UNIT- I

## What is Rehabilitation.

The process of helping a person who has suffered an illness or injury restore lost skills and so regain maximum self. sufficiency.

(E.g) Rehabilitation work after a stroke may help the patient walk and speak clearly again.

## Epidemiology of Rehabilitation

It is the branch of medicine which deals with the incidence, distribution and possible control of diseases and other factors relating to health.

## Historical overview:

* 1970 the turning point in the history of psychiatric epidemiology was the US project sponsored by WHO.
* In middle of 1980 the concept of a worldwide dimension was reinforced by results of the WHO research Determinants of Outcome".

## Frequence and Risk Factors

### 1) Gender Risk

* Epidemiological myth concerns the gender risk and the difference of disease course by sex.
* In Earlier days reported in many psychiatric textbooks that men and women are affected equally by diseases.

* Recent meta-analyses of third generation epidemiology stuides have clarified that this is not the Case.
* For every three males with schizophrenia there are two females with the disease.

## Prenatal, Perinatal Complications

* Neuro-developmental disease caused from a brain damage occurring in early phases of life, that interferes with the normal developmental events.
  (i) seasonality of Birth.
  (ii) prenatal exposition to flu viruses and Toxoplasma gondii.
  (iii) Birth Complications.
  (iv) Brain abnormalities on neuroimaging tools.

## Low IQ

* Poor attention skills, thought disorder-like Symptoms,
* Poor social adjustment
* Psychiatric Symptoms compared to offspring of controls.

## Paternal Age

* Fathers aged 55 or above at the time of offspring birth; once ~~pa~~ paternal age was accounted for statistically, maternal age no longer was a significant predictor of schizophrenia.

## Autoimmune Diseases :

* Association between schizophenia and various inflammatory. autoimmune diseases has been reported in epidemiological surveys.

## Migration.

* The hypothesis that migration is a risk factor for schizophrenia hasbeen accepted by many authors. however, there are not yet concordant theories about the role played by migration on development of the disease.

## Addiction

* Many abuse drugs havebeen related to onset of schizophrenia. Use of D-amphetamine and of cannabis during adolescence can contribute to subsequent onset of disease or to an increase of psychotic symptoms.

## Urbanicity

* The Risk for schizophrenia increases with urban birth especially among males.

## Social Class

* There are 2 hypotheses trying to explaining the strong association observed between low social class and schizophrenia.

* According to the first one, poor environment conditions of underdeveloped areas, such as infectious agents, unemployment, poor quality of maternal and obstetrician care, psychosocial stress can be breaking factors for disease onset.

Genetics :.

* A complex genetic disorder, resulting from a combined effect of environmental factors and more genes, each with small effect on the Individual's phenotype.

Stress :

* Psychosis and inadequate social support, stress may be a trigger factor; moreover, a relationship between environmental stressors and seriousness Psychotic Symptoms has been described.

Family Milieu

* Many researches in 80th have been directed to one of the stressor condition, a critical or „emotional involved family climate termed high expressed emotion" in the early British study.

# Preventive Rehabilation

* Prevention or rehabilitation facilities are facilities according to Article 107, Section 2 SGB V, which serve inpatient treatment, in order to eliminate any deterioration of health which would probably lead to illness in a foreseeable time.

* They are facilities which serve inpatient treatment in order to counteract an endangerment of the healthy development of a child or to cure a disease.
* The facilities must be under continuous specialist medical supervision and with the cooperation of specially trained staff, they are set up to improve the state of health of the patients according to a medical treatment plan mainly by application of treatment including physiotherapy, kinesitherapy, speech therapy or work and occupational therapy and by other suitable means, including also mental & psychic influence.
* They are also set up to help the patients in the development of their own defence healing forces and they are facilities in which the patients can be accomodated and looked after.

* The health insurances may commission me services for preventive health care or services for me rehabilitation including the therapeutic treatments. after a stay in hospital.

## Impairment :.

A loss or abnormality of psychological, Physiological or anatomical structure or function.

* Impairments and disabilities may be temporary or permanent, reversible or irreversible, and progressive or regressive.

## * Visual Impairment :.

* Visual impairment can be defined as a total loss of, or reduced ability to, perceive light and colour.

* Visual impairment where vision is of some help in a testing or working situation, but where effective reading of even moderately enlarged print is not possible, and a visual impairment where print may be used effectively, although it may have to be large type, held very close to the eyes or used with special visual aids and under special lighting conditions.

* The incidence of all kind of visual impairment increases considerably with age. Less than 10 percent of Blind people are under 20 years

of age while nearly 50 percent are 65 years older. In addition, people older than 40 need hig light intensity and contrast than 20-year-olds, and the difference increases dramatically between age 40 and 60.

## Hearing Impairment

* Hearing impairment implies a total or partial loss of the ability to perceive acoustic information.
* The impairment may affect the full range of hearing, or be limited to only parts of the auditory spectrum, which for speech perception is the region between 250 and 4,000 Hz.

## Impairment of Speech Production:

* Speech Impairment refers to any reduction in a person's ability to use speech in a functional and intelligible way.
* The impairment may influence speech in a general way, or only certain aspects of it, such as fluency or voice volume.

* Speech impairment may be due to a number of different factors. It may or may not be linked with difficulties in speech perception or comprehension.

* Speech impairment may be caused by developmental problems as in the case of moderate to severe developmental language disorder.

## Intellectual Impairment:

* People with reduced intellectual ability constitute a very diverse group with a range of sensory, motor and cognitive impairments; most impairments, including visual and auditory impairment, have a higher incidence in the group that is called intellectually impaired.

## Reading Impairment:

* The reading impairment may or may not be associated with other language disorders, such as developmental dysphasia and anarthria due to cerebral palsy.
↳ language disorder due to brain disease or damage

* Severe reading disorder may also be an acquired condition similar to aphasia, and is then usually called alexia.
↳ Inability to understand or produce speech due to brain damage.

## Reduced Function of Legs and Feet

* A reduced function of legs and feet implies dependency on a wheelchair or other mobility aid to help walking.
* The mobility of a wheelchair user depends largely on the dimensions of the wheelchair.
* The length of a wheelchair is usually less than 1.25 meters, including the footboard, and its width is in most cases less than 0.75 meters. This gives a necessary turning radius of 1.4 – 1.5 meters.

## Reduced Function of Arms and Hands

* Reduced function of arms and hands includes the lack of arms or hands, or reduced ability to use them due to reduced strength or co-ordination.
* For a person who lacks both arms or the functional use of both arms, activities related to moving, turning or pressing objects are often impossible, or may have to be replaced by other methods, for example, a mouth stick.
* This does not influence speech communication itself, but implies great difficulty in using a wide range of technical & non-technical equipment.

## Disability :

* A disability is an inability to execute some class of movements, or pick up sensory information of some sort, or perform some cognitive function, that typical unimpaired humans are able to execute or pick up or perform.
* A disability may be Physical, cognitive, mental, sensory, emotional, developmental or some combination of these.
* A view of disability as a social construct holds that society assumes that everyone is a fully functioning, able-bodied person, which prevents the
* When Systems are designed thoughtfully to accommodate the needs, challenges and varying degrees of ability of different people in society, people with disabilities can fully participate in these systems.
* While physical disabilities are easy to identify and appreciate, mental disabilities requires the same level of thought when designing systems.

PRIMARY AND SECONDARY DISABILITIES.

EXAMPLE: ALCOHOL DISORDER.

* Prenatal exposure to alcohol can cause many abnormalities and disabilities that have lifelong Physical, mental, behavioural and social consequences.

Researchers have classified the disabilities into two categories:

(I) Primary Disabilities

(II) Secondary Disabilities.

(I) Primary disabilities:

are defined as those that reflect the primary morphological and neuropsychological damages of Fetal Alcohol spectrum Disorder. These disabilities include:

* facial dysmorphology
* growth retardation: foetus doesn't developed at a rate normal
* Central Nervous System neurodevelopmental abnormalities, with a complex pattern of behaviour or cognitive dysfunction.

Secondary disabilitres :.

are those that appear later in life as a result of complications from undiagnosed or untreated primary disabilities. Examples of secondary disabilities include:

* mental health problem (90%)
* disruptive School experience (60%)
* trouble with law (60%)
* confinement (50%)
* inappropriate sexual behaviour (50%)
* alcohol / drug problems (30%)
* dependent living (80%)
* employment problems (80%).

* Patients with fetal alcohol related abnormalities who demonstrated varying IQ scores were found to have similarities in impaired judgement and low adaptability.

Benefits of early Diagnosis :

* Early diagnosis with proper intervention may decrease the appearance and attenuate the coure of the secondary disabilities.

# REHABILITATION TEAM.

The individuals involved in establishing a plan and goals for the achievement of a patient's maximum potential. The composition of the team will Vary depending on the nature of the patient's problems. the patient is always included as a member of the rehabilitation team.

Rehabilitation Include the following people :.

(I) Consultant in Rehabilitation Medicine
(ii) Liaison Service
(iii) Rehabilitation Nurse
(IV) Health Care Assistant
(v) Medical Social Worker
(VI) Physiotherapist
(vii) Respiratory Physiotherapist.
(Viii) Prosthetist & Orthotist
(IX) Occupational Therapist (OT)
(X) Speech and Language Therapist.
(XI) Psycologist
(xii) Dietitian
(xiii) Pastoral Care

(xiv) Music therapist

(xv) Dance therapist

(xvi) Biomedical Engineer.

## Role of Rehabilitation Team:

(I) Consultant in Rehabilitation Medicine:

* The Consultant in Rehabilitation medicine is responsible for the overall treatment and coordination of patients medical care.

* Medical Registrars support the medical Rehabilitation Consultants and with Senior House Doctors will provide patients day to day medical care.

* Patients Consultant may refer the patients to other Specialist Consultants. (E.g) Orthopaedics, Urology, Plastic surgery, Radiology or Psychiatry.

* Medical team will liaise with ~~yo~~ patients GP and Referring Consultant regarding patient's Care.

Liaision Service:

* The Liaision coordinators provide a link between the hospital, home and healthcare Professionals.

* ~~Helps patient practice what patient are learning in therapy and teach patient and patient family how to handle.~~

* They act as patients advocate and liaise with hospitals to assess and evaluate patients readiness and suitability for admission to a Rehabilitation programme at NRH and continue to link with patients post discharge from NRH.

Rehabilitation Nurse:

* Nursing staff provide care, support and encouragement throughout patient stay and provide an important communication link with other members of the team.

* Helps patient practice what patient are learning in therapies and teach patient and family how to handle patient personal care.

* Clinical Nurse Specialist in Sexuality is available to provide counselling to you patient and relevant others on the impact of your injury on sexuality.

Health Care Assistant:

* The health care Assistant helps provide care and general assistance to patient during stay.

* Assists patient in doing certain daily tasks as patient progress through patient rehabilitation such as dressing, toileting, showering and feeding.

Medical Social Worker :-

* Gives emotional suppor tot patient & his fam

* Gives patient & family information, patient may need in the future about Community agenices.

* Helps patient to solve personal problems that may come up and assists patient with dischrage planning.

Physiotherapist :-

* Therapy services are scheduled weekly for each patient.

* Helps you strengthen your muscles and use them to do daily activities.

* Helps you learn breathing exercises that help you build your stamina and strength.

* Sports and fitness, gym and hydrotherapy programmes are provided by the physiotherapy department.

Respiratory Physiotherapist :-

* Monitors the health of your lungs.

* Give patient treatments to keep patients lungs clear.

* Assesses need for respiratory equipment.

## Prosthetist & Orthotist :

* The Prosthetist / Orthotist produces and fits all artificial limbs, plastic cosmetic appliances and other prosthetic devices.

* Help patient learn to wear and use the prosthesis / orthosis correctly.

* Provides follow-up care post discharge in the NRH clinics or regional clinics around the Country.

## Occupational Therapist (OT).

* Helps y patient to regain skills used in daily living activities such as: dressing, eating, planning and writing.

* Helps ~~ye~~ patient ~~learn to wear and use~~ order equipment patient will need such as bathing equipments, mobility airds or wheelchair.

* Assesses patient home, work and school setting and then suggests modifications that will make it easier for patient to carry out normal daily activities.

## Speech and Language Therapist

* Assesses. and treats all aspects of communication impairment.

* Assesses and treats swallowing difficulties.

* Helps with difficulties in remembering, talking, reading, writing, listening and thinking.

Dietitian:

* Helps patients manage your dietary needs.
* Promotes healthy eating habits and provides educat on how to stay healthy.

Pastoral Care:

* Provides support and counselling on request.
* Addresses patient spiritual needs.

Music therapy:

* Music therapy is a recognized allied health profession, which is becoming acknowgledged in the expanding world of health care as a therapy able to meet the expansive needs of the patient in rehabilitation.

Dance Therapist:

* Working as a dance therapist provides the opportunity to use movement to improve the lives of others.

Bio Medical Engineer:

* Bio Medical Engineer will responsible for operate the Assistive Devices.

UNIT - I

**overview and History**

**Figure 1** A man with an impairment (paralysis of left leg from polio) who uses a simple assistive aid for walking.

The term **rehabilitation engineering** means "the systematic application of engineering sciences to design, develop, adapt, test, evaluate, apply, and distribute technological solutions to problems confronted by individuals with disabilities in functional areas, such as mobility, communications, hearing, vision, and cognition, and in activities associated with employment, independent living, education, and integration into the community."[1]

**Figure 1**, taken by René Baumgartner, MD, in Tanzania in 1993, shows a man with an impairment (paralysis of left leg from polio) who uses a simple assistive aid for walking. The aid is similar to one used in Egypt around 1500 B.C.E. as recorded on an ancient Egyptian stele that is now in the Carlsberg Sculpture Museum in Copenhagen.[2]Surprisingly, this similar mobility aid is still in use in many places over the world. Paintings of Brueghel in the Kunsthistorische Museum in Vienna, include many images of persons of the 16th century with disability (for example, limb loss, polio, and cerebral palsy) using crude crutches, sticks, and other simple mobility aids. Ambroise Paré (1510–1590), a French military surgeon of that period, introduced the ligature. From the Napoleonic Wars, today's rehabilitation teams still prescribe "Nelson's Knife" to assist persons with only one functional arm to cut and spear meat just as it did for Lord Nelson. America's Civil War resulted in many limb amputations.[2]

In 20th century, with World War I and II, the term, rehabilitation engineering became clear and developed excessively. In 1919, Erzatzglieder und Arbeitshilfen (Replacement Limbs and Work Aids) published in German. It could be considered one of the first major publications in the rehabilitation engineering.[3] In around 1915-1916,Ferdinand Sauerbruch, MD in Berlin worked with an engineer to design an artificial arm. Sauerbruch developed the "team" approach during his work on tunnel cineplasty for direct muscular control of artificial hands and arms. In Russia, Nickolai Bernstein and his associates took a scientific motor control approach to prosthetics. In America, Paul B Magnuson (June 14, 1884–November 5, 1968) as a bone and joint surgeon, continuously investigated new treatments and devices for assisting his patients as they faced unique situations presented by their disability. He founded the Rehabilitation Institute of Chicago (RIC) as well as induced Dr. Stanley Coulter to set up the first Physical Medicine Department in the country. After Dr.Magnuson death, Dr. Compere often related. In order to honor the life and legacy of Paul B Magnuson, M.D, Paul B. Magnuson Award established in 1998.[4]

## Major activities in Rehabilitation Engineering

### Table Categories of assisted devices

| | |
|---|---|
| Prosthetics and Orthotics | • Artificial foot and legs<br>• Artificial hand, wrist, and arms<br>• Hand splints and upper limb braces<br>• Functional electrical stimulation orthoses |

| | |
|---|---|
| Assistive Devices for Persons with Visual Impairments | • Devices to aid reading and writing (e.g., closed circuit TV magnifiers, electronic Braille, reading machines, talking calculators, auditory and tactile vision substitution systems)<br>• Devices to aid independent mobility (e.g., Laser cane, Binaural Ultrasonic Eyeglasses, Handheld Ultrasonic Torch, electronic enunciators, robotic guide dogs) |
| Assistive Devices for Persons with Auditory Impairments | • Digital hearing aids<br>• Telephone aids (e.g., TDD and TTY)<br>• Lipreading aids<br>• Speech to text converters |
| Assistive Devices for Tactile Impairments | • Cushions<br>• Customized seating<br>• Sensory substitution<br>• Pressure relief pumps and alarms |
| Alternative and Augmentative Communication Devices | • Interface and keyboard emulation<br>• Specialized switches, sensors, and transducers<br>• Computer-based communication devices<br>• Linguistic tools and software |
| Manipulation and Mobility Aids | • Grabbers, feeders, mounting systems, and page turners<br>• Environmental controllers<br>• Robotic aids<br>• Manual and special-purpose wheelchairs<br>• Powered wheelchairs, scooters, and recliners<br>• Adaptive driving aids<br>• Modified personal licensed vehicles |

from Andrew Szeto((2012)

# Assistive Technology

**Assistive Technology** is defined in the Technology-Related Assistance Act as "any item piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities"[5]. Assistive technology can be created at home and designed specifically for an individual, purchased in a local store, or ordered out of a catalog that is targeted toward people with disabilities and their families. Technology can be high or low. Broadly, Low technology cover daily living aids--from battery operated toys, to eating aids, to mobility aids, to mounting and positioning devices, to recreation, and leisure aids[6]. Some high technology contains computers, software, extended keyboards, electronic communication devices, power wheelchairs, and van lifts for wheelchairs.

Assistive technology cannot resolve all the problems. It can decrease the impact of the disability because the application of technology for persons with disabilities is inexact and will change with time[7].In addition,similarly disabled persons can have very different needs, wants, and preferences[8].So,changes in the assistive technology user's health, living environment, preferences, and circumstances would need periodic reassessment by the user and those rehabilitation professionals[8]. Hopefully assistive technology would increase independence and improve an individual's outlook on life.

However, assistive technology is not without its problems. Many times the devices that are needed could be expensive and resources are not easy to find; or the equipment is purchased and training or support system is not perfect to show the individual how to use it effectively; or the device simply breaks down and needs to be repaired[7].On the other hand, according to data from the 1990 U.S. Census Bureau's National Health Interview Survey, about one-third of the assistive devices not needed for survival are unused or abandoned just 3 months after they were initially acquired.

**Table Professional Fields in Assistive Technology**

| Assistive Technology | Professional with priority |
|---|---|
| **Daily living skills** | Occupational therapy,Rehabilitation technology |
| **Mobility/Seating and positioning** | Occupational therapy,Physical therapy |
| **Augmentative/Written communication** | Speech–language pathology,Special education |
| **Specialized adaptations** | Rehabilitation engineering,Computer technology,Prosthetics/orthotics,Biomedical engineering |
| **Computer access** | Computer technology,Vocational rehabilitation,Biomedical engineering |
| **Academic and vocational skills** | Special education,Vocational rehabilitation,Speech–language pathology,Psychology |

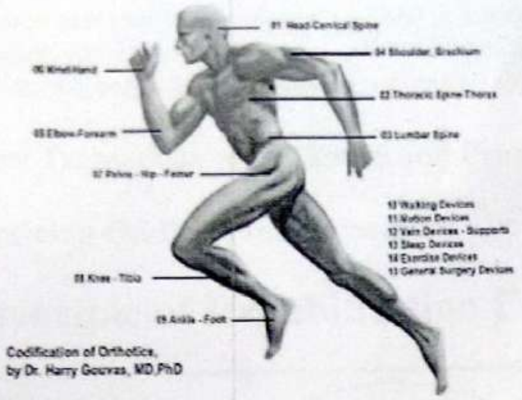
### Daily Living Skills

### Manipulation and Mobility Aids

### Augmentative Alternative Communication

### Computer Access

## Orthotics and Prosthesis in Rehabilitation Engineering




Codification of Orthotics, drawn by Dr. Harry Gouvas

In medicine, a **prosthesis**, (from Ancient Greek*prósthesis*, "addition, application, attachment")is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or congenital conditions. **Orthotics** (Greek: Ορθός, ortho, "to straighten" or "align") is a special field related to the design, manufacture and application of orthoses. An **orthosis** (plural: **orthoses**) is "an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal system[9]". Orthoses and Prosthetics(O&P) are made from various types of materials including thermoplastics, carbon fibre, metals, elastic,fabric or composites with similar properties. Some designs may be purchased at a local retailer. others are more specific and require a prescription from a physician, who will fit the orthosis according to the patient's requirements. An Orthotist and/or Prosthetist is an allied Health Professional who designs, measures, fabricates and fits Orthoses and Prostheses. Orthotists and prosthetists work in special units in major teaching hospitals, rehabilitation centres and the community. They try to magnify the function and comfort of the client by providing the most proper orthotic or prosthetic treatment. O&P combines knowledge of anatomy and physiology, biomechanics, biomaterials and so on.

## The state of Orthotics and Prosthesis

### Upper Extremity Prosthetic Systems

**Upper extremity prostheses** has a variety of options according to the amputation level: shoulder disarticulation, transhumeral(below elbow) prosthesis, elbow disarticulation, transradial(under elbow) prosthesis, wrist disarticulation, full hand, partial hand, finger, partial finger.

- **Passive Functional / Cosmetic Devices**
- **Body Powered / Conventional Devices**
- **Myoelectric / External Power Devices**
- **Hybrid Devices**
- **Adaptive / Recreational Devices**

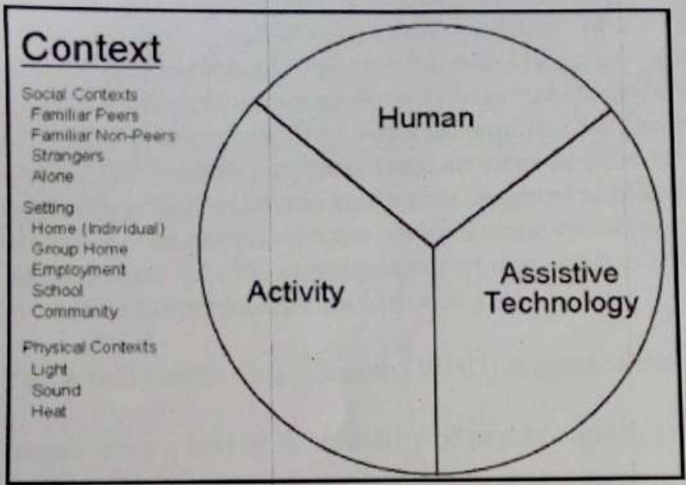
### Lower Extremity Prosthetic Systems

**Lower extremity prostheses** are used at various amputation level. These include hip disarticulation, transfemoral(above knee) prosthesis, knee disarticulation, transtibial prosthesis(below knee), symes, foot, partial foot, and toe.

**New Technology of Orthotics and Prosthesis**

**Training O&P around the world**

## Principle of Rehabilitation Engineering




Human Activity Assistive Technology Model.

This "assistive technology" of the **HAAT model** is divided into four parts: **the human/technology interface**, **the processor**, **the activity output**, and **the environmental interface**. **The human/technology interface** indicates the contact between the person and the technology device. **The processor**, in this case the switch, is the mechanical or electrical linkage that relays or interprets information from the interface so that the desired task can be accomplished. **The activities output** are categorized within three basic performance areas: activities of daily living, work and productive activities, and play and leisure activities. **The environmental interface** is the link between the output of the device and the input from the environment[10]. The final but essential factor in the HAAT model is that the activity enabled by the assistive technology takes place within a socia

UNIT - I

# hapter 5: Impairment, Disability, and Handicap

*John Frederiksen, Mike Martin, Leonor Moniz Pereira, Ramxa2n Puig de la Bellacasa and Stephen von Tetzchner*

*"Although there is clearly a biological difference between the disabled and the able-bodied, this is not the decisive difference between the two groups. Handicap is a social construct. There is a biological sub-stratum, but what it means to be handicapped to others and to oneself is overwhelmingly social and decisively political" (Roth, 1983, p. 56).* Many different types of impairments and disabilities may have an impact on the use of telecommunications. Knowledge about impairments and disabilities is important to understand possible consequences for the use of telecommunications. It is also a prerequisite for designing and producing standard telecommunications equipment and services that can be used by as many people as possible, and for developing specialised equipment designed to alleviate the negative consequences of a disability. The present chapter reviews some common impairments and disabilities. (Chapter 21 reviews some specific consequences of impairments and disabilities for telecommunication use in relation to standardisation activities).

The World Health Organization (WHO) suggested the following definitions in 1980:

Impairment: a loss or abnormality of psychological, physiological, or anatomical structure or function.

Disability: any restriction or lack (resulting from an impairment) of the ability to perform an activity in the manner or within the range considered normal for a human being.

Handicap: a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and culture factors) for that individual.

Impairments and disabilities may be temporary or permanent, reversible or irreversible, and progressive or regressive. The situation people find themselves in may determine to what degree a disability is handicapping for them. It is evident from the definitions above that a handicap is the result both of an impairment and of environmental conditions (cf. Figure 5.1). If environmental barriers are taken away, the person will still be impaired, but not necessarily handicapped. It should also be noted that the definition of disability as distinct from handicap is not without problems, in particular the formulation "considered normal for a human being", and many people with disabilities do not distinguish their use.

The functional ability of people who are diagnosed as having the same impairment or disability may vary widely. For example, some people who are legally blind may be able to utilize differences in light intensity, while others are unable to perceive such differences. People who have clinically similar hearing impairments, as shown on audiograms, may use quite different aspects of the acoustic information available to them. The degree of handicap may vary significantly and may be specific to certain situations.

In this brief review of impairment and disability, differences in degree are dealt with only in a very general manner. The emphasis is on typical features rather than variations. However, when assessing the needs of a single individual, variation that may influence the handicapping effects of the condition must be taken into account.

## 1.0 Visual Impairment

In medical terms, visual impairment can be defined as a total loss of, or reduced ability to, perceive light and colour. The classic definition of blindness is a visual acuity of 6/60 or less in the better eye with optimum correction, or visual acuity of better than 6/60 if the widest diameter of field of vision subtends an angle no larger than 20 degrees. This means that a blind person must be at 6 metres in order to see something that a person with normal sight can see at 60 metres, or that the field of vision is so restricted that only a very limited area can be seen at one time (see Figure 5.2). Within this legal definition, a wide variety of visual impairments can be found. Bauman (1969) distinguishes between a visual impairment where vision is of no practical use in a testing or working situation; a visual impairment where vision is of some help in a testing or working situation, but where effective reading of even moderately enlarged print is not possible, and a visual impairment where print may be used effectively, although it may have to be large type, held very close to the eyes, or used with special visual aids and under special lighting conditions.

Blindness implies a total or near total loss of the ability to perceive form. Partial sight implies an ability to utilize some aspects of visual perception, but with a great dependency on information from other modalities, in particular touch and hearing. Reduced vision may handicap a person in situations which put great demands on the use of vision, but in most situations the person will not be handicapped by the visual impairment; they will, for example, be able to read large type print with glasses.

The incidence of all kind of visual impairment increases considerably with age. Less than 10 percent of blind people are under 20 years of age while nearly 50 percent are 65 years or older (Bauman, 1969). In addition, people older than 40 need higher light intensity and contrast than 20-year-olds, and the difference increases dramatically between age 40 and 60.

Problems with orientation and mobility are one of the typical consequences of failing sight. In the case of elderly people, difficulties in orientation and mobility may be intensified by other cognitive impairments.

## 2.0 Hearing Impairment

Hearing impairment implies a total or partial loss of the ability to perceive acoustic information. The impairment may affect the full range of hearing, or be limited to only parts of the auditory spectrum, which for speech perception is the region between 250 and 4000 Hz (see Figure 3.x in chapter 3).

The term deaf is used to describe people with profound hearing losses while hard of hearing is used for those with mild to severe hearing losses. Hearing loss is expressed in decibel (Db) relative to an audiometric cero which is a standardized normal threshold of hearing. Deafness is usually defined as an average hearing loss of more than 92 Db in the speech area. A person with a hearing loss of 70-90 Db is severely hard of hearing. A person with a hearing loss of 50-60 Db is considered moderately hard of hearing (Davis, 1970). Measured losses of less than 20 Db is considered normal acuity.

The onset of the hearing impairment is important for language development and for identification with the deaf community. A person who was born profoundly deaf or has become deaf at a very early age, i.e. prelingual deafness, is dependent mainly on visual communication for speech and language development, and often uses sign language. A person who becomes deaf later in life usually has a good mastery of both spoken and written language before the onset of deafness. Some deaf people may fall between these two groups. For example, they may become deaf at an early age, but after they have learned to speak, say at 3-4 years of age, and therefore may not have a full mastery of spoken or written language.

For a discussion of telecommunication devices, it is useful to distinguish between deaf people with and without intelligible speech; and between those who can and those who cannot understand speech with amplification. Although some people with prelingual deafness have intelligible speech, this is more typical of those deaf persons who acquired speech and language skills before the onset of the hearing impairment. For people with profound deafness, speech discrimination may be very limited without lip-reading even when they can hear some sound with the help of a hearing aid.

Written text is closely related to spoken language, and the function of writing is to mirror speech (Saussure, 1916). Thus, although mastery of spoken language may not be a prerequisite for learning to read, it greatly facilitates the acquisition of reading and writing. Thus, due to the limited knowledge of spoken language, the written language skills of many prelingually deaf people may often be limited as well (cf., Conrad, 1979).

Post-lingually deafened people usually have intelligible speech, but because they cannot hear their own voice, their control of volume may be erratic, and they may therefore speak too softly or too loudly. While they typically have no special problems in the use of written language for, if their hearing impairment was acquired in childhood, vocabulary and other aspects of both spoken and written language use may be adversary influenced, due to more limited experience with spoken language.

People of any age may have a mild to severe hearing loss, but the majority will be elderly. For people who are hard of hearing, speech and hearing remain the main mode of communication, often with the help of a hearing aid. In the case of a severe hearing impairment, however, the person may be dependent on lip reading in addition to using a hearing aid, and for some types of hearing impairment, a hearing aid is of limited help. Furthermore, although many hard-of-hearing people hear speech with the help of amplification, their ability to understand speech may be hindered due to the effect of hearing loss. The ability to hear is not necessarily equal with the ability to understand what is said.

## 3.0 Impairment of Speech Production

Speech impairment refers to any reduction in a person's ability to use speech in a functional and intelligible way. The impairment may influence speech in a general way, or only certain aspects of it, such as fluency or voice volume. Speech impairment may be due to a number of different factors. It may or may not be linked with difficulties in speech perception or comprehension. Speech impairment may be caused by developmental problems as in the case of moderate to severe developmental language disorder (dysphasia), or by distorted speech due to lack of muscular control (dysarthria). It may be an acquired impairment, for example loss of expressive language skills (expressive aphasia) caused by a stroke or brain tumour, or speech impairment after removal of the larynx (laryngectomy). Acquired disorders are more prevalent with advancing age. When speech impairment is caused by reduced muscular control (apraxia), it is often accompanied by reduced muscular control of the arms. Low volume is often apparent in people who have had laryngectomy and who must speak in a "whispering" voice.

The intelligibility of speech may be reduced by varying degrees: speech may be lacking totally or it may be unintelligible even to people who are familiar with the speaker. In other cases, the speaker may be intelligible to familiar persons, while difficult to understand for others. There may also be situational variation: for example, people who stutter do so in some situations and not in others, depending upon whom they talk to and the communicative load of the situation.

## 4.0 Impairment of Language Comprehension

This category contains a loss of, or a reduction in, the ability to understand language. The disability may imply only an impairment of language, or it may be associated with a more general intellectual impairment.

Several disorders of the central nervous system may include impairment of language comprehension. In some conditions, like severe developmental language disorder (receptive dysphasia), only the language function is affected, while other conditions may influence most intellectual functions. This may, for example, be the case for people with autism.

Impaired language comprehension may be developmental or acquired. In developmental disorders, the impairment of comprehension will also have consequences for the ability of people to express themselves. In some acquired conditions, it is mainly comprehension that is affected while the people are able to express themselves. Aphasia, a language disorder caused by stroke or trauma, may affect language comprehension and/or use.

Many people with limited comprehension may be able to communicate better through the visual modality than through speech. They may use manual signs or special symbol systems (e.g. Bliss, Rebus), but the vocabulary may be severely limited (cf. Kiernan, Reid & Jones, 1982; von Tetzchner & Martinsen, in press).

In the case of people with intellectual impairment, non-verbal modes of instruction may also be affected. Thus, not only communication in itself, but also instruction in the use of different kinds of equipment may be severely hindered.

People with language disorders and a more general intellectual handicap may have some understanding of language but a limited vocabulary and reduced comprehension of sentence structure. The understanding of language may be strongly related to context, which means that comprehension is very dependent on non-linguistic cues, such as the presence of persons or objects, or limited to a small number of well known situations. Most forms of telecommunication will be hindered because of the limitation in non-linguistic contextual cues.

## 5.0 Intellectual Impairment

People with reduced intellectual ability constitute a very diverse group with a range of sensory, motor and cognitive impairments; most impairments, including visual and auditory impairment, have a higher incidence in the group that is called intellectually impaired. One common trait is that they tend to do things slower than other people, another that they have reduced comprehension of instructions and language in general. For the purpose of adapting telecommunication equipment and services, the best strategy may be to consider intellectual impaired people as having multiple impairments (see below).

## 6.0 Reading Impairment

Dyslexia is a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent on fundamental cognitive disabilities, which are frequently of constitutional origin (Critchley, 1970). The reading impairment may or may not be associated with other language disorders, such as developmental dysphasia and anarthria due to cerebral palsy. Severe reading disorder may also be an acquired condition similar to aphasia, and is then usually called alexia.

A lack of reading skills will be a handicap in a wide range of social and professional situations. In particular, it will influence the person's ability to obtain information.

## 7.0 Reduced Function of Legs and Feet

A reduced function of legs and feet implies dependency on a wheelchair or other mobility aid to help walking (e.g. crutch or stick). People with this disability are usually able to communicate normally on the telephone, but may have problems getting to the equipment.

The mobility of a wheelchair user depends largely on the dimensions of the wheelchair. The length of a wheelchair is usually less than 1.25 meters, including the footboard, and its width is in most cases less than 0.75 meters. This gives a necessary turning radius of 1.4-1.5 meters.

Electric wheelchairs may be somewhat wider, but the hands of the user do not extend beyond the arm rests. Thus, the radius of manual and electric wheelchairs will be approximately the same.

In general, a wheelchair user is dependent on an even surface without any significant change of elevation. The maximum abrupt change of level to be managed by somebody driving the wheelchair himself is about 2.5-3 centimetres. Some users may manage an uneven road surface, but it will be most unpleasant, and the wheelchair may break down. For example, it is quite painful for wheelchair users to drive in areas with uneven paving stones. Entering or leaving a sidewalk may be difficult, and even dangerous. Long-distance travel in a hand propelled wheelchair is tiring and may cause cramp in the hands.

A person in a wheelchair with a normal arm function will usually be able to reach 0,4-1,2 m. Thus, for installations to be within reach, they should be placed at not more than 0,4 m from the nearest place a wheelchair user can access, for example, not more than 0.4 meters from the side of a table. People who use walking aids, such as crutches and sticks, are mobile over short distances, but will have difficulties moving longer distances. Therefore, it is essential that they do not have to travel long distances and that suitable resting places are provided. Snow and ice are particularly troublesome for people with difficulties in walking. Even rainy weather may cause considerable problems, as many kinds of surface, such as stripes in pedestrian crossings, woodfloors and paving stones, become very slippery when they are wet. In a telephone booth, it may, for example, cause problems to hold the receiver and dial while holding the balance.

## 8.0 Reduced Function of Arms and Hands

Reduced function of arms and hands includes the lack of arms or hands, or reduced ability to use them due to reduced strength or co-ordination. For a person who lacks both arms, or the functional use of both arms, activities related to moving, turning or pressing objects are often impossible, or may have to be replaced by other methods, for example, a mouth stick. This does not influence speech communication itself, but implies great difficulty in using a wide range of technical and non-technical equipment.

A person who lacks one arm or who has lost the ability to use one arm in a functional way, will typically be handicapped in manipulating equipment that demands the simultaneous use of both hands. This includes a large range of equipment, and especially the simultaneous pressing of two or three keys on computer or terminal keyboards.

For people who cannot move their fingers independently, all fine motor skills will be affected. They may not be able to use keyboards or keypads, ticket automats, etc. Turning of pages, and inserting paper into printing devices, may also be difficult.

Lack of strength is a problem in actions that demands strength when lifting, pressing, pushing etc. People with muscular dystrophy, or other conditions that affect the muscles or muscle control, often have reduced strength.

People with severely reduced strength may be unable to use the keyboard of a typewriter or computer, and the keypad of a telephone. They may not be able to press down the handle to open a door, or to lift a book or a telephone receiver.

People with moderate loss of strength may be able to lift and move only very small objects, and to hold them for only a limited time. They may not be able to push open heavy doors, or to open drawers.

Reduced function of arms and hands due to reduced co-ordination is usually a result of neurological damage, e.g. cerebral palsy, or disease, e.g Parkinsonism.

Reduced ability to coordinate the movements of the arms and hands will influence all activities that demand manipulation of objects or equipment. Impaired coordination may also increase the probability of hitting and breaking things, and to make errors when operating equipment. For example, a person with cerebral palsy or Parkinson's disease may be unable to drive a car, pour a glass of water, write a message, or dial a telephone number.

## 9.0 Impairment of Growth

Impairment of growth primarily includes adults who are significantly shorter than the population mean. This condition is typically caused by malfunctioning of the hormone system.

In general, shortness adversely influences one's access to equipment. Installations that are positioned high up may be difficult to use unless some form of step is provided. Short people also tend to have short arms, which makes manipulation of some types of equipment awkward or difficult.

It should be noted, however, that also people who are significantly taller than the average of the population may have some problems in using equipment that is mounted at a low level, or where the ceiling, for example of a telephone booth, is too low.

## 10.0 Other Impairments and Disabilities

The above categories cover a wide range of impairments and disabilities. There are, however, individuals who do not readily fit into any of these categories. For instance, people who have to spend most of their time in bed cannot readily be included in the category of wheelchair-dependent users. Their lack of mobility is a significant difference in function, and it is necessary to consider the possible problems this more special situation of being bedridden creates. British studies indicate that at any given time, 0.5 percent of the population are in bed for a limited period, due to disease or accident. This is only one example of a common temporary disability.

Some people have multiple impairments; for example, combined visual and hearing impairment, or hearing impairment and problems in controlling the movement of their arms and hands. People with intellectual impairment typically have several impairments. Within the scope of the present chapter, it has not been possible to discuss such multiple impairments. When assessing the needs of people with multiple impairments, it may be difficult to distinguish the effect that the different impairments have on the use of telecommunication equipment, and the impact of multiple impairments may be greater than the added sum of the individual impairments. For example, most people with reading disorders have no problems with the use of ordinary telephones, although their inability to use the telephone directory may prove an obstacle for them. However, if a person with severe reading disorders acquires a profound hearing loss, text transmission via the telephone network is impossible, and the person is excluded from a form of telecommunications ordinarily used by people with hearing impairment.

The impact of each impairment may also vary according to the situation. For example, for a person with moderate hearing impairment and cerebral palsy, manipulating the equipment may be the most difficult task at home where the telephone has augmented amplification. In a public telephone, the low sound intensity may be a relatively greater problem than handling the equipment.

UNIT. I – Epidemiology

# Schizophrenia: from Epidemiology to Rehabilitation

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## Abstract

### Purpose/Objective:

We discuss recent evidences about schizophrenia (frequency, onset, course, risk factors and genetics) and their influences to some epidemiological myths about schizophrenia diffuse between psychiatric and psychopathology clinicians. The scope is to evaluate if the new acquisitions may change the rehabilitation approaches to schizophrenia modifying the balance about the neurodevelopmental hypothesis of schizophrenia accepting that the cognitive deficits are produced by errors during the normal development of the brain (neurodevelopmental hypothesis) that remains stable in the course of illness and the neurodegenerative hypothesis according of which they derived from a degenerative process that goes on inexorably.

### Research Method/Design:

A review of the literature about epidemiology of schizophrenia has been performed and the contributions of some of these evidence to neurodevelopmental hypothesis and to rehabilitation has been described.

### Results:

It cannot be definitively concluded for or against the neurodevelopmental or degenerative hypothesis, but efforts in understanding basis of schizophrenia must go on. Until now, rehabilitation programs are based on the vulnerability-stress model: supposing an early deficit that go on stable during the life under favorable circumstances. So, rehabilitation approaches (as neuro-cognitive approaches, social skill training, cognitive-emotional training) are focused on the individual and micro-group coping skills, aiming to help people with schizophrenia to cope with environmental stress factors.

### Conclusions/Implications:

Coping of cognitive deficits in schizophrenia may represents the starting-point for further research on schizophrenia, cohort studies and randomized trials are necessary to defined the range of effectiveness and the outcome of the treatments.

**Keywords:** Schizophrenia, functioning, epidemiology, genetics, etiology.
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# INTRODUCTION

Aim of the review is to understand whether epidemiological new findings may influences theories that support the rehabilitation approaches to schizophrenia. Indeed, 100 years later the Kraepelin's distinction between affective disorders and schizophrenia (*dementia praecox*), psychiatric research emphasizes the organic etiology of psychosis, in terms of genetic vulnerability, pathological and functional brain alterations. However, even if it's generally accepted that in schizophrenia there may be a cognitive deficit, it's not clear if this impairment is produced by errors during the normal development of the brain (neurodevelopmental hypothesis) that remains stable in the course of illness, or if it is derived from a degenerative process (neurodegenerative hypothesis) that goes on inexorably.

We'll discuss recent evidences on epidemiology of schizophrenia (about frequency, onset, course, risk factors and genetics), and their influences to some epidemiological myths and to rehabilitation approaches.

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# HISTORICAL OVERVIEW

We can distinguish three types of studies that have been carried out over the years: 1) the early 'historical' studies conducted with key informants in the general population or on institutional statistics without standardized diagnosis; 2) the surveys conducted into small communities using fixed diagnostic criteria (that were often difficult to compare and to extend); 3) the most recent researches conducted with standardized descriptive diagnosis, sampling methods and (semi-) structured interview tools to assure reliability.

In the 1970$^{th}$, the key turning point in the history of psychiatric epidemiology was the US / UK project sponsored by WHO [1], aiming to highlight the strong discrepancy in diagnosis of schizophrenia between London's and New York's institutional statistics. Recording interviews and crossing diagnosis with common defined criteria, diagnosis of schizophrenia became reliable [2, 3].

The introduction of common diagnostic criteria on schizophrenia allowed the who International Pilot Study on Schizophrenia. This survey stated that symptoms of schizophrenia are found around the world in many cultures and that profiles of schizophrenic pictures look similar in different cultural backgrounds [4].

In the 70$^{th}$, surveys on affective disorders, hysteria and anxiety indicated in a balanced way that others disorders than schizophrenia seem to be more culturally sensitive, at least as different clinical presentation. In some way an idea that schizophrenia was quite similar in all countries may be counter (as biologic entity) with other less biological entities present in the common professional conscience.

In the middle 80[th], the concept of a worldwide dimension of schizophrenia was reinforced by results of the WHO research "Determinants of Outcome" [5]. Those findings seemed to indicate a stable incidence rate of schizophrenia around the world. All six sites in high mean income countries showed a really stable annual incidence rate, except the Chandīgarh site in India showing little higher incidence rate, around 0.30 [6].

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# FREQUENCE AND RISK FACTORS

## Prevalence and Incidence: the Myth of the Stability

Since today, most psychiatric handbooks state that schizophrenia has a stable frequency around the world. However, a recent review shows that schizophrenia is not distributed equally across cultures and countries. From 132 core studies, 15 migrant studies, and 41 studies based on other special groups, the median values per 1,000 persons for the distributions for point and lifetime prevalence were 4.5 and 4.0, with a very large range in different studies [7]. Prevalence rate may be influenced by different length of disease course in different countries, so it may not be conclusive concerning the stability of incidence.

But the same review and others four in the last two years indicate unequivocally that the incidence rate of schizophrenia varies from different countries and cultures with a large range.

Considering the different published papers on incidence in schizophrenia after 1985, the lowest rates were reported in Vancouver and in Oxfordshire in UK (both with less 0.1 per 1,000), while the highest were reported in Madras with 0.58 and Bavaria with 0.48 [6].

## Gender Risk

Another possible epidemiological myth concerns the gender risk and the difference of disease course by sex.

It is reported in many psychiatric textbooks that men and women are affected equally by schizophrenia. Recent meta-analyses of third generation epidemiological studies have clarified that this is not the case. For every three males with schizophrenia there are two females with the disease [8, 9].

One reason of this "belief" may due to difference that was thought to exist between schizophrenia and affective psychosis in gender risk: one simple and stable concept was that male to female ratio in schizophrenia risk is 1/1, while in affective psychosis is 1/2. However, recent data highlighted that the male to female ratio is 1.2/1 also in bipolar disorders, remaining 1/2.5 only in major depressive disorder.

## Prenatal, Perinatal and Complications of Normal Brain Development for the Pathogenesis of Schizophrenia. Childhood Risk Factors

Many evidences support hypothesis that schizophrenia could be a neuro-developmental disease caused from a brain damage occurring in early phases of life, that interferes with the normal developmental events [10-12]: 1) seasonality of birth; 2) prenatal exposition to flu viruses and Toxoplasma gondii; 3) birth complications; 4) brain abnormalities on neuroimaging tools.

For a long time it has been known that individuals with schizophrenia are more likely to be born in the winter. Consistent data supporting this finding results from studies in Northern and Southern Hemispheres [13]. Despite that relative risk is small, on the order of 5-8% increase for those born in the winter versus summer, corresponding to a relative risk of 1.05-1.08, this datum has been replicated many times. One possible explanation is that mother is passing through the second trimester of her pregnancy in the height of flu season, and it is that infections during that period raise risk for schizophrenia in offspring. Another explanation was offered by a recent study carried out in a country with minimal seasonal weather change [14]. The fact that seasonality effect was found in patients with schizophrenia of a group likely to have increased genetic susceptibility suggests gene-environment interaction, perhaps in terms of epistasis between exogenous factors and maternal-inherited genes.

Recent data emphasize contribution of prenatal exposition to flu virus A and B in determining significant reduction of cognitive performances in children who will develop psychosis in adulthood [15]. Those data suggests a role of environmental factors that may act on fetal brain determining a loss of cognitive performances soon before onset of psychosis.

A meta-analytic review on birth complications acting on schizophrenia risk categorizes different types of birth complications involving I) complications of pregnancy (bleeding, diabetes, Rhesus incompatibility, preeclampsia), II) abnormal fetal growth and development (low birthweight, congenital malformations, reduced head circumference), and III) complications of delivery (uterine atony, asphyxia, emergency Cesarean section); overall risk for developing schizophrenia associated with obstetric complications were generally modest, less that 2.0 [16]. Nevertheless, recent data suggest only a modest association between prematurity, hypoxia, maternal infections and maternal behaviors and risk of the later development of schizophrenia after adjusting for a number of possible confounding factors [17].

Moreover, it has been emphasize that adverse events acting during pregnancy or delivery are associated with an increased risk to develop psychotic-like non-clinical symptoms (PLIKS) that regards 15% of population. Such an association is particularly relevant in case of maternal infectious diseases during pregnancy, gestational diabetes, need of neonatal cardio-pulmonary resuscitation, Apgard's index less than 5 [18].

Researches on infectious agents as possible cause of schizophrenia has become prominent in the past decade. *Toxoplasma gondii* has emerged as a prime candidate for a variety of reasons: I) individuals with schizophrenia, compared to controls, have been reported to have higher prevalence of antibodies to *Toxoplasma gondii*; II) some individuals with adult toxoplasmosis develop psychotic symptoms similar to those of schizophrenia; III) *Toxoplasma* has been shown to induce elevated levels of dopamine in experimentally infected animals; and IV) studies have shown that individuals with schizophrenia, compared to controls, have had greater exposure to cats in childhood [19-22].

Taken together, most studies seem to delineate that exogenous factors acting on brain structure during its developmental phase play an important role in etiopathogenetic of schizophrenia.

## Low IQ

Considering childhood developmental abnormalities, many long-term follow-up studies, both retrospective and prospective, suggest a variety of signs, symptoms, conditions and behaviors associated with raised risk for schizophrenia, but no study is strong enough as to be useful in prediction. Earlier report on high risk groups showed that offspring of schizophrenic parents were more likely to have lower IQ, poor attention skills, thought disorder-like symptoms, poor social adjustment and psychiatric symptoms compared to offspring of controls [23]. Although several concerns have been raised regarding generalization of high risk findings to non-familial forms of schizophrenia, recent longitudinal studies provided evidence that individuals with schizophrenia differ from their peers even in early childhood in several developmental markers, such as age of attaining developmental milestones, levels of cognitive functioning, educational achievement, neurological and motor development, social competence and psychological disturbances. Prospectively collected data from a birth cohort in New Zealand [24] showed that schizophrenic subjects should have suffered significant deficit in neuro-motoric, linguistic and cognitive development in the first decade of their lives. The authors say that the compelling evidence linking an array of childhood developmental abnormalities and schizophrenia echoes with the hypothesis that schizophrenia is a neurodevelopmental disorder.

Evidence also suggests that the association between low IQ is specific to schizophrenia as it was not found in bipolar disorder.

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## Paternal Age

First indication on a role of parental age was based upon the family background data of 1000 patients in the Ontario Hospital, Canada. Gregory [25] reported that parents of patients with schizophrenia were, on average, 2–3 years older than those of the general population.

More recently, several population-based epidemiological studies in Denmark [26], Israel [27], Sweden [28], France [29] and the United States [30] have provided stronger evidence on role of paternal age in schizophrenia. A population-based birth cohort study found that relative risk of schizophrenia is 2.96 in the group of fathers aged 55 or above at the time of offspring birth; once paternal age was accounted for statistically, maternal age no longer was a significant predictor of schizophrenia [31].

Current population-based cohort research tends to support that advancing paternal age-related increased risk of schizophrenia only appears significant among those without family history. Genetic mechanisms that could explain these association are been proposed, including accumulation of de novo mutations in paternal germ cells, trinucleotide repeats expansions, and alterations in genetic imprinting of one or several genes involved in neurodevelopment [31-33]. Using k-means clustering analysis, Lee *et al.* emphasize that paternal age related schizophrenia (PARS) cases differ phenotypically from other patients with schizophrenia in features including discrepancy in verbal and performance intelligence and, in female, in early age at onset [34].

Although definite biological explanation has not yet been done to explain the role of paternal-age, the findings strongly point toward biologically complex transmitted factor acting in developing embryonic nervous system.

## Autoimmune Diseases

The role of neuro-inflammation in schizophrenia has been an issue for long time. Association between schizophrenia and various inflammatory-autoimmune diseases has been reported in epidemiological surveys.

Several studies have shown that individuals with schizophrenia are somehow less likely to have rheumatoid arthritis [35]. However, while it could be that medications for schizophrenia are protective for rheumatoid arthritis in some unknown way, several studies were conducted prior to era of neuroleptic medications. A possible explanation is that a single gene raises risk for one disorder and protects for the other. It has been reported that mothers of individuals with schizophrenia have lower risk for rheumatoid arthritis, but the study is questionable for the small sample size.

Other immune disorders have been linked to schizophrenia, particularly autoimmune thyroiditis and celiac disease [36, 37]. A study from the Danish population registers, reported that persons whose parents had celiac disease were three times as likely to have schizophrenia [38]. Celiac disease is characterized by immune reaction to wheat gluten. One possible explanation is that increased permeability of intestine, raising level of antigen exposure, could increase risk of autoimmune response to brain components. It is also possible that gluten proteins are broken down into psychoactive peptides.

Various data suggest apparent abnormalities of immune system in schizophrenia, but it is not clear whether such those alterations are causal or merely consequent to schizophrenia itself or to the common treatments used in the disease. It can be hypothesized that a general weakness of immune system increased risk determined either by infections or by autoimmune disorders reported in individuals affected with schizophrenia [39].

Recently, a genome-wide microarray study in post-mortem brains of schizophrenia patients has explored expression profiling of immune-modulatory genes, showing that 23 genes were significantly down-regulated in Brodmann area 22 of left superior temporal cortex, supporting the hypothesis that in schizophrenia immune-related genes modifies synaptic functions and stability in a selected cortical area [40]. This study may offer an explanation for findings showing association between autoimmune disorders and schizophrenia and, considering the progressive nature of autoimmune diseases, seem to indicate that schizophrenia may arises from a progressive process of neurodegeneration. However, the study does not clarify if the observed down-regulation of immunomodulatory genes reflects secondary (or even terminal) neural changes to a primary immune response.

## Migration

The hypothesis that migration is a risk factor for schizophrenia has been accepted by many authors; however, there are not yet concordant theories about the role played by migration on development of the disease.

The first epidemiological evaluation of psychiatric disorders in immigrants dates back to more than seventy years ago [41], but the results obtained were limited due to methodological problems, such as the absence of standardized diagnostic criteria, structured interviews, and to investigations being carried out on the general population and not only on subjects who had been seen by psychiatrists. Moreover, it is impossible to consider "immigrants" as a homogeneous group concerning the risk of psychiatric disorders, due to variables as motivation to migration, distance for the host culture, ability to develop mediating structures, and legal (or illegal) residential status [42].

In Europe, the issue about increasing risk of schizophrenia in immigrants was studied by several authors. The interest in migration as putative risk factor for schizophrenia was generated by data showing that persons of African-Caribbean origin migrating in UK have an incidence rate 2.5–14.6-fold higher compared to native people [43]. Following this initial report, high incidence rates have also been reported for persons of Surinamese, hospital admission, found that five and second generation immigrants have an increased risk for severe psychiatric disorders compared to natives. The role of ethnic factors in the risk of Dutch Antillean and Moroccan background migrating in the Netherlands [44, 45] and for all migrants in Denmark [46]. It can be underlined that incidence peak appears 10-12 years after migration and that rate of schizophrenia is high also in the second-generation migrants [47]. In one of the first longitudinal studies, Hjern and colleagues [48], analyzed incidence rates of first schizophrenia was underlined in a study carried out in Malmo [49], which confirmed that migrants had increased risk for schizophrenia compared to natives, but the risk was markedly increased in immigrants of East Africa.

Various hypotheses have been formulated in order to explain role of migration in development of the disease, but at present there are no firm data in favor of one specific theory.

It has been believed that the rate of schizophrenia was high in original Countries of migrants. There are few studies regarding rate of schizophrenia in the original Countries before 1990 [50]; after this period, the Determinants of Outcome in Severe Mental Illness (DOSMD) study demonstrated that in the original Countries rate of schizophrenia was less than in migrating populations, suggesting that biological vulnerability to stress is not sufficient to explain the high rate of schizophrenia in these social groups [51].

According to the "selective migration" theory, individuals affected with schizophrenia are more predisposed to migrate [41]. Despite this hypothesis is fascinating, it conflicts with data from meta-analyses on population-based studies, that show that risk of schizophrenia was higher in second- than in first-generation migrants [52]. Moreover, migration itself and the consequent stress may be difficult to be tolerated in individual affected with schizophrenia [53]. Together, it is difficult to refute the hypothesis that a single biological factor can adequately explain increased risk for schizophrenia in migrants. Socio-environmental elements, acting in concert with genetic factors, may contribute to explain the particular liability of migrant populations to the disease [54].

In the meta-analysis of Cantor-Graae and Selten [52], migrants whose skin color is considerably darker than the background population were reported to have a relative risk of schizophrenia of 4.8. Migrants in general, and specifically whose with dark skin, may be more subject to the effect of poverty and discrimination, particularly in countries where racism is present either individually or institutionally. However, a higher risk for schizophrenia has not been found in Turkish migrants to the Netherlands, despite the fact that Turkish migrants had lower socioeconomic conditions than Surinamese migrants, whose relative risk is high [44, 45]. It has been demonstrated that risk of develop schizophrenia increases when size of migrants in the country of migration is small, while risk is lower in great communities of migrants belonging from the same country [55]. These data reinforce the hypothesis that isolation and lack of social support are determinant factors in the pathogenesis of schizophrenia [56].

However, it can be hypothesized that migrants have a genetic susceptibility to environmental factors present in countries of migration (such as pollution, pathogens, allergens, etc.), absent or rare in the original countries. This hypothesis can put together genetic theory and the role of environmental stressors [57].

Misdiagnosis can explain the high incidence rate of schizophrenia observed in African-Caribbean people; however, misdiagnosis cannot be the unique explanation for this finding. Diagnostic criteria and standard definition of schizophrenia reduce diagnostic errors; thus, using the same criteria also in original countries an overestimate of the disease should be observed [58, 59].

In conclusion, there is no agreement between various authors and the role of migration is still an enigma: it is likely that liability to schizophrenia in migrants may arise from biological factors acting in individuals/ethnic groups genetically predisposed to the disease. These findings could indicate a mixed action of a precocious inherited neurodevelopmental alterations and subsequent environmental-driven neurodegenerative processes in schizophrenia pathogenesis.

## Addiction

Many abuse drugs have been related to onset of schizophrenia. Use of D-amphetamine and of cannabis (both acting on dopaminergic system) during adolescence can contribute to subsequent onset of schizophrenia or to an increase of psychotic symptoms in schizophrenic individuals. However, abuse drugs such as lysergic acid diethylamide (LSD) and psilocybin, acting on serotoninergic system, or dissociative anesthetics, such as ketamine and phencyclidine, acting on glutamate-related system, can equally cause psychotic symptoms. This suggests that dopaminergic imbalance cannot be the only responsible of schizophrenia development, as demonstrated by antipsychotic action of drugs commonly used in treatment of schizophrenia, as clozapine and olanzapine, both having antagonistic 5HT2 action higher compared to D2 action.

Moreover, there are numerous case-control studies showing that persons with schizophrenia are more likely to have taken, or be using, cannabis [60]. Recently there have been prospective studies in Sweden [61], the Netherlands [62], New Zealand [63], and Israel [64] showing higher risk, ranging from 2 to as high as 25, for cannabis smokers. It could be that individuals in the premorbid phase of schizophrenia are responding to initial, mild symptoms of schizophrenia by using drugs. On the other hand, it could be that cannabis precipitates, or even causes, an episode of schizophrenia.

This concept may be explained by a recent cohort study on patients indicating an association with a polymorphism of COMT, involved in dopamine regulation and related to negative symptoms, associated with drug use and young age at onset [65].

Together, data on drug abuse do not aid in clarify if schizophrenia arises from a neurodevelopmental or a neurodegenerative process; however, carriers of several genetic variants taking substances acting on neurotransmitters may be a population particularly prone to schizophrenia. Identification trough biomarkers of such persons can aid in understanding biological relevant pathways of the disease.

## Urbanicity

In the 1930's Farris and Dunham [66] showed that, while the addresses of first admissions for manic depressive illness were distributed more or less randomly throughout Chicago, admissions for schizophrenia tended to come from the center of the city, with decreasing rates as one moves outward into zones of transition, working class, and family. This finding, and other similar findings, was interpreted as due to the selection into the city of individuals who would develop schizophrenia.

Later studies from Europe provides persuasive evidence that risk for schizophrenia increases with urban birth and/or upbringing, especially among males. This studies concern the meta-analysis of Kelly about DSMIII incidence studies and are designed in a strictly prospective way [67], with the cohort defined in late adolescence, well prior to onset, or even at birth. Yet, urbanicity exerts its influence only in childhood and adolescence, not in adulthood (it may indicate that it's necessary a long, continuous or repeated exposure at the environmental factors) [68, 69] and the association between urbanicity and schizophrenia is higher in the more recent cohort studies (so, the impact of urbanicity increases with time) [70, 71]. The mechanism of association is unclear, but it may be related to biological or social/environmental factors or both, acting considerably before psychotic symptoms manifest. There are different potential candidates, including air pollution, cannabis and social exclusion [72]. Urbanicity may have a synergistic effect with genetic vulnerability [73]. Future researches are likely to focus on the relationship between urbanicity and neural aberrant development to explain the possibility of rural protective factors.

## Social Class

There are two hypotheses trying to explaining the strong association observed between low social class and schizophrenia. According to the first one, poor environmental conditions of underdeveloped areas, such as infectious agents, unemployment, poor quality of maternal and obstetrician care, psychosocial stress, can be breaking factors for disease onset.

Second hypothesis, now more quoted, is called the "selection-drift hypothesis". It focuses on the high morbility rate observed in poor economic groups, resulting from social drift process as consequence of low social and working level due to the progressive and deteriorating nature of schizophrenia [74]. This process, together with larger frequency of schizophrenia in following generations, could explain social selection toward bottom and thus the presence of high number of affected individuals in the more poor socio-economic classes. Moreover, decline of performances in job and employment was reported to occur after diagnosis [75], related to the difficult to return to previous pre-morbidity functional conditions.

Apparently, these data point towards a role of degenerative process driven by socioeconomics factors as determinant of schizophrenia. However, well-known data from child psychology studies have clearly demonstrated that poverty, malnutrition, poor maternal and obstetrician care are key determinants in the proper neural development of child.

## Genetics

Schizophrenia is considered a complex genetic disorder, resulting from a combined effect of environmental factors and more genes, each with small effect on the individual's phenotype. The main foundation for the search of molecular genetic risk arises from the twin and adoption studies. Genetic weight in schizophrenia, like in other complex disorder, starts from familial studies establishing the relative risk observed in relatives of affected compared to the risk observed in general population, called $\lambda$; the relative risk of siblings having a proband with the illness is called $\lambda_s$. This value is about 10 in schizophrenia. It is common observation in complex diseases that the relative risk to a relative of an affected proband decays much more rapidly than the proportion of genes shared between them. However, the majority of schizophrenic cases are sporadic, due to the polygenic inheritance model: for a disease with a prevalence of 1% and 90% heritability, more sporadic than familial cases are expected [76].

Inheritance of the disease is confirmed by incidence and prevalence studies in monozygotic and dizygotic twins of schizophrenic patients. These studies demonstrate 60-70% of concordance in monozygotic twins, while concordance rate in dizygotic twins is not different from concordance observed in siblings [77, 78]. The risk of schizophrenia is similar for offspring of both affected and unaffected monozygotic twins, suggesting an inheritable genetic background in risk of schizophrenia without expressing the disease [79, 80]. These data, together with lack of total concordance in monozygotic twins, indicates that epigenetic or not-shared environmental factors, (or both), play a role in pathogenesis of the disease. Studies on adopted "high risk" subjects (as offspring of schizophrenic mothers) demonstrated that to grow up in an adoptive family do not reduce risk to develop the disease [81]. Concordance rate in twins grown up apart is similar to that found in couples of twins grown up together.

Candidate gene studies, which focus on genes potentially involved in a disease, have been a key approach to the genetic of schizophrenia. However, results of these studies are often confusing and no gene has unequivocally been implicated. Candidate gene studies explore linkage or association between the disease and several markers of genes known to codify proteins involved in mechanisms hypothesized in etiopathogenetic of the disorder. Hyperactive dopaminergic signal transduction in the central nervous system has been suggested in the pathophysiology of schizophrenia (dopamine hypothesis). Thus, several studies focused on genes coding for dopamine receptors. The Ser311Cys polymorphism of the dopamine $D_2$-receptor gene has been associated with schizophrenia, particularly in patients without negative symptoms and the association was confirmed by three meta-analyses over 20 published studies [82].

Further applications of genetic research in comprehension of schizophrenia come from data on functional polymorphism Val108 /105 Met of COMT gene. The Val/Met polymorphism results respectively in high and low activity form of COMT, a catabolic enzyme involved in the degradation of a number of bioactive molecules, including dopamine. COMT gene, located in 22q11 chromosome, when deleted results in a complex syndrome that includes schizophrenia. The Val/Met polymorphism has become the most widely studied polymorphism in psychiatry, with data for and against the involvement of COMT in schizophrenia [83]. Some data suggest that the Val allele of COMT, increasing dopamine catabolism, reduces prefrontal cortex physiological activity and cognitive performances [84]. Moreover, according to a recent study, Val158Met COMT polymorphism could interact with use of cannabis in modulating risk to develop the disorder [85].

Large genome-wide linkage studies, mainly performed in the last 10 years, resulted in evidence of linkage in various chromosomal regions, as at 8p23.3-p21.2 and 11p13.1-q14.1 [86], at 18p11.32, 6 and 14 [87]. Some recent studies of association and linkage in schizophrenic populations emphasize several susceptibility genes, focusing on loci at 8p and 22q chromosomes [88, 89]. In total, 12 chromosomal regions containing 2181 known genes and 9 specific genes involved in etiology of schizophrenia have been reported. Biological markers related to variations/polymorphisms of such genes include variation in normal expression of proteins involved in neuronal and glial precocious migration, in nervous cell proliferation, in axonal growth, in synaptogenesis and in apoptosis. However, despite the high number of genes involved, up to now there is not univocal and replicable association in all studies.

The completion of Human Genome Project and the "HapMap" project led to genome-wide scans based on hundreds of thousands of single nucleotide polymorphisms (SNP), that are common genetic variants in the human populations. All findings are "data-driven" rather than "hypothesis-driven", as in the candidate-gene approach, and required many thousands samples and powerful statistical methods. These studies provided molecular evidence for a substantial polygenic component to the risk of psychiatric diseases involving thousands of common alleles, each with very small effect. A meta-analysis of results from the International Schizophrenia Consortium (ISC) compared the genome wide association study (GWAS) method to the hypothesis-driven candidate genes approach, showing that GWAS had 89% of power to detect genetic effects [90]. Collectively, ICS concluded that thousands of common polygenic variants with very small individual effects explain about one-third of the total variation in genetic liability to schizophrenia [91]. A recent large GWAS study reported genetic variations in a region on chromosome 11, containing several candidate genes. Interestingly, in a subsequent imaging study, the authors found that healthy carriers of the risk allele showed altered activation in the cingulated cortex during a cognitive control task [92].

The candidate approach and the GWAS method are not mutually exclusive. Indeed, using a custom-array of 1,536 SNPs to interrogate 94 candidate genes in over 500 subjects, an association with endophenotypes was observed for 46 genes of potential functional significance and supporting a role for glutamate signaling in susceptibility to schizophrenia [93]. Using SNP-based linkage scan strong evidence for linkage in a region of chromosome 8p21 was showed [94], confirmed by another study based on linkage and family-based association and replicated with an independent case-control association study [95]. Other studies focused on copy number variants (CNVs) that are stretches of genomic deletions and duplications likely to have larger phenotypic effect than SNPs. A recent study evaluated previously reported association with CNVs found in the Molecular Genetics of Schizophrenia study. Combined with other data sets, the analysis confirmed deletions in five previously reported regions, including 22q11.2 deletion, and found new evidence for other CNVs [96].

It is conceivable that mutations associated with schizophrenia are different in small isolated populations and large outbred populations. In a pilot study carried out on a small sample in Sardinia [97], one of the authors of this report founded a genotype pattern (rs1360382 on chromosome 9 and rs1303 on chromosome 14) that was highly predictive of schizophrenia, while it was not implicated in none of the recently published large studies [98, 99].

Despite genetic discoveries accumulate, delineation of biological pathways involved in pathophysiology of schizophrenia and consequent development of new therapies is still in its infancy. Together with the application of new tools, insight in mechanism involved in gene-gene interaction and in environmental impact on gene expression (epigenetics) (as exploration of methylation pattern, imprinting and other genetic machineries) can aid to better understand the inheritance of schizophrenia.

## Stress

In individuals with predisposition to psychosis and inadequate social support, stress may be a trigger factor [100]; moreover, a relationship between environmental stressors and seriousness psychotic symptoms has been described.

Since the 70$^{th}$, in long-term outcome studies of schizophrenia, Bleuler [101], Harding *et al* [102], Ciompi [103] and others reported that a majority of patients may recover. Ciompi proposed a complex bio-psycho-social view of schizophrenia [104] based upon the vulnerability-stress model [105]. According to this model, certain preexisting, enduring vulnerability characteristics of the individual interact with stressful stimuli to produce transient intermediate states of processing capacity overload, autonomic hyper arousal, and impaired processing of social stimuli, before the onset of psychosis. These intermediate states increase the level and the frequency of the environmental stressors by causing breaking off in the patient's family and social environment. The feedback loop leads to more extreme processing capacity overload, autonomic hyper arousal, and deficit on processing social stimuli, until the individual's threshold point for the development of psychotic symptoms [106]. Stressful life events, that are independent of the direct effects of the disorder, may play a precipitating role in the onset of, at least, some acute psychotic episodes. Increased numbers of such events are founded to be present in the 3 to 5 weeks before psychotic episode onset [107, 108].

Recently, it was supposed that a deregulation by the ventral subiculum of the hippocampus, determined by stress or drug abuse, may lead to an overdrive to the dopamine system, causing psychotic events [109, 110].

As in the case of drug abuse, stress could act as a risk factor in specific biologically vulnerable individuals. However, findings on stress do not add data for or against either the neurodevelopmental or the degenerative hypothesis.

### Family Milieu

Many researches in 80$^{th}$ have been directed to one of the stressor condition, a critical or emotional involved family climate, termed "high expressed emotion" in the early British study [111]. The findings of a Goldstein's longitudinal study [112] indicated a correlation between certain family stress factors and the subsequent probability of schizophrenia or related disorders in an offspring. Various studies had support the view that a negative affective climate in the family is predictive of relapse in a patient-relative in the short term [113, 114].

The "double link" theory hypothesizes that in families of schizophrenic patients anomalous communication pattern is presents. In such disturbed communication nothing is clearly declared, but a thing is affirmed and after denied or affirmed with words and denied by communicative not-verbal formalities.

A determinant role in breaking psychosis, particularly in symptomatic relapses, seems to play the emotional familiar climate [115]. After neuroleptic drugs introduction, the majority of psychiatric patients came back to live in their own social milieu. More symptomatic relapses were evident in these patients compared to subjects who did not live with their own families; in particular, families characterized by high emotional background seem to facilitate relapses [116].

Overall, these studies indicate that familiar milieu and altered social relationships can contribute to the progressive go on of the illness.

Go to:

## COURSE

### Onset

In the classic long-term follow-up study of Ciompi, about 50% of schizophrenic persons had an acute onset, and 50% a long prodromal phase [103].

The historical study of Hafner suggests that the onset of negative symptoms tends to occur about five years before the initial psychotic episode, with onset of positive symptoms much closer to first hospitalization [117]. Many researchers of the past, as Kraepelin and Bleuler, have observed that schizophrenic individuals showed before the onset of illness a distinctive premorbid personality. Cutting [118] showed the presence of premorbid schizoid personality in 25% of schizophrenic individuals, and other personality disorders in almost 15%. Another study [119] showed that 35% of schizophrenic individuals met DSM-IV diagnostic criteria for personality disorders during premorbid phase; 44% of them were represented by schizoid personality disorder. Premorbid explosive and paranoid traits are commoner in patients with schizophrenia than in patients with other non-organic psychosis, and may shape the expression of symptoms during an illness episode [120]. A more recent longitudinal study [121] of an unselected general community population showed that "paranoid-schizotypal" traits was significantly associated with subsequent onset of both non-affective and affective psychosis; when schizophrenia was analyzed separately, these traits did not remained significant.

Epidemiological literature, since few years ago, has reported a peak of onset in males between 15 and 25 years of age and for females between 25 and 35 years of age, with a strong difference in sex ratio starting at 15 years of age. Yet, it's difficult to compare the data mentioned above with the last researches, due to the selection of the cohort subjects using different diagnostic criteria in comparison with the present criteria.

More recent studies confirm difference of onset in both sexes, but in males the peak is delayed about 2 years from what was previously though.

The recent meta-analysis on previous studies seems to confirm that the peak in males is before that in females, but it is later than previously believed [122].

Crow [123] starting from epidemiological data regarding sex difference in age of onset of schizophrenia, premorbid precursors and outcome, proposed an evolutionary mechanism of sexual selection acting to retain different ranges of variation of the Xq21.3/Yp11.2 homology block that was established by an X to Y duplication 6 million years ago. This duplication and its subsequent modification on the Y may have played a central role in the evolution of the language, distinguishing the Homo sapiens from its precursors. The expression of genes within the homologous region is influenced by the extent to which the X and Y chromosomes pair during male meiosis, and this mechanism generates epigenetic diversity relating to the species capacity for language, but it may been related to a genetic predisposition to psychosis. Moreover, the same author and colleagues [124] proposed that this gene could be the principal determinant of the brain growth, explaining the anomalies of brain development (i.e. ventricular enlargement, reduction of total cortical mass and loss of asymmetry) reported in adolescents with diagnosis of schizophrenia.

All together, the core of researches reporting differences in gender and age at onset seem to point towards a role of precocious neurobiological determinants in the onset of the disease.

### Course and Outcome

In Ciompi's classic study [103] about half of schizophrenic patients had an undulating course, with partial or full remissions followed by recurrences, in an unpredictable pattern. About one-third had relatively chronic, unremitting course with poor outcome. In that study a minority of patients had a steady pattern of recovery with good outcome.

Follow-up studies, which are not strictly prospective, such as the Ciompi's one, can be deceptive, because there is a tendency to focus on residue of chronic cases, making the disorder to appear more chronic than it actually is.

Studies on discharge indicated that about 20% of patients don't require re-admission, many years after discharge. Between these studies, the Danish one [125] is particularly interesting because the sample size and the long follow-up. Following the first discharge, 20% of the surviving patients had not been readmitted after 10 years of follow-up. Readmission risk increased with the number of previous admissions. At the first discharge, readmission risk decreased with increasing age and it was significantly predicted by clinical subtype and gender. Effect of these variables gradually disappeared at later discharges. At the 15th discharge, readmissions were mainly predicted by duration of the latest admission and discharge periods. Data supported the existence of a smaller subpopulation among schizophrenic patients with frequent relapses.

Females show good course and outcome compared to males: collected data indicate lower proportion of females remaining with psychotic symptoms over time from onset compared to males.

A hypothesis of a possible role of estrogen or, more in general, of neuro-active steroids was suggested, both concerning course and outcome and age at onset [126, 127], but no systematic studies were carried out on this topic.

A not alternative hypothesis is that the different age at onset (earlier for males) may influence the course.

It may also be true that social outcome differs by sex. For example, percentage of married females is higher than married males.

There is variation in course of schizophrenia around the world, with better prognosis in so-called "developing" Countries. A summary of data from the WHO study on this issue shows that individuals with schizophrenia in developing Countries are less likely to have been chronically psychotic over the period of follow-up and more likely to have no residual symptoms after five years [128].This result remains to be explained. It could be that individuals meeting criteria for schizophrenia in developing countries include a subset destined for better prognosis because of the risk factor structured in those countries- more deaths of compromised fetuses, for example- or cause connected to good prognosis, such as a parasite psychosis like schizophrenia which is rare in developed countries. Another interpretation is that the environment of recovery in developed world is more pernicious, involving harsher economic competition, greater degree of stigma and smaller family networks who can share the burden of care for persons with schizophrenia [129]. Moreover, also skills requested in developing countries may differ.

## Course and Progressive Hypothetical Cognitive Deficit

Many psychiatrists believe that the course of schizophrenia evolves toward cognitive deficit or, at least, to residual symptoms.

Emil Kraepelin (1856/1926) was the first to suppose an "organic" nature of schizophrenia, and he also suggested that core feature of the illness is the cognitive impairment, so he defined schizophrenia *dementia praecox*, and characterized it as dysfunction in what today we call "executive function", such volition and will.

Although this promising beginning, in the first half and in the early second half of 20th century the interest of researchers focused on effort to demonstrate a psychogenic cause of schizophrenia, with results sometimes at least debatable. Even in 1960th, some researchers interpreted deficit performance in neuropsychological tests by schizophrenic patients as weakness correlated with psychotic symptoms and social problems, rather than reflecting true neurocognitive impairment.

Finally, in the last quarter of 20th century, although role of psychosocial stressors was still recognized, the researchers accepted the fact that schizophrenia is fundamentally a brain disorder, and that it is characterized to diffuse neurocognitive deficits toward most cognitive domains.

Literature on course of schizophrenia seems to produce evidences that a percentage of patients with schizophrenia may have a good outcome, so this literature seems to indirectly refute concept of a progressive, ineluctable cognitive impairment in schizophrenia. In fact, while cognitive impairment is present in most, if not all, schizophrenic patients, there is both inter-patient heterogeneity and within-patient stability of cognitive function over the long-term course of the illness. Neuropsychological studies in the recent past established the primacy of cognitive functions over psychopathological symptoms as determinants of functional outcome and independence in everyday skills.

In a paper published by the group of Dumfries University, Morrison and colleagues [130] say that cognitive impairment can be found in the majority of patients with schizophrenia and it is a strong predictor of eventual social and functional outcome, but the published researches examining long-term course of impairment are inconsistent. Cross-sectional studies provided evidences both for and against progressive deterioration, but these studies are vulnerable to cohort effects producing differences not due to within-individual changes. More recently, well-designed longitudinal studies again produced conflicting results with some supporting the notion of progressive decline and others refuting it.

Morrison and colleagues [130] examined course of schizophrenic cognitive impairment over a period of, on average, 33 years. Participants with schizophrenia were found to show impairment in verbal and non-verbal intelligence at baseline compared with estimated premorbid scores, not found in control group. At follow-up there was a significant decline in non-verbal intelligence over time in participants with schizophrenia compared with controls. This differential change over time was not seen in verbal intelligence. This is in direct contradiction with the longitudinal studies of Gold [131] and Hoff [132] but it is in agreement with a more recent 10-years study showing progressive visual-spatial impairment [133]. These results also suggest that cognitive decline is not global, not resembling a true dementia, but instead affects specific areas of cognition and may thus reflect pathological changes in certain areas of the brain or brain systems involved in visual-spatial problem solving and fluid components of intelligence, as showed by administering visual-spatial processing test [134].

A recent address of research is focused to establish if cognitive impairment in schizophrenia is present in childhood and if it remains stable in adulthood (developmental deficit hypothesis), or if children who develop schizophrenia in adulthood fall behind their peers (developmental lag hypothesis), or even if they have a cognitive decline only immediately before the onset of the disease or as a result of the same (neurodegenerative hypothesis). Apparently, the first hypothesis seems to be more possible than the second and the third one, as confirmed by a vast amount of evidences.

In a recent cohort study [135], Reichenberg and colleagues have evidenced that those children who develop schizophrenia in adulthood showed cognitive impairments that rose early and remained stable. Those deficits concern acquisition of verbal and visual-spatial capacities on tests processing, reasoning and conceptualizing skills; moreover, those children show a lag regard processing speed, attention, problem solving on visual-spatial problems and regard working memory.

Results of two meta-analytic reviews of studies documenting pre-morbid IQ among persons who subsequently developed schizophrenia suggest the presence of at least a mild pre-morbid cognitive deficit, with an average score of 90 to 95. But there was no evidence of age-related decline in IQ during pre-morbid period and there was no difference in the pattern of intellectual skills when considered in terms of Verbal versus Performance IQ [136, 137].

Seidman and colleagues examined changes in IQ of persons with schizophrenia when they were aged 7 years-old and again about 28 years later in Seidman and colleagues examined changes in IQ of person with schizophrenia when they were 7 years-old and again about 28 years later. The researchers showed that persons who developed schizophrenia had lower QI scores when tested as children relatively to non-schizophrenic peers; moreover, schizophrenic patients showed decline of, on average, 10 QI points [138].

Contrary to Kraepelin's suggestion that dementia praecox is characterized by a progressive decline in neurocognitive function, longitudinal and cross-sectional studies of non-institutionalized outpatients with schizophrenia demonstrate stable cognitive deficits after illness onset [139-141]. A possible exception to evidence of stability of cognitive functions in schizophrenia may be considered the case of older schizophrenic patients with a long-time experience of institutionalization [142, 143]. It has long been suggested that there may be a subgroup of patients with schizophrenia, who show a progressively deteriorating course conforming to the Kraepelin's views, termed "Kraepelinian". The Kraepelinian patients are characterized by severe dysfunctions in self-care [144, 145], disturbance in premorbid sociosexual functioning [146], more severe negative symptoms and formal though disorder [147], lower association with affective symptoms [148], extensive family history of schizophrenia spectrum disorders [145], resistance to antipsychotic treatments [144], early age of onset [149]. Decline in overall cognitive functions in those patients seems in fact greater than that which can be attributed to normal aging and it doesn't seem to be attributable to a co-morbid neurodegenerative disease [150]. However, it appears difficult to establish if neurocognitive impairment in long-term institutionalized schizophrenic patients is a featured entity or if it is due to the chronic institutionalization itself. A recent longitudinal study [151] examined a sample of schizophrenic older outpatients that experienced a history of long-term institutionalization, to address the question of environmental role influence or patient individual features regarding neurocognitive impairment and functional outcome. This research suggests that people with schizophrenia with history of institutional stay show evidence of differential declines in ability to perform everyday living skills over 3 to 4 years follow-up period, but cognitive performance did not show evidence of either decline in previously institutionalized outpatients or improvement in individuals without history of institutionalization.

One of the myths regarding cognitive impairment of schizophrenia individuals is the cognitive benefits of second generation antipsychotic medications in comparison with conventional neuroleptics. The most important investigation on cognitive effect of antipsychotic medications was provided by the NIMH-sponsored Clinical Antipsychotic Trials of Intervention Effectiveness (CATIE) schizophrenia study [152]. The CATIE Trial analyzed the cognitive effectiveness of antipsychotic drugs, both conventional neuroleptic (perphenazina) and second generation antipsychotics (olanzapine, quetiapine, risperidone and ziprasidone). There was a significant improvement in cognitive performances within each of the treatment groups, without significant differences in terms of change in any specific cognitive domains. Nevertheless, group treated with conventional neuroleptic showed unexpected greater improvement of cognitive performances than did those randomized to second generation antipsychotics.

As mentioned above, not all patients with schizophrenia show cognitive impairment, and they appear to be neuropsychologically normal. Most of neuropsychological researches about neurocognitive impairment in schizophrenia show a significant but modest association between severity of cognitive deficits and negative symptoms, and none association between cognitive deficits and positive symptoms [153]. Moreover, neuropsychologically normal schizophrenic patients, relative to neuropsychologically impaired ones, show significantly less negative symptoms and extrapyramidal symptoms, have more frequent social contacts, and are less likely to have had no psychiatric hospitalization in year preceding evaluation [154]. The neuropsychologically impaired patients also have worse mean scores on global assessment of psychosocial functioning, lower proportion of paranoid subtype, earlier age of onset and longer duration of disease [155]. Furthermore, a recent research focusing on difference between neuropsychologically normal versus neuropsychologically impaired schizophrenia groups, in reference of functional status, shows no difference in severity of psychopathology, but neuropsychologically normal patients have better scores on measure of social competence and functional capacity and they are more likely to have independent status [156-158].

## Course and Treatment with Regard of Cognitive Impairment

Although the cognitive benefits of both conventional and even second generation antipsychotic drugs appear marginal, recognition of the importance of cognitive impairment as determinant of outcome in schizophrenia has focused actual efforts to develop targeted treatments for it. There are a growing number of studies showing that deficits in elementary neurocognitive function explain 20-60% of variance studies of ability to solve interpersonal problems, social function and measures of skill acquisition in rehabilitation programs, and cognitive deficits are more closely linked to functional outcome than are psychiatric symptoms.

Neurocognitive impairment in schizophrenia patients is treated with cognitive remediation, rehabilitation programs derived from cognitive-behavioral therapy methods, focused on improvement on vigilance and attention deficit, working memory capability, verbal and non-verbal learning memory, processing speed and language. A recent meta-analytic research [159] shows durable effects on global cognition and functioning, while symptoms improvement is small and transient. According to other two meta-analysis [160, 161], the effect of cognitive remediation is emphasized when it is combined with other psychiatric rehabilitation to improving functional outcomes.

While cognitive outcome of treatment is not associated to the methodology adopted (i.e. computer use, duration, type of approach, etc.), it seems to be connected with age, long-term illness and cognitive resources. A recent study [162] indicates that a broad cortical surface area and grey matter reserve is associated with accelerate social-cognitive responses to Cognitive Enhancement Therapy in earlier patients, while patients with less neurobiologic reserve obtain benefits of cognitive rehabilitation after a long treatment duration.

Many studies considered social cognition abilities as a target of rehabilitation interventions, according to the hypothesis that cognitive remediation would improve both cognitive and psycho-social outcomes. In reference to this, a large number of interventions are focused on social skills enhancement. Those rehabilitation approaches are generally based on psychoeducation and share many cognitive-behavioral tools; differences regard target symptom or problem that is attacked. Recently, a research [163] compared two of the rehabilitation therapies focusing on the improvement of neurocognitive and psychosocial outcomes, the Problem Solving Training and the Cognitive-Emotional Rehabilitation, showing that both approaches, based on structured methods to develop solutions to everyday life problems assigning at patient a central role of responsibility, should be effectives.

Vocational rehabilitation program utilizes work to improve symptoms, interpersonal relationships and cognitive functioning. A recent research [164] shows that vocational rehabilitation can improve negative and positive symptoms, though disturbances and paranoid ideation, contributing to enhance cognitive functions. Vocational rehabilitation required fewer economic and human resources to be applied, so it is useful method also in developing countries [164, 165]. Moreover, ability to obtain and to keep employment may help schizophrenic people to avoid stigmatization and auto-stigmatization that lead to emotional stress reaction and cognitive coping responses associated with social cognitive deficits [166].

## Role of Neuroimaging

Neuroimaging is an emergent tool in study of schizophrenia. Many studies start from proposition that schizophrenia arises as a consequence of both an "early developmental" disturbance, as well as "late developmental" changes. The most consistently replicated structural anomaly in brain of chronic schizophrenia individuals is ventricular enlargement, medial temporal lobe structures (i.e. amygdala, hippocampus, and para-hippocampal gyrus) and superior temporal gyrus abnormalities.

In favor of the early developmental changes thesis, longitudinal magnetic resonance imaging (MRI) findings in the ultra-high risk cohort of Melbourne showed excessive neuroanatomical changes in those who convert to psychosis, most prominently in medial temporal and prefrontal regions, indicating an accelerated loss of grey matter in patients compared to healthy controls [167]. Expansion of the ventricular system is particularly pronounced in patients with very poor outcome, and it was been proposed specific to this patient group, associate with cognitive deficits and progressive [168].

Volumetric study of grey matter in subjects with 22q11.2 deletion syndrome and schizophrenia showed a significant grey matter reduction in the Brodmann's area 22, again supporting a neurodevelopmental model of schizophrenia [169]. Studies that apply functional MRI (fMRI) [170] have helped to elucidate potential neural substrates of schizophrenia. Some studies assumed that signs and symptoms of the disease are due to a disordered circuitry within a critical brain region, while other assumed that a disordered connection between brain regions may explain the clinical characteristics of the schizophrenia. Data from functional brain imaging support both the hypotheses [171].

Go to:

## CONCLUSIONS

History of epidemiology of schizophrenia results long-dated and doubtful. Although a lot of steps forward are taken after the earlier studies carried out by Farris and Dunham, it doesn't exist an etiopathogenetic hypothesis shared between different schools of minds. Moreover, some of the consolidated beliefs are debated by later studies, i.e. data regarding prevalence of the disease or differences between sexes. New risk factors are considered, but the true association with schizophrenia is still uncertain. It cannot be definitively concluded for or against the neurodevelopmental or degenerative hypothesis, but efforts in understanding basis of schizophrenia must goes on. Indeed, to obtain firm data for or against one of the two hypotheses, or both, is not without relevance in planning treatments for schizophrenia patients. So, next efforts should be focused on getting ready a multifactorial etiopathogenetic model, considering the recent headways of medical genetics. Furthermore, a better knowledge of risk factors and their relative weights in the risk formulation could raise its positive predictive value in prevention and in the treatment of schizophrenia. It could also be useful in increasing the efficacy of first episode treatment aiming to limit the catastrophic effects that first episode could have to the functioning of people with schizophrenia. It seems that the majority of findings from the most recent researches confirmed the idea that schizophrenia arises *in primis* from a neurodevelopmental disorder and that subsequent symptomatology may be ameliorated using early survey in high risk subjects and precocious treatments in persons who manifested signs and symptoms of the disease. The neurodevelopmental hypothesis also appears the most convincing regard cognitive impairment in schizophrenia, and many researches demonstrated that schizophrenia is not a dementia praecox: in fact, cognitive deficits are stable in the course of illness, and they should improve thanks to cognitive remediation approaches.

Until now, rehabilitation programs move from the vulnerability-stress model. This model may be well adapted to the findings that proved the neurodevelopmental hypothesis: in fact, supposing an early deficit that go on stable during the life under favorable circumstances, it's possible think to rehabilitation models could influence functioning providing people with schizophrenia with integrate and complex strategies (as neuro-cognitive approaches, social skill training, cognitive-emotional training). This kind of intervention acts on the individual and micro-group coping skills, helping to resist to the environmental stress factors.

However, multiple cognitive impairments may represent important causes of psychosocial impairment, stigmatization, poor outcome in schizophrenic patients and, in a general sense, could have a negative impact on functioning in different daily life activities and life domains (social, vocational, and so on). So, cognitive deficits may represent target of randomized trials about neuropsychological rehabilitation in people with schizophrenia and, in general, the starting-point for further researches on schizophrenia. Cohort studies are necessary to defined the range of effectiveness and the outcome of single treatment or mixed treatments based on integration between different kind of rehabilitation approaches (devoted to people with schizophrenia and their families or social worlds) and to measure their influences in real life functioning and on the remediableness of schizophrenic cognitive deficits.

UNIT - I.

Preventive Rehabilitation

# Prevention or rehabilitation facilities

In terms of the Hospital statistics of the Federal Statistical Office:
Prevention or rehabilitation facilities are facilities according to Article 107, Section 2 SGB V, which serve inpatient treatment, in order to eliminate any deterioration of health which would probably lead to illness in a foreseeable time. Furthermore, they are facilities which serve inpatient treatment in order to counteract an endangerment of the healthy development of a child (preventive health care) or to cure a disease, to prevent its worsening or alleviate disease discomfort or to safeguard or to consolidate the treatment success achieved subsequent to hospital treatment, also with the objective of averting a threatening disability or nursing care needs, to eliminate them after occurrence, and to improve or to prevent a worsening (rehabilitation). The facilities must be under continuous specialist medical supervision and with the cooperation of specially trained staff they are set up to improve the state of health of the patients according to a medical treatment plan mainly by application of treatment including physiotherapy, kinesitherapy, speech therapy or work and occupational therapy and by other suitable means, including also mental and psychic influences. They are also set up to help the patients in the development of their own defence and healing forces and they are facilities in which the patients can be accommodated and looked after. The health insurances may commission medical services for preventive health care (medical treatment, pharmaceuticals, dressings, therapy facilities, aids and appliances, outpatient/inpatient preventive health care services) or services for medical rehabilitation including the therapeutic treatments after a stay in hospital (outpatient/inpatient rehabilitation), which demand an inpatient treatment, but not a stay in hospital, only in those preventive or rehabilitation facilities, with which a supply contract according to § 11 SGB V exists. Therefore it is necessary, that the preventive or rehabilitation facilities fulfil the abovementioned requirements. Besides hospitals preventive or rehabilitation units are survey units of the hospital statistics, to which survey sheets are sent. For the differentiation the definition of hospitals takes effect analogically. There are only differences in the aim of the facilities, which in this case is oriented to prevention and/or rehabilitation. In the Hospital statistics the facilities are differentiated into such with such without supply contract according to § 111 SGB V.

UNIT – I

## How are learning disabilities diagnosed?

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[1]:

- 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[3]:

- 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.[4]

### 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.[5]

### 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.[6]

UNIT – I

# What is a "functional diagnosis"?

Enter Keyw or

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.

*Victor Ibrahim, MD*

UNIT - I.
Primary and Secondary Disabilities

## Primary and secondary disabilities associated with Fetal Alcohol Spectrum Disorder

Prenatal exposure to alcohol can cause many abnormalities and disabilities that have lifelong physical, mental, behavioural, and social consequences. Researchers have classified the disabilities into two categories: primary and secondary (1).

**Primary disabilities** are defined as those that reflect the primary morphological and neuropsychological damages of Fetal Alcohol Spectrum Disorder. These disabilities include:

- facial dysmorphology
- growth retardation
- Central Nervous System neurodevelopmental abnormalities, with a complex pattern of behaviour or cognitive dysfunction

**Secondary disabilities** are those that appear later in life as a result of complications from undiagnosed or untreated primary disabilities. Examples of secondary disabilities include:

- mental health problems (90%)
- disruptive school experience (60%)
- trouble with law (60%)
- confinement (50%)
- inappropriate sexual behaviour (50%)
- alcohol/drug problems (30%)
- dependent living (80%)
- employment problems (80%)

Patients with fetal alcohol related abnormalities who demonstrated varying IQ scores were found to have similarities in impaired judgement and low adaptability.

## Benefits of early diagnosis

Early diagnosis with proper intervention may decrease the appearance and attenuate the course of the secondary disabilities. A diagnosis of full-blown Fetal Alcohol Syndrome before the age of 6, can help to prevent some secondary disabilities.

Because more than 90% of children with FASD have mental health problems, psychiatric assessment should always be considered when diagnosing FAS or ARND.

## References


1. Streissguth AP, Barr HM, Kogan J, Bookstein FL. *Understanding the Occurrence of Secondary Disabilities in Clients with Fetal Alcohol Syndrome (FAS) and Fetal Alcohol Effects (FAE)*. Final Report, Centers for Disease Control and Prevention Grant No. R04/CCR888515. August 1996.

UNIT - I .

## Contents: Handicapped vs Disabled



## Definitions

A **disability** is an inability to execute some class of movements, or pick up sensory information of some sort, or perform some cognitive function, that typical unimpaired humans are able to execute or pick up or perform. A disability may be physical, cognitive, mental, sensory, emotional, developmental or some combination of these. A **handicap** is an inability to accomplish something one might want to do, that most others around one are able to accomplish. For example, reading, walking, catching a ball, or communicating.

## The Relationship Between Disability and Handicap

The view of disability as a social construct holds that society assumes that everyone is a fully functioning, able-bodied person, which prevents the disabled from fully functioning in society, thereby *creating* disability. When systems are designed thoughtfully to accommodate the needs, challenges and varying degrees of ability of different people in society, people with disabilities can fully participate in (or use) these systems. One of the major goals of the disability rights movement is to raise awareness of how systems can (and should) be designed to serve all people, not just the majority of people who happen to have no significant impairments. For example, buildings and sidewalks that are designed to be wheelchair-accessible eliminate any handicap for people with physical disabilities (whether permanent or temporary). Closed captioning on TV lets people with hearing impairments to enjoy video programming.

### Sensory, Intellectual or other Neurological Differences

While physical disabilities are easy to identify and appreciate, mental disabilities require the same level of thought when designing systems. Examples include sensory processing challenges that make it hard for some people to stay in very noisy environments or areas with flashing or fluorescent lights. Some kids may have attention, communication or cognitive challenges that can be mitigated by providing extra time for taking their tests. These are all examples of ways in which systems can be designed to let people overcome their disability so it does not become a handicap.

## What is politically correct to say?

It is politically correct to say that a person has a disability and it's impolite to call someone handicapped.

UNIT - I - Rehabilitation Team.

# Who's on the Rehabilitation Team?

Working together in Physiotherapy at NRH (National Rehabilitation Hospital)

During your rehabilitation you will:

- Participate in treatment activities and education sessions.
- Develop your rehabilitation goals with the team.

## Your Team may include the following people

**Consultant in Rehabilitation Medicine**

- The Consultant in Rehabilitation Medicine is responsible for the overall treatment and coordination of your medical care while you are at the NRH
- Medical Registrars support the Medical Rehabilitation Consultants and with Senior House Doctors will provide your day to day medical care during your stay.
- Your Consultant may refer you to other Specialist Consultants, for example: Orthopaedics, Urology, Plastic Surgery, Radiology, or Psychiatry.

- Your medical team will liaise with your GP and referring Consultant regarding your care

**Liaison Service**

- The Liaison coordinators provide a link between the hospital, home, and your health care professionals.
- They act as your advocate and liaise with hospitals to assess and evaluate your readiness and suitability for admission to a Rehabilitation Programme at NRH and continue to link with you post discharge from NRH.

**Rehabilitation Nurse**

- Nursing staff provide care, support and encouragement throughout your stay and provide an important communication link with other members of the team
- Helps you practice what you are learning in therapies and teach you and your family how to handle your personal care
- Clinical Nurse Specialist in Sexuality is available to provide counselling to you and relevant others on the impact of your injury on sexuality.

**Health Care Assistant**

- The Health Care Assistant helps provide care and general assistance to you during your stay
- Assists you in doing certain daily tasks as you progress through your rehabilitation such as dressing, toileting, showering and feeding

**Medical Social Worker**

- Gives emotional support to you and your family
- Gives you and your family information you may need in the future about community agencies
- Helps you solve personal problems that may come up and assists you with discharge planning

**Physiotherapist**

Therapy services are scheduled weekly for each patient

- Helps you strengthen your muscles and use them to do daily activities
- Helps you learn breathing exercises that help you build your stamina and strength
- Sports and fitness, gym, and hydrotherapy programmes are provided by the physiotherapy department

**Respiratory Physiotherapist**

- Monitors the health of your lungs
- Gives you treatments to keep your lungs clear
- Assesses need for respiratory equipment

**Prosthetist & Orthotist**

- The Prosthetist/Orthotist produces and fits all artificial limbs, plastic cosmetic appliances and other prosthetic devices.
- Helps you learn to wear and use your prosthesis/orthosis correctly
- Provides follow-up care post discharge in the NRH clinics or regional clinics around the country

**Occupational Therapist (OT)**

- Helps you to regain skills used in daily living activities such as: dressing, eating, planning and writing.
- Helps you order equipment you will need such as bathing equipment, mobility aids or wheelchair
- Assesses your home, work, and/or school setting, and then suggests modifications that will make it easier for you to carry out normal daily activities

**Speech and Language Therapist**

- Assesses and treats all aspects of communication impairment

- Assesses and treats swallowing difficulties
- Helps with difficulties in remembering, talking, reading, writing, listening, and thinking

**Psychologist**

- Assists you and your family to come to terms with the effects of the difficulties you may experience as a result of your injury/illness
- Helps you identify your own resources and coping mechanisms for dealing with the effects of injury/illness
- Provides specialist neuropsychological assessment if you have sustained a brain injury

**Dietitian**

- Helps you manage your dietary needs
- Promotes healthy eating habits and provides education on how to stay healthy.

**Pastoral Care**

- Provides support and counselling on request
- Addresses your spiritual needs

UNIT- I

# Dance Therapist

Working as a dance therapist provides the opportunity to use movement to improve the lives of others. This career requires a love of dance and a strong desire to help others. Keep reading to discover some of the education and career options available.

## Inside Dance Therapist Careers

Dance therapists use movement to help clients improve emotional, mental and physical health. According to the American Dance Therapy Association (*www.adta.org*), they are trained to help others develop communication skills, reduce stress, boost self-esteem and overcome physical disabilities through movement. If this type of work interests you, take a look at the resources from *Study.com* offered below.

### Education Information

The American Dance Therapy Association (ADTA) recommends that aspiring dance therapists possess a strong dance background in addition to a liberal arts degree. As undergraduates, students can pursue degrees in psychology, dance, recreation therapy and other liberal arts or human services fields.

After earning a bachelor's degree, students can enroll in an ADTA-approved master's degree program in dance therapy. They take courses that may include counseling, body movement assessment, psychotherapy and movement therapy. A program might also include a supervised internship. There were six master's degree programs in the country that were approved by the ADTA as of March 2014. Students who already hold a master's or doctoral degree in a field related to human services can earn a master's degree in dance therapy by completing specific dance therapy courses and training.

Explore some of the schools and degree options related to this field by visiting these links.

- Schools for Dance Majors
- Dance Degree
- Recreation Therapy Schools
- Bachelor of Arts in Psychology

### Distance Learning Options

Prior to entering into a dance therapy program, you may be able to complete some or all of your prerequisite coursework without going to campus. Below you will find information about some of the online courses and degrees for students interested in studying liberal arts or human services fields before pursuing a dance therapy graduate program.

- Online B.A. in Psychology
- Counseling Psychology Online

- Recreational Therapy Online Options

## Career Options

Dance therapists aren't the only types of therapists who focus on movement. If you want to find out about more careers related to dance therapy, check out the following articles.

- Recreational Therapy Job Information
- Career in Physiotherapy
- Occupational Therapy Career
- Career Info for Psychology Bachelor's Degree Holders

## Certification Information

There are two different credentials offered by the Dance Movement Therapy Certification Board, Inc: the Registered Dance/Movement Therapist (R-DMT) credential and the more advanced Certified Dance/Movement Therapist (BC-DMT). A BC-DMT can provide training and work in private practice, while an R-DMT can work only in a clinical or educational setting and cannot provide training. To earn the BC-DMT, several thousands of hours of clinical experience are required.

## Employment Information

Dance therapists work in nursing homes, schools, hospitals, mental health facilities and counseling centers. They use their specialized skills to work with both groups and individuals. The U.S. Bureau of Labor Statistics (BLS) reported that jobs for all types of recreational therapists were expected to increase 13% from 2012-2022 (*www.bls.gov*). The mean earnings for recreational therapists, which includes dance therapists, were $45,520, based on 2013 BLS data. This salary is dependent upon the setting and location in which the therapist works.

UNIT I

# The role of music therapy in paediatric rehabilitation.

Kennelly J[1], Brien-Elliott K.

**Author information**

**Abstract**

Meeting the needs of the child in rehabilitation requires an interdisciplinary approach, whereby a variety of health care professionals are called upon to work together in planning and coordinating each patient's programme. The Registered music therapist is one of the allied health professionals who plays an integral role in this team approach. Music therapy is a recognized allied health profession, which is becoming acknowledged in the expanding world of health care as a therapy able to meet the expansive needs of the patient in rehabilitation. This article will present a literature review which advocates the role of music therapy in rehabilitation, with particular focus on the needs of the paediatric patient. Case vignettes will be used as further evidence to support the role of music therapy in this context, together with considerations for future research.

# PRINCIPLES OF REHABILITATION

## INTRODUCTION :

There are seven principles of rehabilitation.

Principles are the foundation upon which rehabilitation is based.

① Avoid Aggravation ② Timing ③ Compliance ④ Individualization ⑤ Specific sequencing ⑥ Intensity ⑦ Total patient.

① Avoid Aggravation :

It is important not to aggravate the injury during the rehabilitation process. Therapeutic exercise, if administered incorrectly or without good judgment, has the potential to exacerbate the injury, that is make it worse. The primary concern of the therapeutic exercise program is to advance in injured indivial gradually and steadily and to keep setbacks to a minimum.

② Timing :

The therapeutic exercise portion of the rehabilitation program should begin as soon as possible that is as soon as it can occur without causing aggravation. The sooner patients can begin the exercise portion of the rehabilitation program, the sooner they can return to full activity. Following injury, rest is sometimes necessary, but too much rest can actually be deterimental to recovery.

③ Compliance

Without a compliant patient, the rehabilitation program will not be successful. To ensure compliance, it is important to inform the patient of the content of the program and the expected course of rehabilitation. Patients are more compliant when they are better aware of the program they will be following, the work they will have to do, and the components of the rehabilitation process.

④ Individualization:

Each person responds differently to an injury and to the subsequent rehabilitation program. Expecting a patient to progress in the same way as the last patient you had with a similar injury will be frustrating for both you and the patient. It is first necessary to recognize that each person is different.

⑤ Specific sequencing:

A therapeutic exercise program should follow a specific sequence of events. This specific sequence is determined by the body's physiological healing response, and is briefly addressed in the

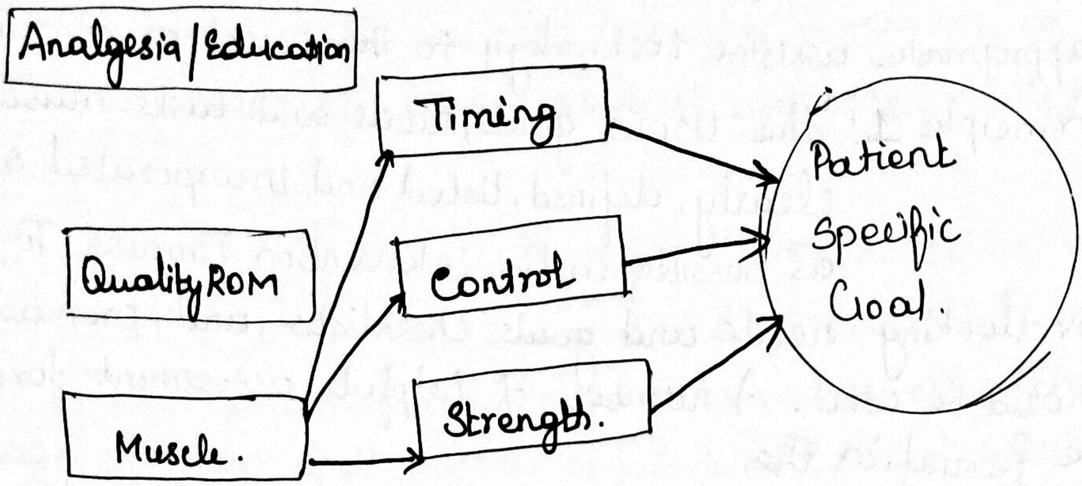
⑥ Intensity:

The intensity level of the therapeutic exercise program must challenge the patient and the injured area but at the same time must not cause aggravation. knowing when to increase intensity without overtaxing the injury requires observation of the patient's response and consideration of the healing process.

⑦ Total Patient:

Consider the total patient in the rehabilitation process. It is important for the unaffected areas of the body to stay finely tuned. This means keeping the cardiovascular system at a preinjury level and maintaining range of motion, strength, coordination, and muscle endurance of the uninjured limbs and joints. The total patient must be ready for return to normal activity.

# REHABILITATION PRINCIPLES




## PRINCIPLES OF ASSISTIVE TECHNOLOGY ASSESSMENT

Rehabilitation engineers not only need to know the Physical principles that govern their designs, but they also must adhere to some key principles that govern the application of technology for people with disabilities.

To be successful, the needs, preferences, abilities, limitations, and even environment of the individual seeking the assistive technology must be carefully considered.

There are at least five major misconceptions that exist in the field of assistive technology.

1. Assistive technology can solve all the problems.
2. Persons with the same disability need the same assistive devices.
3. Assistive technology is necessarily complicated and expensive.
4. Assistive technology prescriptions are always accurate and optimal.
5. Assistive tecnology will always be used.

In addition to avoiding common misconceptions, a rehabilitation engineer and technologist should follow several principles that have proven to be helpful in matching appropriate assistive technology to the person or consumer.

Principle 1: The user's goals, needs, and tasks must be clearly, defined, listed and incorporated as early as possible in the intervention process. To avoid overlooking needs and goals, checklists and premade forms should be used. A number of helpful assessment forms can be found. ~~in the~~

Principle 2: Involvement of rehabilitation professionals with differing skills and know-how will maximize the probability for a successful outcome. Depending on the purpose and environment in which the assistive technology device will be used, a number of professionals should participate in the process of matching technology to a person's needs.

Principle 3: The user's preferences, cognitive and physical abilities and limitations, living situation, tolerance for technology, and probable changes in the future must be throughly assessed, analyzed, and quantified. Rehabilitation engineers will find that the highly descriptive vocabulary and qualitative language used by nontechnical professionals needs to be translated into attributes that can be measured and quantified.

Principle 4. Careful and thorough cosideration of available technology for meeting the user's needs must be carried out to avoid overlooking potentially usefull solutions. Electronic databases can often provide the rehabilitation engineer or assistive technologist with an initial overview of potentially useful devices to prescribe, modify, and deliver to the consumer.

Principle 5. The users preferences and choice must be considered in the selection of the assistive technology device. Surveys indicate that the main reason assistive technology is rejected or poorly utilized is inadequate consideration of the user's needs and preferences.

Principle 6. The assistive technology device must be customized and installed in the location and setting where it primarily will be used. Often seemingly minor or innocuous situation at the usage site can spell success or failure in the application of assistive technology.

Principle 7. Not only must the user be trained to use the assistive device, but also the attendants or family members must be made aware of the device's intended purpose, benefits, and limitations. Unless the attendants or family members alter their ways of interacting, the newly empowered individual will be dissuaded from utilizing the communication device, regardless of how powerful it may be.

Principle 8. Follow-up, readjustment, and assesment of the user's usage patterns and needs are necessary at periodic intervals. Periodic follow-up and adjustments will lessen technology abandonment and the resultant waste of time and resources.

(P. T. O)

# Professional Areas in Assistive Technology

| Technology Area | Responsible Professionals |
|---|---|
| Academic and vocational skills | Special education<br>Vocational rehabilitation<br>Psychology |
| Augmentative communication | Speech-language pathology<br>Special education |
| Computer access | Computer technology<br>Vocational rehabilitation |
| Daily living skills | Occupational therapy<br>Rehabilitation technology |
| Specialized adaptations. | Rehabilitation engineering<br>computer technology<br>Prosthetics / orthotics. |
| Mobility | Occupational therapy<br>Physical therapy |
| Written Communication | Speech, language pathology.<br>Special education. |

# Ergonomic Principles.

Define Ergonomic : Ergonomics derived from two Greek words. Ergo means "WORK". Nomos means 'LAW'. Ergonomics focuses on the study of work performance with an emphasis on worker safety and productivity.

According to OSHA : "Designing the job to fit the workers, instead of forcing the worker to fit the job".

According to Taygai & Smith : defined as "Branch of Science that focuses on obtaining optimal relationships between workers and their work environment.

Ergonomics emerged as a scientific discipline in the 1940s as a consequence of the growing realisation that, as technical equipment become increasingly complex, not all of the expected benefits would be delivered if people were unable to understand and use the equipment to its full potential.

Ergonomics Applies to

- Workstation Design . desks, chairs, space, layout
- Work Postures - sitting. standing, reaching, lifting
- Work Organization - Pace, Breaks, Variety.
- Tools, Equipments and Furniture Design - bodysize, height, gender, promoting neutral postures, reduce vibration, exposure to acceptable lighting, noise, temperature.

- Manual Materials Handling – (lifting, lowering, pulling, pushing, carrying and holding materials).
- Work environment - Ventilation, noise, temperature, humidity lighting and vision).

The necessity of applying Ergonomics Principles

- Ergonomic program is one of the effective plan taken into account by many employers.
- Increase efficiency of the organization.
- Poorly design working environment can cause the injurious outcome on three various systems on human's body.

## Advantages of Ergonomics.

| | | |
|---|---|---|
| Ergonomic advantages. | Reducing discomforts | by reducing the ergonomic risk factors |
| | Increasing productivity | by providing job satisfaction for workers. |
| | Reducing absenteeism. | by making workers to be more engaged and productive by feeling more health and pain-free. |
| | Cost & time Savings | by Minimizing injuries. Improving productivity of employee Reducing workers compensation claims |
| | Increasing morale. | by making employee pleasant & feel valued due to safer work environment. |

# FUNDAMENTAL ERGONOMIC PRINCIPLES

Eight fundamental ergonomic principles to help & identify ergonomic risk factors and maintain your stellar safety record.

## Principle 1. Maintain Neutral Posture.

Neutral postures are postures where the body is aligned and balanced while either sitting or standing, placing minimal stress on the body & keeping joints aligned.

Neutral postures minimize the stress applied to muscles, tendons, nerves and bones and allows for maximum control and force production.

## Principle 2. Work in the Power / Comfort zone.

The power zone for lifting is close to the body, between mi-thigh and mid-chest height. This zone is where the arms and back can lift the most with the least amount of effort. This is called hand shake zone or comfort zone. The principle here is that if you can "Shake hands with your work".

## Principle 3. Allow for Movement and Stretching

The musculoskeletal system is often referred to as the human body's movement system and it is designed to move.

Stretching reduces fatigue, improves muscular balance and posture and improves muscle coordination. Prepare yourbody for work by warming up to improve performance and lower injury risk. A warm. up stretching regimen is a greatway to prepare your body for work.

Principle 4. Reduce Excessive Force:

Excessive force is one of the primary ergonomic risk factors. Many work tasks require high force loads on the human body. Muscle effort increases in response to high force requirements which increases fatigue and other risk.

Elliminating excessive force requirements will reduce worker fatigue and other risk

Principle 5. Reduce Excessive Motions.

Repetitive motion is another one of the primary ergonomic risk factors. Many work tasks and cycles and repetitive in nature, and are frequently controlled by hourly or daily production targets and work processes.

Excessive or unnecessary motions should be reduced if at all possible.

Principle 6. Minimize Contact stress.

Continuous contact or rubbing between hard or sharp objects / surfaces and sensitive body tissue, such as Soft tissue of the fingers, palms, thigh and feet.

This contact creates localized pressure for a small area of the body, which can inhibit blood, nerve function, or movement of tendons and muscles.

Principle 7. Reduce Excessive Vibration

Multiple studies have shown that regular and frequent exposure to vibration can lead to permanent adverse health effects.

Hand-arm Vibration can cause a range of conditions collectively known as hand-arm Vibration syndrome (HAVS). Vibration Syndrome has adverse circulatory and neural effects in the fingers.

Principle 8. Provide Adequate Lighting

Poor Lighting is a common problem in the workplace that can affect a worker's comfort level and performance. Too much or too little light makes work difficult.

Providing workers with adjustable task lighting is often a simple solution to lighting problems.

Conclusion.

Ergonomics doesn't have to be as difficult or complicated as brain surgery. The ergonomic principles included in this article are mostly common sense. It's the practical, day-to-day application of these principles that is challenging for many companies.

# Practice of Rehabilitation

- Rehabilitation counseling is a systematic process which assists persons with physical, mental, developmental cognitive, and emotional disabilities to achieve their personal, career, and independent living goals in the most integrated setting possible through the application of the counseling process
- Scope of Practice statement for Rehabilitation counseling

Apprasisal:

Selecting, administering, scoring, and interpreting instruments designed to assess an individual's apitudes, abilities, achievements, interests, personal characteristics, disabilities and mental, emotional or behavioral disorders as well as the use of methods and techniques for understanding human behavior in relation to coping with, adapting to, or changing life situations.

Diagnosis and Treatment planning:

Assessing, analyzing and providing diagnostic descriptions of mental, emotional or behavioral conditions or disabilities, exploring possible solutions, and developing and implementing a treatment plan for mental, emotional, and psychosocial adjustment or development.

Diagnosis and treatment planning shall not be construed to permit the performance of any act which rehabilitation counselors are not educated and trained to perform.

Counseling Treatment Intervention:

The application of cognitive, affective, behaviroral, and systemic counseling strategies which include developmental, wellness, pathologic and multicultural principles of human behavior.

Referral:

Evaluating and identifying the needs of a client to determine the advisability of referrals to other specialists, advising the client of such judgments, and communicating as requested or deemed appropriate to such referral sources.

# 5 REHABILITATION ENGINEERING AND ASSISTIVE TECHNOLOGY

Andrew Szeto, PhD, PE

## Chapter Contents



*At the conclusion of this chapter, students will:*

- Understand the role played by rehabilitation engineers and assistive technologists in the rehabilitation process.
- Be aware of the major activities in rehabilitation engineering.
- Be familiar with the physical and psychological consequences of disability.

- Know the principles of assistive technology assessment and its objectives and pitfalls.
- Discuss key engineering and ergonomic principles of the field.
- Describe career opportunities and information sources.

## 5.1 INTRODUCTION

Since the late 1970s, there has been major growth in the application of technology to ameliorate the problems faced by people with disabilities. Various terms have been used to describe this sphere of activity, including prosthetics/orthotics, rehabilitation engineering, assistive technology, assistive device design, rehabilitation technology, and even biomedical engineering applied to disability. With the gradual maturation of this field, several terms have become more widely used, bolstered by their use in some federal legislation.

The two most frequently used terms today are *assistive technology* and *rehabilitation engineering*. Although they are used somewhat interchangeably, they are not identical. In the words of James Reswick (1982), a pioneer in this field, "rehabilitation engineering is the application of science and technology to ameliorate the handicaps of individuals with disabilities." In contrast, assistive technology can be viewed as a product of rehabilitation engineering activities. Such a relationship is analogous to health care being the product of the practice of medicine.

One widely used definition for assistive technology is found in Public Law 100-407. It defines assistive technology as "any item, piece of equipment or product system whether acquired commercially off the shelf, modified, or customized that is used to increase or improve functional capabilities of individuals with disabilities." Notice that this definition views assistive technology as a broad range of devices, strategies, and/or services that help an individual to better carry out a functional activity. Such devices can range from low-technology devices that are inexpensive and simple to make to high-technology devices that are complex and expensive to fabricate. Examples of low-tech devices include dual-handled utensils and mouth sticks for reaching. High-tech examples include computer-based communication devices, reading machines with artificial intelligence, and externally powered artificial arms (Fig. 5.1).

Several other terms often used in this field include rehabilitation technology and orthotics and prosthetics. Rehabilitation technology is that segment of assistive technology that is designed specifically to rehabilitate an individual from his or her present set of limitations due to some disabling condition, permanent or otherwise. In a classical sense, orthotics are devices that augment the function of an extremity, whereas prosthetics replace a body part both structurally and functionally. These two terms now broadly represent all devices that provide some sort of functional replacement. For example, an augmentative communication system is sometimes referred to as a speech prosthesis.

### 5.1.1 History

A brief discussion of the history of this field will explain how and why so many different yet similar terms have been used to denote the field of assistive technology

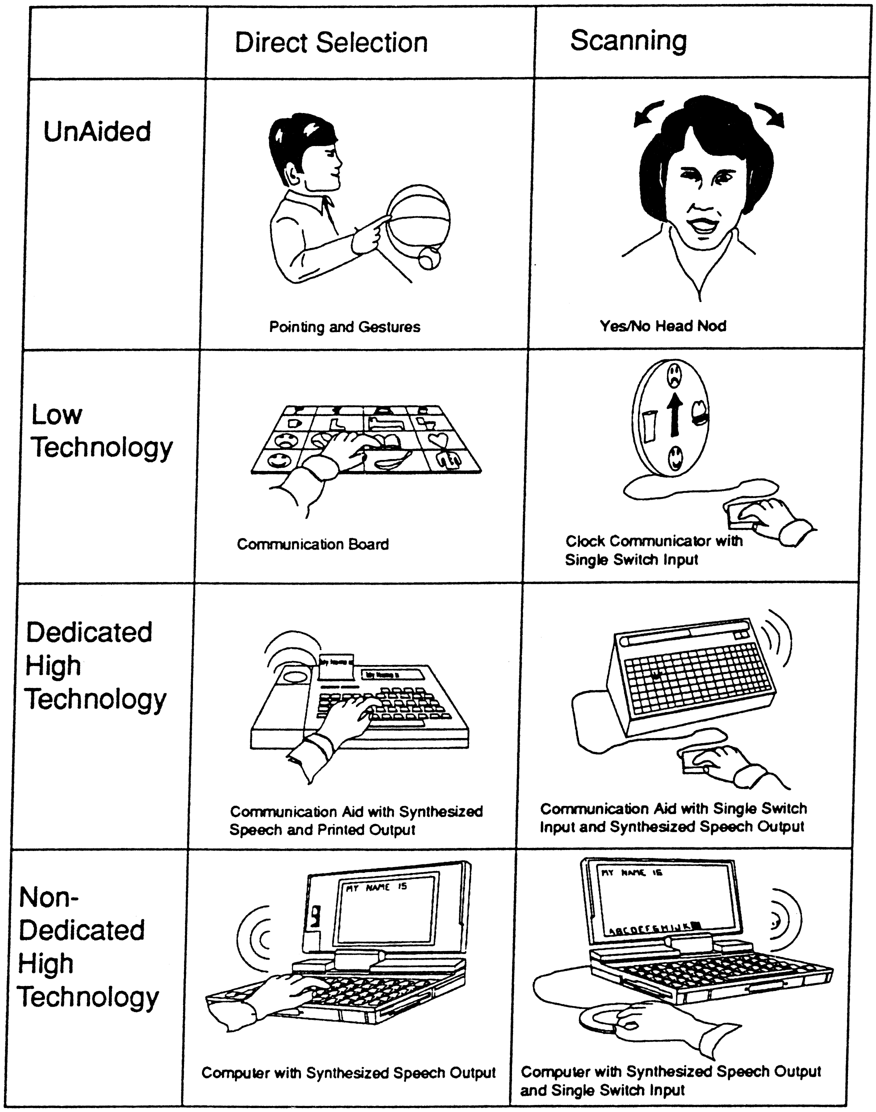



**Figure 5.1** Augmentative communication classification system (from Church and Glennen, 1992).

and rehabilitation. Throughout history, people have sought to ameliorate the impact of disabilities by using technology. This effort became more pronounced and concerted in the United States after World War II. The Veterans Administration (VA) realized that something had to be done for the soldiers who returned from war with numerous and serious handicapping conditions. There were too few well-trained artificial limb and brace technicians to meet the needs of the returning soldiers. To train these much-needed providers, the federal government supported the establishment of a number of prosthetic and orthotic schools in the 1950s.

The VA also realized that the state of the art in limbs and braces was primitive and ineffectual. The orthoses and prostheses available in the 1940s were uncomfortable, heavy, and offered limited function. As a result, the federal government established the Veterans Administration Prosthetics Research Board, whose mission was to improve the orthotics and prosthetic appliances that were available. Scientists and engineers formerly engaged in defeating the Axis powers now turned their energies toward helping people, especially veterans with disabilities. As a result of their efforts, artificial limbs, electronic travel guides, and wheelchairs that were more rugged, lighter, cosmetically appealing, and effective were developed.

The field of assistive technology and rehabilitation engineering was nurtured by a two-pronged approach in the federal government. One approach directly funded research and development efforts that would utilize the technological advances created by the war effort toward improving the functioning and independence of injured veterans. The other approach helped to establish centers for the training of prosthetists and orthotists, forerunners of today's assistive technologists.

In the early 1960s, another impetus to rehabilitation engineering came from birth defects in infants born to expectant European women who took thalidomide to combat "morning sickness." The societal need to enable children with severe deformities to lead productive lives broadened the target population of assistive technology and rehabilitation engineering to encompass children as well as adult men. Subsequent medical and technical collaboration in research and development produced externally powered limbs for people of all sizes and genders, automobiles that could be driven by persons with no arms, sensory aids for the blind and deaf, and various assistive devices for controlling a person's environment.

Rehabilitation engineering received formal governmental recognition as an engineering discipline with the landmark passage of the federal Rehabilitation Act of 1973. The act specifically authorized the establishment of several centers of excellence in rehabilitation engineering. The formation and supervision of these centers were put under the jurisdiction of the National Institute for Handicapped Research, which later became the National Institute on Disability and Rehabilitation Research (NIDRR). By 1976, about 15 Rehabilitation Engineering Centers (RECs), each focusing on a different set of problems, were supported by grant funds totaling about $9 million per year. As the key federal agency in the field of rehabilitation, NIDRR also supports rehabilitation engineering and assistive technology through its Rehabilitation Research and Training Centers, Field Initiated Research grants, Research and Demonstration program, and Rehabilitation Fellowships (NIDRR, 1999).

The REC grants initially supported university-based rehabilitation engineering research and provided advanced training for graduate students. Beginning in the mid-1980s, the mandate of the RECs was broadened to include technology transfer and service delivery to persons with disabilities. During this period, the VA also established three of its own RECs to focus on some unique rehabilitation needs of veterans. Areas of investigation by VA and non-VA RECs include prosthetics and orthotics, spinal cord injury, lower and upper limb functional electrical stimulation, sensory aids for the blind and deaf, effects of pressure on tissue, rehabilitation robotics, technology transfer, personal licensed vehicles, accessible telecommunications, applications of wireless technology, and vocational rehabilitation. Another milestone, the formation of the Rehabilitation Engineering Society of North America (RESNA) in 1979, gave greater focus and visibility to rehabilitation engineering. Despite its name, RESNA is an inclusive professional society that welcomes everyone involved with the development, manufacturing, provision, and usage of technology for persons with disabilities. Members of RESNA include occupational and physical therapists, allied health professionals, special educators, and users of assistive technology. RESNA has become an adviser to the government, a developer of standards and credentials, and, via its annual conferences and its journal, a forum for exchange of information and a showcase for state-of-the art rehabilitation technology. In recognition of its expanding role and members who were not engineers, RESNA modified its name in 1995 to the Rehabilitation Engineering and Assistive Technology Society of North America.

Despite the need for and the benefits of providing rehabilitation engineering services, reimbursement for such services by third-party payers (e.g., insurance companies, social service agencies, and government programs) remained very difficult to obtain during much of the 1980s. Reimbursements for rehabilitation engineering services often had to be subsumed under more accepted categories of care such as client assessment, prosthetic/orthotic services, or miscellaneous evaluation. For this reason, the number of practicing rehabilitation engineers remained relatively static despite a steadily growing demand for their services.

The shortage of rehabilitation engineers with suitable training and experience was specifically addressed in the Rehab Act of 1986 and the Technology-Related Assistance Act of 1988. These laws mandated that rehabilitation engineering services had to be available and funded for disabled persons. They also required an individualized work and rehabilitation plan (IWRP) for each vocational rehabilitation client. These two laws were preceded by the original Rehab Act of 1973 which mandated reasonable accommodations in employment and secondary education as defined by a least restrictive environment (LRE). Public Law 95-142 in 1975 extended the reasonable accommodation requirement to children 5–21 years of age and mandated an individual educational plan (IEP) for each eligible child. Table 5.1 summarizes the major United Stated Federal legislation that has affected the field of assistive technology and rehabilitation engineering.

In concert with federal legislation, several federal research programs have attempted to increase the availablity of rehabilitation engineering services for persons with disabilities. The National Science Foundation (NSA), for example, initiated a program called Bioengineering and Research to Aid the Disabled. The program's goals were (1) to provide student-engineered devices or software to disabled individuals that would improve their quality of life and degree of independence, (2) to enhance the education of student engineers through real-world design experiences, and (3) to allow the university an opportunity to serve the local community. The Office of Special Education and Rehabilitation Services in the U.S. Department of Education funded special projects and demonstration programs that addressed identified needs such as model assessment programs in assistive technology, the application of technology for deaf–blind children, interdisciplinary training for students of communicative

**TABLE 5.1** Recent Major U.S. Federal Legislation Affecting Assistive Technologies

| Legislation | Major Assistive Technology Impact |
|---|---|
| Rehabilitation Act of 1973, as amended | Mandates reasonable accommodation and least restricted environment in federally funded employment and higher education; requires both assistive technology devices and services be included in state plans and Individualized Written Rehabilitation Plans (IWRP) for each client; Section 508 mandates equal access to electronic office equipment for all federal employees; defines rehabilitation technology as rehabilitation engineering and assistive technology devices and services; mandates rehabilitation technology as primary benefit to be included in IWRP |
| Individuals with Disabilities Education Act Amendments of 1997 | Recognizes the right of every child to a free and appropriate education; includes concept that children with disabilities are to be educated with their peers; extends reasonable accommodation, least restrictive environment (LRE), and assistive technology devices and services to age 3–21 education; mandates Individualized Educational Plan for each child, to include consideration of assistive technologies; also includes mandated services for children from birth to 2 and expanded emphasis on educationally related assistive technologies |
| Assistive Technology Act of 1998 (replaced Technology Related Assistance for Individuals with Disabilities Act of 1998) | First legislation to specifically address expansion of assistive technology devices and services; mandates consumer-driven assistive technology services, capacity building, advocacy activities, and statewide system change; supports grants to expand and administer alternative financing of assistive technology systems |
| Developmental Disabilities Assistance and Bill of Rights Act | Provides grants to states for developmental disabilities councils, university-affiliated programs, and protection and advocacy activities for persons with developmental disabilities; provides training and technical assistance to improve access to assistive technology services for individuals with developmental disabilities |
| Americans with Disabilities Act (ADA) of 1990 | Prohibits discrimination on the basis of disability in employment, state and local government, public accommodations, commercial facilities, transportation, and telecommunications, all of which affect the application of assistive technology; use of assistive technology impacts requirement that Title II entities must communicate effectively with people who have hearing, vision, or speech disabilities; addresses telephone and television access for people with hearing and speech disabilities |
| Medicaid | Income-based (“means-tested”) program; eligibility and services differ from state to state; federal government sets general program requirements and provides financial assistance to the states by matching state expenditures; assistive technology benefits differ for adults and children from birth to age 21; assistive technology for adults must be included in state’s Medicaid plan or waiver program |
| Early Periodic Screening, Diagnosis, and Treatment Program | Mandatory service for children from birth through age 21; includes any required or optional service listed in the Medicaid Act; service need not be included in the state’s Medicaid plan |
| Medicare | Major funding source for assistive technology (durable medical equipment); includes individuals 65 or over and those who are permanently and totally disabled; federally administered with consistent rules for all states |

From Cook and Hussey (2002).

disorders (speech pathologists), special education, and engineering. In 1993, NIDRR committed $38.6 million to support Rehabilitation Engineering Centers that would focus on the following areas: adaptive computers and information systems, augmentative and alternative communication devices, employability for persons with low back pain, hearing enhancement and assistive devices, prosthetics and orthotics, quantification of physical performance, rehabilitation robotics, technology transfer and evaluation, improving wheelchair mobility, work site modifications and accommodations, geriatric assistive technology, personal licensed vehicles for disabled persons, rehabilitation technology services in vocational rehabilitation, technological aids for blindness and low vision, and technology for children with orthopedic disabilities. In fiscal year 1996, NIDRR funded 16 Rehabilitation Engineering Research Centers at a total cost of $11 million dollars and 45 Rehabilitation Research and Training Centers at a cost of $23 million dollars (NIDRR, 1999).

### 5.1.2 Sources of Information

Like any other emerging discipline, the knowledge base for rehabilitation engineering was scattered in disparate publications in the early years. Owing to its interdisciplinary nature, rehabilitation engineering research papers appeared in such diverse publications as the *Archives of Physical Medicine & Rehabilitation, Human Factors, Annals of Biomedical Engineering, IEEE Transactions on Biomedical Engineering*, and *Biomechanics*. Some of the papers were very practical and application specific, whereas others were fundamental and philosophical. In the early 1970s, many important papers were published by the Veterans Administration in its *Bulletin of Prosthetic Research*, a highly respected and widely disseminated peer-reviewed periodical. This journal was renamed the *Journal of Rehabilitation R&D* in 1983. In 1989, RESNA began *Assistive Technology*, a quarterly journal that focused on the interests of practitioners engaged in technological service delivery rather than the concerns of engineers engaged in research and development. The IEEE Engineering in Medicine and Biology Society founded the *IEEE Transactions on Rehabilitation Engineering* in 1993 to give scientifically based rehabilitation engineering research papers a much-needed home. This journal, which was renamed *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, is published quarterly and covers the medical aspects of rehabilitation (rehabilitation medicine), its practical design concepts (rehabilitation technology), its scientific aspects (rehabilitation science), and neural systems.

### 5.1.3 Major Activities in Rehabilitation Engineering

The major activities in this field can be categorized in many ways. Perhaps the simplest way to grasp its breadth and depth is to categorize the main types of assistive technology that rehabilitation engineering has produced (Table 5.2). The development of these technological products required the contributions of mechanical, material, and electrical engineers, orthopedic surgeons, prosthetists and orthotists, allied health professionals, and computer professionals. For example, the use of voice in many assistive devices, as both inputs and outputs, depends on digital signal processing chips, memory chips, and sophisticated software developed by electrical and computer engineers. Figures 5.2 through 5.4 illustrate some of the assistive technologies currently available. As explained in subsequent sections of this chapter, the proper design, development, and application of assistive technology devices

**TABLE 5.2** Categories of Assistive Devices

| |
|---|
| Prosthetics and Orthotics |
| Artificial hand, wrist, and arms |
| Artificial foot and legs |
| Hand splints and upper limb braces |
| Functional electrical stimulation orthoses |
| Assistive Devices for Persons with Severe Visual Impairments |
| Devices to aid reading and writing (e.g., closed circuit TV magnifiers, electronic Braille, reading machines, talking calculators, auditory and tactile vision substitution systems) |
| Devices to aid independent mobility (e.g., Laser cane, Binaural Ultrasonic Eyeglasses, Handheld Ultrasonic Torch, electronic enunciators, robotic guide dogs) |
| Assistive Devices for Persons with Severe Auditory Impairments |
| Digital hearing aids |
| Telephone aids (e.g., TDD and TTY) |
| Lipreading aids |
| Speech to text converters |
| Assistive Devices for Tactile Impairments |
| Cushions |
| Customized seating |
| Sensory substitution |
| Pressure relief pumps and alarms |
| Alternative and Augmentative Communication Devices |
| Interface and keyboard emulation |
| Specialized switches, sensors, and transducers |
| Computer-based communication devices |
| Linguistic tools and software |
| Manipulation and Mobility Aids |
| Grabbers, feeders, mounting systems, and page turners |
| Environmental controllers |
| Robotic aids |
| Manual and special-purpose wheelchairs |
| Powered wheelchairs, scooters, and recliners |
| Adaptive driving aids |
| Modified personal licensed vehicles |
| Recreational Assistive Devices |
| Arm-powered cycles |
| Sports and racing wheelchairs |
| Modified sit-down mono-ski |

require the combined efforts of engineers, knowledgeable and competent clinicians, informed end users or consumers, and caregivers.

## 5.2 THE HUMAN COMPONENT

To knowledgeably apply engineering principles and fabricate devices that will help persons with disabling conditions, it is necessary to have a perspective on the

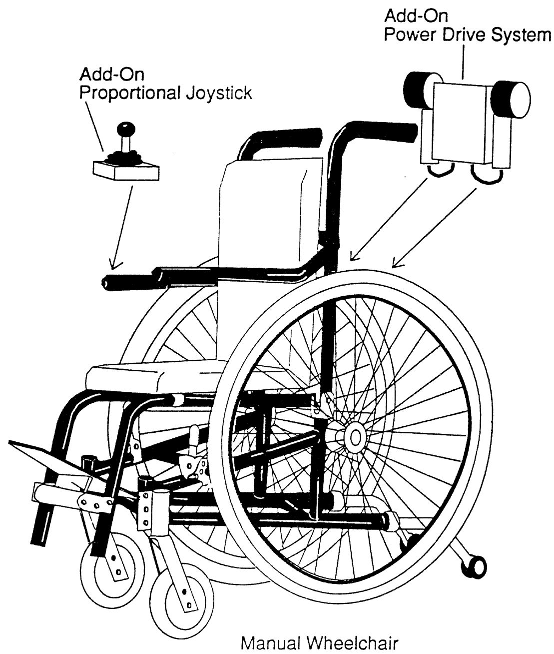



**Figure 5.2** Add-on wheelchair system (from Church and Glennen, 1992).

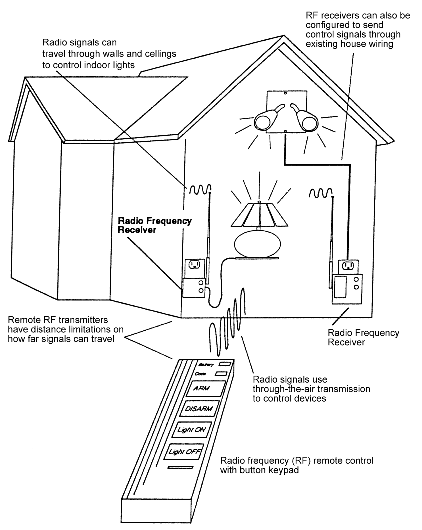



**Figure 5.3** Environmental control unit using radio frequency (RF) control (from Church and Glennen, 1992).

human component and the consequence of various impairments. One way to view a human being is as a receptor, processor, and responder of information (Fig. 5.5). The human user of assistive technology perceives the environment via senses and responds or manipulates the environment via effectors. Interposed between the sensors and effectors are central processing functions that include perception, cognition, and movement control. *Perception* is the way in which the human being interprets the incoming sensory data. The mechanism of perception relies on the neural circuitry found in the peripheral nervous system and central psychological factors such as memory of previous sensory experiences. *Cognition* refers to activities that underlie problem solving, decision making, and language formation. *Movement control* utilizes the outcome of the processing functions described previously to form a motor pattern that is executed by the effectors (nerves, muscles, and joints). The impact of the effectors on the environment is then detected by the sensors, thereby providing feedback between the human and the environment. When something goes wrong in the information processing chain, disabilities often result. Table 5.3 lists the prevalence of various disabling conditions in terms of anatomic locations.

Interestingly, rehabilitation engineers have found a modicum of success when trauma or birth defects damage the input (sensory) end of this chain of information processing. When a sensory deficit is present in one of the three primary sensory channels (vision, hearing, and touch), assistive devices can detect important environmental information and present it via one or more of the other remaining senses. For example, sensory aids for severe visual impairments utilize tactile and/or auditory outputs to display important environmental information to the user. Examples of such sensory aids include laser canes, ultrasonic glasses, and robotic guide dogs. Rehabilitation engineers also have been modestly successful at replacing or augmenting some motoric (effector) disabilities (Fig. 5.6). As listed in Table 5.2, these include artificial arms and legs, wheelchairs of all types, environmental controllers, and, in the future, robotic assistants.

However, when dysfunction resides in the ‘‘higher information processing centers’’ of a human being, assistive technology has been much less successful in ameliorating the resultant limitations. For example, rehabilitation engineers and speech pathologists have been unsuccessful in enabling someone to communicate effectively when that person has difficulty formulating a message (aphasia) following a stroke. Despite the variety of modern and sophisticated alternative and augmentative communication devices that are available, none has been able to replace the volitional aspects of the human being. If the user is unable to cognitively formulate a message, an augmentative communication device is often powerless to help.

An awareness of the psychosocial adjustments to chronic disability is desirable because rehabilitation engineering and assistive technology seek to ameliorate the consequences of disabilities. Understanding the emotional and mental states of the person who is or becomes disabled is necessary so that offers of assistance and recommendations of solutions can be appropriate, timely, accepted, and, ultimately, used.

One of the biggest impacts of chronic disability is the minority status and socially devalued position that a disabled person experiences in society. Such loss of social

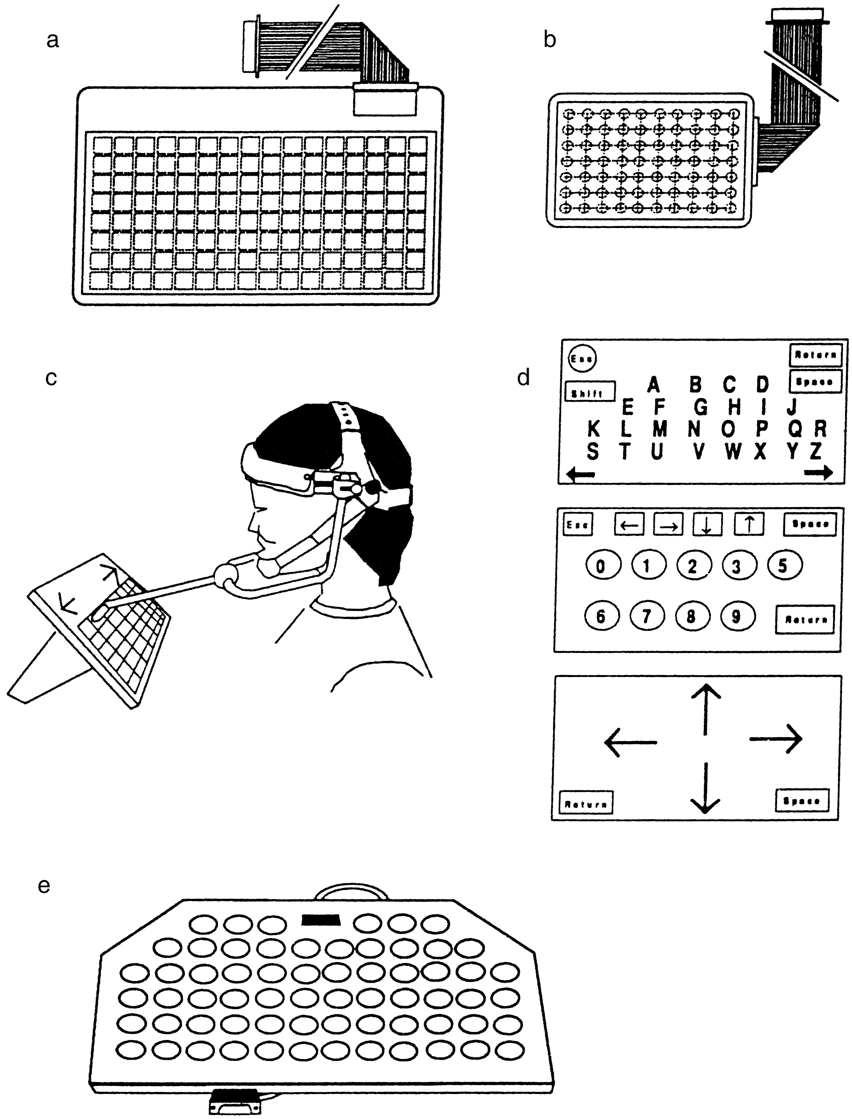



**Figure 5.4** Alternative keyboards can replace or operate in addition to the standard keyboard. (a) Expanded keyboards have a matrix of touch-sensitive squares that can be grouped together to form larger squares. (b) Minikeyboards are small keyboards with a matrix of closely spaced touch-sensitive squares. (c) The small size of a minikeyboard ensures that a small range of movement can reach the entire keyboard. (d) Expanded and minikeyboards use standard or customized keyboard overlays. (e) Some alternative keyboards plug directly into the keyboard jack of the computer, needing no special interface or software (from Church and Glennen, 1992).

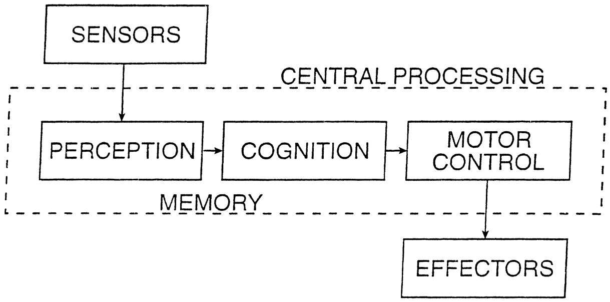



**Figure 5.5** An information processing model of the human operator of assistive technologies. Each block represents a group of functions related to the use of technology.

**TABLE 5.3** Prevalence of Disabling Conditions in the United States

| |
|---|
| 45–50 million persons have disabilities that slightly limit their activities |
| 32% hearing |
| 21% sight |
| 18% back or spine |
| 16% leg and hip |
| 5% arm and shoulder |
| 4% speech |
| 3% paralysis |
| 1% limb amputation |
| 7–11 million persons have disabilities that significantly limit their activities |
| 30% back or spine |
| 26% leg and hip |
| 13% paralysis |
| 9% hearing |
| 8% sight |
| 7% arm and shoulder |
| 4% limb amputation |
| 3% speech |

Data from Stolov and Clowers (1981).

status may result from the direct effects of disability (social isolation) and the indirect effects of disability (economic setbacks). Thus, in addition to the tremendous drop in personal income, a person who is disabled must battle three main psychological consequences of disability: the loss of self-esteem, the tendency to be too dependent on others, and passivity.

For individuals who become disabled through traumatic injuries, the adjustment to disability generally passes through five phases: shock, realization, defensive retreat or denial, acknowledgment, and adaptation or acceptance. During the first days after the onset of disability, the individual is usually in shock, feeling and reacting minimally

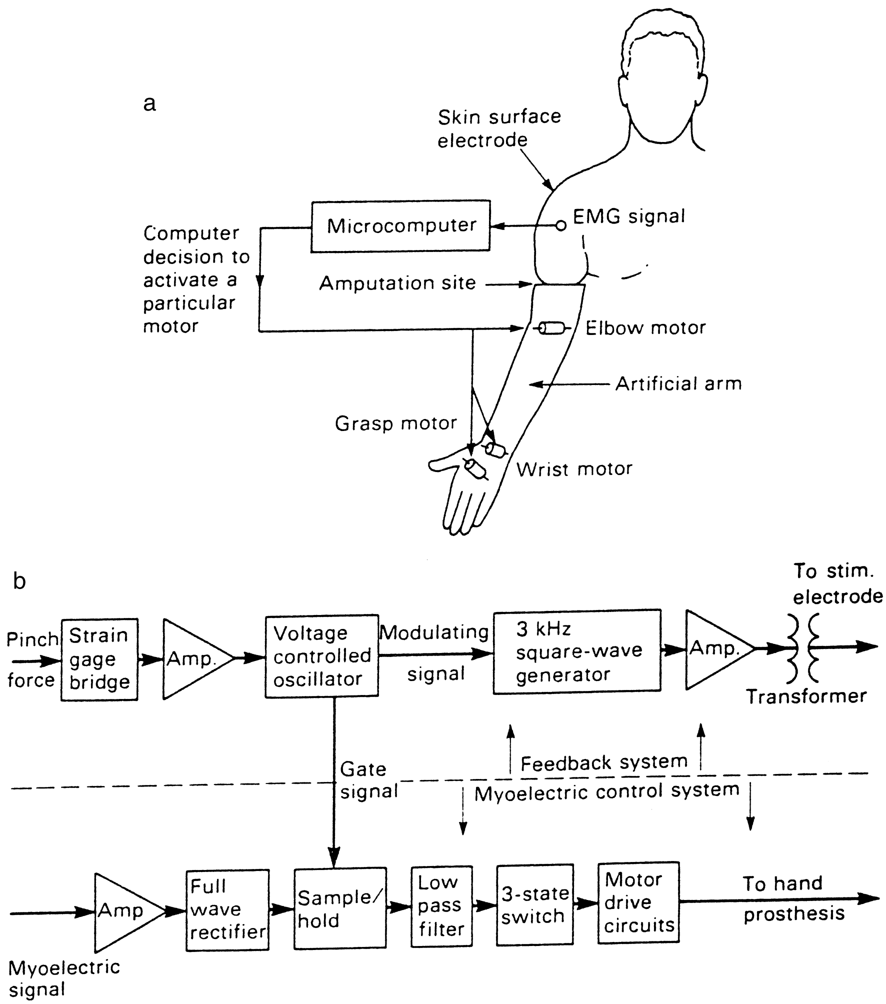



**Figure 5.6** (a) This system generates temporal signatures from one set of myoelectric electrodes to control multiple actuators. (b) Electrical stimulaton of the forearm to provide force feedback may be carried out using a system like this one (from Webster et al., 1985).

with the surroundings and showing little awareness of what has happened. Counseling interventions or efforts of rehabilitation technologists are typically not very effective at this time.

After several weeks or months, the individual usually begins to acknowledge the reality and seriousness of the disability. Anxiety, fear, and even panic may be the predominant emotional reactions. Depression and anger may also occasionally appear during this phase. Because of the individual's emotional state, intense or sustained intervention efforts are not likely to be useful during this time.

In the next phase, the individual makes a defensive retreat in order to not be psychologically overwhelmed by anxiety and fear. Predominant among these defenses is denial—claiming that the disability is only temporary and that full recovery will occur. Such denial may persist or reappear occasionally long after the onset of disability.

Acknowledgment of the disability occurs when the individual achieves an accurate understanding of the nature of the disability in terms of its limitations and likely outcome. Persons in this phase may exhibit a thorough understanding of the disability but may not possess a full appreciation of its implications. The gradual recognition of reality is often accompanied by depression and a resultant loss of interest in many activities previously enjoyed.

Adaptation, or the acceptance phase, is the final and ultimate psychological goal of a person's adjustment to disability. An individual in this phase has worked through the major emotional reactions to disability. Such a person is realistic about the likely limitations and is psychologically ready to make the best use of his or her potential. Intervention by rehabilitation engineers or assistive technologists during the acknowledgment and acceptance phases of the psychosocial adjustment to disability is usually appropriate and effective. Involvement of the disabled individual in identifying needs, planning the approach, and choosing among possible alternatives can be very beneficial both psychologically and physically.

## 5.3 PRINCIPLES OF ASSISTIVE TECHNOLOGY ASSESSMENT

Rehabilitation engineers not only need to know the physical principles that govern their designs, but they also must adhere to some key principles that govern the applications of technology for people with disabilities. To be successful, the needs, preferences, abilities, limitations, and even environment of the individual seeking the assistive technology must be carefully considered. There are at least five major misconceptions that exist in the field of assistive technology:

Misconception #1. *Assistive technology can solve all the problems*. Although assistive devices can making accomplishing tasks easier, technology alone cannot mitigate all the difficulties that accompany a disability.

Misconception #2. *Persons with the same disability need the same assistive devices*. Assistive technology must be individualized because similarly disabled persons can have very different needs, wants, and preferences (Wessels et al., 2003).

Misconception #3. *Assistive technology is necessarily complicated and expensive*. Sometimes low-technology devices are the most appropriate and even preferred for their simplicity, ease of use and maintenance, and low cost.

Misconception #4. *Assistive technology prescriptions are always accurate and optimal*. Experiences clearly demonstrate that the application of technology for persons with disabilities is inexact and will change with time. Changes in the assistive technology user's health, living environment, preferences, and circumstances will require periodic reassessment by the user and those rehabilitation professionals who are giving assistance (Philips and Zhao, 1993).

Misconception #5. *Assistive technology will always be used*. According to data from the 1990 U.S. Census Bureau's National Health Interview Survey, about one-third of the assistive devices not needed for survival are unused or abandoned just 3 months after they were initially acquired.

In addition to avoiding common misconceptions, a rehabilitation engineer and technologist should follow several principles that have proven to be helpful in matching appropriate assistive technology to the person or consumer. Adherence to these principles will increase the likelihood that the resultant assistive technology will be welcomed and fully utilized.

Principle #1. *The user's goals, needs, and tasks must be clearly defined, listed, and incorporated as early as possible in the intervention process*. To avoid overlooking needs and goals, checklists and premade forms should be used. A number of helpful assessment forms can be found in the references given in the suggested reading list at the end of this chapter.

Principle #2. *Involvement of rehabilitation professionals with differing skills and know-how will maximize the probability for a successful outcome*. Depending on the purpose and environment in which the assistive technology device will be used, a number of professionals should participate in the process of matching technology to a person's needs. Table 5.4 lists various technology areas and the responsible professionals.

Principle #3. *The user's preferences, cognitive and physical abilities and limitations, living situation, tolerance for technology, and probable changes in the future must be thoroughly assessed, analyzed, and quantified*. Rehabilitation engineers will find that the highly descriptive vocabulary and qualitative language used by nontechnical professionals needs to be translated into attributes that can be measured and quantified. For example, whether a disabled person can use one or more upper limbs should be quantified in terms of each limb's ability to reach, lift, and grasp.

Principle #4. *Careful and thorough consideration of available technology for meeting the user's needs must be carried out to avoid overlooking potentially useful solutions*. Electronic databases (e.g., assistive technology websites and websites of major technology vendors) can often provide the rehabilitation engineer or assistive technologist with an initial overview of potentially useful devices to prescribe, modify, and deliver to the consumer.

Principle #5. *The user's preferences and choice must be considered in the selection of the assistive technology device*. Surveys indicate that the main reason assistive technology is rejected or poorly utilized is inadequate consideration of the user's

**TABLE 5.4** Professional Areas in Assistive Technology

| Technology Area | Responsible Professionals* |
|---|---|
| Academic and vocational skills | Special education |
| | Vocational rehabilitation |
| | Psychology |
| Augmentative communication | Speech–language pathology |
| | Special education |
| Computer access | Computer technology |
| | Vocational rehabilitation |
| Daily living skills | Occupational therapy |
| | Rehabilitation technology |
| Specialized adaptations | Rehabilitation engineering |
| | Computer technology |
| | Prosthetics/orthotics |
| Mobility | Occupational therapy |
| | Physical therapy |
| Seating and positioning | Occupational therapy |
| | Physical therapy |
| Written communication | Speech–language pathology |
| | Special education |

*Depending on the complexity of technical challenges encountered, an assistive technologist or a rehabilitation engineer can be added to the list of responsible professionals.

needs and preferences. Throughout the process of searching for appropriate technology, the ultimate consumer of that technology should be viewed as a partner and stakeholder rather than as a passive, disinterested recipient of services.

Principle #6. *The assistive technology device must be customized and installed in the location and setting where it primarily will be used*. Often seemingly minor or innocuous situations at the usage site can spell success or failure in the application of assistive technology.

Principle #7. *Not only must the user be trained to use the assistive device, but also the attendants or family members must be made aware of the device's intended purpose, benefits, and limitations*. For example, an augmentative communication device usually will require that the communication partners adopt a different mode of communication and modify their behavior so that the user of this device can communicate a wider array of thoughts and even assume a more active role in the communication paradigm, such as initiating a conversation or changing the conversational topic. Unless the attendants or family members alter their ways of interacting, the newly empowered individual will be dissuaded from utilizing the communication device, regardless of how powerful it may be.

Principle #8. *Follow-up, readjustment, and reassessment of the user's usage patterns and needs are necessary at periodic intervals*. During the first 6 months following the delivery of the assistive technology device, the user and others in that environment learn to accommodate to the new device. As people and the environment change, what worked initially may become inappropriate, and the assistive device may need to be reconfigured or reoptimized. Periodic follow-up and adjustments will lessen technology abandonment and the resultant waste of time and resources.

## 5.4 PRINCIPLES OF REHABILITATION ENGINEERING

Knowledge and techniques from different disciplines must be utilized to design technological solutions that can alleviate problems caused by various disabling conditions. Since rehabilitation engineering is intrinsically multidisciplinary, identifying universally applicable principles for this emerging field is difficult. Often the most relevant principles depend on the particular problem being examined. For example, principles from the fields of electronic and communication engineering are paramount when designing an environmental control system that is to be integrated with the user's battery-powered wheelchair. However, when the goal is to develop an implanted functional electrical stimulation orthosis for an upper limb impaired by spinal cord injury, principles from neuromuscular physiology, biomechanics, biomaterials, and control systems would be the most applicable.

Whatever the disability to be overcome, however, rehabilitation engineering is inherently design oriented. Rehabilitation engineering design is the creative process of identifying needs and then devising an assistive device to fill those needs. A systematic approach is essential to successfully complete a rehabilitation project. Key elements of the design process involve the following sequential steps: analysis, synthesis, evaluation, decision, and implementation.

### Analysis

Inexperienced but enthusiastic rehabilitation engineering students often respond to a plea for help from someone with a disability by immediately thinking about possible solutions. They overlook the important first step of doing a careful analysis of the problem or need. What they discover after much ineffectual effort is that a thorough investigation of the problem is necessary before any meaningful solution can be found. Rehabilitation engineers first must ascertain where, when, and how often the problem arises. What is the environment or the task situation? How have others performed the task? What are the environmental constraints (size, speed, weight, location, physical interface, etc.)? What are the psychosocial constraints (user preferences, support of others, gadget tolerance, cognitive abilities, and limitations)? What are the financial considerations (purchase price, rental fees, trial periods, maintenance and repair arrangements)? Answers to these questions will require diligent investigation and quantitative data such as the weight and size to be lifted, the shape and texture of the object to be manipulated, and the operational features of the desired device. An excellent endpoint of problem analysis would be a list of operational features or performance specifications that the "ideal" solution should possess.

Such a list of performance specifications can serve as a valuable guide for choosing the best solution during later phases of the design process.

### Example Problem 5.1

Develop a set of performance specifications for an electromechanical device to raise and lower the lower leg of a wheelchair user (to prevent edema).

***Solution***

A sample set of performance specifications about the ideal mechanism might be written as follows:

- Be able to raise or lower leg in 5 s
- Independently operable by the wheelchair occupant
- Have an emergency stop switch
- Compatible with existing wheelchair and its leg rests
- Quiet operation
- Entire adaptation weighs no more than five pounds ■

## Synthesis

A rehabilitation engineer who is able to describe in writing the nature of the problem is likely to have some ideas for solving the problem. Although not strictly sequential, the synthesis of possible solutions usually follows the analysis of the problem. The synthesis of possible solutions is a creative activity that is guided by previously learned engineering principles and supported by handbooks, design magazines, product catalogs, and consultation with other professionals. While making and evaluating the list of possible solutions, a deeper understanding of the problem usually is reached and other, previously not apparent, solutions arise. A recommended endpoint for the synthesis phase of the design process includes sketches and technical descriptions of each trial solution.

## Evaluation

Depending on the complexity of the problem and other constraints such as time and money, the two or three most promising solutions should undergo further evaluation, possibly via field trials with mockups, computer simulations, and/or detailed mechanical drawings. Throughout the evaluation process, the end user and other stakeholders in the problem and solution should be consulted. Experimental results from field trials should be carefully recorded, possibly on videotape, for later review. One useful method for evaluating promising solutions is to use a quantitative comparison chart to rate how well each solution meets or exceeds the performance specifications and operational characteristics based on the analysis of the problem.

## Decision

The choice of the final solution is often made easier when it is understood that the final solution usually involves a compromise. After comparing the various promising solutions, more than one may appear equally satisfactory. At this point, the final decision may be made based on the preference of the user or some other intangible factor that is difficult to anticipate. Sometimes choosing the final solution may involve consulting with someone else who may have encountered a similar problem. What is most important, however, is careful consideration of the user's preference (principle 5 of assistive technology).

### Implementation

To fabricate, fit, and install the final (or best) solution requires additional project planning that, depending on the size of the project, may range from a simple list of tasks to a complex set of scheduled activities involving many people with different skills.

**Example Problem 5.2**

List the major technical design steps needed to build the automatic battery-powered leg raiser described in Example Problem 5.1.

***Solution***

The following are some of the key design steps:

- Mechanical design of the linkages to raise the wheelchair's leg rests
- Static determination of the forces needed to raise the occupant's leg
- Determination of the gear ratios and torque needed from the electric motor
- Estimation of the power drain from the wheelchair batteries
- Purchase of the electromechanical components
- Fabrication of custom parts and electronic components
- Assembly, testing, and possible redesign
- Field trials and evaluation of prototype device ■

## 5.4.1 Key Engineering Principles

Each discipline and subdiscipline that contributes to rehabilitation engineering has its own set of key principles that should be considered when a design project is begun. For example, a logic family must be selected and a decision whether to use synchronous or asynchronous sequential circuits must be made at the outset in digital design. A few general hardware issues are applicable to a wide variety of design tasks, including worst-case design, computer simulation, temperature effects, reliability, and product safety. In worst-case design, the electronic or mechanical system must continue to operate adequately even when variations in component values degrade performance. Computer simulation and computer-aided design (CAD) software often can be used to predict how well an overall electronic system will perform under different combinations of component values or sizes.

The design also should take into account the effects of temperature and environmental conditions on performance and reliability. For example, temperature extremes can reduce a battery's capacity. Temperature also may affect reliability, so proper venting and use of heat sinks should be employed to prevent excessive temperature increases. For reliability and durability, proper strain relief of wires and connectors should be used in the final design.

Product safety is another very important design principle, especially for rehabilitative or assistive technology. An electromechanical system should always incorporate a panic switch that will quickly halt a device's operation if an emergency arises. Fuses and heavy-duty gauge wiring should be employed throughout for extra margins of safety. Mechanical stops and interlocks should be incorporated to ensure proper interconnections and to prevent dangerous or inappropriate movement.

When the required assistive device must lift or support some part of the body, an analysis of the static and dynamic forces (biomechanics) that are involved should be performed. The simplest analysis is to determine the static forces needed to hold the object or body part in a steady and stable manner. The basic engineering principles needed for static and dynamic analysis usually involve the following steps: (1) Determine the force vectors acting on the object or body part, (2) determine the moment arms, and (3) ascertain the centers of gravity for various components and body segments. Under static conditions, all the forces and moment vectors sum to zero. For dynamic conditions, the governing equation is Newton's second law of motion in which the vector sum of the forces equals mass times an acceleration vector ($F = ma$).

### Example Problem 5.3

Suppose a 125-lb person lies supine on a board resting on knife edges spaced 72 in. apart (Fig. 5.7). Assume that the center of gravity of the lower limb is located through the center line of the limb and 1.5 in. above the knee cap. Estimate the weight of this person's right leg.

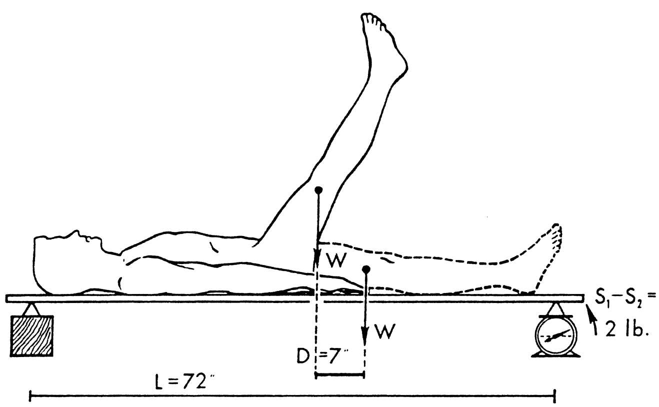



**Figure 5.7** Method of weighing body segments with board and scale (from Le Veau, 1976).

***Solution***

Record the scale reading with both legs resting comfortably on the board and when the right leg is raised almost straight up. Sum the moments about the left knife edge pivot to yield the following static equation:

$$WD = L(S_1 - S_2)$$

where $W$ is the weight of the right limb, $L$ is the length of the board between the supports, $S_1$ is the scale reading with both legs resting on the board, $S_2$ is the scale reading with the right leg raised, and $D$ is the horizontal distance through which the limb's center of gravity was moved when the limb was raised. Suppose the two scale readings were 58 lbs for $S_1$ and 56 lbs for $S_2$ and $D = 7$ in. Substituting these values into the equations would yield an estimate of 20.6 lbs as the weight of the right leg. ■

**Example Problem 5.4**

A patient is exercising his shoulder extensor muscles with wall pulleys (Fig. 5.8). Weights of 20, 10, and 5 lbs are loaded on the weight pan, which weighs 4 lbs. The patient is able to exert 45 lbs on the pulley. What is the resultant force of the entire system? What are the magnitude and direction of acceleration of the weights?

***Solution***

All the weights and the pan act straight down, whereas the 45 lbs of tension on the pulley's cable exerts an upward force. The net force ($F$) is 6 lbs upward. Using Newton's second law of motion, $F = ma$, where $m$ is the mass of the weights and the pan and $a$ is the acceleration of the weights and pan. The mass, $m$, is found by dividing the weight of 39 lbs by the acceleration of gravity (32.2 ft/s$^2$) to yield $m =$ 1.21 slugs. Substituting these values into $a = F / m$ yields an acceleration of 4.96 ft/s$^2$ in the upward direction.

### 5.4.2 Key Ergonomic Principles

Ergonomics or human factors is another indispensable part of rehabilitation engineering and assistive technology design. Applying information about human behavior, abilities, limitations, and other characteristics to the design of tools, adaptations, electronic devices, tasks, and interfaces is especially important when designing assistive technology because persons with disabilities generally will be less able to accommodate poorly designed or ill-fitted assistive devices. Several ergonomic principles that are especially germane to rehabilitation engineering are discussed in the following sections.

#### Principle of Proper Positioning

Without proper positioning or support, an individual who has lost the ability to maintain a stable posture against gravity may appear to have greater deformities and functional limitations than truly exist. For example, the lack of proper arm support may make the operation of even an enlarged keyboard unnecessarily slow

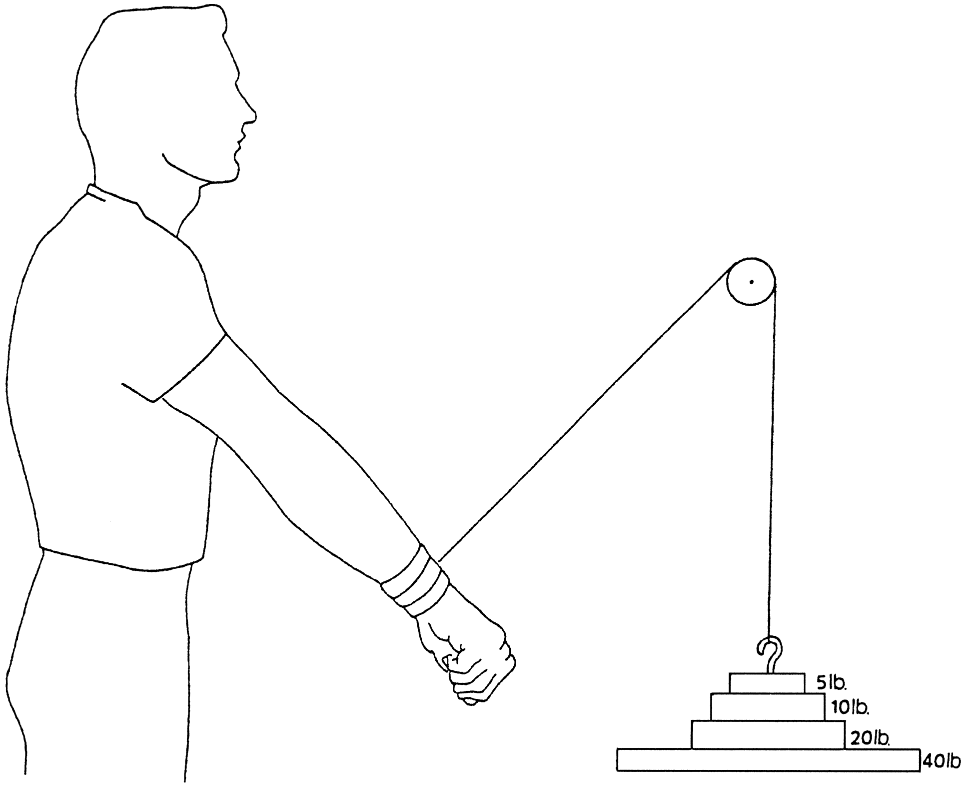



**Figure 5.8** Patient exercising his shoulder extensor muscles with wall pulleys (from Le Veau, 1976).

or mistake prone. Also, the lack of proper upper trunk stability may unduly limit the use of an individual's arms because the person is relying on them for support.

During all phases of the design process, the rehabilitation engineer must ensure that whatever adaptation or assistive technology is being planned, the person's trunk, lower back, legs, and arms will have the necessary stability and support at all times (Fig. 5.9). Consultation with a physical therapist or occupational therapist familiar with the focus individual during the initial design phases should be considered if postural support appears to be a concern. Common conditions that require considerations of seating and positioning are listed in Table 5.5.

## Principle of the Anatomical Control Site

Since assistive devices receive command signals from the users, users must be able to reliably indicate their intent by using overt, volitional actions. Given the variety of switches and sensors that are available, any part of the body over which the user has reliable control in terms of speed and dependability can serve as the anatomical control site. Once the best site has been chosen, an appropriate interface for that

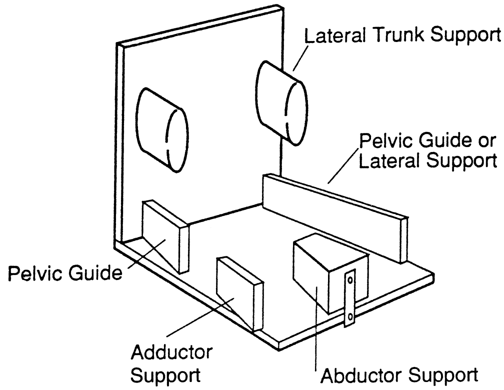



**Figure 5.9** Chair adaptations for proper positioning (from Church and Glennen, 1992).

**TABLE 5.5** Conditions That Require Consideration of Seating and Positioning

| Condition | Description and Characteristics | Seating Considerations |
|---|---|---|
| Cerebral palsy | Nonprogressive neuromuscular | |
| Increased tone (high tone) | Fixed deformity, decreased movements, abnormal patterns | Correct deformities, improve alignment, decrease tone |
| Decreased tone (low tone) | Subluxations, decreased active movement, hypermobility | Provide support for upright positioning, promote development of muscular control |
| Athetoid (mixed tone) | Excessive active movement, decreased stability | Provide stability, but allow controlled mobility for function |
| Muscular dystrophies | Degenerative neuromuscular | |
| Duchenne | Loss of muscular control proximal to distal | Provide stable seating base, allow person to find balance point |
| Multiple sclerosis | Series of exacerbations and remissions | Prepare for flexibility of system to follow needs |
| Spina bifida | Congenital anomaly consisting of a deficit in one or more of the vertebral arches, decreased or absent sensation | Reduce high risk for pressure concerns, allow for typically good upper extremity and head control |
| Spinal cord injury | Insult to spinal cord, partial or complete loss of function below level of injury, nonprogressive once stabilized, decreased or absent sensation, possible scoliosis/kyphosis | Reduce high risk for pressure concerns, allow for trunk movements used for function |
| Osteogenesis imperfecta | Connective tissue disorder, brittle bone disease, limited functional range, multiple fractures | Provide protection |
| Orthopedic impairments | Fixed or flexible | If fixed, support, if flexible, correct |

*(continued)*

**TABLE 5.5** Conditions That Require Consideration of Seating and Positioning (Continued)

| Condition | Description and Characteristics | Seating Considerations |
|---|---|---|
| Traumatic brain injury | Severity dependent on extent of central nervous system damage, may have cognitive component, nonprogressive once stabilized | Allow for functional improvement as rehabilitation progresses, establish a system that is flexible to changing needs |
| Elderly | | |
| Typical aged | Often, fixed kyphosis, decreased bone mass, and decreased strength, incontinence | Provide comfort and visual orientation, moisture-proof, accommodate kyphosis |
| Aged secondary to primary disability | Example—older patients with cerebral palsy may have fixed deformities | Provide comfort, support deformities |

Adapted with permission from *Evaluating, Selecting, and Using Appropriate Assistive Technology,* J. C. Galvin, M. J. Scherer, p. 66, © 1996 Aspen Publishers, Inc.

site can be designed by using various transducers, switches, joysticks, and keyboards. In addition to the obvious control sites such as the finger, elbow, shoulder, and knee, subtle movements such as raising an eyebrow or tensing a particular muscle can also be employed as the control signal for an assistive device. Often, the potential control sites can and should be analyzed and quantitatively compared for their relative speed, reliability, distinctiveness, and repeatability of control actions. Field trials using mock-ups, stopwatches, measuring tapes, and a video camera can be very helpful for collecting such performance data.

When an individual's physical abilities do not permit direct selection from among a set of possible choices, single switch activation by the anatomical control site in combination with automated row-column scanning of a matrix is often used. In row-column scanning, each row of a matrix lights up sequentially from the top to the bottom. When the row containing the desired item is highlighted, the user selects it using a switch. Then each item in that row is scanned (from left to right) until the desired item is chosen by a second switch activation. The speed with which a two-dimensional array can be used to compose messages depends on the placement of the letters in that array. Two popular arrangements of alphanumeric symbols—the alphabetic arrangement and the frequency of occurrence arrangement of the alphabet—are shown in Example Problem 5.5.

### Example Problem 5.5

Assume that a communication device has either an alphabetical arrangement of letters or a frequency arrangement and does row-column scanning as follows: (1) Two switch activations are needed to select a particular item in the array; (2) The dwell time for each row (starting at the top) is 1.5 s; (3) The dwell time along a selected row (starting from the left) is 1.5 s; and (4) The scan begins at the top row after a successful selection.

For both arrangements, calculate the predicted time needed to generate the phrase "I WANT TO GO TO SEA WORLD." Assume zero errors or missed opportunities.

**Alphabetical Arrangement of Letters**

| | | | | | | |
|---|---|---|---|---|---|---|
| SPACE | A | B | C | D | E | F |
| G | H | I | J | K | L | M |
| N | O | P | Q | R | S | T |
| U | V | W | X | Y | Z | TH |
| IN | ER | RE | AN | HE | . | , |

**Frequency Arrangement of Letters**

| | | | | | | |
|---|---|---|---|---|---|---|
| SPACE | E | A | I | L | HE | Y |
| T | O | S | D | P | AN | ER |
| N | R | C | F | IN | ES | Q |
| H | TH | M | B | V | X | Z |
| U | W | G | K | J | . | , |

***Solution***

The time needed to compose the target sentence is equal to the number of steps needed to select each letter and space in that sentence. For the alphabetically arranged array, 5 dwell steps (2nd row plus 3rd column) at 1.5 s per step are needed to reach the letter *I*. For the frequency of occurrence array, 5 dwell steps (1st row plus 4th column) also are needed to reach the letter *I*. To insert a space, both arrays require 2 dwell steps (1st row plus 1st column). For the letter *W*, the same number of dwell steps (7) are needed in both arrays. For the letter *T*, however, 10 dwell steps are needed in the alphabetical array but just 3 dwell steps are needed in the frequency of occurrence array. Each time the letter *T* is used, 7 dwell steps (or 10.5 s) are saved with the frequency of occurrence array. Thus, the time needed to produce the sample sentence, assuming no errors, is 213 s when using the alphabetical array and 180 s when using the frequency array. Notice that even for a 7-word sentence, over half a minute can be saved with the faster frequency arrangement array and that additional time was saved by using the double letter combination *AN* rather than selecting the single letters *A* and *N* separately. ■

## Principle of Simplicity and Intuitive Operation

The universal goal of equipment design is to achieve intuitively simple operation, and this is especially true for electronic and computer-based assistive devices. The key to intuitively simple operation lies in the proper choice of compatible and optimal controls and displays. *Compatibility* refers to the degree to which relationships between the control actions and indicator movements are consistent, respectively, with expectations of the equipment's response and behavior. When compatibility relationships are incorporated into an assistive device, learning is faster, reaction time is shorter, fewer errors occur, and the user's satisfaction is higher. Although people can and do learn to use adaptations that do not conform to their expectations, they do so at a price (producing more errors, working more slowly, and/or requiring more attention). Hence, the rehabilitation engineer needs to be aware of and follow some common compatibility relationships and basic ergonomic guidelines, such as:

- The display and corresponding control should bear a physical resemblance to each other.
- The display and corresponding control should have similar physical arrangements and/or be aided by guides or markers.
- The display and corresponding control should move in the same direction and within the same spatial plane (e.g., rotary dials matched with rotary displays, linear vertical sliders matched with vertical displays).
- The relative movement between a switch or dial should be mindful of population stereotypic expectations (e.g., an upward activation to turn something on, a clockwise rotation to increase something, and scale numbers that increase from left to right).

Additional guidelines for choosing among various types of visual displays are given in Table 5.6.

### Principle of Display Suitability

In selecting or designing displays for transmission of information, the selection of the sensory modality is sometimes a foregone conclusion, such as when designing a warning signal for a visually impaired person. When there is an option, however, the rehabilitation engineer must take advantage of the intrinsic advantages of one sensory modality over another for the type of message or information to be conveyed. For example, audition tends to have an advantage over vision in vigilance types of warnings because of its attention-getting qualities. A more extensive comparison of auditory and visual forms of message presentation is presented in Table 5.7.

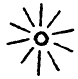
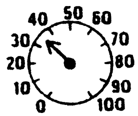
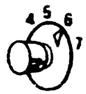
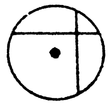
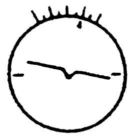
### Principle of Allowance for Recovery from Errors

Both rehabilitation engineering and human factors or ergonomics seek to design assistive technology that will expand an individual's capabilities while minimizing errors. However, human error is unavoidable no matter how well something is designed. Hence, the assistive device must provide some sort of allowance for errors without seriously compromising system performance or safety. Errors can be classified as errors of omission, errors of commission, sequencing errors, and timing errors.

A well-designed computer-based electronic assistive device will incorporate one or more of the following attributes:

- The design makes it inherently impossible to commit the error (e.g., using jacks and plugs that can fit together only one way or the device automatically rejects inappropriate responses while giving a warning).
- The design makes it less likely, but not impossible to commit the error (e.g., using color-coded wires accompanied by easily understood wiring diagrams).
- The design reduces the damaging consequences of errors without necessarily reducing the likelihood of errors (e.g., using fuses and mechanical stops that limit excessive electrical current, mechanical movement, or speed).

**TABLE 5.6** General Guide to Visual Display Selection

| To Display | Select | Because | Example |
|---|---|---|---|
| Go, no go, start, stop, on, off | Light | Normally easy to tell if it is on or off. |  |
| Identification | Light | Easy to see (may be coded by spacing, color, location, or flashing rate; may also have label for panel applications). |  |
| Warning or caution | Light | Attracts attention and can be seen at great distance if bright enough (may flash intermittently to increase conspicuity). |  |
| Verbal instruction (operating sequence) | Enunciator light | Simple "action instruction" reduces time required for decision making. |   |
| Exact quantity | Digital counter | Only one number can be seen, thus reducing chance of reading error. |   |
| Approximate quantity | Moving pointer against fixed scale | General position of pointer gives rapid clue to the quantity plus relative rate of change. |   |
| Set-in quantity | Moving pointer against fixed scale | Natural relationship between control and display motions. |   |
| Tracking | Single pointer or cross pointers against fixed index | Provides error information for easy correction. |  |
| Vehicle attitude | Either mechanical or electronic display of position of vehicle against established reference (may be graphic or pictorial) | Provides direct comparison of own position against known reference or base line. |    |

Abstracted from Human Factors in Engineering and Design, 7th Ed., by Sanders and McCormick, 1993.

**TABLE 5.7** Choosing Between Auditory and Visual Forms of Presentation

| Use Auditory Presentation if | Use Visual Presentation if |
|---|---|
| The message is simple. | The message is complex. |
| The message is short. | The message is long. |
| The message will not be referred to later. | The message will be referred to later. |
| The message deals with events in time. | The message deals with location in space. |
| The message calls for immediate action. | The message does not call for immediate action. |
| The visual system of the person is overburdened. | The auditory system of the person is overburdened. |
| The message is to be perceived by persons not in the area. | The message is to be perceived by someone very close by. |
| Use artificially generated speech if the listener cannot read. | Use visual display if the message contains graphical elements. |

Adapted and modified from Saunders and McCormick (1993, p. 53, Table 3-1).

- The design incorporates an "undo," "escape," or "go-back" command in devices that involve the selection of options within menus.

## Principle of Adaptability and Flexibility

One fundamental assumption in ergonomics is that devices should be designed to accommodate the user and not vice versa. As circumstances change and/or as the user gains greater skill and facility in the operation of an assistive device, its operational characteristics must adapt accordingly. In the case of an augmentative electronic communication device, its vocabulary set should be changed easily as the user's needs, skills, or communication environment change. The method of selection and feedback also should be flexible, perhaps offering direct selection of the vocabulary choices in one situation while reverting to a simpler row-column scanning in another setting. The user should also be given the choice of having auditory, visual, or a combination of both as feedback indicators.

## Principle of Mental and Chronological Age Appropriateness

When working with someone who has had lifelong and significant disabilities, the rehabilitation engineer cannot presume that the mental and behavioral age of the individual with disabilities will correspond closely with that person's chronological age. In general, people with congenital disabilities tend to have more limited variety, diversity, and quantity of life experiences. Consequently, their reactions and behavioral tendencies often mimic those of someone much younger. Thus, during assessment and problem definition, the rehabilitation engineer should ascertain the functional age of the individual to be helped. Behavioral and biographical information can be gathered by direct observation and by interviewing family members, teachers, and social workers.

Special human factor considerations also need to be employed when designing assistive technology for very young children and elderly individuals. When designing adaptations for such individuals, the rehabilitation engineer must consider that they may have a reduced ability to process and retain information. For example, generally more time is required for very young children and older people to retrieve information from long-term memory, to choose among response alternatives, and to execute correct responses. Studies have shown that elderly persons are much slower in searching for material in long-term memory, in shifting attention from one task to another, and in coping with conceptual, spatial, and movement incongruities.

The preceding findings suggest that the following design guidelines be incorporated into any assistive device intended for an elderly person:

- Strengthen the displayed signals by making them louder, brighter, larger, etc.
- Simplify the controls and displays to reduce irrelevant details that could act as sources of confusion.
- Maintain a high level of conceptual, spatial, and movement congruity, i.e., compatibility between the controls, display, and device's response.
- Reduce the requirements for monitoring and responding to multiple tasks.
- Provide more time between the execution of a response and the need for the next response. Where possible, let the user set the pace of the task.
- Allow more time and practice for learning the material or task to be performed.

## 5.5 PRACTICE OF REHABILITATION ENGINEERING AND ASSISTIVE TECHNOLOGY

### 5.5.1 Career Opportunities

As efforts to constrain health care costs intensify, it is reasonable to wonder whether career opportunities will exist for rehabilitation engineers and assistive technologists. Given an aging population, the rising number of children born with cognitive and physical developmental disorders, the impact of recent legislative mandates (Table 5.1), and the proven cost benefits of successful rehabilitation, the demand for assistive technology (new and existent) will likely increase rather than decrease. Correspondingly, employment opportunities for technically oriented persons interested in the development and delivery of assistive technology should steadily increase as well.

In the early 1980s, the value of rehabilitation engineers and assistive technologists was unappreciated and thus required significant educational efforts. Although the battle for proper recognition may not be entirely over, much progress has been made during the last two decades. For example, Medi-Cal, the California version of the federally funded medical assistance program, now funds the purchase and customization of augmentative communication devices. Many states routinely fund technology devices that enable people with impairments to function more independently or to achieve gainful employment.

Career opportunities for rehabilitation engineers and assistive technologists currently can be found in hospital-based rehabilitation centers, public schools, vocational rehabilitation agencies, manufacturers, and community-based rehabilitation technology suppliers; opportunities also exist as independent contractors. For example, a job announcement for a rehabilitation engineer contained the following job description (Department of Rehabilitative Services, Commonwealth of Virginia, 1997):

> Provide rehabilitation engineering services and technical assistance to persons with disabilities, staff, community agencies, and employers in the area of employment and reasonable accommodations. Manage and design modifications and manufacture of adaptive equipment. . . . Requires working knowledge of the design, manufacturing techniques, and appropriate engineering problem-solving techniques for persons with disabilities. Skill in the operation of equipment and tools and the ability to direct others involved in the manufacturing of assistive devices. Ability to develop and effectively present educational programs related to rehabilitation engineering. Formal training in engineering with a concentration in rehabilitation engineering, mechanical engineering, or biomedical engineering or demonstrated equivalent experience a requirement.

The salary and benefits of the job in this announcement were competitive with other types of engineering employment opportunities. Similar announcements regularly appear in trade magazines such as *Rehab Management* and *TeamRehab* and in newsletters of RESNA.

An example of employment opportunities in a hospital-based rehabilitation center can be seen in the Bryn Mawr Rehabilitation Center in Malvern, Pennsylvania. The Center is part of the Jefferson Health System, a nonprofit network of hospitals and long-term, home care, and nursing agencies. Bryn Mawr's assistive technology center provides rehabilitation engineering and assistive technology services. Its geriatric rehabilitation clinic brings together several of the facility's departments to work at keeping senior citizens in their own homes longer. This clinic charges Medicare for assessments and the technology needed for independent living. Support for this program stems from the potential cost savings related to keeping older people well and in their own homes.

Rehabilitation engineers and assistive technologists also can work for school districts that need to comply with the Individuals with Disabilities Education Act. A rehabilitation engineer working in such an environment would perform assessments, make equipment modifications, customize assistive devices, assist special education professionals in classroom adaptations, and advocate to funding agencies for needed educationally related technologies. An ability to work well with nontechnical people such as teachers, parents, students, and school administrators is a must.

One promising employment opportunity for rehabilitation engineers and assistive technologists is in community-based service providers such as the local United Cerebral Palsy Association or the local chapter of the National Easter Seals Society. Through the combination of fees for service, donations, and insurance payments, shared rehabilitation engineering services in a community service center can be financially viable. The center would employ assistive technology professionals to provide information, assessments, customized adaptations, and training.

Rehabilitation engineers also can work as independent contractors or as employees of companies that manufacture assistive technology. Because rehabilitation engineers understand technology and the nature of many disabling conditions, they can serve as a liaison between the manufacturer and its potential consumers. In this capacity, they could help identify and evaluate new product opportunities. Rehabilitation engineers, as independent consultants, also could offer knowledgeable and trusted advice to consumers, funding agencies, and worker compensation insurance companies. Such consultation work often involves providing information about relevant assistive technologies, performing client evaluations, and assessing the appropriateness of assistive devices. It is important that a rehabilitation engineer who wishes to work as an independent consultant be properly licensed as a Professional Engineer (PE) and be certified through RESNA as described in the next section. The usual first step in attaining the Professional Engineer's license is to pass the Fundamentals of Engineering Examination given by each state's licensing board.

### 5.5.2 Rehabilitation Engineering Outlook

Rehabilitation engineering has reached adolescence as a separate discipline. It has a clearly defined application. For example, rehabilitation engineering research and development has been responsible for the application of new materials in the design of wheelchairs and orthotic and prosthetic limbs, the development of assistive technology that provides a better and more independent quality of life and better employment outcomes for people with disabilities, the removal of barriers to telecommunications and information technology through the application of universal design principles, the development of hearing aids and communication devices that exploit digital technology and advanced signal processing techniques, and the commercialization of neural prostheses that aid hand function, respiration, standing, and even limited walking.

Beginning with the Rehabilitation Act of 1973 and its subsequent amendments in 1992 and 1998, rehabilitation engineering in the United States has been recognized as an activity that is worthy of support by many governments, and many universities offer formal graduate programs in this field. Fees for such services have been reimbursed by public and private insurance policies. Job advertisements for rehabilitation engineers appear regularly in newsletters and employment notices. In 1990, the Americans with Disabilities Act granted civil rights to persons with disabilities and made reasonable accommodations mandatory for all companies having more than 25 employees. Archival journals publish research papers that deal with all facets of rehabilitation engineering. Student interest in this field is rising. What is next?

Based on some recent developments, several trends will likely dominate the practice of rehabilitation engineering and its research and development activities during the next decade.

- Certification of rehabilitation engineers will be fully established in the United States. Certification is the process by which a nongovernmental agency or professional association validates an individual's qualifications and knowledge in a defined functional or clinical area. RESNA is leading such a credentialing effort for providers of assistive technology. RESNA will certify someone as a Professional Rehabilitation Engineer if that person is a registered Professional Engineer (a legally recognized title), possesses the requisite relevant work experience in rehabilitation technology, and passes an examination that contains 200 multiple-choice questions. For nonengineers, certification as an Assistive Technology Practitioner (ATP) or Assistant Technology Supplier (ATS) is available. Sample questions from RESNA's credentialing examination are provided at the end of the chapter.

- Education and training of rehabilitation technologists and engineers will expand worldwide. International exchange of information has been occurring informally. Initiatives by government entities and professional associations such as RESNA have given impetus to this trend. For example, the U.S. Department of Education supports a consortium of several American and European universities in the training of rehabilitation engineers. One indirect goal of this initiative is to foster formal exchanges of information, students, and investigators.
- Universal access and universal design of consumer items will become commonplace. Technological advances in the consumer field have greatly benefited people with disabilities. Voice-recognition systems have enabled people with limited movement to use their computers as an interface to their homes and the world. Telecommuting permits gainful employment without requiring a disabled person to be physically at a specified location. Ironically, benefits are beginning to flow in the opposite direction. Consumer items that once were earmarked for the disabled population (e.g., larger knobs, easy-to-use door and cabinet handles, curb cuts, closed-caption television programming, larger visual displays) have become popular with everyone. In the future, the trend toward universal access and products that can be used easily by everyone will expand as the citizenry ages and the number of people with limitations increases. Universal design—which includes interchangeability, component modularity, and user friendliness—will be expected and widespread.
- Ergonomic issues will play a more visible role in rehabilitation engineering. When designing for people with limitations, ergonomics and human factors play crucial roles, often determining the success of a product. In recognition of this, *IEEE Transactions on Rehabilitation Engineering* published a special issue on "Rehabilitation Ergonomics and Human Factors" in September 1994. The Human Factors and Ergonomics Society has a special interest group on "Medical Systems and Rehabilitation." In the next decade, more and more rehabilitation engineering training programs will offer required courses in ergonomics and human factors. The understanding and appreciation of human factors by rehabilitation engineers will be commonplace. The integration of good human factors designed into specialized products for people with disabilities will be expected.
- Cost-benefit analysis regarding the impact of rehabilitation engineering services will become imperative. This trend parallels the medical field in that cost containment and improved efficiency have become everyone's concern. Econometric models and socioeconomic analysis of intervention efforts by rehabilitation engineers and assistive technologists will soon be mandated by the federal government. It is inevitable that health maintenance organizations and managed care groups will not continue to accept anecdotal reports as sufficient justification for supporting rehabilitation engineering and assistive technology (Gelderbom & de Witte, 2002; Andrich, 2002). Longitudinal and quantitative studies in rehabilitation, performed by unbiased investigators, will likely be the next major initiative from funding agencies.

- Quality assurance and performance standards for categories of assistive devices will be established. As expenditures for rehabilitation engineering services and assistive devices increase, there will undoubtedly be demand for some objective assurance of quality and skill level. One example of this trend is the ongoing work of the Wheelchair Standards Committee jointly formed by RESNA and the American National Standards Institute. Another example of this trend is the drive for certifying assistive technology providers and assistive technology suppliers.
- Applications of wireless technology will greatly increase the independence and capabilities of persons with disabilities. For example, navigational aids that utilize the Global Positioning System, Internet maps, cellular base station triangulation, and ubiquitous radio frequency identification tags will enable the blind to find their way indoors and outdoors as easily as their sighted counterparts. Wireless technology also will assist people with cognitive limitations in their performance of daily activities. Reminders, cueing devices, trackers and wandering devices, and portable personal data assistants will enable them to remember appointments and medications, locate themselves positionally, follow common instructions, and obtain assistance.
- Technology will become a powerful equalizer as it reduces the limitations of manipulation, distance, location, mobility, and communication that are the common consequences of disabilities. Sometime in the next 20 years, rehabilitation engineers will utilize technologies that will enable disabled individuals to manipulate data and information and to alter system behavior remotely through their voice-controlled, Internet-based, wireless computer workstation embedded in their nuclear-powered wheelchairs. Rather than commuting daily to work, persons with disabilities will or can work at home in an environment uniquely suited to their needs. They will possess assistive technology that will expand their abilities. Their dysarthric speech will be automatically recognized and converted into intelligible speech in real time by a powerful voice-recognition system. Given the breathtaking speed at which technological advances occur, these futuristic devices are not mere dreams but realistic extrapolations of the current rate of progress.

Students interested in rehabilitation engineering and assistive technology R & D will be able to contribute toward making such dreams a reality shortly after they complete their formal training. The overall role of future practicing rehabilitation engineers, however, will not change. They still will need to assess someone's needs and limitations, apply many of the principles outlined in this chapter, and design, prescribe, modify, or build assistive devices.

## EXERCISES

Like the engineering design process described earlier in this chapter, answers to the following study questions may require searching beyond this textbook for the necessary information. A good place to begin is the Suggested Reading section. You also may try looking for the desired information using the Internet.

1. The fields of rehabilitation engineering and assistive technology have been strongly influenced by the federal government. Describe the impact federal legislation has had on the prevalence of rehabilitation engineers and the market for their work in assistive technology. Explain and provide examples.
2. As a school-based rehabilitation engineer, you received a request from a teacher to design and build a gadget that would enable an 8-year-old, second-grade student to signal her desire to respond to questions or make a request in class. This young student uses a powered wheelchair, has multiple disabilities, cannot move her upper arms very much, and is unable to produce understandable speech. Prepare a list of quantitative and qualitative questions that will guide your detailed analysis of this problem. Produce a hypothetical set of performance specifications for such a signaling device.
3. Write a sample set of performance specifications for a voice-output oscilloscope to be used by a visually impaired electrical engineering student for a laboratory exercise having to do with operational amplifiers. What features would be needed in the proposed oscilloscope?
4. Write a sample set of performance specifications for a foldable lap tray that will mount on a manual wheelchair. Hints: What should its maximum and minimum dimensions be? How much weight must it bear? Will your add-on lap tray user make the wheelchair user more or less independent? What type of materials should be used?
5. Sketch how the leg raiser described in Example Problem 5.1 might fit onto a battery-powered wheelchair. Draw a side view and rear view of the leg-raiser-equipped wheelchair.
6. Do a careful search of commercially available electronic communication devices that meet the following performance specifications: speech output, icon-based membrane keyboard, portable, weigh less than 7.5 lbs, no more than 2.5 in. thick, no larger than a standard three-ring binder, and able to be customized by the user to quickly produce frequently used phrases. Hints: Consult "The Closing the Gap Product Directory" and the "Cooperative Electronic Library on Disability." The latter is available from the Trace Research and Development Center at the University of Wisconsin, Madison. Also try visiting the applicable websites.
7. A person's disabilities and abilities often depend on his or her medical condition.
   a) A person is known to have spinal cord injury (SCI) at the C5–C6 level. What does this mean in terms of this person's probable motoric and sensory abilities and limitations?
   b) Repeat part (a) for a person with multiple sclerosis. Include the prognosis of the second individual in contrast to the person with SCI.
8. To be portable, an electronic assistive device must be battery powered. Based on your study of technical manuals and battery handbooks, list the pros and cons of using disposable alkaline batteries versus lithium-hydride rechargeable batteries. Include in your comparison an analysis of the technical issues (e.g., battery capacity, weight, and charging circuitry), cost issues, and

practicality issues (e.g., user preferences, potential for misplacement or improper usage of charger, and user convenience).

**9.** A young person with paraplegia wishes to resume skiing, canoeing, sailing, and golfing. For each of these sports, list four or five adaptations or equipment modifications that are likely to be needed. Sketch and briefly describe these adaptations.

**10.** A 21-year-old female who has muscular dystrophy requested assistance with computer access, particularly for writing, using spreadsheets, and playing computer games. She lacks movement in all four extremities except for some wrist and finger movements. With her left hand, she is able to reach about 6 in. past her midline. With her right hand, she is able to reach only 2 in. past her midline. Both her hands can reach out about 8 in. from the body. If given wrist support, she has good control of both index fingers. Based on this description, sketch the work area that she appears able to reach with her two hands. Describe the adaptations to a standard or contracted keyboard that she would need to access her home computer. For additional information, consult the "Closing the Gap Product Directory," the "Cooperative Electronic Library on Disability," and the suggested reading materials listed at the end of this chapter.

**11.** The two main computer user interfaces are the command line interface (CLI), as exemplified by UNIX commands, and the graphical user interface (GUI), as exemplified by the Windows XP or Apple's OS X operating systems. For someone with limited motoric abilities, each type of interface has its advantages and disadvantages. List and compare the advantages and disadvantages of CLI and GUI. Under what circumstances and for what kinds of disabilities would the CLI be superior to or be preferred over the GUI?

**12.** One of the major categories of assistive devices is alternative and augmentative communication devices. Describe the electronic data processing steps needed for text-to-speech conversion. How have the technological advances in personal computing made this conversion faster and the speech output more lifelike?

**13.** What would the second scale reading ($S_2$) be if the person in Example Problem 5.3 raised both of his legs straight up and $D$ was known to be 14 in.?

**14.** How much tension would be exerted on the pulley in Example Problem 5.4 if the weights were observed to be falling at 1.5 ft/s$^2$?

**15.** How much contraction force must the flexor muscles generate in order for a person to hold a 25-lb weight in his hand, 14 in. from the elbow joint? Assume that the flexor muscle inserts at 90° to the forearm 2 in. from the elbow joint and that his forearm weighs 4.4 lbs. Use the equilibrium equation, $\Sigma F_X = \Sigma F_y = \Sigma M = 0$, and Figure 5.10 to aid your analysis.

**16.** How much force will the head of the femur experience when a 200-lb person stands on one foot? Hint: Apply the equilibrium equation, $\Sigma F_X = \Sigma F_y = \Sigma M = 0$, to the skeletal force diagram in Figure 5.11 in your analysis.

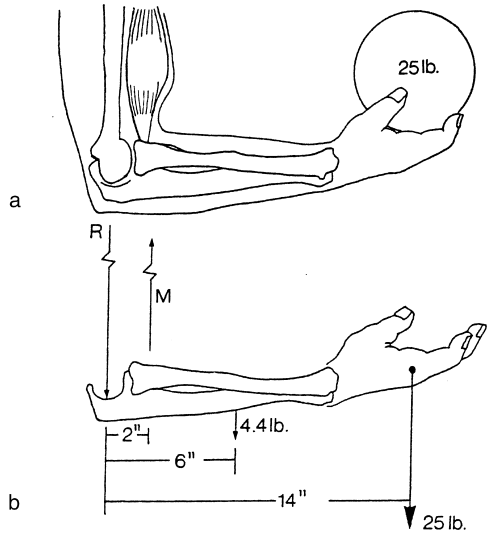



**Figure 5.10** Static forces about the elbow joint during an elbow flexor exercise (from Le Veau, 1976).

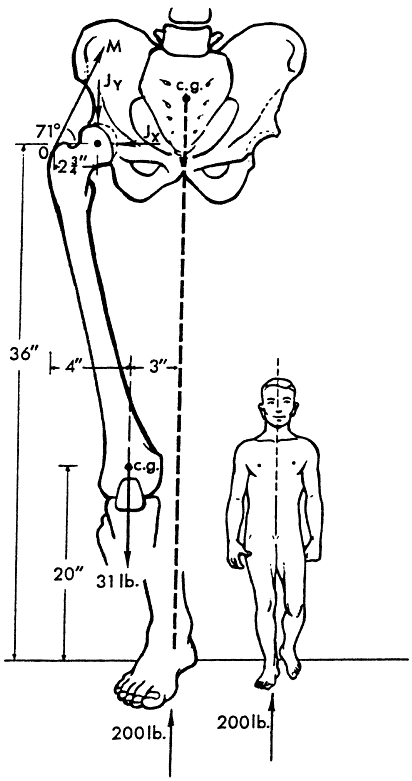
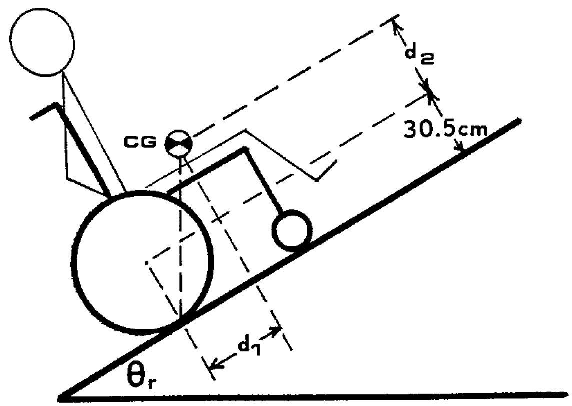



**Figure 5.11** Determination of the compression force on the supporting femoral head in unilateral weight bearing (from Le Veau, 1976).

**17.** Under static or constant velocity conditions, the wheelchair will tip backwards if the vertical projection of the combined center of gravity ($CG$) of the wheelchair and occupant falls behind the point of contact between the rear wheels and the ramp surfaces. As shown in Figure 5.12, the rearward tipover angle ($\theta_r$) is determined by the horizontal distance ($d_1$) and the vertical distance ($d_2$) between $CG$ and the wheelchair's rear axles.

a) Using static analysis, derive the equation relating $\theta_r$, $d_1$, and $d_2$.
b) Using the platform approach depicted in Figure 5.7, suggest a method for determining $d_1$.
c) Assuming that $d_1$ and $d_2$ averaged 13 cm and 24 cm, respectively, for able-bodied individuals, what would $\theta_r$ be?
d) How would $d_1$ and $d_2$ change if the wheelchair occupant leaned forward instead of sitting back against the chair? How would $\theta_r$ be affected by this postural shift?



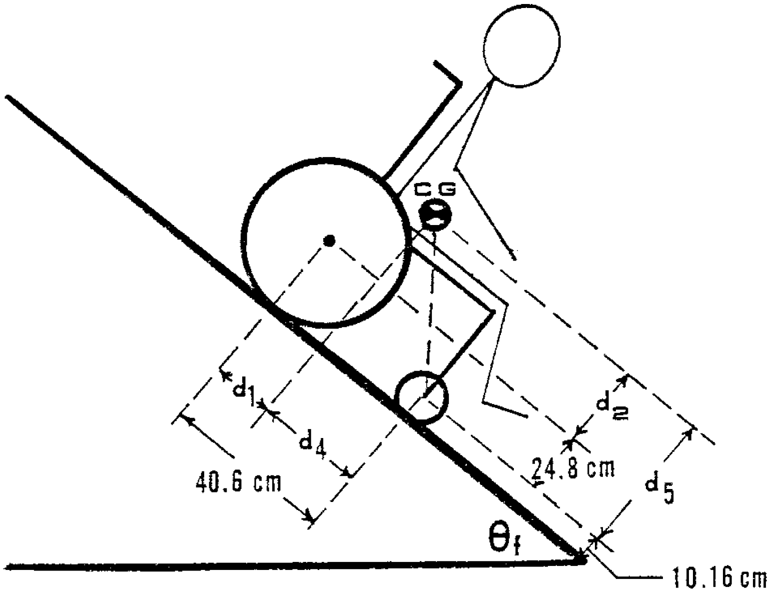

$d_1$ = horizontal distance in cm (relative to the incline) between the CG and the rear axles.

$d_2$ = vertical distance in cm (relative to the incline) between the CG and the rear axles.

$\theta_r$ = static rearward tipover angle.

**Figure 5.12** Conditions under which the occupied wheelchair will begin to tip backwards. The tipover threshold occurs when the vertical projection of the combined *CG* falls behind the rearwheel's contact point with the inclined surface (from Szeto and White, 1983).

**18.** Perform a static analysis of the situation depicted in Figure 5.13 and derive the equation for the probable forward tipover angle ($\theta_r$) using the data and dimensions shown. Assuming that $d_1$ and $d_2$ were the same as given in problem 17 and $d_4$ and $d_5$ averaged 27 cm and 49 cm, respectively, what would $\theta_r$ be?




$d_1$ = horizontal distance in cm (relative to the incline) between the *CG* and the rear axles.

$d_2$ = vertical distance in cm (relative to the incline) between the *CG* and the rear axles.

$d_4$ = horizontal distance in cm (relative to the incline) between the *CG* and the casters.

$d_5$ = vertical distance in cm (relative to the incline) between the *CG* and the rear axles.

$\theta_f$ = forward tipover angle.

**Figure 5.13** Conditions under which the occupied wheelchair will begin to tip forward. The tipover threshold occurs when the vertical projection of the combined *CG* falls behind the caster wheel's contact point with the inclined surface (from Szeto and White, 1983).

**19.** For persons with good head control and little else, the Head Master (by Prentke Romich Co., Wooster, OH) has been used to emulate the mouse input signals for a computer. The Head Master consists of a headset connected to the computer by a cable. The headset includes a sensor that detects head movements and translates such movements into a signal interpreted as 2-dimensional movements of the mouse. A puff-and-sip pneumatic switch is also attached to headset and substitutes for clicking of the mouse. Based on this brief description of the Head Master, draw a block diagram of how this device might work and the basic components that might be needed in the Head Master. Include in your block diagram the ultrasonic signal source, detectors, timers, and signal processors that would be needed.

**20.** Based on the frequency of use data shown in Tables 5.8, 5.9, and 5.10, design an optimized general purpose communication array using row-column scanning. Recall that row-column scanning is a technique whereby a vocabulary element is first highlighted row by row from the top to bottom of the array. When the row containing the desired element is highlighted, the user activates a switch to select it. Following the switch activation, the scanning proceeds within the selected row from left to right. When the desired vocabulary element is highlighted again, a second switch activation is made. In row-column scanning, the first press of a switch selects the row and the second press selects the column. Hint: Arrange the most frequently

**TABLE 5.8** Simple English Letter Frequency from 10,000 Letters of English Literary Text

| | | |
|---|---|---|
| E =1231 | L = 403 | B = 162 |
| T = 959 | D = 365 | G = 161 |
| A = 805 | C = 320 | V = 93 |
| O = 794 | U = 310 | K = 52 |
| N = 719 | P = 229 | Q = 20 |
| I = 718 | F = 228 | X = 20 |
| S = 659 | M = 225 | J = 10 |
| R = 603 | W = 203 | Z = 9 |
| H = 514 | Y = 188 | |

Data from Webster et al. (1985).

**TABLE 5.9** Frequency of English Two- and Three-Letter Combinations from 25,000 Letters of English Literary Text

**Two-letter Combinations**

| | | | | |
|---|---|---|---|---|
| TH = 1582 | HE = 542 | ON = 420 | NT = 337 | RA = 275 |
| IN = 784 | EN = 511 | OU = 361 | HI = 330 | RO = 275 |
| ER = 667 | TI = 510 | IT = 356 | VE = 321 | LI = 273 |
| RE = 625 | TE = 492 | ES = 343 | CO = 296 | IO = 270 |
| AN = 542 | AT = 440 | OR = 339 | DE = 275 | |

**Three-letter Combinations**

| | | | | |
|---|---|---|---|---|
| THE = 1182 | ERE = 173 | HAT = 138 | NCE = 113 | MAN = 01 |
| ING = 356 | HER = 170 | ERS = 135 | ALL = 111 | RED = 101 |
| AND = 284 | ATE = 165 | HIS = 130 | EVE = 111 | THI = 100 |
| ION = 252 | VER = 159 | RES = 125 | ITH = 111 | IVE = 96 |
| ENT = 246 | TER = 157 | ILL = 118 | TED = 110 | |
| FOR = 246 | THA = 155 | ARE = 117 | AIN = 108 | |
| TIO = 188 | ATI = 148 | CON = 114 | EST = 106 | |

Data from Webster et al. (1985).

**TABLE 5.10** Frequency of English Words from 242,432 Words of English Literary Text

| | | | |
|---|---|---|---|
| THE = 15,568 | FOR = 1869 | HAVE = 1344 | THIS = 1021 |
| OF = 9757 | AS = 1853 | YOU = 1336 | MY = 963 |
| AND = 7638 | WITH = 1849 | WHICH = 1291 | THEY = 959 |
| TO = 5739 | WAS = 1761 | ARE = 1222 | ALL = 881 |
| A = 5074 | HIS = 1732 | ON = 1155 | THEIR = 824 |
| IN = 4312 | HE = 1721 | OR = 1101 | AN = 789 |
| THAT = 3017 | BE = 1535 | HER = 1093 | SHE = 775 |
| IS = 2509 | NOT = 1496 | HAD = 1062 | HAS = 753 |
| I = 2292 | BY = 1392 | AT = 1053 | WHERE = 753 |
| IT = 2255 | BUT = 1379 | FROM = 1039 | ME = 752 |

Data from Webster et al. (1985).

used vocabulary elements earliest in the scanning order. See Example Problem 5.5.

**21.** An electronic guide dog has been proposed as an electronic travel aid for a blind person. List some of the specific tasks that such a device must perform and the information processing steps involved in performing these tasks. List as many items and give as many details as possible. Hints: Consider the problems of obstacle detection, information display, propulsion system, inertial guidance, route recall, power supply, etc.

**22.** The ability of the user to visually scan an array of options and make appropriate choices is fundamental to many assistive devices. Analyze the difference between visual pursuit tracking and visual scanning in terms of the oculomotor mechanisms that underlie these two activities.

**23.** Based on Table 5.7, what type of speech synthesis technology would be the most appropriate for the following situations: (a) an augmentative communication system capable of unlimited vocabulary for someone who can spell? (b) a voice output system for a blind person that reads the entire screen of a computer display? (c) an augmentative communication system for a young girl who needs a limited vocabulary set? (d) voice feedback for an environmental control system that echoes back simple one-word commands, such as "on," "off," "lights," "bed," "TV," and "drapes." Explain or justify your answer.

**24.** Safe and independent mobility by persons with severe visual impairments remains a challenge. To relieve such persons of their dependence on guide dogs or a sighted human guide, various portable navigational aids using a Global Positioning System (GPS) receiver have been marketed.

   **a)** Conduct an Internet investigation of GPS as the basis for a portable navigational aid for the blind. Address the following issues: How does GPS work? Can GPS signals be reliably received at every location? How accurate are GPS signals in terms of resolution? Is this level of resolution sufficient for finding the entrance to a building? Can dead reckoning and inertial guidance help when GPS signals are lost?

b) Describe the various operational requirements of an ideal portable navigational aid for the blind. Consider such ergonomic issues as the user interface, input and output requirements, and target retail price. List some of the human factor design issues involved.

## Sample Multiple-Choice Questions from RESNA's Credentialing Examination in Assistive Technology

1. Which of the following abilities is necessary for development of skilled upper-extremity movements?
   a. Equilibrium reactions in the standing position
   b. Ability to cross midline
   c. Good postural control of the trunk and head
   d. Pincer grasp
2. A 12-year-old male with Duchenne's muscular dystrophy is being evaluated for a mobility system. The therapist notes that he has lateral bending of the trunk and leans to the left. The most appropriate next step is assessment for
   a. Kyphosis
   b. Lordosis
   c. Left-sided weakness
   d. Scoliosis
3. The most appropriate location for training and instruction in functional use of an assistive technology device is
   a. A quiet area with few distractions
   b. The individual's home environment
   c. The environment in which the device will be used
   d. A training center where several therapists are available
4. An architect with C4–C5 quadriplegia would like to use a computer-assisted design (autoCAD) system when he returns to work. The most appropriate first step is assessment of the client's ability to use
   a. Mouthstick
   b. Eye-blink switch
   c. Alternate mouse input
   d. Sip-and-puff switch
5. Under the Individuals with Disabilities Education Act, assistive technology is defined as a device that
   a. Increases functional capability
   b. Improves mobility or communication
   c. Compensates for physical or sensory impairment
   d. Is considered durable medical equipment
6. In addition to the diagnosis, which information must be included in a physician's letter of medical necessity?
   a. Cost of assistive technology requested
   b. Client's prognosis
   c. Client's range of motion
   d. Client's muscle tone

7. Plastic is an ideal seat base for the person with incontinence because it is
   **a.** Light weight
   **b.** Less costly than wood
   **c.** Nonabsorbent
   **d.** Detachable from wheelchair
8. When considering structural modification of a newly purchased commercial device, which of the following is the *most* important concern?
   **a.** Future use by other individuals
   **b.** Voidance of warranty
   **c.** Resale value
   **d.** Product appearance
9. A client is interested in using a voice-recognition system to access the computer. Which of the following factors is *least* critical to success with this method?
   **a.** Hand function
   **b.** Voice clarity
   **c.** Voice-recognition system training
   **d.** Type of computer system used
10. A 9-year-old is no longer able to drive her power-base wheelchair. Training was provided following delivery of the wheelchair 2 years ago. Which of the following is the first step in evaluation?
   **a.** Interview the parents and child
   **b.** Perform a cognitive evaluation
   **c.** Reevaluate access in the wheelchair
   **d.** Contact the wheelchair manufacturer

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UNIT- III

## THERAPEUTIC EXERCISE TECHNIQUE:

- It refers to physical activities that helps to restore, build physical strength, balance, stability.
- Accelerating the patient's recovery from injuries and diseases which have altered his normal way of living.
- **Goal:** Return an injured person to a pain free, fully functioning state, to promote the activity and minimize the effects of inactivity, increase the normal range of motion, strength the weak muscles, improve the performance in daily activities.
- Managed by a physio therapist by slow progression.

## Coordination exercise:

- Balance is the ability to stay upright or stay in control of body movement, and **Coordination** is the ability to move two or more body parts under control, smoothly and efficiently.
- Coordination is one element of movement that is important in sports and in day-to-day living.
- Adding exercises to your daily routine may improve your coordination overall.
- There are two types of balance: static and dynamic.

1. Static balance is maintaining equilibrium when stationary,
2. Dynamic balance is maintaining equilibrium when moving.

We use our eyes, ears and 'body sense' to help retain our balance. Coordination is a complex skill that requires not only good balance, but good levels of other fitness components such strength and agility. Balance and coordination can be improved through practice and training within specific sports.

Balance and Coordination is one of the main fitness components, a factor for success in many sports. In certain sports, such as gymnastics and surfing, balance is one of the most important physical attributes. Good coordination is also vital for sports involving hitting objects. In many other sports, including team sports, good balance and coordination is an important part of skill development and the overall fitness profile. A vote of the top sports has hitting sports such as baseball, tennis and squash ranked highest. See also another list ranking sports in which balance is important.

**Priniciple of Coordination exercise:**

- Constant repetition of few motor activities.
- Use of sensory cues to enhance motor performance.
- Increase of speed of the activity over time.

**Training Methods:**

Physical coordination is a motor skill that requires the integration of spatial perception and physical movement to achieve a desired result. A simple activity, such as cutting paper with scissors, requires a well-timed coordinated series of actions involving complex neural and muscular processes. Physical coordination can be enhanced by habitually engaging in actions that require synchronization between multiple muscle groups or body parts.

Physical coordination naturally develops in infants as they explore their environment and handle various objects. Children learn to time movements to create a result, for instance, using eye-hand coordination when eating food or playing with toys. Coordination continues to develop during recreational activities, playing musical instruments or when engaged in sports, such as throwing a football while running across a field. Physical coordination that requires precise timing between the hands, fingers and eyes is referred to as dexterity.

The cerebellum is the part of the brain that primarily controls movement and coordination. Physical coordination is impaired when there is damage to the cerebellum or other parts of the brain that affects its functioning.

There are many factors that can decrease the coordination of walk: deformity, muscle weakness, pain. One of the main factors is deficit of the neurological control.

**Categories of Coordination Exercise:**

There are 2 main categories of coordination exercise. They are:

1. **Gross motor activity:** Movement concerned with large muscles.

Eg: kneeling, standing, walking, running.

2. **Fine motor activity:** Movement concerned with ~~large~~ small muscles.

Eg: writing, picking up small objects.

**Purpose of performing Coordination Exercise:**

Determine the muscle activity characteristic during voluntary movement.

Access the **ability** of muscle or muscle group **to work** together to perform a task or functional activity.

Determine the level of skill and efficiency of movement.

Identify the ability to initiate , control, terminate action.

Assist with establishing goals of the diagnosis of underlying impairments, functional limitations and disability.

**Examples of Coordination & Balance Exercise**

Balance and coordination skills are necessary for everyday tasks. Good balance skills require control of many muscles to carry out activities without falling over. Coordination skills include eye-hand coordination, bilateral coordination and smooth, controlled movements of the body.

**Jumping Rope**

Jumping rope is a common exercise in boxing and martial arts to improve footwork, balance and coordination. You will get into a rhythm after some practice, so mix up your routine once you're comfortable with the basic motion. Run in place while spinning the rope, hop on one foot, alternate kicking one foot out and cross the rope in front of you. Experiment with different footwork combinations to challenge your coordination.

**Speed Bag**

The speed bag is another boxing staple and effective coordination exercise. Just as with rope jumping, you can create a rhythm with the speed bag, so it is a good idea to change the routine as you go. Hit the bag with different parts of your hand or change the number of times it bounces back and forth before you hit it again. In the beginning, just making contact each time is enough to challenge your reflexes and coordination.

**Racquet Sports**

Sports that are played with a racquet and ball -- such as tennis, squash, racquetball and ping pong -- are effective coordination exercises. If you don't have a partner, hit the ball against a wall or tilt the ping pong table up to hit the ball to yourself. Practice moving from side to side and hitting the ball from different elevations to refine your hand-eye coordination.

**Simple One-Leg Balancing**

Lift one knee up until your hip is bent at a 90-degree angle. Hold it there for as long as possible. Time how long you can keep your balance. Take care not to let your legs touch each other. If you prefer, hold onto the back of a chair while you lift your leg and then remove your hand slowly to see how long you can hold the position.

**Complex One-Leg Balancing**

This exercise is the same as the simple one-leg balancing example except you do this exercise standing on a soft surface, such as a pillow. Try balancing with your eyes closed, with or without the unstable surface. You could also try reaching out for nearby objects while keeping your balance.

**Balancing on Hands and Knees**

Go down on hands and knees on a gym mat or folded blanket. Stretch one hand out in front of you and stretch the opposite leg out in the air behind you. Keep your core muscles contracted to help you balance. Now repeat on the other side.

**Twist Jumps**

Starting from a standing position, jump in place and turn 90 degrees to land neatly without losing your balance. Increase the degree of turning to 180 degrees or 360 degrees without losing your balance on landing.

**Balance Beam Exercises**

A low balance beam can be made out of a row of bricks or a sturdy plank laid between two bricks. Start by walking forward and backward along the beam. Increase the demands by balancing a beanbag on your head as you do so or by bending to pick up objects as you walk.

**Obstacle Course**

Set up an obstacle course that has a balance beam, a stretch of space for running and markers for changing direction. Include a space for a forward roll or somersault. Time yourself as you complete the obstacle course and try to improve your time without losing your balance. Do the obstacle course from a different direction to add interest.

**Hopscotch**

Draw a hopscotch grid on the ground, making it as long or as complex as you wish. Try different combinations of jumping and hopping through the various squares without touching any of the lines. Toss a beanbag into a square or two and avoid those squares as you jump.

**Ball Exercises A**

Simple toss-catch games can become more challenging if your feet have to remain within a certain space. Try standing on a pillow to throw a ball in the air or against the wall and then catch it again without moving off the pillow.

**Ball Exercises B**

Sit on an exercise ball on an exercise mat and put your arms out to the side for balance. Gently lift one foot off the ground while keeping your balance. Lower and repeat with the other foot.

**Heel-To-Toe Exercises**

Walk heel-to-toe along a line marked on the ground or along a stretch of rope. Keeping your feet in the heel-to-toe position, catch a ball thrown to you by a friend, or toss a ball against a wall and catch it again. Bending the knees may help to keep your balance as you catch the ball. Also try lifting one foot to stretch out and pick up objects to the side and then return to the heel-to-toe position.

## FRENKEL EXERCISE:

**Frenkel exercises** are a set of exercises developed by Professor Heinrich Sebastian Frenkel to treat ataxia in particular cerebellar ataxia. They are a system of slow repetitious exercises. They increase in difficulty over the time of the program. The patient watches his hand or arm movements (for example) and corrects them as needed. Although the technique is simple, needs virtually no exercise equipment, and can be done on one's own, concentration and some degree of perseverance is required. So it is performed by the ataxic patients to facilitate the restoration of coordination.

It is used to bring back the rhythmic, smooth and coordinated movements. The exercises are performed in supine, sitting, standing and walking. Each activity is performed slowly with the patient using vision to carefully guide correct movement. These exercises require a high degree of mental concentration and effort. For those patients with the prerequisite abilities, they may be helpful in regaining control of movement through cognitive compensation strategies. Patients with partial sensation can progress to practicing exercises with eyes closed.

**Principle of Frenkel exercise:**

The main principles of Frenkel exercises are the following:

- Concentration or attention
- Precision
- Repetition

Frenkel exercise consists of a planned series of exercises designed to help patient compensate for the inability to tell where the arms and legs are- in space without looking.

- 1. Exercises are designed primarily for coordination; they are not intended for strengthening.
- 2. Commands should be given in an event, slow voice; the exercises should be done to counting.
- 3. It is important that the area is well lit and that patients are positioned so that they can watch the movement of their legs.
- 4. Avoid fatigue. Perform each exercise not more than four times. Rest between each exercise.
- 5. Exercises should be done within normal range of motion to avoid over-stretching of muscles.
- 6. The first simple exercises should be adequately performed before progressing to more difficult patterns.

**General Instructions for Frenkel exercises:**

- Exercises can be performed with the part supported or unsupported, unilaterally or bilaterally.
- They should be practiced as smooth, timed movements, performed at a slow, even tempo by counting out loud.

- Consistency of performance is stressed and a specified target can be used to determine range.
- Four basic positions are used: lying, sitting, standing and walking.
- The exercises progress from postures of greatest stability (lying, sitting) to postures of greatest challenge (standing, walking).
- As voluntary control improves, the exercises progress to stopping and starting on command, increasing the range and performing the same exercises with eyes closed.
- Concentration and repetition are the keys to success.

**Techniques of frenkel exercise:**

- Patient is positioned and suitably clothed so that he can see the limbs throughout the exercise.
- A clear explanation and demonstration of the exercise is given before movement is attempted, to give the patient a clear mental picture of it.
- The patient must give his full attention to the performance of exercise to make movement smooth and accurate.
- The speed of movement is dictated by physio therapist by means of rhythmic counting, movement of her hand, or the use of suitable music.
- Range of movement is indicated by marking the spot on which the foot or hand is to be placed.
- The exercise must be repeated many times until it is perfect and easy. It is then discarded and more difficult one is substituted.
- As these exercises are very tiring at first, frequent rest periods must be allowed.

**Frenkel exercises for lower limb:**

***Exercises for the legs in lying:***

- Flex and extend one leg by the heel sliding down a straight line on the table.
- Abduct and adduct hip smoothly with knee bent and heel on the table.
- Abduct and adduct leg with knee and hip extended by sliding the whole leg on the table.
- Flex and extend hip and knee with heel off the table.
- Flex and extend both the legs together with the heel sliding on the table.

- Flex one leg while extending the other.
- Flex and extend one leg while taking the other leg into abduction and adduction.
- Heel of one limb to opposite leg (toes, ankle, shin, patella).
- Heel of one limb to opposite knee, sliding down crest of tibia to ankle.

Whether the patient slides the heels or lifts it off the bed he has to touch it to the marks indicated by the patient on the plinth. The patient may also be told to place the heel of one leg on various points of the opposite leg under the guidance of the therapist.

*Exercises for the legs in Sitting:*

- One leg is stretched to slide the heel to a position indicated by a mark on the floor.
- The alternate leg is lifted to place the heel on the marked point.
- From stride sitting posture patient is asked to stand and then sit.
- Rise and sit with knees together.
- Sitting hip abduction and adduction.

*Exercises for the legs in Standing:*

- In stride standing weight is transferred from one foot to other.
- Place foot forward and backward on a straight line.
- Walk along a winding strip.
- Walk between two parallel lines
- Walk sideways by placing feet on the marked point.
- Walk and turn around
- Walk and change direction to avoid obstacles.

**Frenkel exercises for upper limb:**

Similar exercises can be devised for the upper limb wherein the patient may be directed to place the hand on the various points marked on the table or wall board to improve coordination of all the movements in the upper limb.

***Some examples of Frankel exercises of upper limb in sitting position:***

- Have patient sit in front of a table and place a number of objects on the table. The patient then touches each object with the right hand and then the left hand.
- The patient flexes the right shoulder to 90 degree with elbow and wrist extended. The patient then takes his or her right index finger and touches the tip of his or her nose. This exercise is then repeated with the left hand. The exercise is performed alternating right and left index finger.
- The patient taps bilateral hands on bilateral thighs while alternating palmer and dorsal surfaces as fast as possible.

## GAIT ANALYSIS:

### GAIT:

Gait may be described as a translatory progression of the body as a whole,produced by coordinated, rotatory movements of body segments.

Gait is nothing but a person's manner of running, walking or stepping. Gait in humans relates to locomotion gained through the movement of human limbs. Gait is a two-legged, biphasic forward driving force of center of gravity of human body. There are different sinuous movements of different segments of the human body with minimum usage of energy. The difference in gait patterns are described on the basis of differences in movement of limb patterns, forces, overall velocity, kinetic and potential energy cycles, and variations in the contact with the ground. Human gaits can move either naturally or as a result of specialized training in different ways.

It is the study of human locomotion. It is used for measuring the body movements, body mechanics, and the activity of the muscles.

It is used to access, plan, treat individuals with conditions affecting their ability to walk. It helps the athletes to run more efficiently and identify movement related problems in people with injuries.

A typical gait analysis lab has several cameras placed around a treadmill, which are linked to a computer. The patient has markers located at various points of the body. The patient walks on the treadmill and the computer calculates the trajectory of each marker in 3D. Many labs use surface electrode attached to the skin to detect the EMG. For eg., a muscle of the leg. Deviation from normal patterns are used to diagnose, predict the outcome of treatment, determine the effectiveness of training program.

Gait analysis is used to analyse the walking ability of human. Its goal is to keep yourself moving pain free throughout your life.

**Gait cycle or Stride:**

A single gait cycle or stride is defined as period when one foot contacts the ground to when that same foot contacts the ground again.

**Stages of gait:**

**I. Stance phase:** the stance phase begins at the instant that one extremity contacts the ground and continuous only as long as some portion of the foot is incontact with the ground.

- **Heel strike**: the beginning of the stance phase when the heel contacts the ground.
- **Foot flat:** It occurs immediately following heel strike, when sole of the foot contacts the floor.
- **Mid stance**: the point at which the body passes directly over the reference extremity.
- **Heel off:** the point following midstance at which time the heel of the reference extremity leaves the ground.
- **Toe off:** the point following heel off when only the toe of the reference extremity is in contact with the ground.

**II. Swing phase:** the swing phase begins as soon as the toe of one extremity leaves the ground and ceases just before heel strike or contact of the same extremity.

- **Acceleration:** the portion of beginning swing from the moment the toe of the reference extremity leaves the ground to the point when the reference extremity is directly under the body.

- **Midswing:** portion of the swing phase when the reference extremity passes directly below the body. Midswing extends from the end of acceleration to the beginning of deceleration.
- **Deceleration:** the swing portion of the swing phase when the reference extremity is decelerating in preparation for heel strike.

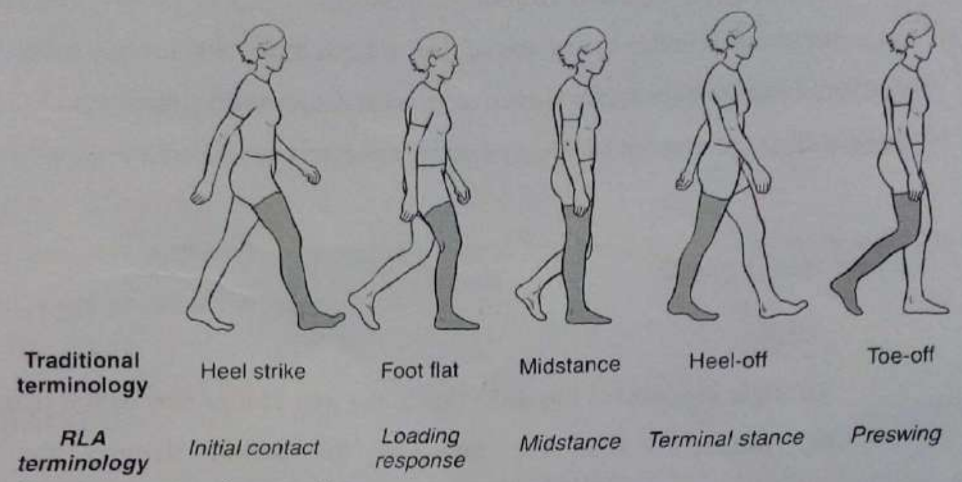
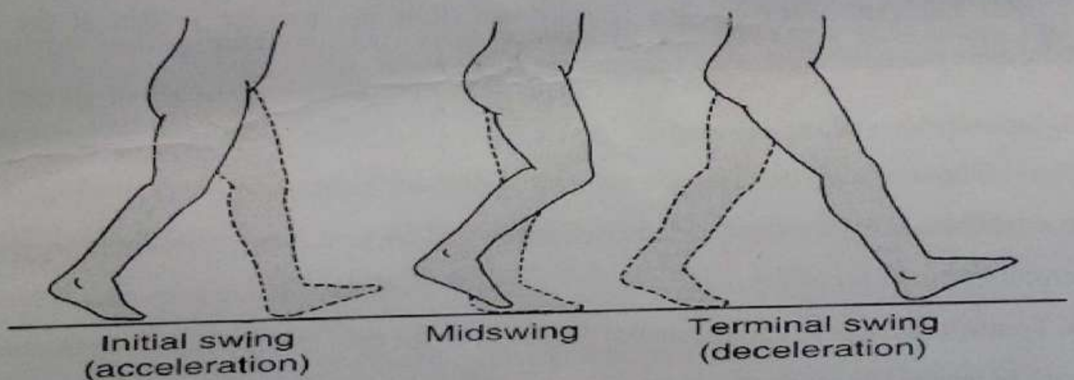



Figure 22-3. The five components of stance phase.




**Acceleration Midswing Deceleration**

**Variables:**

**Stance time:** It is the amount of time that elapses during stance phase of one extremity in a gait cycle.

**Single-support time:** It is the amount of time that elapses during the period when only one extremity is on supporting surface in the gait cycle.

**Double-support time:** It is the amount of time that a person spends with both the feet on the ground during one gait cycle.

**Stride length:** It is the linear distance from the point of heel strike of one lowerextremity to thenext heel strike of the same extremity.

**Step length:** It is the linear distance from the point of heel strike of one lower extremity to the next heel strike of the opposite extremity.

**Stride duration:** It refers to amount of time it takes to accomplish one stride.

**Step duration:** It refers to the amount of time spent during a single step.

**Cadence:** It is the number of steps taken by a person per unit of time.

## Pathological gaits:

1. **Antalgic or painful hip gait**: this is the gait of a person with a painful condition in the hip joint. To minimize the pain the person shortens the time duration of the stance phase on the painful side and quickly transfers the weight to the painless leg.

2. **Stiff hip gait:** when one hip is ankylosed, it is not possible to flex at the hip joint during walking to clear the ground in the swing phase

**3. Unstable hip gait:**

The stability of the hip in walking is provided by the bony components of the joint being kept in stable position by the muscles and ligaments around the joint.Any problem in these structures causes instability of hip.

**a. Trendelenberg gait**: eg. Anatomical disruption on the right side Ex: non union fracture neck of femur. The action of gluteus medius in pulling the pelvis downwards in the stance phase is ineffective or weak due to lack of a stable fulcrum. The pelvis drops on the opposite (i.e. left) side causing instability.

**b. Gluteus medius gait**: when the right gluteus medius is paralyzed, it is unable to pull down the pelvis on the right due to a functional deficiency of the abductor mechanism in the stance phase.

**4. Gluteus maximus gait**: when the gluteus maximus muscle is paralyzed, the stabilizing factor is lost and the patient leans backward at the hip to passively extend it and keep the centre of gravity over the stance leg. This causes the backward lurch in the gluteus maximus gait.

**5. Quadriceps gait**: when quadriceps power is weak or paralyzed; the locking is done by passively pushing the knee backward by the patient putting his handover the front of thelower thigh. This results in a limp and may even cause genu recurvatum.

**6. High stepping gait**: when there is a foot drop, the foot slaps on the ground on heel strike and then drops in the swing phase. To get the foot clear the ground, the hip is flexed more and this causes the high stepping gait.

**7. Short leg gait:** inequality of the legs is obvious when the shortening of one leg is more than 1". It leads to gait with a marked pelvic tilt downwards and an equines deformity at the foot.

**8. Scissoring gait:** this is characteristic gait of a spastic child with marked bilateral spasm at the hips and equines spasm in the ankle.

## GAIT TRAINING:

It is the act of learning how to walk after an injury or disability. This technique utilize a BWS(Body weight support) system to be promising in their ability to improve and possibly restore walking function. Body-weight support (BWS) systems or unweighting devices are starting to become more and more popular and have been the subject of much study. BWS systems can be used prior to the patient gaining adequate motor control or having sufficient strength to fully bear weight. The patient will wear a specialized trunk harness with adjustable straps, which attach to an overhead suspension system. The harness and its attachments support a certain amount of the patient's body weight.

Gait training is the physical therapy which helps to

- Improve your ability to walk.
- Strengthen your muscles and joints.
- Improve your balance and posture.
- Develop your muscle.
- Retrain your legs for repetitive motion.
- Lower the risk of falling.
- Increase your mobility.
- Build your endurance.

A BWS system can be used on a treadmill or over ground for gait training. Body-weight supported treadmill training (BWSTT) enables individuals with motor deficits that have rendered them incapable of completely supporting their own body weight to practice and experience locomotion at physiological speeds.Depending on the severity of the person's impairment, one or more physiotherapists may be present to assist in maintaining the patient's appropriate posture and moving their legs through as kinematically physiological a gait pattern as possible.Recently, electromechanical devices such as the Hocoma Lokomat robot-driven gait orthosis have been introduced with the intention of reducing the physical labour demands on therapists.This system uses a computer-controlled exoskeleton to repeatedly and consistently guide lower-limb movements, making BWSTT a more feasible option for long-term and widespread use.

Another device category, so-called end-effector gait trainers, activates the human gait pattern over moving foot-plates as opposed to an orthosis. The German society for Neurorehabilitation has recently recommended end-effector devices for gait rehabilitation after stroke due to current medical evidence.

Treadmill training, with or without a body-weight support, is an emerging therapy and is being used with stroke patients to improve kinematic gait parameters.These patients often present with significant gait deviations and body weight-supported treadmill training can provide an intense repetitive practice of a more natural gait pattern. Literature continues to emerge examining the influence treadmill speed may have on the improvement of gait patterns and functional independence. Research has shown that a greater gain in independent walking ability is seen in hemiparetic stroke patients who participate in structured speed-dependent treadmill training compared to conventional training.Improvements in gait parameters included walking speed, cadence, stride length and Functional Ambulation Category scores.In speed-dependent treadmill training, belt speed is increased to the maximum-achievable speed the patient can maintain for 10 seconds without stumbling, followed by a period of recovery. If the patient were capable of maintaining the speed safely and comfortably during the 10-second bout, it would then be increased by 10% in the next attempt, following the same work and recovery procedures. Research has shown that this form of gait training demonstrates a more normal walking pattern without the compensatory movements commonly associated with stroke.

Although gait training with parallel bars, treadmills and support systems can be beneficial, the long-term aim of gait training is usually to reduce patients' dependence on such technology in order to walk more in their daily lives.

Gait training can be useful for people with the following conditions:

- Amputation
- Osteoarthritis
- Muscular dystrophy
- Cerebral palsy
- Stroke
- Parkinson's disease
- Multiple sclerosis
- Brain and spinal cord injuries
- After surgery
- Sports injury

Gait training for neurologic patients -also called locomotion therapy- many times is performed on treadmills while 2 therapists assisting the patients leg to move forward step by step. This is extremely exhausting for the therapists who many times have unergonomic working position and thus not only suffering from fatigue but also from back and shoulder pain.

~~Equipments need in gait training~~

Some walking abnormalities have been given names:

- **Propulsive gait** : a stooped, stiff posture with the head and neck bent forward
- **Scissors gait** : legs flexed slightly at the hips and knees like crouching, with the knees and thighs hitting or crossing in a scissors-like movement
- **Spastic gait** : a stiff, foot-dragging walk caused by a long muscle contraction on one side
- **High Steppage gait** : foot drop where the foot hangs with the toes pointing down, causing the toes to scrape the ground while walking, requiring someone to lift the leg higher than normal when walking or hip -circumduction during walking
- **Waddling gait** : a duck-like walk that may appear in childhood or later in life

- **Ataxic or broad-based gait** : a walk like drunken person walking.

**Conventional gait training:**

Conventional gait training has focused on part-practice of components of gait in preparation for walking. It includes

- Symetrical Weight bearing training
- Weight shifting
- Stepping training (swinging / clearance )
- Heel strike
- Single leg standing
- Push off / Calf rise.

Followed by

Circuit training (reaching in sitting and standing, sit-to-stand, step-ups, heel lifts, isokinetic strengthening, walking over obstacles, up and down slopes).

Traditional approaches to stroke recovery have a focus on neurofacilitation or neurodevelopmental techniques (NDT) to inhibit excessive tone, stimulate muscle activity if hypotonia is present and to facilitate normal movement patterns through hands-on techniques. Strength training to improve walking ability Task-specific training to improve walking ability.

## Relaxation exercises:

Muscles which are free from tension and at rest are said relaxed. Tension develops in muscles as they work during contraction and this tension is reduced to a variable degree as the muscles come to rest during relaxation. Some people relax by watching TV, sports, exercise, listening to music etc. It is a technique that promotes stress, the elimination of tension throughout the body, and a calm and peaceful state of mind.

It is a method, process, procedure, or activity that helps a person to relax; to attain a state of increased calmness; or otherwise reduce levels of pain, anxiety, stress or anger.

There are 2 techniques useful for the symptoms of anxiety and over breathing, muscle tension. They are: 1. Deep breathing exercises 2. Muscular relaxation exercises

1. **Deep breathing exercises:** Many people have a tendency to breathe faster than normal when they are anxious. If you practise deep breathing when you are relaxed, then you should be able to do this when you feel tense or anxious to help you to relax and breathe slowly, deeply through your nose and out through your mouth.

   Mainly use lower chest muscle ( diaphragm) to breathe. Try to relax your shoulders and upper chest muscles when you breathe. With each breathe out, continuosly try to relax those muscles until you are mainly using your diaphragm to breathe.

   If u practise these exercise daily, you will find that they reduce your overall level of tension.

2. **Muscular relaxation exercises:** Lie down or sit in chair. Close your eyes. You are going to work on each of your muscle group. With each group of muscles, first tense the muscles as much as u can, then relax them fully. Breathe in when you tense the muscles and breathe out when you relax.

   **Hands:** clench 1hand tightly for a few seconds as you breathe in. You should feel your forearm muscles tense; then relax as you breathe out. Repeat other hand also.

   **Arms:** Bend an elbow and tense all the muscles in the arms for a few second as you breathe in; then relax as you breathe out. Repeat other hand also.

   **Shoulders:** Raise your shoulders as high as u can as you breathe in; then relax as you breathe out.

   **Neck:** Press your head back as hard as is comfortable and roll it slowly from side to side; then relax.

**Chest:** Take a deep breathe and hold it for a few seconds; then realx and go back to normal breathing.

**Stomach:** Tense the stomach muscles as tightly as possible; then relax.

**Legs:** With your legs flat on the floor, bend your feet and toes towards your face as hard as you can; then relax. Then bend them away from your face for a few seconds; then relax.

**What can you do:** when you exercise, focus your attention on your breath; squeeze and then release tense or numb parts of your body; focus on the present rather than something that's past or in future; visualize in detail a scene that makes you feel peaceful; listen to music that calms and lifts you up.

**Benefits of relaxation technique:**

- Slow down your heart rate.
- Lowering BP.
- Slowing your breathing rate.
- Reducing activity of stress hormone.
- Increase blood flow to major muscles.
- Reducing activity of stress hormone.
- Increase blood flow to major muscles.
- Reducing muscle tension and chronic pain.
- Improving concentration and mood.
- Lowering fatigue.
- Reducing anger and frustation.

**Progressive muscle relaxation:** This exercise involves systematically relaxing different muscle groups. This is a good exercise for those who have trouble concentrating, experiencing mental distractions.Most progressive muscle relaxation practitioners start at the feet and work their way up to the face.

1. Loosen your clothing, take off your shoes, and get comfortable.

2. Take a few minutes to relax, breathing in and out in slow, deep breaths.
3. When you're relaxed and ready to start, shift your attention to your right foot. Take a moment to focus on the way it feels.
4. Slowly tense the muscles in your right foot, squeezing as tightly as you can. Hold for a count of 10.
5. Relax your right foot. Focus on the tension flowing away and the way your foot feels as it becomes limp and loose.
6. Stay in this relaxed state for a moment, breathing deeply and slowly.
7. When you're ready, shift your attention to your left foot. Follow the same sequence of muscle tension and release.
8. Move slowly up through your body, contracting and relaxing the muscle groups as you go.
9. It may take some practice at first, but try not to tense muscles other than those intended.

Before practicing progressive muscle relaxation, consult with your doctor if you have a history of muscle spasms, back problems, or other serious injuries that may be aggravated by tensing muscles.

**Creating a symbol of relaxation:**

- When you are practicing relaxation, choose an image that conveys peace, comfort, mental and physical letting go.
- We can choose any image like seashore, natural scenary, god, a pet animal or a person you love.
- Everytime you do relaxation, call up that image. Allow the image to grow and fill awareness.
- Let all the qualities of that symbol come to mind, and imagine them moving through your body on the rhythm of your breath.
- As you practise this more, you'll be able to close your eyes anywhere and relax quickly by calling up your symbol and filling your awareness with it for a few minutes.

**Relaxation response:**

When stress overwhelms your nervous system your body is flooded with chemicals that prepare you for "fight or flight." While the stress response can be lifesaving in emergency situations where you need to act quickly, it wears your body down when constantly activated by the stresses of everyday life.

No one can avoid all stress, but you can counteract it by learning how to produce the relaxation response, a state of deep rest that is the polar opposite of the stress response. The relaxation response puts the brakes on stress and brings your body and mind back into a state of equilibrium. The goal is to be both physically relaxed and mentally alert at the same time.

the relaxation response also increases energy and focus, combats illness, relieves aches and pains, heightens problem-solving abilities, and boosts motivation and productivity. Best of all, anyone can reap these benefits with regular practice.

**Finding the relaxation technique that's best for you:**

There is no single relaxation technique that is best for everyone. When choosing a relaxation technique, consider your specific needs, preferences, fitness, and the way you tend to react to stress. The right relaxation technique is the one that resonates with you and fits your lifestyle. It is able to focus your mind and interrupt your everyday thoughts in order to elicit the relaxation response. In many cases, you may find that alternating or combining different techniques will keep you motivated and provide you with the best results.

How you react to stress may influence the relaxation technique that works best for you:

**The "fight" response.** If you tend to become angry, agitated, or keyed up under stress, you will respond best to stress relief activities that quiet you down, such as meditation, progressive muscle relaxation, deep breathing, or guided imagery.

**The "flight" response.** If you tend to become depressed, withdrawn, or spaced out under stress, you will respond best to stress relief activities that are stimulating and energize your nervous system, such as rhythmic exercise, massage, mindfulness, or power yoga.

**The immobilization response.** If you've experienced some type of trauma and tend to "freeze" or become "stuck" under stress, your challenge is to first rouse your nervous system to a fight or flight response (above) so you can employ the applicable stress relief techniques. To do this, choose physical activity that engages both your arms and legs, such as running, dancing, or tai chi, and perform it mindfully, focusing on the sensations in your limbs as you move.

**Mindfulness meditation:**

Mindfulness is the quality of being fully engaged in the present moment, without analyzing or otherwise "over-thinking" the experience. Rather than worrying about the future or dwelling on the past, mindfulness meditation switches the focus to what's happening right now.

Meditations that cultivate mindfulness have long been used to reduce stress, anxiety, depression, and other negative emotions. Some of these meditations bring you into the present by focusing your attention on a single repetitive action, such as your breathing, a few repeated words, or the flickering light of a candle. Other forms of mindfulness meditation encourage you to follow and then release internal thoughts or sensations. Mindfulness can also be applied to activities such as walking, exercising, or eating.

**Basic mindfulness exercise:**

1. Sit on a straight-backed chair or cross-legged on the floor.
2. Focus on an aspect of your breathing, such as the sensations of air flowing into your nostrils and out of your mouth, or your belly rising and falling as you inhale and exhale.
3. Once you've narrowed your concentration in this way, begin to widen your focus. Become aware of sounds, sensations, and your ideas.
4. Embrace and consider each thought or sensation without judging it good or bad. If your mind starts to race, return your focus to your breathing. Then expand your awareness again.

**Five-minute self-massage to relieve stress:**

A combination of strokes works well to relieve muscle tension. Try gentle chops with the edge of your hands or tapping with fingers or cupped palms. Put fingertip pressure on muscle knots.

Knead across muscles, and try long, light, gliding strokes. You can apply these strokes to any part of the body that falls easily within your reach. For a short session like this, try focusing on your neck and head:

- Start by kneading the muscles at the back of your neck and shoulders. Make a loose fist and drum swiftly up and down the sides and back of your neck. Next, use your thumbs to work tiny circles around the base of your skull. Slowly massage the rest of your scalp with your fingertips. Then tap your fingers against your scalp, moving from the front to the back and then over the sides.
- Now massage your face. Make a series of tiny circles with your thumbs or fingertips. Pay particular attention to your temples, forehead, and jaw muscles. Use your middle fingers to massage the bridge of your nose and work outward over your eyebrows to your temples.
- Finally, close your eyes. Cup your hands loosely over your face and inhale and exhale easily for a short while.

## Strengthening exercises:

It is a type of physical exercise specializing in the use of resistance to induce muscular contraction which builds the strength, anaerobic endurance, and size of skeletal muscles. When properly performed, strength training can provide significant functional benefits and improvement in overall health and well-being, including increased bone, muscle, tendon and ligament strength and toughness, improved joint function, reduced potential for injury, increased bone density, increased metabolism, increased fitness, improved cardiac function, and improved lipoprotein lipid profiles, including elevated HDL ("good") cholesterol. Training commonly uses the technique of progressively increasing the force output of the muscle through incremental weight increases and uses a variety of exercises and types of equipment to target specific muscle groups. Strength training is primarily an anaerobic activity, although some proponents have adapted it to provide the benefits of aerobic exercise through circuit training.

**For rehabilitation or to address an impairment:**

For many people in rehabilitation or with an acquired disability, such as following stroke or orthopaedic surgery, strength training for weak muscles is a key factor to optimise recovery. For people with such a health condition, their strength training is likely to need to be designed by an appropriate health professional, such as aphysiotherapist or an occupational therapist.

**Techniques:**

The basic principles of strength training involve a manipulation of the number of repetitions (reps), sets, tempo, exercises and force to cause desired changes in strength, endurance or size by overloading of a group of muscles. The specific combinations of reps, sets, exercises, resistance and force depend on the purpose of the individual performing the exercise: to gain size and strength multiple (4+) sets with fewer reps must be performed using more force. A wide spectrum of regimens can be adopted to achieve different results, but the classic formula recommended by the American College of Sports Medicine reads as follows:

- 8 to 12 repetitions of a resistance training exercise for each major muscle group at an intensity of 40% to 80% of a one-repetition max (RM) depending on the training level of the participant.
- Two to three minutes of rest is recommended between exercise sets to allow for proper recovery.
- Two to four sets are recommended for each muscle group.

Typically failure to use good form during a training set can result in injury or an inability to meet training goals – since the desired muscle group is not challenged sufficiently, the threshold of overload is never reached and the muscle does not gain in strength. There are cases when cheating is beneficial, as is the case where weaker groups become the weak link in the chain and the target muscles are never fully exercised as a result.

The benefits of strength training include increased muscle, tendon and ligament strength, bone density, flexibility, tone, metabolic rate and postural support.

General strength exercises are the physical exercises that are used in overall body conditioning. They are not directly related to the specific actions seen in a specific sport (i.e., strengthening the muscles as they are used in a specific sport and increasing an athlete's functional potential for improved performance).

strength training exercises work your muscles by applying a resistance against which the muscles need to exert a force. The aim is to use an appropriate weight or resistant force that will work the target muscles to fatigue, over 8 to 12 repetitions of an exercise. A typical beginner's strength training programme involves 8 to 10 exercises that work the major muscle groups of the body. These exercises are usually performed 2 to 3 times every week.

Whilst going to a gym will provide access to specific strength training equipment and supervision, as well as providing an environment that some people find supportive, it's not essential and some strength training can be undertaken at home. For example, in many exercises, the weight of your own body is used as the resistance against which the muscles need to work, and a pair of hand-weights or even 2 soup cans can supply the resistance in some exercises.

**Strength training exercises**

**At the start.** Begin with one set of each exercise, comprising as few as 5 reps, no more than twice a week.

**Your aim.** Gradually increase, over a few weeks, to one set comprising 8 to 12 reps for each exercise every second or third day.

**Beyond this.** Once you can comfortably do 12 reps of an exercise you should look at progressing further. Options include increasing weight or resistance – thus increasing the intensity of muscular effort – or increasing the number of sets of each exercise to 2 or 3. The health benefits of strength training can be attained safely by most people if they do 1 set of 8 to 10 reps of each exercise each second or third day. If you have a particular sporting goal in mind and want to increase your level of fitness further, talk to a trained fitness instructor about how to increase the intensity and duration of your strength training programme gradually.

**Tips for strength training**

- Always exercise the largest muscle groups first, such as your hips and upper legs, then move to your lower legs, upper torso, arms, abdominals and lower back.
- The abdominals and back muscles are stabilising muscles which help you to maintain correct posture and should be exercised at the end of the session so that they are not fatigued too early.
- When lifting a weight, breathe continuously throughout the movement – don't hold your breath or your blood pressure may go up.
- When lifting a weight, control the movement: take 2 seconds for the lifting movement, pause for one second, then 4 seconds for the lowering movement.
- Concentrate on maintaining good posture – use a mirror to see that your body is aligned correctly.
- Limit strength training sessions to one hour in length – no more.
- Don't do strength training sessions on consecutive days unless you work different muscle groups in each session, e.g. arms on Monday; legs on Tuesday.

1.**Goblet Squat**

This is a squat done while holding a weight in front of you (like a goblet), which adds more of a workout for your core and legs.

"**How to:** *Hold a dumbbell with both hands underneath the 'bell' at chest level, and set your feet shoulder-width apart with your toes pointing slightly outwards. Push your butt back like you're sitting in a chair and descend until your elbows reach the inside of your knees.*

*Keeping your heels flat, pressing onto the floor, pause at the bottom of the squat, and return to a full standing position. If your heels rise push your hips further back and work on partial ranges of motion until mobility and form improve. Repeat for four sets of 8-10 reps."*

2.**Pallof Press**

This "anti-rotation" movement is challenging because you must resist rotation, working your obliques, abs, lower back, glutes, and more.

"**How to:** *Stand perpendicular to a cable column with the column's arm set around shoulder height. Grab the handle with both hands and pull it in to the chest, maintaining tension on the cable. Feet should be shoulder-width apart, and the feet, knees, hips and shoulders all remain square and facing straight ahead throughout movement.*

*Holding the chest high, squeeze through the stomach and press the handle away from the body, extending the arms straight while resisting any twisting or rotation. It's at this point the resistance will be highest. Continue to engage your core, and ensure you remain square and straight and resist the rotational force. Bring arms back in to the chest and repeat for three sets of 10 reps per side."*

3.**Dumbbell Row**

The dumbbell row helps to develop a strong back, arms and core. Plus, because it works your lats, traps, and rhomboids, it supports proper posture by pulling your shoulders back and helping to stabilize your spine.

*"How to: Grab a dumbbell (20 pounds is plenty for most to start) and find a bench. Start with your left hand on the bench with left arm extended, while your right arm holds the dumbbell and right foot is on the ground. Retract your shoulders, brace your abs, and pull the weight up on the side of your body until the elbow passes the side of the body. Lower under control and repeat for three sets of 6-8 reps on each side."*

4.**Push-Up**

Push-ups are a deceptively simple functional movement that works your upper-body muscles while engaging your core and allowing you to use the full range of motion in your shoulder blades.

"**How to:** *Start on your knees facing the floor with your hands at shoulder-width, planted directly under the shoulders. Assume a plank position by straightening your legs, supporting your weight with hands and feet. Squeeze your backside to keep your trunk engaged and lower your body slowly to the ground. The elbows should be slightly tucked — like arrows, rather than flared like the letter 'T'. Descend until your chest is just above the ground and return to the starting position by fully extending your arms, and repeat.*

*Note: If you can't do five push-ups with good form, elevate your hands on a bench or chair to begin building up your strength. If push-ups are easy, try elevating your feet on a chair on adding a weight vest. Make sure you're able to perform three sets of 12 push-ups with your bodyweight before adding a vest or elevating your feet."*

5.**Split Squat (Stationary Lunge)**

This is important because it involves single-leg movements that help minimize training imbalances. Split squats will help to build lower-body strength while improving balance, flexibility, and stability in your hips.

*"How to: Stand with feet shoulder-width apart. Next, take a step forward with your right foot, and a large step backwards with your left foot -- this is your starting position. Keep the front heel flat and descend into a lunge, bringing your back knee towards the floor. Stop just short of the knee touching the ground on the back leg with the front heel still flat on the ground. Pause for one second and return to standing. Perform 6-8 reps on your right leg, then 6-8 reps on your left leg, and repeat for three sets."*

6.**Lateral Squat**

This is a combination of a lateral lunge and a squat, useful for stretching your groin and inner thighs while also working out your hips, thighs, and trunk.

*"How to: Stand tall with your feet wider than shoulder-width apart, heels flat on the ground and toes pointed forward. Initiate the movement by pushing your hips backwards, bending your left leg, and leaning to your left with your right foot angled out slightly. The left knee should be bent, left heel flat on the floor, and right leg extended with your weight over the left side of your body. This is one rep. Return to a standing position and descend doing the same movement on your right side to even things out. Perform six reps per leg for three sets."*

7.**Hip Extension (Glute Bridges/Hip Thrusts)**

This exercise helps to train your glutes, which are often underutilized if you sit for long periods each day.

*"How to: Position the back of your shoulders across a stable bench, feet planted firmly on the ground, about six inches away from your butt (a). Squeezing the glutes, push through your heels*

*to rise up into a bridge position with the hips fully extended. The shoulders down to the knees should be in line, with the knees bent at 90 degrees. Hold the position at the top, glutes, core and hamstrings engaged (b). Lower the hips down and repeat for three sets of eight reps (c). Beginners can continue with just bodyweight, whereas more advanced lifters can progress to rolling a barbell over the top of the hips for added difficulty."*

## Types of contraction:

- Muscle contractions are defined by changes in the length of the muscle during contraction. Isotonic contractions generate force by changing the length of the muscle and can be
- concentric contraction causes muscles to shorten, thereby generating force.
- Eccentric contractions cause muscles to elongate in response to a greater opposing force.
- Isometric contractions generate force without changing the length of the muscle.

- ***concentric***

An isotonic contraction where the muscle shortens.

- ***Isometric***

A muscular contraction in which the length of the muscle does not change.

- ***isotonic***

A muscular contraction in which the length of the muscle changes.

- ***eccentric***

An isotonic contraction where the muscle lengthens.A muscle fiber generates tension through actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten, or remain the same. Although the term contraction implies shortening, when referring to the muscular system, it means the generation of tension within a muscle fiber. Several types of muscle contractions occur and are defined by the changes in the length of the muscle during contraction.

### Isotonic Contractions

Isotonic contractions maintain constant tension in the muscle as the muscle changes length. Isotonic muscle contractions can be either concentric or eccentric.

### Concentric Contractions

A concentric contraction is a type of muscle contraction in which the muscles shorten while generating force, overcoming resistance. For example, when lifting a heavy weight, a concentric contraction of the biceps would cause the arm to bend at the elbow, lifting the weight towards the shoulder. Cross-bridge cycling occurs, shortening the sarcomere, muscle fiber, and muscle.

### Eccentric Contractions

An eccentric contraction results in the elongation of a muscle while the muscle is still generating force; in effect, resistance is greater than force generated. Eccentric contractions can be both voluntary and involuntary. For example, a voluntary eccentric contraction would be the controlled lowering of the heavy weight raised during the above concentric contraction. An involuntary eccentric contraction may occur when a weight is too great for a muscle to bear and so it is slowly lowered while under tension. Cross-bridge cycling occurs even though the sarcomere, muscle fiber, and muscle are lengthening, controlling the extension of the muscle.

### Types of Muscle Contraction

An isotonic concentric contraction results in the muscle shortening, an isotonic eccentric contraction results in the muscle lengthening. During an isometric contraction the muscle is under tension but neither shortens nor lengthens.

### Isometric Contractions

In contrast to isotonic contractions, isometric contractions generate force without changing the length of the muscle, common in the muscles of the hand and forearm responsible for grip. Using the above example, the muscle contraction required to grip but not move a heavy object prior to lifting would be isometric. Isometric contractions are frequently used to maintain posture.

Isometric contractions are sometimes described as yielding or overcoming.

### Yielding

A yielding contraction occurs when a muscle contraction is opposed by resistance. For example, when holding a heavy weight steady, neither raising nor lowering it.

### Overcoming

An overcoming contraction occurs when a muscle contraction is opposed by an immovable object, such as the contraction generated in the muscles when pushing against a wall.

In both instances, cross-bridge cycling is maintaining tension in the muscle; the sarcomere, muscle fibers, and muscle are not changing length.

## Mobilisation exercise:

An exercise involving, either completely or in part, the implementation of mobilization plans. Mobilization is a manual therapeutic technique that fosters movement in stagnant tissues and joints. Spinal mobilization uses massage to break down scar tissue and restrictions that are typically associated with trauma to the soft tissue such as a strained muscle or pulled ligament.

Joint mobilization is a manual therapy intervention, a type of passive movement of a skeletal joint. It is usually aimed at a 'target' synovial joint with the aim of achieving a therapeutic effect. When applied to the spine, it is known as spinal mobilization. These techniques are often used by chiropractors, osteopaths, occupational therapists, and physical therapists.

Mobility sounds great, but how exactly does it differ from the stretches we've been doing for ages? Stretching normally focuses solely on the muscle itself. Mobility is a more all-encompassing practice that addresses multiple elements that influence performance. This includes the sliding surfaces (muscles, ligaments, tendons,fascia), and the the joint and motor control necessary to perform a movement correctly.

Mobility Matters: 5 Tips to Help You Move Better

**1. Make mobility personal.**

While our joints might function similarly on the surface, our bones, ligaments and tendons are all slightly different. This means a mobility exercise that works well for your lifting partner might not be suited for you. "You have to pick the right exercise for the person, and not the other way around." "own your practice" to reference the sense of empowerment each athlete should feel over their own mobility work. You're in charge of deciding what specific area of the body you need to work on most. You're also responsible for how far you push yourself into the movement.

**2. Take deep breaths.**

Breathing can have a huge effect on how much you benefit from a particular movement. Slow, controlled breathing increases the parasympathetic response, helping to relax your body and reduce tension. "It should almost be like a releasing of air, not like you're pushing the air out,"

**3. Time it right.**

hold positions beyond the typical 30 seconds. "One of the biggest errors that we've seen is that people don't mobilize long enough to actually make change," Holding a position for two minutes or longer gives the tissues a chance to adapt and you a chance to get comfortable.

**4. Tune into pain.**

Pain is a telltale indicator that a specific area needs some work. "put the ball on the back of your shoulder to address the soft tissue there, and you find anything that's painful, you stop,". "That's the place you have to work."

That doesn't mean all pain is good pain, though. too much pain actually works against you. "The body's natural instinct is to guard itself and protect itself. It's going to push back and get tighter." So, how much pain is too much? Stay away from anything that hurts excessively.

**5. Work mobility into your routine.**

While mobility exercises can be extremely beneficial, athletes need to get out and practice. Think of mobility as a piece to your training puzzle. Get in the gym to see how you're moving and what needs some work. Then, work on those specific elements with targeted mobility work. Rest and repeat.

**General Mobility Exercises**

The following are a selection of general mobility exercises. They are not in any specific order.

**Shoulder Circles**

Stand tall with good posture. Raise your right shoulder towards your right ear, take it backwards, down and then up again with a smooth rhythm. Perform this shoulder circling movement eight times and then repeat with the other shoulder. Breathe easily throughout

**Arm Circles**

Stand tall with good posture. Lift one arm forward then take it backwards in a continuous circling motion, keeping your spine long throughout. Perform this arm circling movement eight times, before repeating with the other arm. Avoid the tendency to arch your spin whilst carrying out the circling movement. Breathe easily throughout.

**Side Bends**

Stand tall with good posture, feet slightly wider than shoulder-width apart, knees slightly bent and hands resting on hips. Lift your trunk up and away from your hips and bend smoothly first to one side, then the other, avoiding the tendency to lean either forwards or backwards. Repeat the whole sequence sixteen times with a slow rhythm, breathing out as you bend to the side, and in as you return to the centre.

**Trunk Twists**

Stand tall with good posture. Have your feet slightly wider than hip-width apart, knees slightly bent, hands resting on hips. Keeping your spine long and your hips facing forward, turn smoothly and slowly round to one side, then the other. Repeat the sequence sixteen times, breathing easily throughout the movement.

**Half Squat**

Stand tall with good posture holding your hands out in front of you for balance. Now bend at the knees until your thighs are parallel with the floor. Keep your back long throughout the movement, and look straight ahead. Make sure that your knees always point in the same direction as your toes. Once at your lowest point, fully straighten your legs to return to your starting position. Repeat the exercise sixteen times with a smooth, controlled rhythm. Breathe in as you descend, and out as you rise.

**Standing Calf Stretch**

Stand tall with one leg in front of the other, hands flat and at shoulder height against a wall or suitable immovable object. Ease your back leg further away from the wall, keeping it straight and press the heel firmly into the floor. Keep your hips facing the wall. You will feel the stretch in the calf of the rear leg. Repeat on the other side. Breathe easily throughout the exercise. Perform 3 to 6 stretches and hold each stretch for 5 to 10 seconds.

**Lower Calf Stretch**

Position yourself as for the standing calf stretch exercise. This time, however, flex the knee of the rear leg, whilst still keeping the heel pressed firmly on to the floor. The sensation of stretch should now be experienced lower down in the calf. Repeat on the other side, breathing easily throughout. Perform 3 to 6 stretches and hold each stretch for 5 to 10 seconds.

**Seated Hamstring and Groin Stretch**

Sit tall with both legs fully outstretched. Flex your right knee so that the right foot rests comfortably along your left inner thigh, with the right knee as close as possible to the floor. Keeping your spine long and your shoulders down away from your ears, hinge forwards from the hips to reach towards your flexed left foot. Go as far forward as possible, then relax your spine to reach even further forward, holding this stretch position. You will feel the stretch along the back of the outstretched leg, and along the inside and rear of the flexed leg. Repeat with the other leg, breathing easily throughout. Perform 3 to 6 stretches and hold each stretch for 5 to 10 seconds..

**Lying Hamstring Stretch**

Lie flat on the floor with your knees flexed to approximately ninety degrees Raise your left leg, grasping it loosely behind the thigh with both hands. Now ease this leg as close to your chest as possible. You will feel the stretch along the back of the flexed thigh. Repeat with the other leg. Breathe easily throughout. Perform 3 to 6 stretches and hold each stretch for 5 to 10 seconds.

**Lying Quadriceps Stretch**

Lie face down on the floor, resting your forehead on your right hand. Press your hips firmly into the floor and bring your left foot up towards your buttocks, easing it closer to them with your right hand. You will feel the stretch along the front of the thigh. Repeat on the other side, breathing easily throughout the exercise. Perform 3 to 6 stretches and hold each stretch for 5 to 10 seconds.

## Endurance Exercise (Aerobic)

Endurance training is the act of exercising to increase endurance. The term endurance training generally refers to training the aerobic system as opposed toanaerobic. The need for endurance in sports is often predicated as the need of cardiovascular and simple muscular endurance, but the issue of endurance is far more complex. Endurance can be divided into two categories including: general endurance and specific endurance. It can be shown that endurance in sport is closely tied to the execution of skill and technique. A well conditioned athlete can be defined as, the athlete who executes his or her technique consistently and effectively with the least effort

Endurance exercise is one of the four types of exercise along with strength, balance andflexibility. Ideally, all four types of exercise would be included in a healthy workout routine and AHA provides easy-to-follow guidelines for endurance and strength-training in its Recommendations forPhysical Activity in Adults.

They don't all need to be done every day, but variety helps keep the body fit and healthy, and makes exercise interesting. You can do a variety of exercises to keep the body fit and healthy and to keep your physical activity routine exciting. Many different types of exercises can improve strength, endurance, flexibility, and balance. For example, practicing yoga can improve your balance, strength, and flexibility. A lot of lower-body strength-training exercises also will improve your balance.

Also called aerobic exercise, endurance exercise includes activities that increase your breathing and heart rate such as walking, jogging, swimming, and biking.

Endurance activity keeps your heart, lungs and circulatory system healthy and improves your overall fitness. As a result, people who get the recommended regular physical activity can reduce the risk of many diseases such asdiabetes, heart disease and stroke.

**How much do I need?**

Building your endurance makes it easier to carry out many of your everyday activities. If you're just starting out on an exercise routine after being sedentary, don't rush it. If you haven't been active for a long time, it's important to work your way up over time.

Start out with 10-15 minutes at a time and then gradually build up. The AHA recommends that adults get at least 150 minutes (2 1/2 hours) of moderate to vigorous activity per week. Thirty minutes a day five days a week is an easy goal to remember. Some people will be able to do more. It's important to set realistic goals based on your own health and abilities.

**Making Progress**

When you're ready to do more, you can build on your routine by adding new physical activities; increasing the distance, time, or difficulty or your favorite activity; or do your activities more often. You could first build up the amount of time you spend doing endurance activities, then build up the difficulty of your activities. For example, gradually increase your time to 30 minutes over several days to weeks by walking longer distances. Then walk more briskly or up hills.

**Examples of endurance exercise:**

- Walking briskly
- Running / jogging
- Dancing
- Swimming
- Biking
- Climbing stairs at work
- Playing sports such as tennis, basketball, soccer or racquetball

**What if I'm recovering from a cardiac event or stroke?**

Some people are afraid to exercise after a heart attack. But regular physical activity can help reduce your chances of having another heart attack.

The AHA published a statement in 2014 that doctors should prescribe exercise to stroke patients since there is strong evidence that physical activity and exercise after stroke can improve cardiovascular fitness, walking ability and upper arm strength.

If you've had a heart attack or stroke, talk with your doctor before starting any exercise to be sure you're following a safe, effective physical activity program.

## Risks of excessive endurance training

The potential for negative health effects from long-term, high-volume endurance training have begun to emerge in the scientific literature in recent years. The known risks are primarily associated with training for and participation in extreme endurance events, and affect the cardiovascular system through adverse structural remodeling of the heart and the associated arteries, with heart-rhythm abnormalities perhaps being the most common resulting symptom. Endurance Exercise can also reduce Testosterone levels.

## 7-ways-to-boost-your-endurance-and-stamina

### 1. Combine strength days with cardio days.

It's a simple equation: the more muscle you can get working, the more it will challenge your heart and your cardiovascular system. Instead of building cardio-*only* workouts (the pitfall that'll prevent you from building endurance) make sure to weave strength days into your training. "Most people reserve one day for strength and another day for cardio. Try combining the two instead," says Torres. "Use a bench press, immediately followed by pull-ups, then run a mile as fast as you can… and repeat." Another good example: Jump rope for a minute, followed by squats, an overhead press, and finally sit ups. Repeat.

### 2. Reduce your amount of rest between sets.

Men typically give themselves between 30 and 90 seconds ofrecovery time in between sets, but if your goal is greater endurance, be prepared to sacrifice break time. "By the end of your sets, your muscles should be burning—you should be breathing heavily and sweating," says Torres. "Only take a break if you physically can not continue." Torres suggests selecting a series of movements like 10 pull-ups, 10 squats, 10 push-ups, 10 sit-ups. Do three rounds of the series back to back, taking asminimal a break as possible.

**3. Do fast-paced, high-intensity lifting.**

"When you use weights at an extremely rapid pace, it will not only improve your strength, but also carry over to improve yourendurance activity," says Torres. "It's one of the best ways to ignite your metabolism. When people do an excessive amount of endurance-only training, they actually slow down their metabolism because it starts to eat away at your muscle tissue."

**4. Choose compound movements over isolation.**

Compound moves that require using more than one joint—like squats, step-ups, push-ups and pull-ups—will improve your endurance more so than exercises in isolation. "Isolated exercises like bicep curls and leg lifts aren't going to stimulate you enough to increase your stamina," he says.

**5. Remember: Routine is the enemy.**

Switching up your workout is essential to building endurance and stamina. According to Torres, the human body gets used to a workout after two weeks. So if you're always running, start doingMuay Thai instead. Or if you're an avid cyclist, change it up by running stairs. "You need to move the muscles in a different way so that you don't develop overuse. Plus, it becomes more motivating," he says. "It's important to keep the mind guessing."

**6. Go for hybrid exercises.**

A squat with an added overhead press (a "thruster"), jumping pull-ups, and lunges with bicep curls are all great hybrids: exercises that take two separate movements and combine them. "The more muscles you can get working in a movement, the more it will stimulate yourheart muscles, which in turn improves your stamina."

**7. Add explosive movements to your workout.**

Explosive movements that take a lot of energy challenge your strength, endurance and stamina simultaneously. Once you become more explosive, you'll notice that you'll actually start moving faster. Torres says: try adding things like burpees, box jumps, jumping knee tucks and power push-ups to your workout routine.

# Unit- IV

## Communication:

Communication is a process of exchanging information, ideas, thoughts, feelings and emotions through speech, signals, writing, or behavior. In communication process, a sender(encoder) encodes a message and then using a medium/channel sends it to the receiver (decoder) who decodes the message and after processing information, sends back appropriate feedback/reply using a medium/channel.

**Types of Communication:**

People communicate with each other in a number of ways that depend upon the message and its context in which it is being sent. Choice of communication channel and your style of communicating also affects communication. So, there are variety of types of communication.

Types of communication based on the communication channels used are:

1. Verbal Communication
2. Nonverbal Communication

**1. Verbal Communication**

Verbal communication refers to the the form of communication in which message is transmitted verbally; communication is done by word of mouth and a piece of writing. Objective of every communication is to have people understand what we are trying to convey. In verbal communication remember the acronym KISS(keep it short and simple).

When we talk to others, we assume that others understand what we are saying because we know what we are saying. But this is not the case. usually people bring their own attitude, perception, emotions and thoughts about the topic and hence creates barrier in delivering the right meaning.

So in order to deliver the right message, you must put yourself on the other side of the table and think from your receiver's point of view. Would he understand the message? how it would sound on the other side of the table?

Verbal Communication is further divided into:

- Oral Communication
- Written Communication

### Oral Communication

In oral communication, Spoken words are used. It includes face-to-face conversations, speech, telephonic conversation, video, radio, television, voice over internet. In oral communication,

### Written Communication

In written communication, written signs or symbols are used to communicate. A written message may be printed or hand written. In written communication message can be transmitted via email, letter, report, memo etc. Message, in written communication, is influenced by the vocabulary & grammar used, writing style, precision and clarity of the language used.

Written Communication is most common form of communication being used in business. So, it is considered core among business skills.

Memos, reports, bulletins, job descriptions, employee manuals, and electronic mail are the types of written communication used for internal communication. For communicating with external environment in writing, electronic mail, Internet Web sites, letters, proposals, telegrams, faxes, postcards, contracts, advertisements, brochures, and news releases are used.

### 2. Nonverbal Communication

Nonverbal communication is the sending or receiving of wordless messages. We can say that communication other than oral and written, such as gesture, body language,posture, tone of voice or facial expressions, is called nonverbal communication.Nonverbal communication is all about the body language of speaker.

Nonverbal communication helps receiver in interpreting the message received. Often, nonverbal signals reflects the situation more accurately than verbal messages.Sometimes nonverbal response contradicts verbal communication and hence affect the effectiveness of message.

Nonverbal communication have the following three elements:

**Appearance**
Speaker: clothing, hairstyle, neatness, use of cosmetics
Surrounding: room size, lighting, decorations, furnishings

**Body Language**
facial expressions, gestures, postures

**Sounds**
Voice Tone, Volume, Speech rate

Types of Communication Based on Purpose and Style

Based on style and purpose, there are two main categories of communication and they both bears their own characteristics. Communication types based on style and purpose are:

1. Formal Communication
2. Informal Communication

**1. Formal Communication**

In formal communication, certain rules, conventions and principles are followed while communicating message. Formal communication occurs in formal and official style. Usually professional settings, corporate meetings, conferences undergoes in formal pattern.

In formal communication, use of slang and foul language is avoided and correct pronunciation is required. Authority lines are needed to be followed in formal communication.

2. **Informal Communication**

Informal communication is done using channels that are in contrast with formal communication channels. It's just a casual talk. It is established for societal affiliations of members in an organization and face-to-face discussions. It happens among friends and family. In informal communication use of slang words, foul language is not restricted. Usually. informal communication is done orally and using gestures.

Informal communication, Unlike formal communication, doesn't follow authority lines. In an organization, it helps in finding out staff grievances as people express more when talking informally. Informal communication helps in building relationships.

## Aphasia:

It is a communication disorder that results from damage or injury to language parts of the brain. It's more common in older adults, particularly those who have had a stroke.

Aphasia gets in the way of a person's ability to use or understand words. Aphasia does not impair the person's intelligence. People who have aphasia may have difficulty speaking and finding the "right" words to complete their thoughts. They may also have problems understanding conversation, reading and comprehending written words, writing words, and using numbers.

**What Causes Aphasia?**

Aphasia is usually caused by a stroke or brain injury with damage to one or more parts of the brain that deal with language. According to the National Aphasia Association, about 25% to 40% of people who survive a stroke get aphasia.

Aphasia may also be caused by a brain tumor, brain infection, or dementia such as Alzheimer's disease. In some cases, aphasia is a symptom of epilepsy or other neurological disorder.

**What Are the Types of Aphasia?**

There are types of aphasia. Each type can cause impairment that varies from mild to severe. Common types of aphasia include the following:

1. **Expressive aphasia (non-fluent):** With expressive aphasia, the person knows what he or she wants to say, yet has difficulty communicating it to others. It doesn't matter whether the person is trying to say or write what he or she is trying to communicate.it is also called as Broca's aphasia. The features of Expressive aphasia are:

- severely reduced speech, often limited to short utterances of less than four words
- limited vocabulary
- clumsy formation of sounds
- difficulty writing (but ability to read and understand speech).

2. **Receptive aphasia (fluent):** With receptive aphasia, the person can hear a voice or read the print, but may not understand the meaning of the message. Oftentimes, someone with receptive aphasia takes language literally. Their own speech may be disturbed because they do not understand their own language. It is also called as Wernicke's aphasia. The features of Wernicke's aphasia are:

- impaired reading and writing
- an inability to grasp the meaning of spoken words (producing connected speech is not affected)
- an inability to produce sentences that hang together
- the intrusion of irrelevant words in severe cases.

3. **Anomic aphasia:** With anomic aphasia, the person has word-finding difficulties. This is called anomia. Because of the difficulties, the person struggles to find the right words for speaking and writing. The features of anomic aphasia are:

- an inability to supply the words for the very things the person wants to talk about, particularly the significant nouns and verbs
- speech that's full of vague expressions of frustration
- a difficulty finding words in writing as well as in speech.

4. **Global aphasia:** This is the most severe type of aphasia. It is often seen right after someone has a stroke. With global aphasia, the person has difficulty speaking and understanding words. In addition, the person is unable to read or write.
5. **Primary progressive aphasia:** Primary progressive aphasia is a rare disorder where people slowly lose their ability to talk, read, write, and comprehend what they hear in conversation over a period of time. With a stroke, aphasia may improve with proper therapy. There is no treatment to reverse primary progressive aphasia. People with primary progressive aphasia are able to communicate in ways other than speech. For instance, they might use gestures. And many benefit from a combination of speech therapy and medications. Primary progressive aphasia (PPA) is a condition where language capabilities become slowly and progressively worse, leading to a gradual loss of the ability to:

- read
- write
- speak
- understand what other people are saying.

Deterioration can happen slowly, over a period of years. Other mental functions such as memory, reasoning, insight and judgement are not usually affected.

It's important to get an accurate diagnosis for PPA. This is to rule out other degenerative brain disorders like Alzheimer's disease where language and memory and reason are affected.

There is no cure for PPA. However a person can still communicate effectively with the right tools, support and PPA support group.

Aphasia may be mild or severe. With mild aphasia, the person may be able to converse, yet have trouble finding the right word or understanding complex conversations. Severe aphasia limits the person's ability to communicate. The person may say little and may not participate in or understand any conversation.

**What Are the Symptoms of Aphasia?**

The main symptoms of aphasia include:

- Trouble speaking
- Struggling with finding the appropriate term or word
- Using strange or inappropriate words in conversation

Some people with aphasia have problems understanding what others are saying. The problems occur particularly when the person is tired or in a crowded or loud environment. Aphasia does not affect thinking skills. But the person may have problems understanding written material and difficulties with handwriting. Some people have trouble using numbers or even doing simple calculations.

**How Is Aphasia Diagnosed?**

Usually, a doctor first diagnoses aphasia when treating a patient for a stroke, brain injury, or tumor. Using a series of neurological tests, the doctor may ask the person questions. The doctor may also issue specific commands and ask the person to name different items or objects. The results of these tests help the doctor determine if the person has aphasia. They also help determine the severity of the aphasia.

**How Is Aphasia Treated?**

Treatment for someone with aphasia depends on factors such as:

- Age
- Cause of brain injury
- Type of aphasia
- Position and size of the brain lesion

For instance, a person with aphasia may have a brain tumor that's affecting the language center of the brain. Surgery to treat the brain tumor may also improve the aphasia.

A person with aphasia who has had a stroke may benefit from sessions with a speech-language pathologist. The therapist will meet regularly with the person to increase his or her ability to speak and communicate. The therapist will also teach the person ways to communicate that don't involve speech. This will help the person compensate for language difficulties.

**Other treatments:**

Research is currently being carried out to study whether other treatments can benefit people with aphasia.

These include:

- medication – such as piracetam, bifemelane, piribedil, bromocriptine and idebenone
- transcranial magnetic stimulation – where an electromagnet placed on the scalp is stimulated for a short time using an electric current to stimulate parts of the brain affected by aphasia

Although some studies have suggested these treatments may benefit some people with aphasia, further research is necessary. You can search the database of clinical trials for aphasia to find trials that are studying these treatments.

## AUGMENTATIVE COMMUNICATION:

The field was originally called ”augmentative communication”, the term served to indicate that such communication systems were to supplement natural speech rather than to replace it. The addition of alternative followed later, when it became clear that for some individuals non speech systems were their only means of communication.

Augmentative and alternative communication (AAC) includes all forms of communication (other than oral speech) that are used to express thoughts, needs, wants, and ideas. We all use AAC when we make facial expressions or gestures, use symbols or pictures, or write.

People with severe speech or language problems rely on AAC to supplement existing speech or replace speech that is not functional. Special augmentative aids, such as picture and symbol

communication boards and electronic devices, are available to help people express themselves. This may increase social interaction, school performance, and feelings of self-worth.
AAC users should not stop using speech if they are able to do so. The AAC aids and devices are used to enhance their communication.

Message generation is generally much slower than spoken communication, and as a result rate enhancement techniques may be used to reduce the number of selections required. These techniques include "prediction", in which the user is offered guesses of the word/phrase being composed, and "encoding", in which longer messages are retrieved using a prestored code.

The evaluation of a user's abilities and requirements for AAC will include the individual's motor, visual, cognitive, language and communication strengths and weaknesses. The evaluation requires the input of family members, particularly for early intervention. Respecting ethnicity and family beliefs are key to a family-centeredand ethnically competent approach. Studies show that AAC use does not impede the development of speech, and may result in a modest increase in speech production. Users who have grown up with AAC report satisfying relationships and life activities; however, they may have poor literacy and are unlikely to be inemployment.

The Convention on the Rights of Persons with Disabilities defines augmentative and alternative communication one of communications as well as display of text, large-print, tactile communication, plain language, accessible multimedia and accessible information and communications technology

Augmentative and alternative communication is used by individuals to compensate for severe speech-language impairments in the expression or comprehension of spoken or written language. People making use of AAC include individuals with a variety of congenital conditions such as cerebral palsy, autism, intellectual disability, and acquired conditions such as amyotrophic lateral sclerosis, traumatic brain injury and aphasia.

**Types of AAC:**

**1: Unaided AAC:**

Unaided AAC systems are those that do not require an external tool, and include facial expression, vocalizations, gestures, andsign languages and systems. Informal vocalizations and gestures such as body language and facial expressions are part of natural communication, and such signals may be used by those with profound disabilities. More formalized gestural codes exist that lack a base in a naturally occurring language. For example, the Amer-Ind code is based on Plains Indian Sign Language, and has been used with children with severe-profound disabilities, and adults with a variety of diagnoses including dementia, aphasia and dysarthria. The benefits of gestures and pantomime are that they are always available to the user, usually understood by an educated listener, and are efficient means of communicating.

In contrast, sign languages have a linguistic base and permit the expression of an unlimited number of messages.[18]Approaches to signing can be divided into two major categories, those that encode an existing language, and those that are languages in their own right. Signing Exact English may be considered the most widely used example of the former and American Sign Language as a common example of the latter. Signing is used alone or in conjunction with speech to support communication with individuals with a variety of disorders.[21] The specific hand shapes and movements of sign and gesture require an individual to have adequate fine motor and motor planning skills. Sign languages require more fine-motor coordination and are less transparent in meaning than gestural codes such as Amer-Ind; the latter limits the number of people able to understand the person's communication without training.

**2. Aided AAC:**

This communication board, showing a food category, is a low-tech AAC aid.

This speech generating device, showing available categories in a grid layout, is a high-tech AAC aid. An AAC aid is any "device, either electronic or non-electronic, that is used to transmit or receive messages"; such aids range from communication books to speech generating devices. Since the skills, areas of difficulty and communication needs of AAC users vary greatly, an equally diverse range of communication aids and devices is required.

**Low-tech**

Low-tech communication aids are defined as those that do not need batteries, electricity or electronics. These are often very simple communication boards or books, from which the user selects letters, words, phrases, pictures, and/or symbols to communicate a message. Depending on physical abilities and limitations, users may indicate the appropriate message with a body part, light pointer, eye-gaze direction, or a head/mouth stick. Alternatively, they may indicate yes or no while a listener scans through possible options.

**High-tech**

High-tech AAC aids permit the storage and retrieval of electronic messages, with most allowing the user to communicate using speech output. Such devices are known as speech generating devices (SGD) or voice output communication aids (VOCA). A device's speech output may be digitized and/or synthesized: digitized systems play recorded words or phrases and are generally more intelligible while synthesized speech uses text-to-speech software that can be harder to understand but that permits the user to spell words and speak novel messages.

High-tech systems may be dedicated devices developed solely for AAC, or non-dedicated devices such as computers that run additional software to allow them to function as AAC devices. They may be static or dynamic in form. Static communication devices have symbols in fixed positions on paper overlays, which are changed manually. To increase the vocabulary available, some static devices have multiple levels, with different words appearing on different levels. On dynamic AAC devices, the user can change the symbols available using page links to navigate to appropriate pages of vocabulary and messages.

High-tech devices vary in the amount of information that they can store, as well as their size, weight and thus their portability. Access methods depend on the abilities of the user, and may include the use of direct selection of symbols on the screen or keyboard with a body part, pointer, adapted mice or joysticks, or indirect selection using switches and scanning. Devices with voice output offer its user the advantage of more communicative power, including the ability to initiate conversation with communication partners who are at a distance. However, they typically require programming, and tend to be unreliable. Because of the latter, low tech systems often recommended as a backup in case of device failure.

**Specific groups of AAC users:**

**Cerebral palsy**

Cerebral palsy is a term referring to a non-progressive developmental neuromotor disorder with an upper motor neuron lesion origin. Depending on the location of the brain lesion, individuals with cerebral palsy can have a wide variety of gross and fine motor challenges, including different forms and areas of the body affected. Fine motor planning, control and coordination are often affected. Dysarthria, a speech disorder resulting from neurological damage to the motor-speech system, occurs in an estimated 31% to 88% of those with cerebral palsy. Such individuals may require AAC support for communication. Approximately one half to one third have some degree of intellectual impairment, and visual and hearing problems are also common. Gross and fine motor challenges are often of particular concern in accessing an AAC device. Appropriate seating and positioning are important to facilitate optimum stability and movement. Extensive motor training and practice may be required to develop efficient AAC access and use. The trend towards custom-placed sensors and personalized signal processing may assist in facilitating communication for those who are incapable of using other AAC technologies.

**Intellectual impairment**

Phrases can be recorded onto simple switch-operated AAC devices by a user or carer so that the recording is played when the switch is pressed.

Individuals with intellectual impairments face challenges in developing communication skills, including problems withgeneralization (the transfer of learned skills into daily activities). They may lack communication opportunities in their daily lives, and responsive communicators who understand their communication methods. AAC intervention for this population emphasizes partner training as well as opportunities for integrated, natural communication. Studies have shown that appropriate use of AAC techniques with children and adults with intellectual impairments can enhance communication skills, increase participation in activities,choice-making, and even influence the perceptions and stereotypes of communication partners.

While most individuals with intellectual disabilities do not have concomitant behavioural issues, problems in this area are typically more prevalent in this population than others. AAC approaches may be used as part of teaching functional communication skills to non-speaking individuals as an alternative to "acting out" for the purpose of exerting independence, taking control, or informing preferences.

**Autism:**

Autism is a disorder of neural development characterized by impaired social interaction and communication, and by restricted and repetitive behaviour. Typically there is particular difficulty acquiring expressive communication skills. People with autism have been found to have strong visual processing skills, making them good candidates for an AAC approach. AAC intervention in this population is directed towards the linguistic and social abilities of the child, including providing the person with a concrete means of communication, as well as facilitating the development of interactional skills.

**Developmental verbal dyspraxia:**

Developmental verbal dyspraxia, also known as Childhood apraxia of speech, is a developmental motor speech disorderinvolving impairments in the motor control of speech production. The speech of a child with developmental verbal dyspraxia may be unintelligible to the point that daily communication needs cannot be met. A child with developmental verbal dyspraxia often experiences great amounts of frustration, so AAC can be a strategy to support communication alongside more traditional speech therapy to improve speech production.

A wide variety of AAC systems have been used with children with developmental verbal dyspraxia. Manual signs or gestures are frequent introduced to these children, and can include the use of fingerspelling alongside speech. Manual signs have been shown to decrease errors in articulation. Aided AAC systems typically include communication boards and speech generating devices. A multimodal approach is often used, with several AAC approaches introduced so that the child can take advantage of the most effective method for a particular situation.

**Traumatic brain injury:**

Traumatic brain injury can result in severe motor speech disorders; dysarthria is the most common such disorder, accounting for roughly a third of all cases. Depending on the stage of recovery, AAC intervention may involve identifying consistent communication signals, the facilitation of reliable yes/no responses to questions, and the ability to express basic needs and answer questions. Individuals who do not recover natural speech to a degree sufficient to meet their communication needs typically suffer from severe impairments related to cognition. Difficulties with memory and learning new skills may influence AAC choices; well-established competencies such as spelling may be more effective than AAC systems that require navigation through multiple pages to access information.

**Locked-in syndrome:**

Strokes that occur in the brainstem may cause profound deficits, including locked-in syndrome, in which cognitive, emotional and linguistic abilities remain intact but all or almost all voluntary motor abilities are lost. Most people affected by this type of stroke rely on AAC strategies to communicate, since few recover intelligible speech or functional voice. The AAC strategies used vary with the individual's preferences and motor capabilities which may change over time. As eye movements are most likely to be preserved, eye blinks are frequently used for communication. Low-tech alphabet boards are often introduced immediately to provide the individual with basic communication. Partner-assisted scanning may be used, in which the AAC user signals when the desired letter is named by a communication partner. When vertical and horizontal eye movements are functional, a transparent alphabet board may be used in which the AAC user looks at the desired letter and this is acknowledged by the communication partner. Individuals with locked-in syndrome have difficulty using high-tech devices due to issues with motor control, vision, memory, alertness and linguistic ability. In particular, a voluntary, reliable and easily controlled muscle movement is necessary to access such a device, such as head, jaw, hand or finger movements. In some individuals, intensive practice, even long after the initial stroke, has been shown to increase the accuracy and consistency of head movements, which can be used to access a communication device.

**Parkinson's disease:**

Parkinson's disease is a progressive neurological condition in which dysarthria may develop later in the progression of the disease. Some individuals eventually lose all functional speech. AAC approaches are generally used to supplement and support natural speech. A portable amplifier, for example, may be used to increase the volume of speech and thus its intelligibility. The individual may be taught to point to the first letter of each word they say on an alphabet board, leading to a reduced speech rate and visual cues for the listener to compensate for impaired articulation. Entire words can be spelled out if necessary. In users that have reduced range and speed of movement, a smaller than usual selection display may be preferred. High-tech AAC keyboard speech-generating devices are also used; keyguards may be required to prevent accidental keystrokes caused by the tremor typical of the disease. Factors affecting AAC use in Parkinson's disease include motor deficits and cognitive changes; the latter may result in unawareness of their problems with spoken communication.

**Multiple sclerosis:**

Dysarthria is the most common communication problem in individuals with multiple sclerosis (MS), however, significant difficulties with speech and intelligibility are uncommon. Individuals with MS vary widely in their motor control capacity and the presence of intention tremor, and methods of access to AAC technology are adapted accordingly. Visual impairments are common in MS and may necessitate approaches using auditory scanning systems, large-print

## Visual aids:

It is a term for a medical rehabilitation to improve vision or low vision. In other words, it is the process of restoring functional ability and improving quality of life and independence in an individual who has lost visual function through illness or injury. Most visual rehabilitation services are focused on low vision, which is a visual impairment that cannot be corrected by regular eyeglasses, contact lenses, medication, or surgery. Low vision interferes with the ability to perform everyday activities. Visual impairment is caused by factors including brain damage, vision loss, and others. Of the vision rehabilitation techniques available, most center on neurological and physical approaches.

**Types of visual aid:**

A person who is blind or has some visual loss may need information which is usually written down or provided in standard print in an alternative format such as: audio, on CD or as an MP3 file, braille, email or large print. People who are blind, deafblind or have some visual loss may require information to be sent or shared with them electronically via email instead of in a written or printed format. The use of email enables the recipient to use their own assistive technology or software, for example a ‘screen reader’ which converts text to speech. Depending on the software or assistive technology used, a person who is blind or has some visual loss may require information sent to them electronically (emailed) in one or more specific formats such as plain text (with or without attachments), HTML, and with attachments in Word or PDF format.

A person who is blind or has some visual loss may need visual information in the form of an audible alert. For example, many blind people cannot read their name on a screen or notice and so will need to be told or guided to the appropriate room and / or seat.

**Braille :**

It is a tactile writing system used by people who are blind or visually impaired. It is traditionally written with embossed paper. Braille-users can read computer screens and other electronic supports thanks to refreshable braille displays. They can write braille with the original slate and stylusor type it on a braille writer, such as a portable braille note-taker, or on a computer that prints with a braille embosser.

Braille characters are small rectangular blocks called *cells* that contain tiny palpable bumps called *raised dots*. The number and arrangement of these dots distinguish one character from another. Since the various braille alphabets originated as transcription codes of printed writing systems, the mappings (sets of character designations) vary from language to language. Furthermore, in English Braille there are three levels of encoding: Grade 1 – a letter-by-letter transcription used for basic literacy; Grade 2 – an addition of abbreviations and contractions; and Grade 3 – various non-standardized personal shorthands.

Braille cells are not the only thing to appear in braille text. There may be embossed illustrations and graphs, with the lines either solid or made of series of dots, arrows, bullets that are larger than braille dots, etc. A full Braille cell includes six raised dots arranged in two lateral rows each having three dots.[3] The dot positions are identified by numbers from one through six.[3] 64 solutions are possible from using one or more dots.[3] A single cell can be used to represent an alphabet letter, number, punctuation mark, or even an entire word.[3]

Audio: information recorded from speech or synthetic (computer-generated) speech onto cassette tape, CD (compact disc) or as an electronic file such as an MP3

**BSL interpreter - hands-on signing:** a BSL(british sign language) interpreter who is able to sign with the hands of the person they are interpreting for placed over their hands, so that they can feel the signs being used. A type of communication support which may be needed by a person who is deafblind.

**Low vision aids:**

There are many low vision aids and devices to help you with your daily activities. Talk with your ophthalmologist or vision rehabilitation team about solutions for your specific needs. From talking watches to tablet computers, there are lots of low vision tools. Also ask if you will need training in how to use the devices.

Here are some low vision aids:

Optical low vision aids. These use magnifying lenses to make objects look larger and easier to see.

- Magnifying spectacles. Magnifying spectacles are worn like eyeglasses to keep your hands free. They can be used for reading, threading a needle, or doing other close-up tasks.
- Stand magnifiers. These magnifiers rest above the object you are looking at. This helps to keep the lens at a proper distance. Being on a stand also is helpful to people who have a tremor or arthritis. Some stand magnifiers have built-in lights.
- Hand magnifiers. There are magnifiers designed to help with different amounts of vision. Some models have built-in lights.
- Telescopes. These are used to see objects or signs far away. Some telescopes can be attached to eyeglasses. Others are held like binoculars.
- Video magnifiers. These electronic devices make printed pages, pictures, or other small objects look bigger. You often can adjust them to meet your special vision needs. For instance, with some magnifiers you can add contrast to make printed words darker. There

are a lot of new video magnifiers. Talk with your ophthalmologist about which ones can help you.

**Low vision devices**.

These are designed to help with everyday tasks.

- Audio books and electronic books. With audio books, you can listen to text that is read aloud. With electronic books like Kindle®, Nook® and others, you can increase word size and contrast.
- Smartphones and tablets let you change word size, adjust lighting and use voice commands. There also are many apps to choose from, such as programs that read material aloud, magnify, or illuminate, Another app, EyeNote, is free for Apple products. It scans and identifies the denomination of U.S. paper money.
- Computers that can read aloud or magnify what is on the screen.
- Talking items such as watches, timers, blood pressure cuffs, and blood sugar machines.
- Large-print books, newspapers, magazines, playing cards and bank checks.
- Telephones, thermostats, watches and remote controls with large-sized numbers and high contrast colors.

New advances in consumer technology are not a cure-all for those with low vision. Many people will need other devices and aids as well. They will also need vision rehabilitation to achieve their best possible vision. But for many people, these digital devices and apps offer more options for portable, lower-cost low vision aids.

## Writing aids:

Persons with disability find it difficult to write. If a person without hands, then he/she ll train to write using his legs or mouth. Even patients with stroke cant able to write. There are many writing aids in different models available. Some of them are:

**Wanchik Writing Splints:**

The Wanchik Writing Splints wrap comfortably around the palm to give individuals with weak hand, finger, or wrist dexterity the support and control needed to write. Three sizes are available and can be used by children or adults. The Wanchik Writers can be used by both left- and right-handed individuals.

**Ring Pen Ultra Writing Aid :**

The Ring Pen Ultra Writing Aid is a new ergonomic contoured grip that holds a pen, pencil or paint brush and in a more comfortable position. The holder provides better control and does not require a tight grip generally needed to hold conventional writing implements. The Ring Pen Ultra is a contoured molded gripper that firmly grips a pen or pencil. The user's index finger slips through the opening in the center. The balanced design provides much better control, making it easier to position the tip on the paper and reduce the amount of tremor from the fingers. People with poor fine motor control, hand disabilities, or decreased dexterity who have difficulty writing may find this writing aid helpful.

The Adjustable Head Pointer assists individuals with limited hand use in writing, drawing, turning pages, or activating switches or controls. This adaptive device can also help people with limited verbal communication skills to use communication boards.

**Head piece:**

The head piece consists of adjustable lightweight plastic bands for fitting individual head sizes and shapes. The bands are secured with metal hardware, and topped with a 19 inch aluminum pointer rod. The bands are padded for comfort. The pointer rod is length and angle adjustable in any direction, and is fitted with a removable pencil holder.

**Classic Ring Pen writing aid:**

The Classic Ring Pen writing aid was developed after years of combined efforts of medical specialists and designers. This balanced ergonomic pen is designed to reduce the stress and pain of writing. The Classic Ring Pen has an ergonomically designed barrel with a center opening that allows one finger to fit through the ring, providing a natural resting place for the writing finger. The barrel fits snugly between two other fingers. The center of gravity for the pen coincides with the point of support, allowing the user to write in a stable manner with minimal effort applied. Standard writing pens must be tightly gripped with three fingers and are unbalanced in the hand. Individuals who find it very difficult and painful to grip a conventional pen will find the patented Classic Ring Pen does not require a tight grip.

## Hearing aid:

A hearing aid or deaf aid is a device designed to improve hearing. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations. Small audio amplifiers such as PSAPs or other plain sound reinforcing systems cannot be sold as "hearing aids".

Earlier devices, such as ear trumpets or ear horns, were passive amplification cones designed to gather sound energy and direct it into the ear canal. Modern devices are computerised electroacoustic systems that transform environmental sound to make it more intelligible or comfortable, according to audiometrical andcognitive rules. Such sound processing can be considerable, such as highlighting a spatial region, shifting frequencies, cancelling noise and wind, or highlighting voice.

Modern hearing aids require configuration to match the hearing loss, physical features, and lifestyle of the wearer. This process is called "fitting" and is performed by audiologists. The amount of benefit a hearing aid delivers depends in large part on the quality of its fitting. Devices similar to hearing aids include the bone anchored hearing aid, and cochlear implant.

### Uses

Hearing aids are incapable of truly correcting a hearing loss; they are an *aid* to make sounds more accessible. Two primary issues minimize the effectiveness of hearing aids:

- When the primary auditory cortex does not receive regular stimulation, this part of the brain loses cells which process sound. Cell loss increases as the degree of hearing loss increases.
- Damage to the hair cells of the inner ear results in sensorineural hearing loss, which affects the ability to discriminate between sounds. This often manifests as a decreased ability to understand speech, and simply amplifying speech (as a hearing aid does) is often insufficient to improve speech perception.

## Types:

### Body worn aids:

This was the first type of hearing aid invented by Harvey Fletcher while working at Bell Laboratories. Body aids consist of a case and an earmold, attached by a wire. The case contains the electronic amplifier components, controls and battery while the earmold typically contains a miniature loudspeaker. The case is typically about the size of a pack of playing cards and is carried in a pocket or on a belt. Without the size constraints of smaller hearing devices, body worn aid designs can provide large amplification and long battery life at a lower cost. Body aids are still marketed in emerging markets because of their lower cost.

### Behind the ear aids:

Behind the ear aids are also called "receiver-in-the-aid" or RITA devices. These devices are useful for people who require significant amplification across many frequencies due to moderate to severe hearing loss. Larger models tend to be easier to handle for changing batteries or configuring controls. The earmolds on these are easier to clean than other sorts of devices, but they also will be more visible and prone to buildup of wax. If the earmold is not vented then that can make the ear feel plugged.

Behind the ear aids (BTE) consist of a case, an earmold or dome and a connection between them. The case contains the electronics, controls, battery, microphone(s) and often the loudspeaker. Generally, the case sits behind the pinna with the connection from the case coming down the front into the ear. The sound from the instrument can be routed acoustically or electrically to the ear. If the sound is routed electrically, the speaker (receiver) is located in the earmold or an open-fit dome, while acoustically coupled instruments use a plastic tube to deliver the sound from the case’s loudspeaker to the earmold. BTEs are also easily connected to assistive listening devices, such as FM systems, to directly integrate sound sources with the instrument. BTE aids are commonly worn by children who need a durable type of hearing aid.

**Mini BTE (or "on-the-ear") aids:**

A new type of BTE aid called the mini BTE (or "on-the-ear") aid. It also fits behind/on the ear, but is smaller. A very thin, almost invisible tube is used to connect the aid to the ear canal. Mini BTEs may have a comfortable ear piece for insertion ("open fit"), but may also use a traditional earmold. Mini BTEs allow not only reduced occlusion or "plugged up" sensations in the ear canal, but also increase comfort, reduce feedback and address cosmetic concerns for many users.

**Receiver in the canal/ear (CRT/RIC/RITE):**

In a "receiver in the canal" device, the receiver is the speaker which sends sound into the ear. To fit this device may have either a custom-made mold or a general use dome fitting. Many users find this device to be more comfortable. The larger versions are easier to wear. Disadvantages are that these need to be replaced more often due to moisture and wax damage. Also they have technical limits on how much low frequency amplification they can do.

**BTE Cross System:**

Cross systems are used for people with hearing loss in one ear or significantly more in one ear, this system allows the user to wear technically a microphone in one ear and the speech is transferred into a speaker in the good ear, whilst the cone in the good ear allow normal hearing

**BTE Bi Cross System:**

BTE Bi Cross System is the same as the Cross system, however it can also enhance the hearing in the individuals better ear by enhancing the volume of the input, therefore channeling the sound into the good ear, whilst enhancing the clarity and volume for it also

**Earmolds:**

An earmold is created from an impression taken of the individual's outer ear. This usually ensures a comfortable fit and reduces the possibility of feedback. Earmolds are made from a variety of hard (firm) and soft (pliable) materials. The color of the case and earmold of a BTE aid can be modified and optional decorations can be added.

**In the ear aids:**

In the ear aids (ITE) devices fit in the outer ear bowl (called the concha). Being larger, these are easier to insert and can hold extra features. They are sometimes visible when standing face to face with someone. ITE hearing aids are custom made to fit each individual's ear. They can be used in mild to some severe hearing losses. Feedback, a squealing/whistling caused by sound (particularly high frequency sound) leaking and being amplified again, may be a problem for severe hearing losses. Some modern circuits are able to provide feedback regulation or cancellation to assist with this. Venting may also cause feedback. A vent is a tube primarily placed to offer pressure equalization. However, different vent styles and sizes can be used to influence and prevent feedback. Traditionally, ITEs have not been recommended for young children because their fit could not be as easily modified as the earmold for a BTE, and thus the aid had to be replaced frequently as the child grew. However, there are new ITEs made from a silicone type material that mitigates the need for costly replacements. ITE hearing aids can be connected wirelessly to FM systems, for instance with a body-worn FM receiver with induction neck-loop which transmits the audio signal from the FM transmitter inductively to the telecoil inside the hearing instrument.

**Mini in canal (MIC) or completely in canal (CIC) aids:**

They are generally not visible unless the viewer looks directly into the wearer's ear. These aids are intended for mild to moderately severe losses. CICs are usually not recommended for people with good low-frequency hearing, as the occlusion effect is much more noticeable. Completely-in-the-canal hearing aids fit tightly deep in the ear. It barely visible. Being small, it will not have a directional microphone, and its small batteries will have a short life, and the batteries and controls may be difficult to manage. Its position in the ear prevents wind noise and makes it easier to use phones without feedback. In-the-canal hearing aids are placed deep in the ear canal. They are barely visible. Larger versions of these can have directional microphones. Being in the canal, they are less likely to cause a plugged feeling. These models are easier to manipulate than the smaller completely in-the-canal models but still have the drawbacks of being rather small.

In-the-ear hearing aids are typically more expensive than behind-the-ear counterparts of equal functionality, because they are custom fitted to the patient's ear. In fitting, an audiologist takes a physical impression (mold) of the ear. The mold is scanned by a specialized CAD system, resulting in a 3D model of the outer ear. During modeling, the venting tube is inserted. The digitally modeled *shell* is printed using a rapid prototyping technique such as stereolithography. Finally, the aid is assembled and shipped to the audiologist after a quality check.[20]

**Invisible in canal hearing aids:**

Invisible in canal hearing aids (IIC) style of hearing aids fits inside the ear canal completely, leaving little to no trace of an installed hearing aid visible. This is because it fits deeper in the canal than other types, so that it is out of view even when looking directly into the ear bowl (concha). A comfortable fit is achieved because the shell of the aid is custom-made to the individual ear canal after taking a mould. Invisible hearing aid types use venting and their deep placement in the ear canal to give a more natural experience of hearing. Unlike other hearing aid types, with the IIC aid the majority of the ear is not blocked (occluded) by a large plastic shell. This means that sound can be collected more naturally by the shape of the ear, and can travel down into the ear canal as it would with unassisted hearing. Depending on their size, some models allow the wearer to use a mobile phone as a remote control to alter memory and volume settings, instead of taking the IIC out to do this. IIC types are most suitable for users up to middle age, but are not suitable for more elderly people.

**Extended wear hearing aids:**

Extended wear hearing aids are hearing devices that are non-surgically placed in the ear canal by a hearing professional. The extended wear hearing aid represents the first "invisible" hearing device. These devices are worn for 1–3 months at a time without removal. They are made of soft material designed to contour to each user and can be used by people with mild to moderately severe hearing loss. Their close proximity to the ear drum results in improved sound directionality and localization, reduced feedback, and improved high frequency gain. While traditional BTE or ITC hearing aids require daily insertion and removal, extended wear hearing aids are worn continuously and then replaced with a new device. Users can change volume and settings without the aid of a hearing professional. The devices are very useful for active individuals because their design protects against moisture and earwax and can be worn while exercising, showering, etc. Because the device's placement within the ear canal makes them invisible to observers, extended wear hearing aids are popular with those who are self-conscious about the aesthetics of BTE or ITC hearing aid models. As with other hearing devices, compatibility is based on an individual's hearing loss, ear size and shape, medical conditions, and lifestyle. The disadvantages include regular removal and reinsertion of the device when the battery dies, inability to go underwater, earplugs when showering, and for some discomfort with the fit since it is inserted deeply in the ear canal, the only part of the body where skin rests directly on top of bone.

**Disposable hearing aids:**

Disposable hearing aids are hearing aids that have a non-replaceable battery. These aids are designed to use power sparingly, so that the battery lasts longer than batteries used in traditional hearing aids. Disposable hearing aids are meant to remove the task of battery replacement and other maintenance chores (adjustment or cleanings).

**Bone anchored hearing aids:**

A bone anchored hearing aid (BAHA) is an auditory prosthetic based on bone conduction which can be surgically implanted. It is an option for patients without external ear canals, when conventional hearing aids with a mould in the ear cannot be used. The BAHA uses the skull as a pathway for sound to travel to the inner ear. For people with conductive hearing loss, the BAHA bypasses the external auditory canal and middle ear, stimulating the functioning cochlea. For people with unilateral hearing loss, the BAHA uses the skull to conduct the sound from the deaf side to the side with the functioning cochlea. This can be worn from the age of one month as babies tend to tolerate this arrangement very well. When the child's skull bone is sufficiently thick, a titanium "post" can be surgically embedded into the skull with a small abutment exposed outside the skin. The BAHA sound processor sits on this abutment and transmits sound vibrations to the external abutment of the titanium implant. The implant vibrates the skull and inner ear, which stimulate the nerve fibers of the inner ear, allowing hearing.

The surgical procedure is simple both for the surgeon, involving very few risks for the experienced ear surgeon. For the patient, minimal discomfort and pain is reported. Patients may experience numbness of the area around the implant as small superficial nerves in the skin are sectioned during the procedure. This often disappears after some time. There is no risk of further hearing loss due to the surgery. One important feature of the Baha is that, if a patient for whatever reason does not want to continue with the arrangement, it takes the surgeon less than a minute to remove it. The Baha does not restrict the wearer from any activities such as outdoor life, sporting activities etc.

**Wireless hearing aids:**

Recent hearing aids include wireless hearing aids. One hearing aid can transmit to the other side so that pressing one aid's program button simultaneously changes the other aid, so that both aids change background settings simultaneously. FM listening systems are now emerging with wireless receivers integrated with the use of hearing aids. A separate wireless microphone can be given to a partner to wear in a restaurant, in the car, during leisure time, in the shopping mall, at lectures, or during religious services. The voice is transmitted wirelessly to the hearing aids eliminating the effects of distance and background noise. FM systems have shown to give the best speech understanding in noise of all available technologies. FM systems can also be hooked up to a TV or a stereo.

2.4 gigahertz Bluetooth connectivity is the most recent innovation in wireless interfacing for hearing instruments to audio sources such as TV streamers or Bluetooth enabled mobile phones. Current hearing aids generally do not stream directly via Bluetooth but rather do so through a secondary streaming device (usually worn around the neck or in a pocket), this bluetooth enabled secondary device then streams wirelessly to the hearing aid but can only do so over a short distance. This technology can be applied to ready-to-wear devices (BTE, Mini BTE, RIE, etc.) or to custom made devices that fit directly into the ear.

## Orthotics

**Orthotics**(*ortho*, "to straighten" or "align") is a specialty within the medical field concerned with the design, manufacture and application of orthoses. An *orthosis* is "an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal system".An orthotist is the primary medical clinician responsible for the prescription, manufacture and management of orthoses. An orthosis may be used to:

- Control, guide, limit and/or immobilize an extremity, joint or body segment for a particular reason
- To restrict movement in a given direction
- To assist movement generally
- To reduce weight bearing forces for a particular purpose
- To aid rehabilitation from fractures after the removal of a cast
- To otherwise correct the shape and/or function of the body, to provide easier movement capability or reduce pain

Patients who benefit from an orthosis may have a condition such as spina bifida or cerebral palsy, or have experienced a spinal cord injury or stroke. Equally, orthoses are sometimes used prophylactically or to optimise performance in sport.

### Manufacture and materials

Orthoses were traditionally made by following a tracing of the extremity with measurements to assist in creating a well-fitted device. Subsequently, the advent of plastics as a material of choice for construction necessitated the idea of creating a plaster of Paris mould of the body part in question. This method is still extensively used throughout the industry. Currently, CAD/CAM, CNC machines and 3D printing are involved in orthotic manufacture.

Orthoses are made from various types of materials including thermoplastics, carbon fibre, metals, elastic, EVA, fabric or a combination of similar materials. Some designs may be purchased at a local retailer; others are more specific and require a prescription from a physician, who will fit the orthosis according to the patient's requirements. Over-the-counter braces are basic and available in multiple sizes. They are generally slid on or strapped on with Velcro, and are held tightly in place. One of the purposes of these braces is injury protection.

## Classification

### Upper-limb orthoses

Upper-limb (or upper extremity) orthoses are mechanical or electromechanical devices applied externally to the arm or segments thereof in order to restore or improve function, or structural characteristics of the arm segments encumbered by the device. In general, musculoskeletal problems that may be alleviated by the use of upper limb orthoses include those resulting from trauma[7] or disease (arthritis for example). They may also be beneficial in aiding individuals who have suffered a neurological impairment such as stroke, spinal cord injury, or peripheral neuropathy.

Types of upper-limb orthoses

- Upper-limb orthoses
  - Clavicular and shoulder orthoses
  - Arm orthoses
  - Functional arm orthoses
  - Elbow orthoses
- Forearm-wrist orthoses
- Forearm-wrist-thumb orthoses
- Forearm-wrist-hand orthoses
- Hand orthoses
- Upper-extremity orthoses (with special functions)

### Lower-limb orthoses

A lower-limb orthosis is an external device applied to a lower-body segment to improve function by controlling motion, providing support through stabilizing gait, reducing pain through transferring load to another area, correcting flexible deformities, and preventing progression of fixed deformities.

The term **caliper** or **calipers** remains in widespread use for lower-limb orthoses

## Foot orthoses :

Foot orthoses comprise a custom made insert or footbed fitted into a shoe. Commonly referred to as "orthotics" these orthoses provide support for the foot by redistributing ground reaction forces as well as realigning foot joints while standing, walking or running. A great body of information exists within the orthotic literature describing the sciences that might be used to aid people with foot problems as well as the impact "orthotics" can have on foot, knee, hip, and spine deformities. They are used by everyone from athletes to the elderly to accommodate biomechanical deformities and a variety of soft tissue inflammatory conditions such as plantar fasciitis.[9] They may also be used in conjunction with properly fitted orthopaedic footwear in the prevention of foot ulcers in the at-risk diabetic foot.

Foot orthoses, commonly called orthotics, are specially designed shoe inserts that help support the feet and improve foot posture. People who have chronic foot or leg problems that interfere with the health and functioning of their feet may be prescribed orthoses by their podiatrist. For example, someone prone to calluses can have the pressure of their body weight redistributed across their feet with the aid of custom-fitted shoe inserts. Athletes may also wear orthoses to help correct foot problems that could hinder their performance. These prescription shoe inserts are either ‘off the shelf’ or made from scratch using a plaster cast or computer-aided digital picture of the patient’s foot.

### Foot conditions treated with orthotics

Some of the foot and lower limb problems that can be successfully treated in the long term with orthoses include:

corns and calluses, foot ulceration, tendonitis, recurrent ankle sprains, recurrent stress fractures of foot and leg bones, heel pain, front-of-knee pain (patellofemoral syndrome), some hip and low back pains (particularly those made worse by long periods of walking or standing.

### Orthotics are individually designed

Orthoses are designed to address the person’s particular foot problems. The various types of orthoses can include:

- functional foot (customised kinetic) orthoses – to offer all the features below, including postural adjustment
- prefabricated orthoses – these devices can be customised by a podiatrist to provide relief for a specific problem
- cushioning orthoses – to offer extra shock absorption to the foot
- pressure relief orthoses – to remove pressure spots (that could be responsible for complaints such as corns or calluses) by redistributing the person's body weight across the sole of the foot.

**Prescribing orthotics**

When prescribing your orthoses, your podiatrist will consider various factors, including:

- existing foot problems (such as corns and calluses)
- foot structure and function
- biomechanical considerations, including posture and walking pattern
- type of footwear commonly worn
- occupation (such as whether your job involves standing up for long periods of time)
- lifestyle factors (such as preferred sports).

**Foot assessment for orthotics**

If foot orthoses are considered necessary, a comprehensive understanding of your foot function will be required. This may be done by examining your foot, including the range of motion of your foot joints, the strength of the muscles in your feet, and the position of the bones in your feet when you stand. Your walking pattern will be assessed in detail (on a flat surface, a treadmill, or or by repeating the activity that triggers your pain).

**Long-term treatment with orthotics**

Orthoses will usually be prescribed with other therapies, such as a program of stretching and strengthening exercises to improve your posture and alignment. These exercises are generally developed by the podiatrist in consultation with you and started at the time of orthotic prescription.

For people with diabetic foot ulcers, wound cleaning and dressings are provided, as well as pressure-relieving orthoses to improve the rate of healing. You may need to visit your podiatrist after your orthoses are fitted to make sure they are working properly. In some cases, small adjustments to the shoe inserts are needed. Your podiatrist will devise an ongoing treatment plan to help you manage your foot problems in the long term.

**Things to remember**

- Foot orthoses are specially designed shoe inserts that help support the feet and correct any imbalances.
- Some of the foot and lower limb problems that can be successfully treated in the long term with orthoses include corns and calluses, foot ulceration, tendonitis, recurrent ankle sprain, plantar fasciitis or heel spur syndrome and recurrent stress fractures.
- Other treatments may include exercises and recommendations on footwear.

## Ankle-foot orthosis:

An ankle-foot orthosis (AFO) is an orthosis or brace that encumbers the ankle and foot. AFOs are externally applied and intended to control position and motion of the ankle, compensate for weakness, or correct deformities. AFOs can be used to support weak limbs, or to position a limb with contracted muscles into a more normal position. They are also used to immobilize the ankle and lower leg in the presence of arthritis or fracture, and to correct foot drop; an AFO is also known as a foot-drop brace. An AFO is generally constructed of lightweight polypropylene-based plastic in the shape of an "L", with the upright portion behind the calf and the lower portion running under the foot. They are attached to the calf with a strap, and are made to fit inside accommodative shoes. The unbroken "L" shape of some designs provides rigidity, while other designs (with a jointed ankle) provide different types of control.

Obtaining a good fit with an AFO involves one of two approaches:

1. provision of an off-the-shelf or prefabricated AFO matched in size to the end user
2. custom manufacture of an individualized AFO from a positive model, obtained from a negative cast or the use of computer-aided imaging, design, and milling. The plastic used

to create a durable AFO must be heated to 400 °F (200 °C), making direct molding of the material on the end user impossible.

Ankle foot orthoses or AFO's help to provide stability, control and protection for the feet. They also help to provide proprioceptive feedback so that we know where our feet are in space - something important for people who have peripheral neuropathy associated with diseases such as diabetes mellitus and Charcot Marie Tooth.

Ankle foot orthoses are made according to the specific needs of each person. They are made in many different styles according to the medical, biomechanical and environmental needs of the individual.

Some main categories of Ankle Foot Orthoses are listed below.

**Flexible ankle foot orthosis-** a light weight straightforward design that prevents the foot from plantar flexing (dropping) to allow a smooth swing of the foot without catching the toe on the ground. Variations in the shape and strapping are made based on client needs. The Flexible AFO is usually made from polypropylene plastic with hook and loop (Velcro) closures for the strap. The flexible AFO is often used for people who have had a stroke (CVA), Multiple Sclerosis, poliomyelitis or other nerve injuries.

**Hinged ankle foot orthosis** are effective devices that are used to control plantar and/or dorsi flexion (up or down movement of the foot) and side to side movement. Several designs are used with a large variety of joints (hinges) available. The type of joint selection is based on the client needs and consideration is made for weight and shape of device. The hinged AFO is most often used for people who have foot drop due to issues such as stroke (CVA) or Cerebral Palsy. The hinged ankle foot orthosis can be plastic - see picture of custom hinged ankle foot orthosis, or Klenzak orthosis (conventional style).

**Tubular ankle foot orthosis** - also called a circumferential AFO, the tubular AFO encloses the entire lower leg and foot. The removable, cast-like brace provides ultimate stability and protection for the leg and foot. The brace is lined usually with foam and leather to give added protection to the sensitive skin. The tubular AFO is most often used for people with complications from Diabetes Mellitus or other Peripheral Neuropathies.

**Silicone Ankle Foot Orthosis (SAFO)** - the SAFO is a new design used for people who have a flaccid paralysis of the feet with pathologies such as Charcot-Marie-Tooth Disease, Multiple Sclerosis, Poliomyelitis, Stroke and Spinal Cord Injury. The circumferential design offers optimal proprioception (so you "know where your feet are") with excellent plantar flexion (dropfoot) control. The very low profile device can be worn with or without shoes.

## Knee-ankle-foot orthosis (KAFOs)

A knee-ankle-foot orthosis (KAFO) is an orthosis that encumbers the knee, ankle and foot. Motion at all three of these lower limb areas is affected by a KAFO and can include stopping motion, limiting motion, or assisting motion in any or all of the three planes of motion in a human joint: saggital, coronal, and axial. Mechanical hinges, as well as electrically controlled hinges have been used. Various materials for fabrication of a KAFO include but are not limited to metals, plastics, fabrics, and leather. Conditions that might benefit from the use of a KAFO include paralysis, joint laxity or arthritis, fracture, and others. Although not as widely used as knee orthoses, KAFOs can make a real difference in the life of a paralyzed person, helping them to walk therapeutically or, in the case of polio patients, on a community level. These devices are expensive and require maintenance. Some research is being done to enhance the design; even NASA helped spearhead the development of a special knee joint for KAFOs.

A KAFO is a long-leg orthosis that spans the knee, the ankle, and the foot in an effort to stabilize the joints and assist the muscles of the leg. While there are several common indications for such an Orthosis, muscle weakness and paralysis of the leg are the ones most frequently identified. The most common causes of muscle weakness include: Poliomyelitis, Muscular Dystrophy, Multiple Sclerosis, Spinal Cord Injury.Until recently, the best option for a patient with weakness of the muscles that control the knee was to wear a KAFO with a locked knee joint. This provided stability to the knee to prevent involuntary flexion, but caused other associated problems like muscle atrophy and increased energy expenditure in gait. Within the past few years, a newer design of knee joint has been developed that can automatically lock and unlock at the appropriate phases of the gait cycle to allow a more fluidic walking style. These knee joints can be used to create a KAFO that is appropriate for certain patients with knee weakness that fit the treatment criteria of the system. Each KAFO is custom-made to the specific requirements of the individual. There are numerous design options available that make usage of the Orthosis both functional and comfortable. A detailed examination and assessment of the patient allows us to suggest the best available component combination.



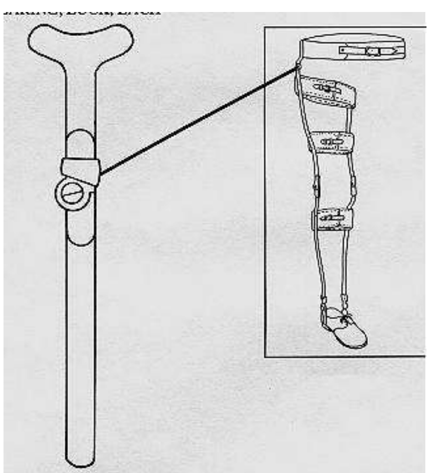

***Hybrid KAFO*** ***Graphite KAFO*** ***Single Ankle Joint KAFO*** ***Specialty KAFO***

## HKAFO (HIP-KNEE-ANKLE-FOOT-ORTHOSIS)

The HKAFO is a KAFO (knee-ankle-foot-orthosis) with an extension of hip joint and pelvic components. This device is used on patients requiring more stability of the hip and lower torso, due to paralysis and weakness, in addition to the lower extremity involvement. The brace will provide pelvic stability in several planes, from rotation, to side-to-side, and front-to-back motions. Primarily the hip section and hip joint of the brace stabilizes and aligns the lower leg underneath, reducing unwanted motion, while increasing steps per minute and reducing energy expenditure.

HKAFO's are used for patients with paraplegia, spina bifida, recurrent hip dislocation and other high neurological impairments.

The term HKAFO is an acronym that stands for hip-knee-ankle-foot-orthosis and describes the part of the body that this device encompasses. This device is a basically a KAFO with the addition of a hip joint and pelvic section. The addition of the hip joint and pelvic section provide control to selected hip motions. These selected motions about the hip are front to back, side to side, and rotation. One reason the hip section is added to a KAFO is to reduce or minimize the risk of the hip moving out of proper position or dislocating. Another common reason is to stabilize the hip and lower spine in cases where the patient is weak or paralyzed.



## Biomechanical principles of orthoses:

1. There are six orthotic functional characteristics: 1. Redistribution of load 2. Correction of misalignment 3. Guidance of growth 4. Control of motion 5. Pain reduction 6. Reduction

of muscle tone 1. Redistribution of load 1. There is a mismatch of body’s mass or its mechanical effect and anatomical structure. 2. This may be caused by adiposity or by underdevelopment, deformity, trauma of the anatomical structures dealing with mass and forces. 3. Such mis-proportions may congenital or acquired. 4. It may be a temporary of long term condition.

2. • The aim is to correct such mis-proportions. • To provide body and opportunity to heal or be relieved of pain, while damaged of uncapable body segments are being partially or completely relieved from weight loads and their effects. Possible unwanted side-effects • The redistribution of load will create an increase of load to new weight bearing areas. • This may lead to unwanted tissue problems. • Load bearing orthoses must, therefore, be cared for continuous fit, alignment and function by the orthotist. Orthotic Examples – Weight Bearing HKAFO: • Weight redistribution or unloading of the lower extremity can be achieved by a HKAFO with ischial weight bearing support.
3. • The orthosis will transfer weight from the ischium directly to the ground. • The ischium is well equipped to deal with such loads. • The orthosis, however, can not reduce the pressure application to joints as created by such force derived from muscle contractions. Orthotic Example Weight - Bearing Orthosis AFO •Weight redistribution or unloading the distal lower extremity. •Patellar tendon is the load transfer area (PTB type load transfer). •There is a load increase at the tibial head/patellar tendon. •The orthosis can not reduce the pressure application to joints as created by such force derived from muscle contractions.
4. Orthotic Example Load redistribution at Knee Joint (Osteo-arthritis) • The knee will be partially unloaded by an alignment change. • The orthosis is forcing the knee into artificial valgus or varus. • There will be a load increase at the contra-lateral compartment. • Also ligaments may be afflicted by an increase in tensile stress. Orthotic Example Load redistribution in the forefoot • This is the unloading of forefoot by redistributing pressure on mid and hind foot. •This type of orthosis is used if there is a problem of toes or in the anterior plantar area like ulcers. •Increases load on mid and hind foot. •Can not reduce joint force created by muscular contractions.
5. Orthotic Example Load Re-distribution by Med. Arch Support • Medial custom molded arch support relieve overloads of the foot by evenly distributing the loads to other areas. •

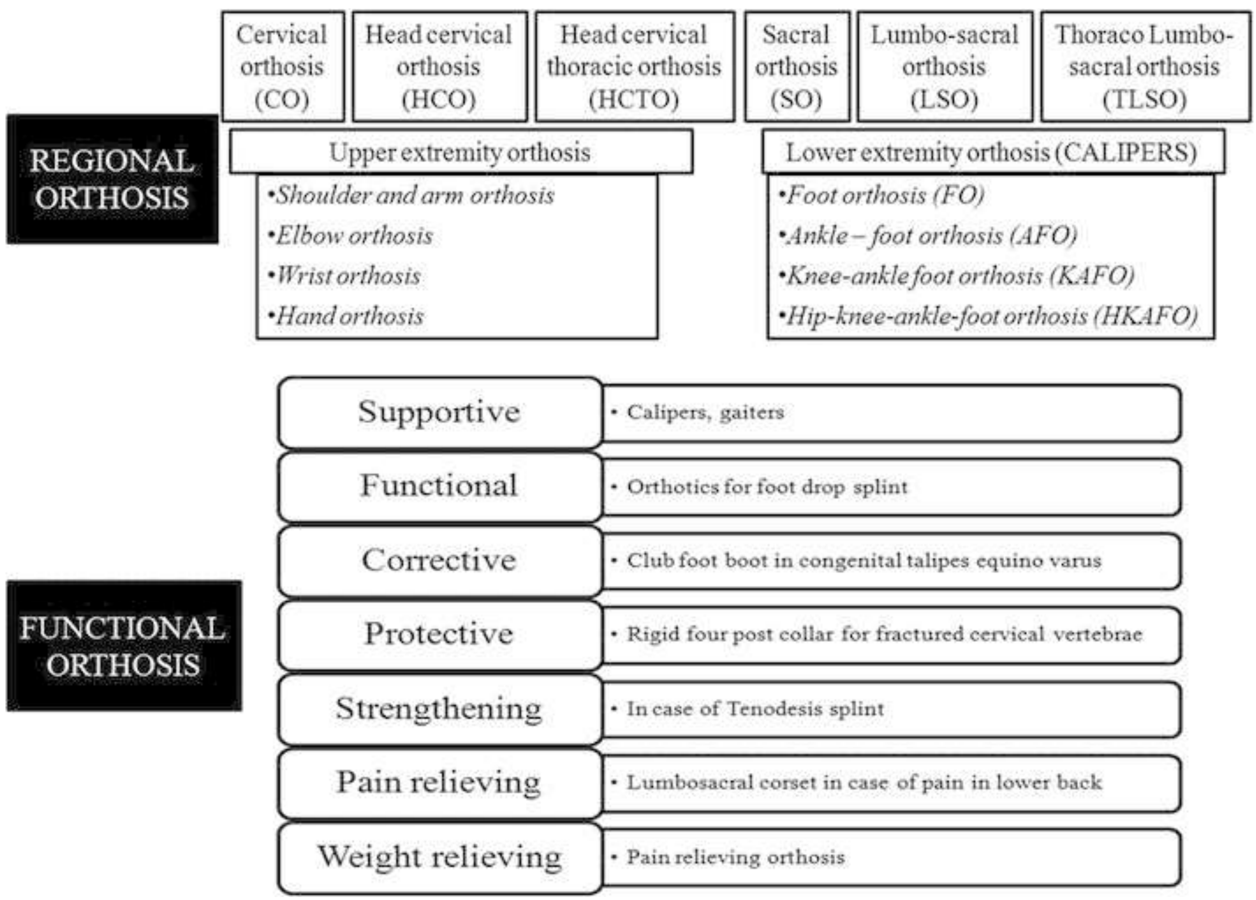
Such supports play an important role in Pes Cavus, diabetic conditions. 2. Correction of Mis-alignment Congenital or acquired conditions may disturb the anatomical alignment. This may be seen in deformities of skeletal structures . This may be seen in angular abnormalities in skeletal segments e.g. genu varum or valgum. In limitations of the range of motion.

6. • Realignment of such skeletal segments in relation to the reference system or to each other is desirable. • This will simultaneously lead to load redistribution. • Will help to stretch the ligaments or muscles which have been short or contracted. • In children, it will guide the growth process in a bio-mechanically correct direction Possible unwanted side-effects • Realignment is not possible without application of force. • This will increase pressure on skin and underlying tissues. • This may lead to unwanted effects of tissue problem. • Orthotic realignment needs continuous control of fit and function by the orthotist.
7. Orthotic Example – realignment of Pes Valgus • This is custom support realigns the heel. • It forces a valgus misalignment back into neutral position. • It supports and realigns the medial arch of the foot. • And de-rotates the forefoot back into neutral alignment. • It acts not only as supportive element but also as realignment or corrective element. Realignment of Club foot • Outhouses meant for CTEV realign pathologic inversion, supination and plantar flexion components. • It also acts as an stabilizing element after the surgery.
8. Orthotic Example – realignment of a Pathological Angle • Genu valgum is a deformity of the longitudinal axis of the leg. • It is observed in frontal plane. • The anterior mid line of thigh create a pathological angle with leg. • Three point correction orthosis will counter the deforming forces and realign the deformity. • A knee contracture is a condition that disallow physiological degree of extension of the knee joint. • The joint is realigned by a three point correction orthosis. • In cases where the contracture is spastic-neurological caused by brain trauma or similar, the application of corrective orthosis is contraindicated.
9. Orthotic Example – realignment of a Pathological Angle • Kyphosis is a misalignment of upper vertebral column. • It is observed in sagittal plane. • Specific spinal orthoses are able to realign the curve as long as the spinal column is flexible and growing. • In

geriatric patients, the realignment would not be considered for similar deformity. The orthotic application is rather to support for load redistribution. • A scoliosis is a three-dimensional misalignment of the vertebral column. • It is observed from all planes. • Specific spinal orthoses are able to realign the curve to normalas long as the spinal column is flexible.

10. • The treatment through growth guidance orthoses is generally targeted at children. • Guidance of growth is not necessarily the prime function of the orthoses. • But it is well accepted side effect of other means or principles of orthotic treatment. Possible unwanted side-effects • Increased force over the areas which are not meant for it, in order to achieve the function of growth guidance by means of application of forces. • This leads to tissue problems. • Requires more attention since the target group is, generally, the children. • Since the children are growing and changing the situation for perfect fit, growth guidance orthoses need continuous control of fit, alignment and function.

**Functional and regional orthosis:**



## Prosthesis

a **prosthesis** (*prósthesis*, "addition, application, attachment") is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or congenital conditions. Prosthetic amputee rehabilitation is primarily coordinated by a prosthetist and an inter-disciplinary team of health care professionals including psychiatrists, surgeons, physical therapists, and occupational therapists.

### Types

A person's prosthetics should be designed and assembled according to the patient's appearance and functional needs. For instance, a patient may need a transradial prosthesis, but need to choose between an aesthetic functional device, a myoelectric device, a body-powered device, or an activity specific device. The patient's future goals and economical capabilities may help them choose between one or more devices.

Craniofacial prostheses include intra-oral and extra-oral prostheses. Extra-oral prostheses are further divided into hemifacial, auricular (ear), nasal, orbital and ocular. Intra-oral prostheses include dental prostheses such as dentures, obturators, and dental implants.

Prostheses of the neck include larynx substitutes, trachea and upper esophageal replacements,

Somato prostheses of the torso include breast prostheses which may be either single or bilateral, full breast devices or nipple prostheses.

**Limb prostheses**

Limb prostheses include both upper- and lower-extremity prostheses.

**Upper-extremity prostheses** are used at varying levels of amputation: forequarter, shoulder disarticulation, transhumeral prosthesis, elbow disarticulation, transradial prosthesis, wrist disarticulation, full hand, partial hand, finger, partial finger.

A transradial prosthesis is an artificial limb that replaces an arm missing below the elbow. Two main types of prosthetics are available. Cable operated limbs work by attaching a harness and cable around the opposite shoulder of the damaged arm. The other form of prosthetics available are myoelectric arms. These work by sensing, via electrodes, when the muscles in the upper arm move, causing an artificial hand to open or close. In the prosthetic industry a trans-radial prosthetic arm is often referred to as a "BE" or below elbow prosthesis.

**Lower-extremity prostheses** provide replacements at varying levels of amputation. These include hip disarticulation, transfemoral prosthesis, knee disarticulation, transtibial prosthesis, Syme's amputation, foot, partial foot, and toe. The two main subcategories of lower extremity prosthetic devices are trans-tibial (any amputation transecting the tibia bone or a congenital anomaly resulting in a tibial deficiency) and trans-femoral (any amputation transecting the femur bone or a congenital anomaly resulting in a femoral deficiency).

A transfemoral prosthesis is an artificial limb that replaces a leg missing above the knee. Transfemoral amputees can have a very difficult time regaining normal movement. In general, a transfemoral amputee must use approximately 80% more energy to walk than a person with two whole legs.[2] This is due to the complexities in movement associated with the knee. In newer and more improved designs, hydraulics, carbon fiber, mechanical linkages, motors, computer microprocessors, and innovative combinations of these technologies are employed to give more control to the user. In the prosthetic industry a trans-femoral prosthetic leg is often referred to as an "AK" or above the knee prosthesis.

A transtibial prosthesis is an artificial limb that replaces a leg missing below the knee. A transtibial amputee is usually able to regain normal movement more readily than someone with a transfemoral amputation, due in large part to retaining the knee, which allows for easier movement. Lower extremity prosthetics describes artificially replaced limbs located at the hip level or lower. In the prosthetic industry a trans-tibial prosthetic leg is often referred to as a "BK" or below the knee prosthesis.

## Hand and arm replacement:

- An **artificial limb** usually replaces a missing limb, such as an arm or leg.
- The type of artificial limb used is determined largely by the extent of amputation of the missing extremity – each one is a little different.
- Reasons include disease, accidents, and congenital (birth) defects.

**Prosthetics - Artificial Limbs**

Artificial limbs have been used for more than 2,000 years. The earliest known artificial limb was a leg made of **metal** plates surrounding a wooden core. It was not, however, until the World War II that the major developments in artificial limbs occurred. In this period, much progress was made by surgeons and prosthetic makers to help wounded soldiers adjust to civilian life with the help of newly designed and effective prostheses.

War has been the greatest impetus for advances in prosthetic design. For centuries, **amputation** was the most common therapy for traumatic injuries to a soldier's extremities. But until the middle of the nineteenth century, most patients died of **infection** due to the unsanitary surgical techniques of the time, leaving little room for advances in prosthetic technology for the survivors. Amputated hands were often replaced by simple hooks, and amputated legs by wooden pegs topped with open saddle-like sockets. Since the second world war, improvements in low-weight, high-strength materials and techniques for fitting and shaping artificial limbs have made these types of prosthesis much more useful and comfortable for the patients.

Candidates for artificial limbs to replace legs, feet, arms, and hands are those who have either lost the limb as a result of surgical amputation or were born with an impaired or missing limb. The process of preparing a patient for an artificial limb begins with the amputation. The amputating surgeon considers the best design for the stump or remaining part of the limb. After the wound has healed, a prosthetist chooses an artificial limb or prosthesis that will either have to be a weight-bearing replacement, or an arm and hand prosthesis that will have to manage a number of different movements.

There are several criteria of acceptability for limb prostheses. They must be able to approximate the function of the lost limb. They should be light, comfortable to wear, and easy to put on and take off. Substitute limbs should also have a natural appearance.

Pre-constructed artificial limbs are available for ready use. Going to a prosthetist, one who specializes in constructing and fitting artificial limbs, gives better results in adjusting the prosthesis to the individual's requirements. Recent technological developments have enabled prosthetists to add to artificial joints made from plastic, **carbon** fiber, or other materials that enable the wearer to include a variety of motions to the limb prosthesis. These motions include **rotation** around the joint and counter pressures that stabilize a weight bearing joint, like the knee, or they may even be able to control the length of the stride of an artificial leg.

The prosthetist first makes a mold from the stump of the missing limb. This mold forms the basis for the artificial limb and holds the top of the prosthesis comfortably on the stump. The socket can be constructed from various materials, such as leather, plastic, or **wood** and is attached to the stump by a variety of means. The leg prosthesis socket in which the residual limb fits is aligned with the feet, ankles, and knees for each individual. Improvements have been made in foot design to make them more responsive and in designing comfortable and flexible sockets. Materials such as carbon graphite, **titanium**, and flexible thermoplastics have permitted great advances in leg prostheses. Applications of electronic technology allows for a wider range of sensory feedback and control of artificial knee swing and stance.

Extending from the socket is the strut, which is the artificial replacement of the thigh, lower leg, upper arm, or forearm. Different types of material can go into the making of the strut. The strut is covered by foam rubber pressed into the shape of the limb it is replacing. The outer covering for the finished prosthesis can be made from different types of materials, such as wood, leather, or metal.

## Hand and Arm Transplant Surgery

Hand and arm transplantation surgery, the transfer of the hand(s)/arm(s) from a deceased human donor to a patient with amputation of one or both hands/arms, is an experimental reconstructive procedure that has the potential to significantly improve the lives of upper extremity amputees.

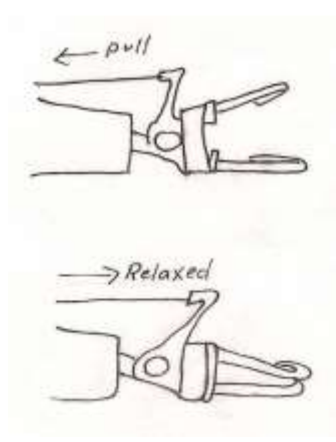
In early October 2011, a Brigham and Women's Hospital (BWH) team of more than 40 surgeons, nurses, anesthesiologists, residents, radiologists, and physician assistants worked for more than 12 hours to perform a bilateral (double) hand transplant for Richard Mangino, 65, of Revere, MA. Mangino, a quadruple amputee, lost his arms below the elbows and legs below the knees after contracting sepsis in 2002. The transplant involved a composite of multiple tissues, including skin, tendons, muscles, ligaments, bones, and blood vessels on both the left and right forearms and hands.

The BWH hand and arm transplant team, representing a wide variety of medical and surgical specialties, now hopes to build upon this success to provide other amputee patients with the significant benefits of hand and arm transplantation. Toward this goal, BWH is actively seeking qualified candidates for our hand/arm transplant research study. Our team will be studying a small group of people to help develop best practices that will improve outcomes for current and future hand and arm transplant recipients.

We describe hand and arm transplant surgery as a life-giving procedure because it has the potential to dramatically improve, i.e., restore, both a patient's mental and physical health and his/her ability to function and integrate in society. However, as with any other type of organ transplantation, this improvement will require the patient to make a lifetime commitment to taking medications that suppress the body's immune system.

Functionally, hand and arm transplant surgery can provide a patient with new hands/arms that, after extensive rehabilitation, allow him/her to perform daily activities and, in most cases, return to work. Furthermore, the ability to restore a near-normal aesthetic appearance of the upper extremities can lead to tremendous psychological benefits, including elevated confidence and mood.

## Body powered prosthesis:



Body-powered prostheses work by using cables to link the movement of the body to the prosthesis and to control it. Moving the body in a certain way will pull on the cable and cause it to open, close, or bend.

A body-powered prosthesis will consist of a:

1. Socket or interface *(see Sockets and Interfaces page)*
2. Suspension system *(see Sockets and Interfaces page)*
3. Harness
4. Control cable
5. Wrist unit
6. Terminal Device (TD - hook or hand)
7. And possibly:
    - a triceps cuff (below-elbow)
    - hinges (below elbow)
    - elbow (above elbow)
    - shoulder (shoulder disarticulation or higher)

***Body-powered Components***

**TERMINAL DEVICES (TD's)**

Body powered terminal devices may be hooks or mechanical hands. They can be ***voluntary opening*** (remain closed until pull on the cable opens them. Relaxing closes the TD around an object with a grip force determined by a pre-set resistance) or ***voluntary closing*** (remain open until pulling on the cable closes it with a grip force proportional to the amount of force the person puts on the cable).

**Hooks** come in various shapes and sizes. They can be made of aluminum, steel, or titanium and can be rubber lined for better gripping. The amount of force a voluntary opening hook can hold with (called grip force) is determined by the number of rubber bands holding the hook closed.

Body-Powered hook (5x hook, Hosmer)

TDs may also be hands. They are more cosmetic, but they are also more bulky and grip force tends to be less.

Body-Powered mechanical hand (OttoBock)

TDs take on other forms, too. These are sometimes called prehensors because they resemble neither hook nor hand. *(UCLA CAPP TD and TRS Grip prehensor)*


Others are made for specific activities, like holding a baseball bat or driving. *See Adaptive page*.

**WRISTUNITS**

Wrist units connect the TD to the prosthesis and restore some of the function of the anatomical wrist.

**Friction Wrists** allow passive rotation and positioning by the other hand. *(Hosmer friction wrist)*

**Locking Wrists** can lock in a variety of positions to prevent rotation when grasping or lifting. *(Hosmer)*

**Quick Disconnect** Wrists allow swapping of TDs. Some models lock in various positions as well. *(Hosmer)*

**Flexion units** provide wrist flexion or bending. Using this feature usually requires pressing a button to allow bending and to release it from a locked/bent position. *(Hosmer wrist flexion unit)*


And some units have a combination of features. *(TAD's N-Abler + Hosmer 4 function wrist)*

ELBOWS

Body-powered elbows are controlled by the same cable that operates the TD with an additional attachment or button that operates the elbow lock. When the elbow is unlocked, pulling on the cable will flex (bend) the elbow. When the elbow is locked or fully flexed, pulling on the cable will operate the TD
OttoBock's Ergo Arm is an Elbow-forearm unit that just requires a TD
Some models of the Ergo Arm are wired to accommodate a myoelectric TD, and in some models the elbow lock is operated electronically as well.

## Myoelectric prostheses:

For upper-limb amputees, myoelectric-controlled prostheses offer the ultimate combination of function and natural appearance. Designed to mimic human anatomy and motion, electronic components are the closest alternative to an anatomical hand or arm.

Thanks to constantly advancing technology, the latest prosthetic systems feature astonishing capabilities: Elbows that flex and extend with muscle signals so you can reach for a beverage and bring it to your lips, Wrists that bend and rotate, allowing you to position objects for convenient viewing and handling, Hands that can lug a suitcase or hold an egg without cracking it, Thumbs that can change orientation to over multiple hand positions

### What is a Myoelectric prosthesis?

"Myoelectric" is the term for electric properties of muscles. A myoelectric-controlled prosthesis is an externally powered artificial limb that you control with the electrical signals generated naturally by your own muscles.

Hand, wrist and elbow myoelectric components are available. With amputations above the elbow, a "hybrid prosthesis" may combine myoelectric-controlled components with body-powered components to control shoulder and/or elbow function. A skin-like glove covers the prosthesis for a natural appearance.

### How does it work?

A myoelectric prosthesis uses the existing muscles in your residual limb to control its functions. One or more sensors fabricated into the prosthetic socket receive electrical signals when you intentionally engage specific muscles in your residual limb. Sensors relay information to a controller, which translates the data into commands for the electric motors and moves your joints. If muscle signals cannot be used to control the prosthesis, you may be able to use switches with a rocker or pull-push or touch pad.

The strength and speed of movements can be controlled by varying your muscle intensity. All of it happens in an instant. For those with damage to nerves or muscles in the residual limb or for people with no arms, muscles in the chest or back can be used to direct movements of a myoelectric prosthesis.

When a myoelectric prosthesis has several joints, each joint might need to be controlled by the same muscle. Sequential control allows positioning of one joint at a time. For example, you might use a muscle contraction to signal the elbow to bend, then use another contraction to signal the hand to close. With AxonBus technology, however, it will soon be possible to control multiple joints simultaneously.

### The power behind a myoelectric system

Although a myoelectric prosthesis is controlled by natural electricity generated by your own muscles, the system needs a battery to power motors and electronics, and batteries need charging. Some batteries need to be removed from the prosthesis for charging. With others, a cord from a charging unit can be plugged into the prosthesis.

A myoelectric prosthesis is connected to the residual limb via a custom fabricated socket. The user ‘pulls in’ to the unique socket with a donning sock, which creates suction and helps suspend the socket.

Hybrid prostheses, which combine both myoelectric-controlled and body-powered components, is another option. A hybrid prosthesis may include a hand and wrist controlled that are myoelectrically along with an elbow that is controlled by a harness and cables worn on the torso and controlled by shoulder movements.

Compared to a traditional body-powered prosthesis, a myoelectric-controlled arm provides greater comfort, more range of motion, a larger functional area, and a more natural appearance. It may, however, cost and weigh more.

### Prosthetic hands and terminal devices

Because upper-limb prostheses can end with a variety of artificial replacements for a hand, prosthetists refer to this broad assortment as “terminal devices”.

### Prosthetic hands

The human hand is one of our most complex body parts. A perfect interplay of nerves, tendons, muscles and bones makes it a remarkably versatile, precision instrument. Recreating as many of its numerous functions as possible is one of the greatest challenges for medical technology.

Myoelectric hands may feature:

- A variety of sizes for children as young as 18 months and adults
- A cosmetic glove in a variety of skin colors or a transparent glove to show the hi-tech inner workings
- A hand for amputation at or below the wrist
- Ability to carry heavy loads (up to a set limit)
- Aluminum construction for lighter weight
- A manually adjustable thumb
- A positionable thumb, driven by a separate motor, which allows for multiple grip patterns
- A neutral position for a natural look and action while walking or at rest
- Powerful grip force and grip speed
- Grip force and grip speed proportional to the strength of the myoelectric signal
- A "virtual switch" that requires a slightly stronger myoelectric signal to open the hand after applying maximum gripping force
- A sensor in the thumb that detects friction caused by objects slipping and automatically tightens the grip to prevent dropping
- A slip-clutch to quickly release the hand's grip in an emergency
- Passive functions to resist weight bearing and other loads
- Multiple grip options, such as pinching with the thumb and index finger, power grip for handles, open palm for holding a platter, opposition power grip for grasping cylindrical object with a big diameter, three-point grip with thumb, index finger and middle finger, and holding flat objects between two fingers
- A handshake function that automatically sets the grip force
- A choice of multiple programs to tailor the speed and build-up of grip force to individual abilities and requirements
- Separate fingers
- Individually powered fingers with movable joints
- Ability to extend the index finger to point or press a button
- Fingers that spread when the hand opens and come together when the hand closes—so you can hold credit cards or bills between your fingers

## Terminal devices: Greifer

A Greifer is a powerful, highly functional terminal device made by Ottobock. Designed to perform gripping applications, it excels at manual labor and other tasks. Features may include:

Control of grip speed and grip force

- A flexible joint for convenient positioning
- Adjustable gripping surfaces
- Easy to swap out with other myo hands
- Powerful grip force

## Myoelectric wrists

Myoelectric-controlled wrists make it easier to grip and control objects close to the body. They also limit compensating movements you may make with your shoulder and the rest of your body—allowing you to move more naturally.

Capabilities may include:

- Multiple positions of flexion and extension in set increments
- Quick detachment for changing between terminal devices
- A flexible mode that mimics natural movement with a spring-loaded mechanism that returns the wrist to a neutral position
- Progressive resistance in flexible mode
- A rigid mode that locks the flexion or extension in increments for holding and carrying objects
- 360-degree rotation, with stops at multiple positions

## Prosthetic Elbows

Myoelectric-controlled elbows, which typically include a forearm, flex and extend so you can do more without unnatural compensating movements. Capabilities may include:

- Bending the elbow in set increments

- Continuous adjustment—variable bending of the elbow—for more natural movement and exact positioning of the prosthetic hand
- Locking and unlocking for reliable loading up to a certain weight limit
- Automatic balance that creates a natural arm swing during walking
- Patient-adjustable counterbalance that makes the arm feel lighter

## Externally Powered limb prosthetics:

An externally powered prosthesis has components that are moved by motors and powered by batteries. The system is controlled by a microprocessor that uses signals from the body to tell the prosthesis what to do. Signals are generated one of two ways: body movement (see input devices below) or, more commonly, electrical signals generated by the wearer's muscles.
An externally-powered prosthesis will consist of:
Socket or Interface , Suspension system , Input device, Microprocessor, Battery, Terminal Device (TD), Wrist Rotator, Elbow, Harness (usually for additional suspension in above elbow prostheses)

***Externally powered components:***

**PARTIAL HAND OPTIONS**

Prodigits by Touch Bionics

**TERMINAL DEVICES**

In a traditional **powered hand**, there is an internal mechanism and a thick outer glove made of silicone or rubber-like material. Although from the outside it is the shape of a normal hand, the internal mechanism only has three fingers: the thumb, index and middle. The ring and pinky fingers are empty inside the glove, and grasp is generated only from the first 3 fingers.  The hand opens and closes only one way, and all the fingers move together to form a pinching motion.

***Examples:***

Ottobock's system electric hands: *(internal structure and outer glove)*

Motion Control's myoelectric hand:

Ottobock's Transcarpal hand: *A low profile design for people with long residual limbs and not much room for components.*

**Hook shapes** have some benefits over hands (see "Which is Best" page) and so there are externally powered hook-like devices available, too.

Motion Control's ETD (Electronic Terminal Device): 

Ottobock's Greifer 

Newer designs of externally powered hands have individually moving fingers and are called "**articulated hands."** However, individual fingers can't be controlled separately; *e.g.* you can't actively point your index finger. What happens is that the fingers will start moving together and stop individually when they meet resistance. For example, to point the index finger, you would start from a fully open position. Next, you would tell the hand to close while using your other hand to hold the index finger in place. The other four fingers would curl around to form a fist, and the index finger would remain straight. Even though this seems awkward, it is still an improvement over the limited, jaw-like, pinching motion of traditional externally powered hands. When grabbing an object, articulated fingers will wrap around it. All fingers will make contact with the object and hold it more securely, as a human hand does.

Touch Bionic's iLimb 

RSL Steeper's bebionic hand 


Ottobock's Michelangelo hand 

*Orthocare Innovations Contineo hand* 

**WRIST ROTATORS**

These components provide rotation at the wrist (palm up/palm down).  Currently, only two manufacturer's offer wrist rotators.

***Examples:***

Ottobock's wrist rotator

Motion Control's MC rotator and ProWrist Controller.

Other wrists are wired for use with myo-hands and provide passive or manually positioned flexion and extension (wrist up/wrist down). They can be used as the only wrist component or they can be paired with rotators to provide powered rotation.

***Examples:***

Ottobock's MyoWrist 2Act

Ottobock's MyoWrist Transcarpal
*A "Low Profile" wrist for people with especially long residual limbs.*

Motion Control's Multi-flex Wrist

**ELBOWS and ELBOW/FOREARM UNITS**

The most commonly used myoelectric elbows are actually elbow/forearm units. The elbow down to the wrist is one piece and pre-made, already containing the battery and the wiring necessary to be connected to a myo TD. These units simplify things for the prosthetist and the resulting prosthesis is usually more cosmetic than if the forearm is made separately.

***Examples***:

Motion Control's Utah arm

Ottobock's Dynamic Arm

**HYBRID ELBOWS**

These elbows are body-powered elbows wired for use with a Myo-TD.

Example: Ottobock's Ergo Arm Hybrid Plus: 

***How Externally Powered Prostheses Work:***

The brain tells muscles to move with electrical signals sent through nerves. When a signal is received, it is multiplied as it spreads throughout the muscle and can be detected with special equipment placed on the skin. When your arm is amputated, muscles may not have a joint to move anymore, but they are still there and can still receive signals from your brain. For example, your brain can still tell your bicep to flex your elbow, and the muscle will still generate an electrical signal the same way it does normally. It will even still tense up, but it doesn't have an elbow to move anymore. Sometimes the signal is still strong enough that it can be detected and used to control the operation of a prosthetic elbow or Terminal Device (TD). The signals are picked up via electrodes embedded in the prosthetic socket and transmitted to a microprocessor, where the signal will be interpreted and used to operate the prosthesis. Essentially, we are using the signal that used to move your arm to move the prosthesis instead. There are other ways of controlling an externally powered prosthesis as well, and I will talk about them a little later.

***Terms and Concepts***

**Contraction** of a muscle, for simplicity sake, is when a person activates the muscle or tenses it up. For example, your biceps are contracting when you bend (flex) your elbow. Your triceps are contracting when you straighten (extend) it. It is the contraction of the muscle that generates the signal we pick up with electrodes.

A **myo-site** is a place on the residual limb where we can pick up the electrical signal generated by a muscle contraction. An electrode is placed there to pick up the signal. We usually like to use opposing muscles to avoid them being active at the same time, causing the prosthesis to become confused about what you want it to do. The larger and stronger the muscle, the better the signal.

The **microprocessor** is the "brains" of an externally powered prosthesis. It takes the signals and uses them to control the prosthesis. This is done with a computer program, or *control scheme*, that dictates which signal will trigger what function and under what conditions. A function is an action of a prosthetic component, such as "hand open" or "hand close."

***Controlling an Externally Powered Prosthesis***

The **control scheme** may be simple: signal present = hand open, no signal = hand close. Or the system may be more complex, allowing the speed or strength of the component to be controlled directly by the strength or speed of the muscle contraction. For example, strong contraction = fast close or strong grip of a hand, or slow contraction = slow closing of hand with less force. Some of these systems are more intuitive than others, although that seems to be a subjective opinion. Control schemes are chosen based on the number of good quality muscle signals/myo-sites available and the number of devices and functions you wish to control. Generally, the higher the amputation, the harder it is to find and isolate good quality signals. At the same time, there are usually more components you want to control!

There are two main categories of control schemes:

**Digital control** can be thought of as a simple on/off, like a light switch. Signal present = on, absent = off

**Proportional control** is a strategy of controlling an externally powered prosthesis in which the strength or speed of the signal controls the strength or speed of the prosthetic component (in *proportion* to the signal).

**Controlling multiple functions:**

If you are using an above-elbow prosthesis with an externally powered hand, wrist, and elbow, there are 6 different functions to control: 1) open the hand, 2) close the hand, 3) rotate the wrist to the right, 4) rotate the wrist to the left, 5) bend (flex) the elbow, and 6) straighten (extend) the elbow. Therefore, the prosthesis needs 6 different cues for it to know what it should do. People rarely have that many myo-sites, so we have to 'double up' functions for each myo-site. We do this in one of two ways:

1) By having the signal from 1 myosite site control different functions depending on whether or not it is fast or slow, hard or soft.

2) By using another cue to tell the prosthesis to switch between two functions. Sometimes the cue is a switch (see below), or it can be a co-contraction of two muscles at the same time.

***Input Devices***

Input devices are methods of generating a signal to operate an externally powered device. (They are the in-put to the microprocessor--the brain of the prosthesis.) Electrodes pick up an electrical signal generated by your muscles. Force transducers, Linear Potentiometers, Touch Pads, and Switches translate the body's actual movement (not muscle activity) into an electrical signal that can be used similarly to that from the electrodes.

**ELECTRODES**

Electrodes are the most commonly used input device. They detect the electrical activity of muscles and are usually found in conjunction with other elements to filter out ambient electrical activity and magnify the signal they detect. These things together are referred to as the "Electrode assembly", athough we usually still call the whole thing an electrode. The electrical signal they detect is called an Electromyographic signal, or **EMG**. Electrodes must be placed close to the muscle whose activity they are supposed to detect. Usually they are placed over the biggest/main part of the muscle (called the muscle belly). Placement is very precise, and being off, even just a few millimeters, can make a big difference in the quality and strength of the signal the electrode sees. Intermittent contact or sliding of the electrode over the skin produces "noise" that can confuse the microprocessor, so they must be held firmly in place.

Electrodes can be adjusted for sensitivity, a parameter that we refer to as the **Gain**. A higher gain means it is more sensitive. We can't increase the gain infinitely because we are amplifying the ambient noise as well, just like turning the radio up really loud will make the static in the background get louder too. There is an optimal range of strength of signal, and gains are adjusted so that the signal getting to the microprocessor is in that ideal range.


**FORCE TRANSDUCER**

A force transducer measures force. It is attached to a harness and uses a cable or strap to produce tension on the device. This tension is measured and translated into a signal the way an EMG signal is picked up by an electrode. You can pull really hard on it, or just a little. The variable force is converted into a variable signal that can operate a prosthetic component in proportion to the strength of the force. It is a type of proportional strain gauge.