of morbidity or mortality secondary to the attempts to perform an MRADL; or
- Prevents the member from completing an MRADL within a reasonable time frame.

2. The member's mobility limitation cannot be sufficiently resolved by the use of an appropriately fitted cane or walker.

3. The member's home provides adequate access between rooms, maneuvering space, and surfaces for use of the manual wheelchair that is provided.

4. Use of a manual wheelchair will significantly improve the member's ability to participate in MRADL's, and the member will use it on a regular basis in the home.

5. The member has not expressed an unwillingness to use the manual wheelchair that is provided in the home.

6. The member has sufficient upper extremity function and other physical and mental capabilities needed to safely self-propel the manual wheelchair that is provided in the home during a typical day. Limitations of strength, endurance, range of motion, or coordination, presence of pain, or deformity or absence of one or both upper extremities are relevant to the assessment of upper extremity function.

A wheelchair is a wheeled mobility device in which the user sits on and is able to be mobile. The device is propelled either manually (by turning the wheels by the hand) or via various automated systems such as electric motors. Wheelchairs are used by people for whom walking is difficult or impossible due to illness (physiological or physical), injury, or disability.

A wheelchair assists people to become more mobile and independent. There are many different types of wheelchairs that are used for various reasons. It is important to understand the limitations and safe operation of whatever wheelchair you choose.

The chair seat size (width and depth), seat-to-floor height, footrests/leg rests, front caster outriggers, adjustable backrests, controls, and many other features can be customized on, or added to, many basic models, while some users, often those with specialized needs, may have wheelchairs custom-built.

Manual Wheelchair

A manual wheelchair is one that is propelled by the user. It is usually done by pushing on round bars that surround the wheels. This wheelchair also has handles on the back so it can be pushed by another person. A manual wheelchair is easy to maintain, is lightweight, and is the least expensive to buy.

Electric Wheelchairs

Electric wheelchairs are propelled by a motor and battery. They are very sophisticated. They are operated with a joy stick or push buttons. Some electric wheelchairs use advanced technology and can climb up stairs, move across gravel and even raise up to give access to high shelves. Electric wheelchairs need strong frames to support the motor and battery so they are very heavy and also quite expensive.

Sports Wheelchairs

As the name suggests, sports wheelchairs are designed for playing sports. They are ultra lightweight yet very stable. They are often used for tennis, wheelchair basketball, and marathons

Powerchair Football and Power Soccer Wheelchairs

A new sport has been developed for power chair users called power chair football or power soccer. It is the only competitive team sport for powerchair users.

Standing Wheelchairs

A standing wheelchair is one that supports the user in a standing position. They can be used as both a wheelchair and a standing frame, allowing the user to sit or stand in the wheelchair. They will move from sitting to standing with a hydraulic pump or electric-powered assist.

Pediatric Wheelchairs

Pediatric wheelchairs are both in manual and electric form. They are just smaller scale down versions of the larger adult wheelchairs. These are usually adjustable so they can grow with the child and expand to accommodate increased weight and bulk as the child grows.

Beach Wheelchairs

All Terrain Wheelchairs allow users to enter the water and provide a better mobility in the sand. There are lots of different models available. In many countries in Europe where the Accessible Tourism is well set, many beaches are wheelchair accessible and provide this kind of wheelchairs to clients free of charge.

Three-wheeled wheelchairs

3 wheeled wheelchairs are not a new concept and have frequently been used in the design of racing wheelchairs, tennis wheelchairs, and other sports as well as everyday all purpose

wheelchairs.

Recent technological advances are slowly improving wheelchair and EPW technology. Some wheelchairs, such as the iBOT, incorporate gyroscopic technology and other advances, enabling the chair to balance and run on only two of its four wheels on some surfaces, thus raising the user to a height comparable to a standing person.

They can also incorporate stair-climbing and four-wheel-drive feature motorized assists for hand-powered chairs are becoming more available and advanced.

Dog Wheelchairs

Yes, there is such a thing as wheelchairs for dogs. They were created to help handicapped and injured dogs regain their mobility. Many times, the problem is hip displacement or a spinal cord injury that leaves the dog with no control over his back legs.

The dog wheelchair fits onto the back legs and rolls across the floor and the dog moves forward with his front legs. This helps the dog regain mobility and go on to lead a happy and healthy life.