

## **REPORT ON A CONFERENCE FOR WHEELCHAIR MANUFACTURERS**

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The wheelchair is considered the most widely used and the single most important piece of permanent or temporary equipment for the chronically disabled person. This vehicle supports the person's body segments, serves as a device in which and from which he performs activities, and functions as a substitute form of ambulation. The wheelchair becomes an extension of the person and assumes significance comparable to basic subsistence needs.

In line with the magnitude of this product, the question can be raised whether the existing wheelchair provides the support, mobility, and adaptability which the disabled person demands. What are the specific wheelchair requirements of persons with major disabilities? How aware of these specific needs are the wheelchair producers?

A conference, "Wheelchairs and the Rehabilitation of the Chronically Disabled," was developed to promote communication between the United States wheelchair manufacturers and persons with a specific interest in the relation of wheelchair function to the user. Goals of the conference were to disseminate information to the manufacturer, to determine his views and problems, and to stimulate and motivate problem-solving and new ideas. The conference was sponsored by the American Rehabilitation Foundation and the Vocational Rehabilitation Administration.

The conference, held at Kenny Rehabilitation Institute, Minneapolis, Minnesota, February 3-5, 1965, consisted of lectures, demonstrations, a panel, and discussion periods. Among the areas covered were: medical information on major disabilities, basic wheelchair requirements for function and safety, problems of wheelchair rental firms and equipment loan closets, review of wheelchair literature and architectural barriers for the wheelchair user.

The audience consisted of wheelchair manufacturing personnel including designers, executives, and sales personnel, representing half of the present

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United States wheelchair manufacturing companies, and in addition, a few selected guests. Faculty included representatives from major rehabilitation research and training centers and other health and sales agencies.

Dr. Paul M. Ellwood, Executive Director of the American Rehabilitation Foundation, stated, "We recognize that the wheelchair industry has some very special obligations and opportunities, and at the same time has some unique problems—like producing a quality product for a competitive but not necessarily knowledgeable market.

"Producing wheelchairs for the disabled is quite unlike the drug industry. There is no regulatory agency looking down its nose at the wheelchair manufacturer. This procedure can be stifling to initiative and certainly internally generated standards are preferable. Recognition is made, however, of the difficulty of developing a set of industrywide standards, and at the same time producing a product at a reasonable price. It is our hope that this conference can stimulate the development of new and better approaches to wheelchair design and manufacture."

### Conference Faculty List

- |                                   |  |
|-----------------------------------|--|
| Bergstrom, Doris A., R.N., R.P.T. | Coordinator, Rehabilitation Equipment Seminars<br>American Rehabilitation Foundation   |
| Bilka, Paul S., M.D.              | Director, Arthritis Service<br>Kenny Rehabilitation Institute<br>Associate Clinical Professor<br>Department of Medicine<br>University of Minnesota<br>Minneapolis, Minnesota |
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| Ellwood, Paul M., M.D.            | Executive Director<br>American Rehabilitation Foundation   |
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The person with a hemiplegia usually can be taught a standing transfer, moving in the direction of his good side (1). Both the wheelchair and the object to which a transfer is made should be stable during the transfer. If assistance is needed from another person, a belt should be placed around the patient's waist so it can be grasped by the assistant.

The wheelchair generally used should be a collapsible chair with a fixed back, 24 in. wheels in back, 8 in. casters in front, brakes, padded fixed armrests, and removable footrests. The latter are needed for two reasons, 1. to give foot space during the transfer, and 2. to permit the footrest for the patient's non-involved leg to be removed when wheeling the chair.

A heel loop is needed for the involved foot to prevent it from sliding back off the pedal. For comfort, a 2 in. seat cushion can be used. An elevating footrest helps reduce edema in the involved leg and an armtray (2) attached to the armrest of the wheelchair is helpful in reducing edema of the upper extremity.

Persons with a hemiplegia are taught to wheel the chair with their non-involved hand and foot. Therefore, the seat height must be low enough for the leg to obtain good purchase on the floor. At present, no wheelchair among the less expensive models is sufficiently low to allow the short, obese person to propel the chair adequately.

### **WHEELCHAIR NEEDS OF THE PERSON WITH QUADRIPLEGIA AND PARAPLEGIA**

**ELWIN EDBERG, R.P.T.**

Wheelchairs for patients with a quadriplegic or paraplegic spinal cord lesion should have the following basic features:

- a. *8 in. casters* for uneven surfaces such as a throw-rug or an uneven sidewalk. In areas where the frost has pushed the sidewalk up, the chair with smaller casters will stop and the patient can go forward out of the chair. A chair with 8 in. casters is easier to propel.
- b. *Forward locking brakes*
- c. *Non-marking tires*
- d. *Swingaway removable footrests* with heel loops so that the patient can have a closer forward approach when getting into a bathtub or when transferring to a car.
- e. *Extra long footplates* for a person with a shoe larger than size nine.
- f. *Telescoping footrests* for quick adjustment to leg length.
- g. *Seat height* high enough so that the adjusted foot pedal will be at least 3 in. from ground, in order to clear uneven surfaces.
- h. *Armrests* fitted so that the elbows can rest comfortably without drooping of shoulders.
- i. *Padded armrests.*

- j. *Desk-type armrests* so that a patient can get close to a table or a desk.
- k. *Seat length* approximating a hand's width between the front of the seat and the posterior knee.
- l. *Chair width* as narrow as possible, so that the thickness of the hand fits loosely between the skirt guard and the patient's hips.

More specific wheelchair needs for the following levels of lesion are listed below:

a. Lesions from Lumbar 1-5 Level

An upright wheelchair is needed for long distances even though the person also may be ambulatory with crutches and braces. If he should need a wheelchair most of the time, it should be heavy duty (heavy duty wheel and axle, heavier reinforced frame and heavy reinforcement in the upholstery). Standard hand-rims, a 2 in. or 3 in. foam cushion, and a crutch holder and strap will be needed. Padded detachable desk armrests with pin locks are necessary so that when a patient pulls up on the armrests, they will not come out. If he goes up and down curbs frequently, the wheelchair should have pneumatic tires to cushion the wheelchair in its ascent and descent on the curb and pavement. If the person weighs less than 175 lb. and does not use the chair very much, a lightweight chair is recommended for ease in getting in and out of an auto.

b. Lesions from Thoracic 1-12 Level

Wheelchair needs are essentially the same as for lesions from the lumbar 1-5 roots. Those with a thoracic 1-8 lesion will need a 3-in. cushion. Patients with thoracic-1 lesions may have some hand weakness and can get better friction with plasticized handrims.

c. Lesions from Cervical 5-8 Level

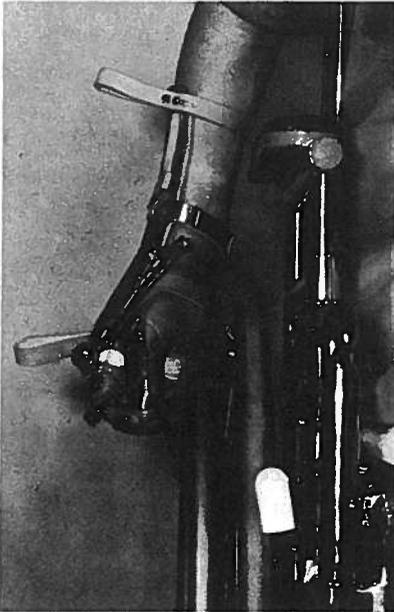
For lower cervical lesions the wheelchair needs mentioned above apply with some additions. Additional height at the back of the upright chair covering approximately 1 in. above the inferior angle of the scapula is necessary for trunk support. Plasticized handrims, with eight 1½ in. spacers, or handrims with eight 1 in. vertical projections will be needed. A seat belt at chest height should be used for those with poor balance and/or severe flexion spasticity. Caster locks and a 3-in. seat cushion are needed. A satisfactory method for wheeling the chair should be developed for the patient with a cervical-7 lesion who has tenodesis hand splints (Fig. 1). The patient with a cervical lesion lacks endurance for long distance traveling. In this instance, he may need an electric wheelchair with the two-wheel belt drive or the one-wheel drive with handle modifications.

A person with a cervical-5 root lesion should have a sitting posture

10 to 15 deg. back from the vertical. He should be able to manipulate an electric semi-reclining wheelchair with an adapted mouth stick control.

**Suggestions for Wheelchair Improvement**

- a. After a patient has been in a wheelchair for two or three years, he often begins to slouch. This problem might be corrected by having the wheelchair designed so that the seat can be reclined further to prevent him from sliding out.



**FIGURE 1.** Quadriplegic patient propelling wheelchair with flexor hinge handsplint with no metal on ulnar side. Plastic-coated handrims are used to increase friction on contact. (Rancho Los Amigos Hospital, Downey, California.)



**FIGURE 2.** Commercial caster lock adapted for independent manipulation by quadriplegic patient. Plunger fits into hole in caster fork to prevent swiveling. (Rancho Los Amigos, Downey, California.)

- b. An improved method for locking commercially available caster locks should be developed for the person who lacks hand function and trunk balance (Fig. 2).
- c. The plastic heel loops which have appeared on the market recently are not satisfactory because they do not stay on the pins. This becomes a problem especially when the patient has spasticity of the lower extremities.

- d. Handrims need constant tightening.
- e. The electric wheelchair starts too rapidly. It also is very jerky; the movement sometimes causes spasticity to occur in patients with a spinal cord injury. Some dampening device needs to be added to this chair so it will start more smoothly.
- f. Hand brakes should lock by going forward. A person with upper-extremity weakness can lock the brake better when pushing forward than when pulling back.

### **SKIN TOLERANCE FACTORS OF PROLONGED SITTING**

BETH FOWLES, Ph.D.

A major problem of the person who lacks normal sensation can be the development of pressure sores on the ischial tuberosities from prolonged sitting in a wheelchair.

A study by Reswick, et al., *A Device to Measure Pressure Distribution between the Human Body and Various Supporting Surfaces* (3), was done to determine the amounts of pressure in the sitting area of normal and patient subjects. The following contains part of the summary prepared for the conference notebook:

“A pressure mat consisting of a large number of multicellular inflatable flexible cells was designed for frequent readings in order to obtain shifting pressure patterns under different patients in various environmental conditions.

“Each air cell in the mat has an electrical contact on the roof of the cell and another on the floor. When the pressure within the mat is greater than the outside pressure, the cells inflate causing the contacts to separate. When a patient is seated on the mat certain areas cause the contacts to close and others remain open. Drawing a line between open and closed contacts forms an isobar which corresponds to the pressure to which this mat is inflated (Fig. 3) . . .

“The tests were run on 1 in., 3 in., and 6 in. foam cushions with feet supported and again with feet unsupported.

“The experimental results revealed the following:

- a. There is a great reduction of pressure when 3-in. foam rubber is used in place of one inch, but the improvement by using a 6-in. foam rubber cushion is negligible.
- b. Disabled patients invariably produce the same type of pattern as tall, healthy subjects—showing concavity under the iliac wings and high pressure concentrations under the ischial tuberosities, with steep gradients.
- c. Heavy-bodied subjects develop much lower maximum pressures than thin specimens of much less weight, even with the least cushioning.

- d. Surgical intervention reduces the maximum pressure levels. (*Author's note: This is in reference to paring down and smoothing down the ischial tuberosities to take some of the roughness off them.*)

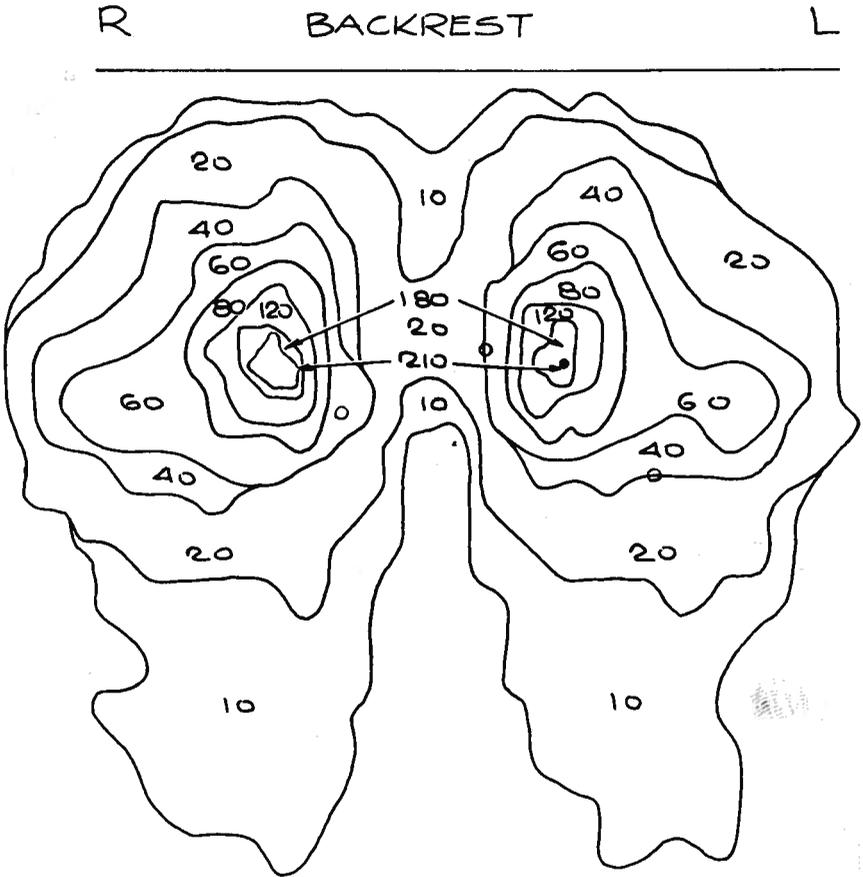


FIGURE 3. Weight distribution of male control subject sitting on 1 in. foam rubber, with feet supported. Twenty-eight years old, 145 lb., 76.5 percent ideal weight. Pattern similar to that of disabled subjects. (From final report—A Device to Measure Pressure Distribution Between the Human Body and Various Supporting Surfaces by J. B. Reswick, Sc.D., O. Lindan, M.D., Ph.D., and A. Lippay, B.Eng., Case Institute of Technology and Highland View Hospital, Cleveland, Ohio, June, 1964.)

- e. Changes in body position can produce drastic changes in pressure patterns and maximum levels—supporting the feet, leaning to one side, etc., increase the loading of the ischial tuberosities.”

## WHEELCHAIR NEEDS OF THE PATIENT WITH ARTHRITIS

ELWIN EDBERG, R.P.T.

Arthritis is a very painful disease. The person with arthritis needs a wheelchair that fits, one that is comfortable and best suited to his function. The rate of progression of the disease also should be considered.

Wheelchairs are indicated for arthritic patients who have:

- a. *Lower-Extremity Involvement.* Pain can be in the hips, knees, ankles, or feet. Limited range of motion, fixed deformities and ulcers might be present. There may be lack of endurance due to pain or weakness. Crutches may be suitable for short distances and wheelchairs for longer distances.
- b. *General Weakness.* This can be due either to the disease itself or to lack of activity.
- c. *Destroyed Joint Surfaces.* Persons with osteoarthritis are discouraged from walking long distances because the disease causes increased destruction of their joint surfaces.
- d. *Lower-Extremity Flare-ups.* In this instance, a wheelchair is needed for a limited period of time.

General wheelchair needs for arthritics are the same as those for all persons with a paraplegia and quadriplegia, with the following exceptions:

- a. Elevating leg rests are necessary for patients who have a tendency to develop knee flexion contractures, and for those whose legs and/or feet develop edema.
- b. The seat should be as high as possible from the floor for those who have difficulty coming to a standing position because of severe lower-extremity involvement. A high seat requires less effort for standing and sitting, but it must not be so high that a person cannot use the handrims functionally. An adjustable height seat is useful when it is necessary to equalize the wheelchair seat height to the place of transfer, i.e., bed, car.
- c. A reclining chair may be needed for persons with hip extension contractures. These chairs require a wedged seat cushion (placed with the thin section under the hips) to prevent sliding forward in the chair.
- d. Patients with severe upper-extremity involvement may be able to maneuver a chair with their feet. A four-caster chair or a regular upright chair with a seat low enough to allow the feet to put traction on the floor may be used.
- e. Persons with severe upper-extremity involvement, especially in the hands, can use 1 in. vertical projections on the handrims to improve their grip when wheeling.

One of the solutions for persons with severe generalized involvement is the use of motorized wheelchairs, as was mentioned for paraplegics or quadriplegics.

Suggestions for Wheelchair Improvement:

- a. Reclining wheelchairs should have an instruction plate with directions for folding. Patients or relatives do not know how to fold this type of chair because they are confused by the rod in the back.
- b. Jerky starting of electric chairs can be very painful for the person with arthritis.
- c. On some brands of chairs, elevating leg rests become difficult to raise and lower after a short period of use.
- d. Some method is needed to prevent sliding down in the chair. Sliding generally can be prevented by using the wedged cushions mentioned above, or by placing the patient's feet on the foot pedals of elevating leg rests. Weight bearing on the hip is not permitted for a while for many patients who have had surgery in a lower extremity or hip joint. Sliding down in the chair with resultant pressure on the feet produces undesired pressure to the hip, knee, and/or ankle joints. The pressure to a degree simulates weight bearing.

### **WHEELCHAIR NEEDS OF THE PERSON WITH AN AMPUTATION**

**ROBERT WOOD, R.P.T.**

Most of us tend to attribute amputations to war injuries. The fact remains, however, that during World War II there were 18,000 amputations among the wounded and disabled. During that same period, 120,000 of the civilian population lost a limb.

Today 35,000 to 40,000 amputations occur each year; a person has one chance in 958 of having an amputation. Within Veterans Administrations facilities, the most frequent cause of loss of limb is arteriosclerosis or other vascular disorders, with diabetes running second. Most persons over 60 years of age lose a limb because of vascular insufficiency. Since vascular deterioration tends to be generalized, brain damage is a concomitant problem. Therefore, safety and simplicity are important in wheelchair function.

Many persons with lower-extremity amputations need wheelchairs. Generally, those with a unilateral lower-extremity amputation need a wheelchair for a short time, perhaps in a hospital only. However, persons over 60, unless unusually capable, need a chair permanently. All persons with a bilateral amputation need a chair on a part-time basis. No matter how well their prosthetic devices fit, they will be unable to wear them at all times, since abrasions will occur. The chair also is needed on occasion during the night for personal hygiene activities and emergencies.

Each person's wheelchair needs should be evaluated and a chair should be ordered by prescription. However, some generalizations can be made. Persons with a unilateral amputation can manage with a standard fixed feature chair. Younger persons with a bilateral amputation also can manage with a standard chair, with an occasional need for removable armrests. These persons usually want to reach the rims for easy propulsion, thereby sacrificing the stability of the "amputee" chair for mobility. Persons over 60, however, will need more stability, and should have the chair with the large wheels set back.

Recommendations for Wheelchairs:

- a. A unit to maintain knee extension for below-knee amputations. Present elevating leg rests are not constructed to permit free joint range for proper fitting of a prosthesis.
- b. A change or addition to the standard wheelchair rim to provide better traction for hand grip. Intravenous tubing wrapped around the rim has been helpful.

## **WHEELCHAIR NEEDS OF CHILDREN WITH PHYSICAL DISABILITIES**

NORMA STEINKE, O.T.R.

Knowledge of growth segments of children of all ages would be helpful in obtaining more useful, adjustable, and adequately proportioned equipment for pediatric wheelchairs. The child's wheelchair needs relate to: *a.* physical requirements according to changes in growth, muscular development and coordination, and his disability, and *b.* social aspects of development according to need for mobility and participation in social activities.

The wheelchair should support as many body segments as necessary for the individual. Consideration is given first to head control, then shoulder and trunk support, and finally to the position of the arms and legs.

Types of head support include a head halter suspended from overhead; a plastic shield which forms a C-shaped support permitting the head to move forward from the shield and back; and small head pillows.

Shoulder support has long been a problem, since strapping down this part of the body too firmly can cause circulation cutoff. One of the most satisfactory methods of shoulder support is the use of a wide chest strap with suspender straps which go up over the shoulders and through holes in the back of the chair. The chest strap goes directly back along the lateral side of the trunk and through the back of the chair.

Wheelchairs often are too wide for the small hips of children. Supports can be made from a padded masonite board covered with plastic or upholstery fabric. A strap, if needed, should come from under the seat of the chair and across the thigh and hip area.



Most cues for the upright position are in the head. There are a number of physiological reactions called righting reactions:

- a. For the eyes to work properly, the head must be in the normal upright position so that the eyes are on a horizontal line.
- b. For the labyrinthine reflexes to work properly, the head should be balanced in an upright position in relation to gravity.
- c. For the neck reflexes to work properly, the head must be oriented upright and the body vertically under it.

When these relationships are disturbed, the control of the muscles of the body changes so that balance and judgment of position change. In these instances, support giving orientation in space while the person is active is needed. Head orientation in space influences trunk orientation in space and balance on the legs. Head orientation also affects the ability to coordinate eye motion. This is a critical problem and no satisfactory equipment for solving it is available.

Among the types of support is a head sling with a spring attached to an overhead bar. The amount of support to the head is adjusted by varying the amount of tension used. Tension is reduced as head control improves.

A newer type of support is a stocking cap attachment (Fig. 5). It is made of stockinet and has a firm band which fits below the bulges of the forehead and the occiput, and it is fastened with Velcro. The supporting bar should be adjustable vertically and anterior-posteriorly. The mechanism for attachment to the chair should be convenient and durable without loose parts which may be lost.

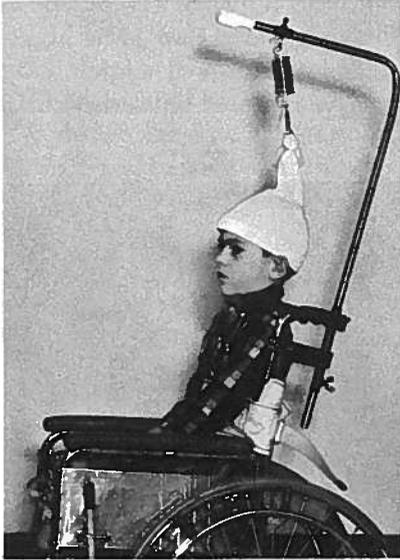
It is surprising to see the changes in balance occurring from the stockinet cap support. This type is useful for some persons as a temporary training device and for others as a continuing kind of support.

The person with a dystonia has prolonged pull of his muscles and cannot relax in the stockinet cap. He will need a more rigid support such as a back brace which has an attachment to include the chin and occiput. Mounting of this support on the wheelchair also would be desirable.

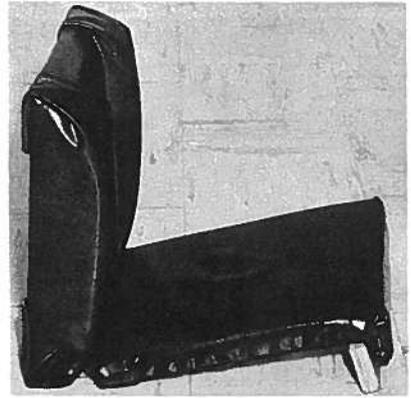
A felt collar that supports the head laterally and posteriorly is another device for keeping the head upright. It would be desirable to be able to attach this support to the back of the wheelchair. Then the person could be centered in the chair and his head would be supported.

In addition to head support, maintenance of good trunk posture is necessary. Brain-damaged children have difficulty with lateral trunk support. An anteriorly elevated seat helps relax spasticity and holds the child more firmly to the back of the chair. Lateral padding plus a safety belt helps maintain a vertical position (Fig. 6). A safety belt alone is inadequate because the present width of chairs is variable and not related to the width of the child. The child can sag sideways and a scoliosis can

develop. If the righting reflexes are to be trained, the child must be given lateral support to maintain the correct upright posture. The manufacturer could help by developing methods of adequate support.



**FIGURE 5.** Stockinet cap overhead support. A method to attach the unit to the wheelchair is not commercially available. (University of Minnesota Medical School, Minneapolis, Minnesota.)



**FIGURE 6.** Removable type lateral trunk support with front of seat elevated. Not commercially available. (University of Minnesota Medical School, Minneapolis, Minnesota.)

More flexibility is needed in fitting various dimensions of the wheelchair to the child such as the height of foot pedal support, seat width, back depth, and depth of the head support.

Another wheelchair need is upper-extremity equipment. Abduction as well as horizontal and vertical motions are desired. A research study on upper-extremity prosthesis with a suspension deltoid sling was done recently at the University of Michigan (4).

Everyday needs of a disabled person should be considered. Feeding means getting the hand or feeding appliance to the mouth. Reaching the top of the head and the back of the neck relates to dressing. Reaching down beside the chair to the wheels of the chair often is limited when using an appliance. If a person can reach up, he can't reach down.

A link feeder allows fairly good horizontal motion, but limited vertical motion. The deltoid aid or suspension feeder has many limitations; it lacks pivot motion and allows limited amount of range.

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A counterbalanced pulley system (Fig. 7, 8) has improved the deltoid sling. However, this unit is a fairly large, cumbersome, conspicuous apparatus, and is not transported easily by car. A model which will clamp on the back of a semi-reclining wheelchair and at the level of the axle has been made.

One way of reducing the size and bulk of a deltoid aid would be to use the Hunter spring, a flat spring with constant tension. A deltoid aid unit with an enclosed Hunter spring which could be mounted on a wheelchair would contribute greatly to upper-extremity support.



FIGURE 7. Deltoid aid which can be counterbalanced to provide whatever assistance is needed. (University of Minnesota Medical School, Minneapolis, Minnesota.)

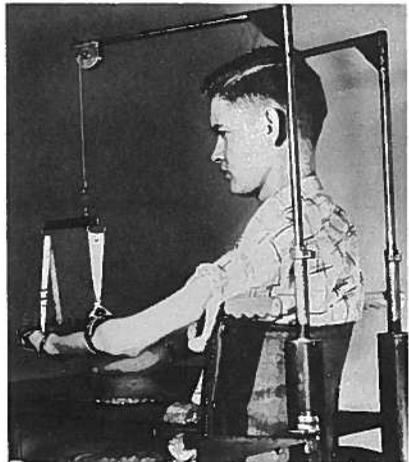


FIGURE 8. Posterior view of counterbalanced deltoid aid sling showing attachment to wheelchair. Less bulky apparatus is desirable. Satisfactory equipment of this type is not available commercially. (Minnesota Medical School, Minneapolis, Minnesota.)

## POSTURE AS IT RELATES TO THE WHEELCHAIR

MARTIN MUNDALE, R.P.T.

For good postural alignment, the back of the wheelchair should recline between 5 and 10 deg. and the anterior part of the seat should be 1 in. higher than the posterior part.

The position of the lower extremities is exceedingly important in postural alignment. Fine adjustment in footrest height is necessary to obtain this alignment. Though individual needs always must be considered, a rough guideline for adjustment may be used by obtaining a position of the thigh at a right angle to the trunk and having the feet supported to main-

tain this position (5). Excessive dropping downward of the leg can cause edema of the lower leg and foot because of pressure on the soft tissues under the thigh. Three to 4 in. of space between the edge of the wheelchair seat and the popliteal area are recommended.

Support for the forearm also is related to good posture. Because cushions of varying heights are used in the seat of the chair, the standard armrest height often is too low. Flexibility in armrest height is necessary for a comfortable right-angle position of the elbow.

Good postural alignment is closely related to the tautness of the back and seat leatherette. The metal insert side pockets might be made wider to permit narrowing of the leatherette after it has stretched from use. An alternate method might be to add a zipper to the leatherette to allow room for a  $\frac{1}{4}$  in. piece of plywood to reduce the sag from the stretched leatherette.

Because the seat belt is recognized as a frequently needed safety device, it is recommended that this feature be standard on all wheelchairs.

### WHEELCHAIR NEEDS FOR AGED PERSONS

HERBERT SCHÖENING, M.D.

More than 80 percent of wheelchairs used today are obtained or ordered without a prescription and an evaluation of requirements. Many of these wheelchair users are over 60 years of age. Most wheelchairs in hospitals and nursing homes are purchased on the basis of price rather than a patient's needs.

Many aged persons need wheelchairs. These persons may be at home, in a nursing home, or in a chronic disease unit. The wheelchair they use may belong to them, to a nursing home, hospital, rental agency, or loan closet.

These persons often have no real muscular weakness, though some may have had cerebrovascular accidents, or arthritis. Their nutritional state may be poor; lack of adipose tissue causes discomfort on bony prominences when sitting. They frequently have poor judgment and are lethargic. Some are ambulatory for short distances, but may need a wheelchair for longer distances, such as trips to social events. They may use a wheelchair for a short or extended time, or permanently. Many will spend only a limited time daily in the chair. Wheelchair propulsion frequently is dependent on another person.

Basic wheelchair needs for these persons are comfort, safety, and utility. The chair should have a soft seat and back; good adjustability of the footrests so that weight can be spread over the entire thigh rather than centered on the ischial tuberosities; a "soft" ride; and possibly a semi-reclining feature for greater trunk support. Safety features necessary are

safety straps or belts, good brakes, and removable footrests for transferring in and out of the chair. The chair should be sturdy, inexpensive, and collapsible, and should have a carrier for equipment or articles. It usually does not need precision maneuverability since another person most likely will be pushing the chair.

Since physical endurance is generally low and fatigability tends to be high, the person who propels the chair himself should have one with Cadillac mobility. Persons with progressive degenerative diseases may be able to function independently or with minimal assistance for a long period of time, given the proper equipment. This applies to young persons as well as older persons. The chair should be freely mobile; should have removable features depending on the transfer method, with consideration also made for features needed due to decreasing abilities with the passage of time; should meet the individual's needs for postural support; and should be durable.

There is a need to inform hospitals, nursing homes, physicians, and agencies which sell wheelchairs that purchase of adequate, safe and functional equipment will result in lower costs in the long run. A good part of this information can be supplied by the manufacturer through advertising and literature.

### **WHEELCHAIR ANALYSIS**

Moderator — DORIS BERGSTROM, R.N., R.P.T.

At this point in the conference, audience and faculty members had a chance to raise questions or to comment about facets of wheelchairs (structure, function, design) which had not been mentioned or fully considered in the previous conference material. This was done by using diagrammatic sketches of wheelchairs and overlays of wheelchair parts prepared for Vue-Graph presentation.

Some specific points include the following:

- a. A major problem with large wheels is that spokes break quite readily. Some manufacturers have 36 spokes on all their chairs now, in contrast to the average 28, and this is considered a distinct advantage. Dust and lint enter the axle; the major maintenance problem is cleaning them.
- b. A problem with 8 in. casters is that they often shimmy, especially at greater speeds. One manufacturer stated that a different type of fork, called a traveler fork, functions better than the standard universal fork.
- c. Lack of upper-extremity muscle function and fatigue frequently are present with the physical disability. Therefore, it is extremely important that the wheels on the chairs move freely and easily.

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- d. All wheelchairs should have minimum features, one of these is brakes (Fig. 9). Problems which occur with the conventional type of brake are: notches which hold the brakes, wear out quickly; the brake can pop out when brushed against; the ratchet tends to loosen and come off the chair. An advantage of the conventional brake is that it can be partially applied to slow the speed when a person is going down a ramp.
- e. A certain amount of resistance must be overcome to apply the toggle brake. This resistance can be too great for persons with limited hand function. Also, this brake needs frequent adjusting. A handgrip similar to the type used on English bicycles might have merit.

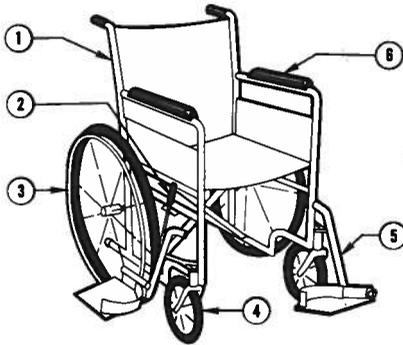


FIGURE 9. Recommended features of basic collapsible wheelchair: 1. fixed back, 2. brakes, 3. 24-in. wheel in back, 4. 8-in. caster in front, 5. removable footrest, 6. padded fixed armrests. (Kenny Rehabilitation Institute, Minneapolis, Minnesota.)

- f. A caster lock with the brake handle mechanism adapted for persons with poor hand function and poor trunk balance is a needed feature in selective instances.
- g. An improved method of locking to prevent swiveling of the 5-in. caster locks on the glideabout chair is needed. Persons with arthritis frequently are unable to bend down to reach the present locks. One company reports it has a brake that can be applied at seat height, one at either side. The brake secures the chair to the floor without touching the casters. A 5-in. caster with both a swivel and brake lock is available commercially on walkers. It also might be suitable for the glideabout.
- h. All chairs also need removable footrests. Problems with the swinging detachable type are: sticking of the pin in the pin lock style; wedging and distortion of the footrest attachment to the chair. A more simple adjustment of the footplate height is needed. Much time is spent adjusting this for the patient when a wheelchair is assigned. Also, the lower section of the footrest tends to rotate when bumped. Every

- company uses a different size nut for the adjustment. Standardizing of such parts would be helpful.
- i. Contouring the padded calf support of the elevating footrest is recommended. Adjustment of the calf support up or down also would be desirable. Thick padding on the calf support is recommended. The bar at the knee area of the elevating footrest is too high on present wheelchairs. If the leg rests against the metal, it causes discomfort and pressure, and can produce neurologic disability by hitting the right spot.
  - j. Wheelchair armrests should be padded thickly. Increasing the forward length of the padded section is suggested for hand support.
  - k. Rubber tips on brake handles and vertical projections should be attached more firmly as they come off and get lost. The same is true of the handgrips. For safety's sake, the latter should be securely attached; a serious accident could occur if they come off while taking a person down a ramp or up or down stairs.
  - l. The two parts of removable armrests which telescope into the wheelchair bend easily. These parts and the telescoping section of the footrests rust readily from moisture during cleaning and from changes in temperature.
  - m. The semi-reclining chair is useful and necessary. However, releasing the knobs to raise and lower the chair is difficult. Because of this, the back cannot be raised and lowered easily by one person while a patient is sitting in the chair.
  - n. Gas sterilization is recommended by one manufacturer as the most effective method for destroying staphylococcus. Equipment sales and rental companies and hospitals are beginning to use this method. Steam cleaning also is used.

### **METHODS OF EVALUATING THE STRUCTURAL AND FUNCTIONAL DESIGN OF WHEELCHAIRS**

EDWARD PEIZER, Ph.D.

The Veterans Administration, as a large consumer of wheelchairs, is interested in developing a valid basis for the appraisal of wheelchairs. The method of evaluation should be based on acceptable standards and appropriate specifications required to meet those standards.

The term "standard" refers to value judgments on what is useful, what is good, what is bad and what is to be avoided in respect to workmanship, durability, comfort, ease of operation and function. Specifications relate to such things as dimensions, weights, and performance factors which are required to attain the standards.

Standards should serve to screen out poor quality of materials, inadequate function, safety hazards, excessive cost, and a high maintenance potential. They should not stifle design creativity. They should not be designed to exercise favoritism for one type of design over another where function and other matters are equal. They should not reduce the capacity for customizing, for making adaptations and modifications for specific patient disabilities and for specific needs.

The adequacy of standards rests on:

- a. A set of valid requirements. These requirements should be based on the precise functions the wheelchair should provide for the patients. In effect, they form the basis of our standards.
- b. A translation of these requirements into appropriate hardware and functions. The selection of materials, fastenings, and the design of components are specified only to the extent necessary without undue restriction on creativity. These items are better specified by functional statements related to safety, comfort, ease of operation and function.
- c. A reliable evaluation system. Compliance with the specification must be checked periodically to ensure that changes in manufacturing technique or the use of equivalent materials have not reduced overall quality below standards. In addition, new designs must be compared to acceptable standards.

In this whole process, the patient is a key factor; he has to put energy into the wheelchair before it becomes functional. The chair supports him; he depends on it for mobility and for performing other activities while in the chair. The translation of functional standards into a mechanical design is a rather difficult exercise at best. This has been done by the Veterans Administration for lift aids, but not as yet for wheelchairs. Perhaps the same methods used for lift aids could be used for attacking the problem with wheelchairs.

The specific factors to be considered for each element of wheelchair use are:

1. Mechanical Factors

- a. *Dimensions.* Environmental and architectural limitations as well as anthropometric limitations must be recognized for determining the size of the chair.
- b. *Materials.* The rapid development of synthetics and the advances in metallurgy make it more prudent to specify strength and durability limits rather than particular materials.
- c. *Strength and durability of materials.* This includes maintenance as well as stress resistance.
- d. *Color.* This in general should be a matter of patient choice tempered by cost considerations.

- e. *Weight.* Weight considerations involve 2 factors. The total weight of a wheelchair is more significant in portability than in propulsion. A difference of 5 to 10 lb. is not especially significant in propulsion on level ground, but it may be critical in lifting the chair into a car. Secondly, the distribution of weight is a factor in the stability of the chair.

## 2. Functional Factors

These questions relate to what is done on or with the wheelchair. How much stability and maneuverability are required to allow patients to get in and out? Where should persons grasp the chair for the most efficient stroke? Functional standards for straight operation on the level must take into account requirements for turning. Ease of movement on inclines, curbs, and small obstacles is related to caster size, the 8-in. caster being more functional than the 5-in. caster.

Certainly the chair should be stable enough to prevent tipping the patient out. Stability is the relationship between a vertical projection of the center of gravity of the object and the area of the base of support. The relative position of the center of gravity changes when the wheelchair goes up an incline and a lesser force can then topple the chair. When a person is in a chair, the center of gravity shifts; therefore, it should be determined while a person is in the chair, or with an appropriate weight representing the patient. When a person strokes the chair, the front wheels are driven forward and the patient is driven backwards. The forces of stroking, therefore, shift the center of gravity and influence stability. If compensation to prevent toppling is necessary, the patient has to modify his stroke, an undesirable practice because the efficiency of the stroke may be reduced.

Another matter relates to the force and energy requirements. How much should a person be required to do? Where are the force inputs? Some of these are folding, lifting, starting, and stopping. When seven commercially available chairs, each weighted with 150 lb. were started from a dead stop, starting forces ranged from about 3.1 lb. to 5.8 lb.

Once the chair is in motion at a uniform rate of speed, the energy expenditure is directly related to friction. The theoretical energy cost to the person should be minimal, but differences in the frictional requirements can change the cost radically. The energy drain due to friction is affected by the type and material of the tires, and the wheel bearings. Recent studies have shown that wheelchair propulsion uses less energy than normal gait (6). Energy costs in wheelchair propulsion can increase precipitously

by malalignment, high friction, or poor stroking kinematics. These costs are determined by monitoring cardiac and pulmonary response while using a wheelchair.

Careful consideration of these factors in the light of realistic assessments of wheelchair use can provide a sound basis for developing adequate standards for wheelchairs and valid methods for evaluating them.

## **WHEELCHAIR LITERATURE**

**BETH FOWLES, Ph.D.**

Wheelchair literature can be divided into two categories: 1. literature prepared by persons and agencies presenting specific information about the wheelchair or needs for its use, and 2. literature prepared by the wheelchair companies regarding their products.

The first category includes procedural wheelchair activities (4, 7), type of chair depending on wheelchair needs,<sup>8</sup> building structure related to wheelchair use (9), and other related subjects.\*

Manufacturers' literature includes catalogs, brochures, instructions for measuring and ordering wheelchairs, owners manuals, price lists, and parts lists. A good deal of excellent material has been produced by the companies. Since wheelchairs frequently are sold as well as purchased by persons who have little or no knowledge of wheelchair structure or function, literature prepared by the companies can help supply valuable information that purchasers may not get from other sources.

The owner's manual can be an especially valuable source of information to the customer. Only a few companies produce this information, but it is recommended that all companies make this material available. This information might include:

- a. Instruction for assembling the wheelchair if it is delivered in a carton.
- b. Complete details with illustrations on wheelchair care and maintenance.
- c. A tool kit with printed instructions on the specific uses of each tool for fitting each screw, nut, and bolt which may require adjustment. Photographs or illustrations will help clarify a difficult subject.
- d. A list of wheelchair parts and simple instructions for ordering necessary replacements.
- e. An illustrated and explained list of instructions on control of the wheelchair in various situations. Special attention should be given to

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\*For a more complete list prepared for the conference, write to Beth Fowles, Ph.D., Highland View Hospital, Cleveland, Ohio.

safety measures for the patient and an assisting individual. Instructions might include:

1. How to open and close wheelchair.
2. How to push it when in folded position.
3. The technique of reclining the backrest, with a patient seated in the wheelchair.
4. Application of anti-tipping levers to wheelchairs.
5. How to position the levers to stabilize the wheelchair, and their safety value.
6. Best method of transferring a wheelchair into an automobile or trunk by the patient or another person. Pictures will greatly assist in illustrating this subject.
7. How to get a wheelchair up and down curbs, stairs, and ramps.
8. Suggested techniques for safe transfer of patients with varied disabilities, from bed to wheelchair, from wheelchair to toilet, from wheelchair to automobile, etc.
9. Addresses and telephone numbers of wheelchair representatives in various cities.
10. Suggestions of qualified shops where wheelchairs may be repaired and serviced.

#### **PANEL — THE COMMUNITY AND THE WHEELCHAIR**

**CORRINE LARSON, R.P.T.**

There is a great need for education of persons on wheelchairs. As consultant to the public health nurse on home visits, I find that a major wheelchair problem lies in the fact that a well-meaning aunt or uncle often brings a disabled person an inadequate chair. Once the purchase is made, it is generally necessary to "make do" with the article.

A great many inadequate wheelchairs exist in the community. A lack of brakes used to be a problem, but this has been improved. The wooden chair is still used sometimes. Often the chair is so outdated that it is difficult to have brakes applied or to improve the chair by applying new parts.

Advice is given to equipment loan closet personnel on the purchase of new equipment and acceptance of donated equipment. To be really functional, loan closet equipment should be multi-purpose rather than uni-purpose. A major problem for the small loan closet facility is the organization of an adequate care and maintenance system.

**DUEY KUHN**

The large wheelchair dealer sells, rents, and repairs wheelchairs, the latter, however, with frequent reluctance. There are so many brands of

chairs with so many parts that it is impossible to stock this equipment; nor can parts, even simple ones such as bearings, always be found. The dealer would be most grateful if all separate wheelchair parts were stamped with an identification number.

Other facets of wheelchair structure which would improve convenience of sale and rental are: 1. swinging detachable footrests which are interchanged readily with elevating footrests, 2. a mechanism for easy conversion of the standard wheelchair center of gravity to that needed for the person with a bilateral lower-extremity amputation, and 3. an adult size chair with a low seat height (without markedly increasing the cost of the chair).

In a rough estimate of my agency's sales, about 95 percent of all wheelchairs are sold without guidance or prescription. Most of the time the dealer has no idea whether the chair really fits the individual's needs. He is faced with a group of very uninformed customers. Often sales are made by telephone. Frequently, a chair is rented without certainty that the wheelchair is adequate, and then the problem may be compounded if the customer purchases the same chair.

Education of the public, professional groups, hospital and nursing-home personnel, loan equipment personnel, and dealers is a major need.

### **Discussion**

The manufacturing representatives indicated that they have a specific responsibility to broaden wheelchair education. A spokesman from one company cited two obligations: 1. to act as teachers at the dealer level, with the dealer acting as a teacher to the customer, and 2. to create proper literature for educating dealers and dissemination to the wheelchair user. He stated that manufacturers have taken steps in this direction, but they could make further progress. The manufacturer should lay the basic foundation so that the dealer can perform his job properly.

## **ARCHITECTURAL BARRIERS**

**CHARLES CANIFF**

Architectural barriers are of personal concern to me as an individual with a paraplegia (10). Many disabled persons do not have access to many community facilities and services because of architectural barriers. There is increasing social concern over this situation. This problem should be attacked from many directions—industry; professional institutions, organizations, and persons; and the community in general.

At present, some work is being done to alleviate the problem. Building specifications have been prepared to define the needs of wheelchair users (9). The paraplegia association is developing a list of motels which are best suited for the wheelchair user. One individual has compiled a list of accom-

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modations for the wheelchair user in a directory titled, "The Wheelchair Traveler" (11). Included is a list of other available directories. Communities are preparing lists of various types of facilities which readily admit wheelchairs. The hotel industry also has expressed interest in the problem. Certain airlines have devised ways of making air travel convenient for the wheelchair passenger.

But all of this is just a start. At present, there is no association of wheelchair manufacturers with which persons and groups concerned with the architectural barrier problem can communicate. It is virtually impossible to work with each manufacturer independently. Alleviation of architectural barriers, it would seem, would be a natural interest for wheelchair manufacturers just as good highways are of importance to automobile manufacturers.

### **SUMMARY OF DISCUSSION PERIODS**

The following points are derived from discussions during the wheelchair conference. They include comments and suggestions, but not necessarily conclusions.

#### **Brakes**

- a. A handgrip used on the back of the wheelchair might be a more adaptable grip for a brake handle.
- b. To prevent brake handles from bending and breaking, a piece of tubular steel flattened on one end can be used to fit over the brake. A cane tip then is used over the end of the tube.
- c. Many patients have visual impairment and cannot see the little grooves into which the brake lever fits. Lack of strength also is a problem in locking present brakes.
- d. Patients forget whether to push or pull to lock the brakes. This process varies from wheelchair to wheelchair. Although it is felt that brakes generally push to lock, there may be some occasions when pulling might be advantageous.
- e. If it were mechanically and economically feasible, it might be valuable to have control of both brakes from either side of the chair, rather than locking them independently.

#### **Wheelchair Seat Height**

- a. The distance from the seat to the floor can be a critical point for the short person when wheeling the chair with one or both feet.
- b. The problem of seat height in relation to propelling the chair would be less if one-wheel drive mechanisms could be accepted. However, many persons with a hemiplegia have difficulty learning how to use

the one-wheel drive chair. Also, the added rim makes the chair wider, it is a very expensive model, and it does not adapt readily for general institutional use.

### **Wheelchair Seats**

- a. A British study states that a hammock seat spreads weight over the entire gluteal area producing anesthesia of the skin and poor posture. Therefore, the solid seat was recommended.
- b. The Case Institute of Technology study indicates that the more pressure kept off the ischial tuberosities and distributed to the buttocks and thighs, the less likelihood of breakdown of the tuberosities from sitting. This is a serious problem for persons who lack sensation.
- c. Other studies point out that the ischial tuberosities are equipped to bear weight and that the rest of the flesh is not. One study argues against the contour seat because the joints of the hip are thrown out of alignment if weight is carried in that area.

### **Full Reclining Chair**

When the chair is fully reclined, there is inadequate support for the person's arms. Armrests might telescope posteriorly and tilt at an angle for arm support.

### **Design Problems**

- a. Manufacturers report they can build anything, but whether the purchaser can afford to pay for it is another matter. It is hard to design a lot of things into a standard chair.
- b. Many problems occur because it is insisted that wheelchairs fold. A person might be able to stay in his chair when he drives his car. Many persons spend 10-12 hours a day in a wheelchair and do not fold it and put it away. Another trouble spot is the large wheel. Because a lot of force is concentrated on the hub, keeping the wheel circular is hard. Other disadvantages of the large wheel are the addition of 7 in. to the width of the chair, and 12 in. to the length. The large wheel does aid in moving the chair up and down curbs.
- c. The electric one-wheel drive chair, currently available, is quite a revolutionary type of chair which meets many of the above requirements. It is not a folding chair, but does fit in the car trunk.

### **Arthritis**

It is estimated that 10 percent of the 12-14 million persons with arthritis need wheelchairs. Chairs are needed permanently for many persons. For others, they are needed therapeutically when the disease is active.

**Economy Wheelchair**

Many wooden chairs still are being sold primarily because of their low maintenance and high durability value. However, functional features also are needed as well as durability. The chair is not conducive to independent transfers. More people are required to get a person in and out of a wooden chair than the conventional type. The wheelchair purchaser should be concerned with accident prevention; insurance rates are high in hospitals due to lifting injuries. Lifting a patient from a wooden chair probably is more conducive to personnel back injuries than any type of transfer.

**Basic Hospital Wheelchair**

There is a great need for education of administrative and purchasing personnel regarding wheelchairs. It is hoped that nurses and therapists will become sophisticated enough in wheelchair equipment that the purchaser will consider them as resource persons. Many courses in rehabilitation wheelchair orientation include patient evaluation and agency needs.

**Wheelchair Prescription**

- a. Without an individual evaluation and prescription there is a great chance for error in the features and type of wheelchair purchased.
- b. It has been observed that a progressive rehabilitation program within a hospital generally indicates that administration personnel, physicians, and hospital staff have a good knowledge of wheelchairs. Conversely, when rehabilitation services are not available, knowledge is lacking. With the advance of rehabilitation, there should be more sophistication in wheelchair knowledge.

**Objective Wheelchair Testing**

- a. Nurses and therapists feel it is difficult to obtain an objective wheelchair evaluation within an independent setting. Patients become accustomed to a certain brand or style of wheelchair, are frequently biased, and respond subjectively.
- b. Reports do not go out of the Veterans Administration laboratory unless they are accompanied by clinical studies. These studies are an attempt to independently corroborate what the laboratory findings indicate. The chair is sent to some of the local VA installations for use by patients; the personnel are not told of the laboratory findings. Independent statements made by patients help substantiate the laboratory findings.
- c. Not much equipment is needed to measure certain performance factors in the clinic, such as average speed. Timing can be done by

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measuring distance, using a stopwatch, and counting strokes. Sequence shots of a person can be made with a simple camera with a rotating disk in front of it. Cost would be only about \$60.00, if a more precise measurement level is not desired.

- d. The Veterans Administration researchers have just begun to crack the field in obtaining some understanding of the wheelchair and its complexities.
- e. Wheelchairs are submitted to the laboratory through the central Veterans Administration operation. Reports are submitted to the central office and the information then is sent to the manufacturer. All reports are confidential. Aspects of the chair studied concern engineering, design, stability, safety and energy requirements.

### **Wheelchair Maintenance**

- a. The average cost of what wheelchair maintenance is or should be has not been determined. A relationship between cost and the activity of the wheelchair user likely exists. A relationship also may exist depending on whether the chair's parts are regularly checked and replaced, or whether repairs are made only when the chair breaks down.
- b. Weather is a factor in cold parts of the country. Leatherette almost freezes. For example, in winter when the chair is removed from the trunk of a car and opened quickly, the leatherette cracks. Breakdown of the upholstery then begins. A problem such as this is related to the determination of functional standards; upholstery should not crack in cold weather.

### **SUMMARY**

The wheelchair conference prompted animated discussion and stimulated thinking. Perhaps more than anything else, it gave a group of competitive manufacturers an opportunity to meet formally and informally with a group of professional persons having a keen interest in their product. The faculty was pleased and encouraged by the interest of the manufacturing representatives.

Critical concepts from the conference are:

1. A basic wheelchair with minimum features. The day has arrived when the "vanilla" wheelchair no longer has a place in the dealer's storeroom. All standard wheelchairs need brakes, removable footrests, armrests padded for comfort, 24 in. wheels at the back of the chair, and 8 in. casters in front. Ease in maneuverability is of major importance for the person who propels his own chair.
2. The need for individual evaluation of wheelchair requirements. This

is most effective through the use of a prescription. The shockingly high percentage of wheelchairs ordered without guidance is in itself an indication of general lack of wheelchair sophistication and the need for intensive education.

3. Research for determining mechanical and functional wheelchair standards. Objective laboratory studies have been started; these are followed by clinical evaluation.
4. Interchangeability of wheelchair parts. Standardization of basic parts, such as nuts, screws, bolts, and bearings, among all wheelchair companies would eliminate much inconvenience in present agency use and in rental and loan of wheelchairs.
5. Need for increased dissemination of information through the manufacturer's literature. This can be a direct and vital tool in the transfer of information to less knowledgeable persons and agencies.
6. Selective equipment needed on commercially available basis. Many adaptations are being made in institutional settings because the needed features are not commercially produced. Yet there is sufficient need for many of these devices so that commercial production is warranted.
7. Attack on architectural barriers. The wheelchair industry could be an effective coordinator with national agencies in the alteration of cultural concepts which confine and block the wheelchair user.

It is easy to be critical about a product or some feature of a product, but it is sometimes exceedingly difficult for the manufacturer to make the suggested change. However, there have been some recent astute modifications in wheelchair design that are doubly effective because of their simplicity. Perhaps more of these ideas will occur as a result of the conference. Some changes in design already have been observed. Pending changes also are known. Interest in collective efforts toward reduction of architectural barriers has been expressed, but no formal steps have been taken to date.

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