Clinical Prosthetics and Orthotics, Vol. 11, No. 2, pp. 82–90

Wheelchairs for Paraplegic Patients

by A. Bennett Wilson, Jr.

The best current estimates of the incidence and prevalence of spinal cord injury in the U.S. is 30–32 and 900 cases per million of population respectively.[5] About half of these cases are paraplegic. Added to this are paraplegics due to spina bifida, a few polio cases, etc. By definition, paraplegics have to rely on one or more assistive devices if mobility is to be achieved.

Only a small segment of the paraplegic population make use of lower-limb orthoses, and even those who do have orthoses, and use them, need a wheelchair as well, in order to make the most of their available energy. For the very few who can "walk" enough not to feel the need for a wheelchair in work and activities of daily living, wheelchairs permit participation in athletic activities that would otherwise be impossible.

Wheelchairs can be classified as either "manual" or "powered". The manual wheelchair is designed to be propelled by the occupant or by an attendant. Tests have shown that the energy cost of using a manual wheelchair for mobility on a smooth, level surface can be appreciably less than that of unimpaired persons walking on the same type of surface.[4] The conditions, of course, are reversed when uneven surfaces or ascending surfaces are encountered. The "powered" wheelchair is designed to be propelled by a battery-powered electric motor or motors. Originally conceived to be used by patients unable to propel themselves, powered chairs are sometimes indicated so that a paraplegic can make more effective use of his own energy.

The basic manual wheelchair has two sideframes connected by a cross-bar that is pivoted about its intersection and a flexible seat and back to allow folding, two large driving wheels at the rear, and two caster wheels at the front (Figure 1).[6] This is a configuration that has evolved over the years since the original patented design of Everest and Jennings[2] in 1936 for the folding mechanism, and represents a rather elegant compromise between maneuverability, stability, and portability. Many concerted attempts, especially in recent years, to develop better designs have not been very successful. The use of new materials has made it possible to produce significantly lighter wheelchairs, but the original configuration is basically the same.

It must be remembered that a change in the design to emphasize one feature generally affects adversely one or more of the other features. An example is when the wheelbase of the basic chair is lengthened to provide more stability for the bilateral leg amputee; maneuverability is sacrificed. Designers of some of the "sports" chairs, in order to reduce weight, have eliminated the folding mechanism. Portability is achieved by connecting and disconnecting driving wheels for transport in an automobile.

PRESCRIPTION CONSIDERATIONS

Variations of the basic chair are available for amputees, hemiplegics, and others, but the basic chair of proper dimensions is generally the most suitable for paraplegic patients. The range of dimensions of the basic wheelchairs available in the United States are shown in Figure 2.

Even when sensation is present, the hammock type seat is seldom used without cushions, which are needed to provide a better distribution of pressure over the thighs and buttocks for comfort, if for no other reason.

Cushions and other seating systems affect the relationship between the user and the chair and, therefore, must be selected and taken into ac-

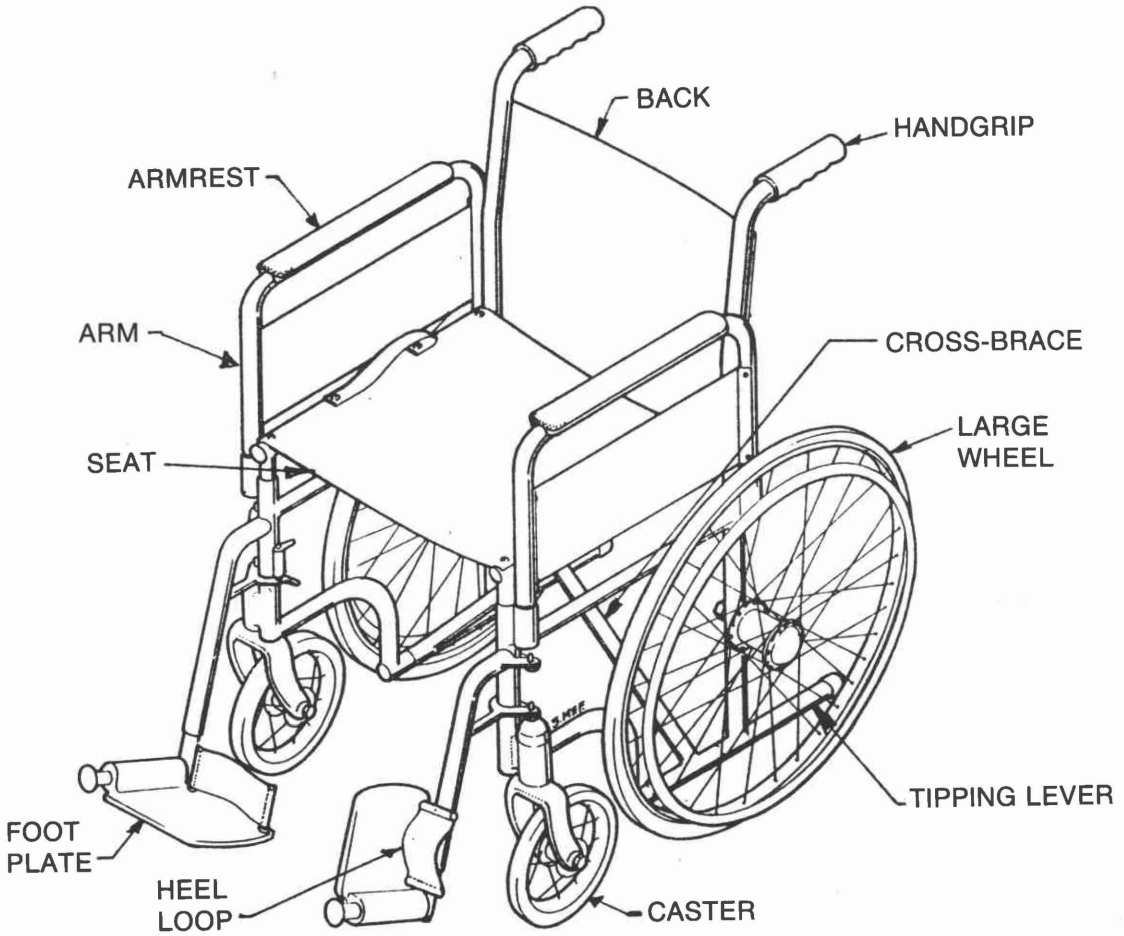

Figure 1. The basic wheelchair—folding frame, 24-inch diameter wheels in the rear, 8-inch diameter casters in the front, flexible seat and back.

count before the final dimensions of the chair are determined.

The importance of selecting the most appropriate chair and seat cushion cannot be over emphasized. The dimensions of the chair must distribute the forces of the body properly while also placing the user in a position, with respect to the driving wheels, to provide maximum efficiency during propulsion.

SEAT WIDTH AND DEPTH

Selection of the proper seat width is important to comfort and stability. A seat that is too narrow is not only uncomfortable, but access to the chair is made difficult. Furthermore, the chances of pressure sores developing is increased. A seat that is too wide encourages the user to lean toward one side, thus promoting scoliosis and increased pressure over the buttocks on one side. In addition, a seat wider than is necessary makes propulsion more difficult.

A seat that is too shallow reduces the area in contact with the buttocks and thighs and causes more pressure on the soft tissues in contact with the seat than is necessary or safe. Furthermore, the location of the footrests is changed so that the feet and legs are not supported properly, and the balance of the user can be affected.

A seat that is too long can restrict circulation in the legs.

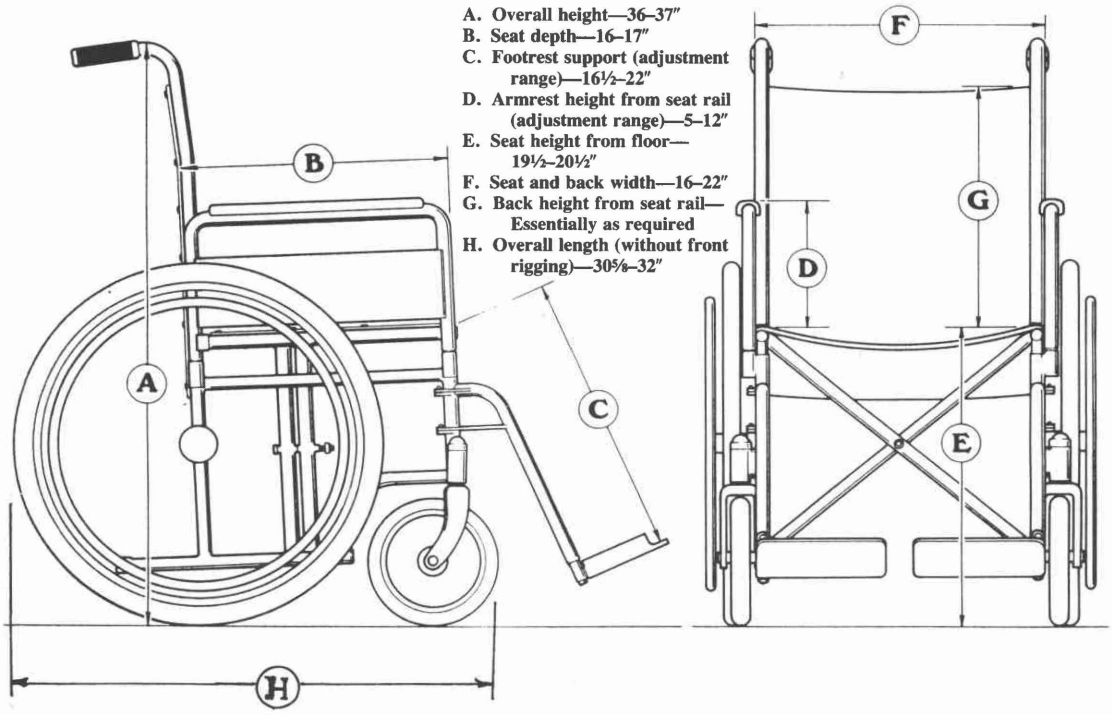

Figure 2. Dimension ranges for the basic adult wheelchairs from major U.S. manufacturers.

SEAT HEIGHT

The height of the seat above the ground of the basic adult chair is 19½–20½ inches. Tall persons require a seat that is higher and deeper; short persons require a seat that is lower. Usually these requirements can be met by a stock chair; if not, properly dimensioned units can be had on special order. Obviously, the cushion or seating system to be used will affect the end result.

SEAT TYPE

Seats available from wheelchair manufacturers are sling or hammock types, made of a flexible material, and solid seats which are generally removable (Figure 3).

The sling seats are, by far, the type most used. A solid seat installed to permit folding is available, or a removable solid wooden seat may be purchased or made.

BACKREST

The backrest of the basic chair is made of a flexible material stretched between the two side

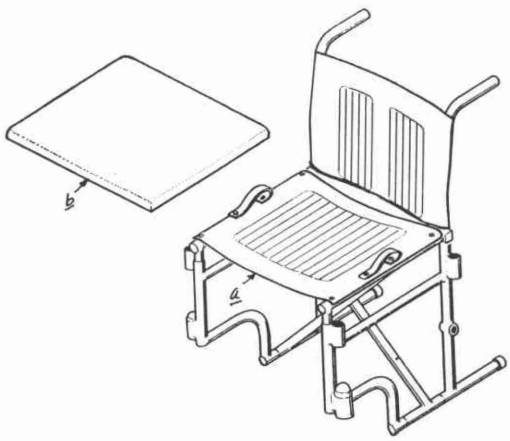

Figure 3. Seat types—a. hammock or sling; b. solid.

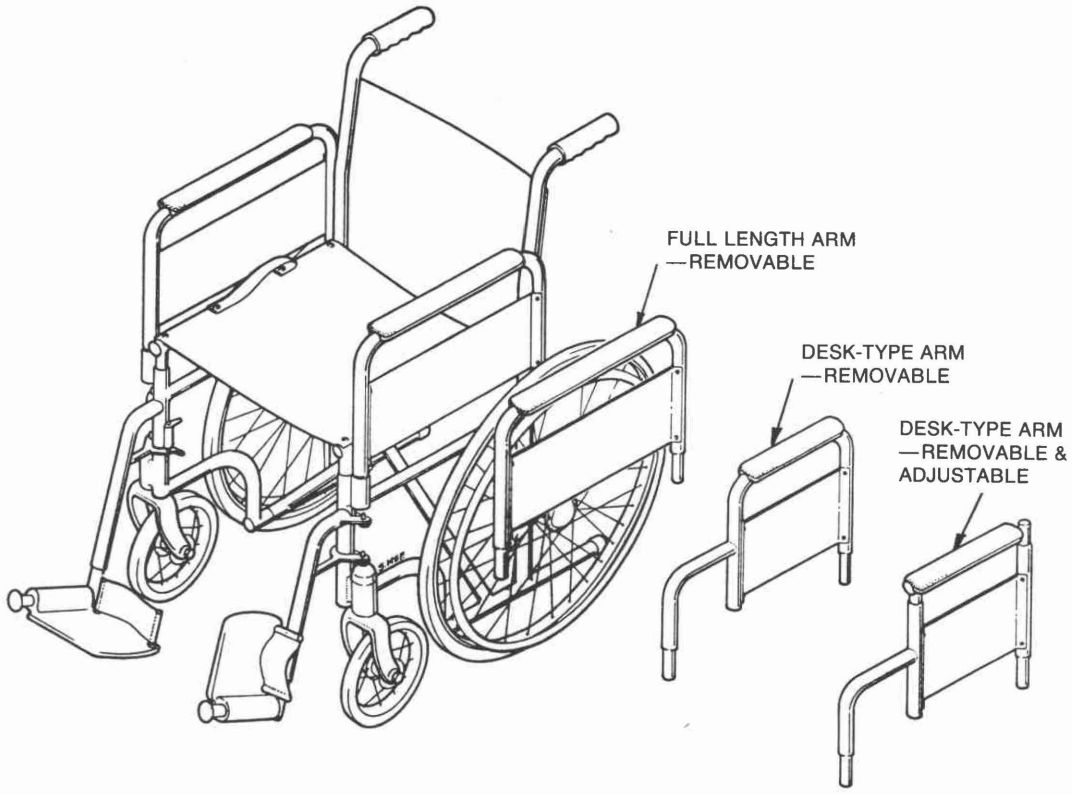

Figure 4. The basic wheelchair with the most popular types of arms—removable full-length, removable desk-type, and removable, adjustable desk-type.

frames which are fixed with respect to the seat. The backrest should be high enough to provide support without inhibiting motion, yet not so low that the scapulae can hang over the back of the chair and cause discomfort.

ARMS (Figure 4)

The lightest chairs have fixed arms or none at all. But an overriding factor in wheelchair prescription is transfer into and from the wheelchair, especially when the patient is unable to stand for a brief period. For this reason, most patients require chairs with arms that can be removed easily.

Chair arms not only provide support for the patient's arms in a resting attitude, but also provide lateral support and a reaction point for the hands when the asensitive patient elevates his body at regular intervals to prevent restriction of circulation and thus pressure sores.

Both removable and fixed arms are available in full-length and desk models; both of these styles are available with the height fixed or adjustable.

The desk models are foreshortened to permit the user to get closer to a desk or table top. The removable desk arm is by far the most popular type. The full length models are indicated when the forepart is needed to support the arms of the user in rising from the chair, or when lordosis, obesity, or some other physical factor makes it necessary to use the front part of the arm for support. The standard removable desk model can be reversed to provide this feature.

WHEELS AND TIRES

The basic chair has two 24 inch diameter rear wheels and two eight inch caster wheels in the front (Figure 5).

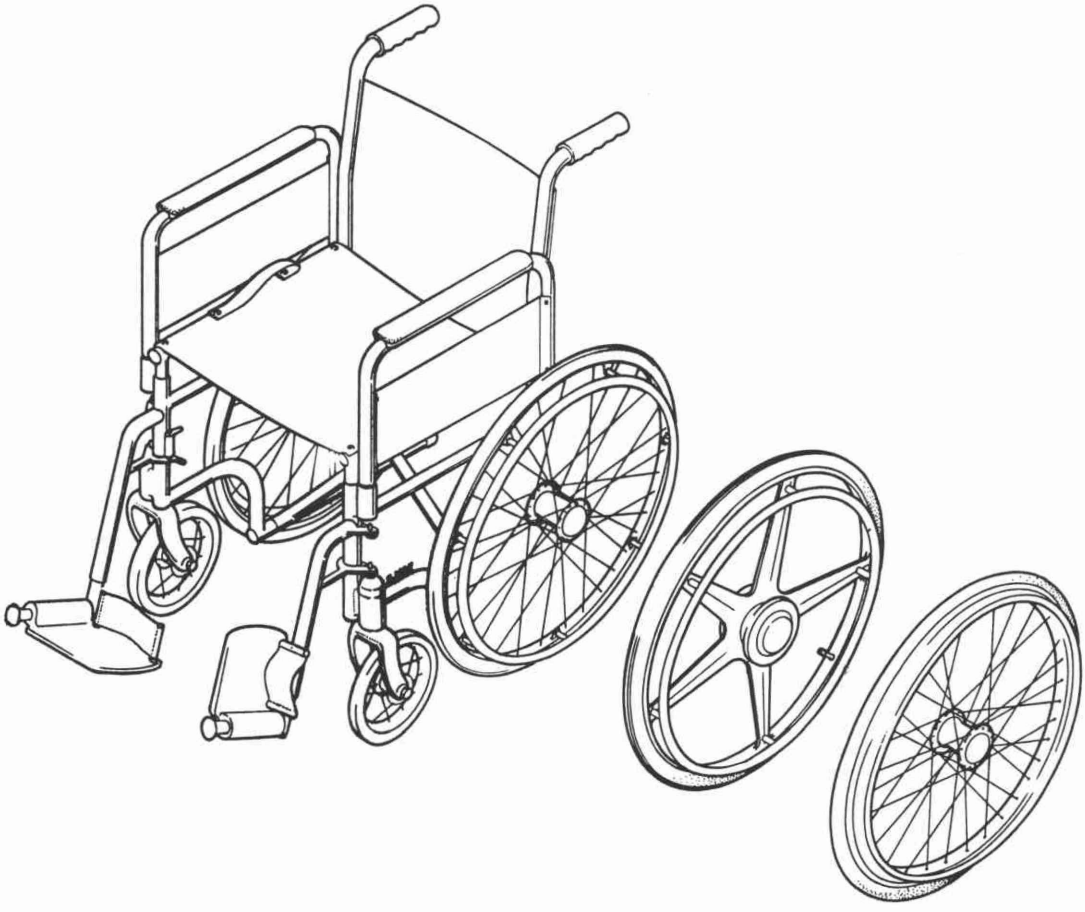

Figure 5. Basic wheelchair with standard 24-inch diameter wire-spoke wheel and two options: the cast magnesium wheel and a wheel with special built in hand rim.

The standard rear wheel for many years has been a wire spoke wheel, but wheels of cast metal alloy and wheels of cast plastic have been made available recently to overcome the maintenance problems inherent in the wire wheel design without adding more weight.

Three types of tires are available in several widths and tread types. Pneumatic, semi-pneumatic, and solid tires are available (Figure 6). The eight inch diameter wheel with solid rubber tires is standard on the basic chair, and is suitable for use on smooth surface and indoors. The semi-pneumatic and pneumatic tires provide shock absorption, and, thus, are more suitable for rough surfaces and outdoor use.

Pneumatic tires provide a more cushioned ride and their shock absorber action tends to prolong the life of a wheelchair when kept inflated properly.

HANDRIMS

Handrims are attached to the driving wheels of wheelchairs to permit control without soiling the hands. The standard handrim is a circular steel tube. For users who have problems gripping the smooth surface of a metal ring, vinyl coated rings and a variety of knobs and projections can be added to the ring.

CASTERS

Casters make steering possible and are available in two diameters: eight inches and five inches. The five inch model is available only with solid tires, and is used on children's chairs and in special circumstances on adult chairs and basketball chairs, when more maneuverability is desired.

PARKING LOCKS

Most users need some means of securing one or more wheels to keep the chair from rolling down inclines or to provide stability during transfer to and from the chair. Two types of parking locks are available from the large wheel (Figure 7): toggle and lever. Selection depends upon user preference.

Pin type locks are also available. These retain a caster in the trail position and are used to prevent swiveling during lateral transfer.

CUSHIONS

The vast majority of paraplegics require, and can use successfully, seat cushions that are

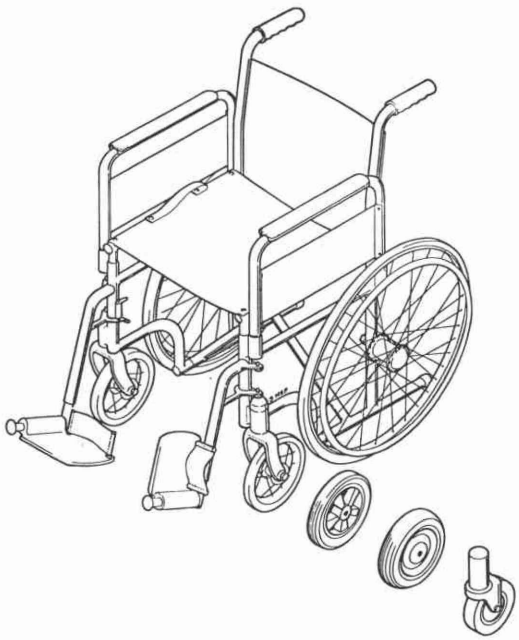

Figure 6. Basic wheelchair and optional casters available. Shown on the chair is the standard 8-inch diameter wheel with solid rubber tire. Next in order are: the 8-inch wheel with the semi-pneumatic tire; the 8-inch wheel with pneumatic tire; a 5-inch diameter wheel with solid rubber tire.

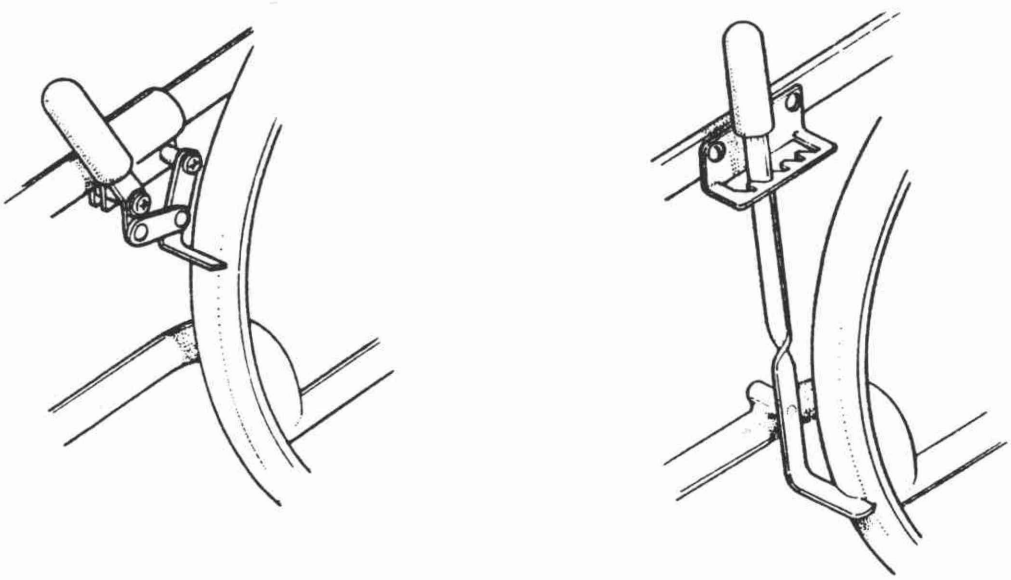

Figure 7. Two types of parking locks—left, toggle type; right, lever type. Variations of these two types of locks are available.

mass produced and are widely available at reasonable prices. A great many designs of seat cushions are available. Some have been developed by trial and error, the designs being based on what has proven to be acceptable to the inventor or his customers; other designs have a more scientific basis, but because the exact cause of decubitus ulcers is not known, precise criteria for design of wheelchair seating have not been established.[1] Although each of the cushion designs available has advantages and disadvantages, most of which are not clearly defined, selection of seat cushions for individual cases is seldom simple or straightforward.

Commercially available cushions may be divided roughly into five categories, including "miscellaneous" or "other", based on material and design (Figure 8).

1. Foam
2. Viscoelastic foam
3. Gel
4. Fluid
5. Other

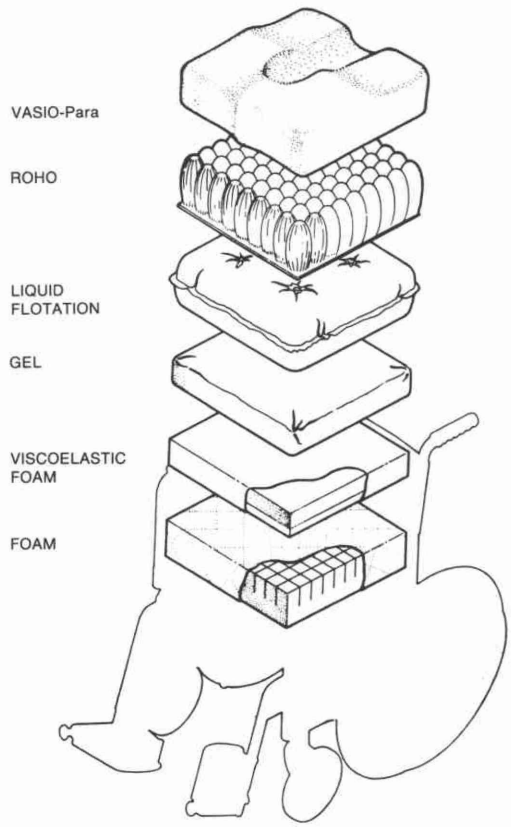

Figure 8. Various types of seat cushions that are available.

Foam Cushions

Foam cushions generally use polyurethane or polyether foam, and are available in various configurations. The simplest are homogeneous rectangular blocks 2–4 inches thick; some are contoured; and others are composed of two or more layers of material of different densities, some of which may contain hollow spaces or cores in an attempt to distribute the load to specific areas.

Viscoelastic Foam Cushions

Viscoelastic foam is less resilient than ordinary foam.

Gel Cushions

Gel cushions consist of rather firm emulsion enclosed in a "non breathing" plastic casing.

Fluid Flotation Cushions

Water, air, or water-and-foam particles are used in a flexible, tailored plastic bag to provide distribution of forces. The overall effect varies with the amount of fluid introduced.

Other Types

Many other designs that combine several elements are available. Prominent among these are the ROHO, which uses a collection of air-filled tufts to distribute the loads and the VASIO (Veterans Administration Spinal Injury Orthosis), in which foams of two different densities are combined and contoured to meet the special needs of paraplegic patients.

Each type and design has advantages and disadvantages, and, therefore, selection of the type most appropriate for individual patients is not easy. Until more is known, selection has to be made on a trial basis.

SPORTS CHAIRS

Since the introduction of wheelchair basketball shortly after World War II, a constant stream of modifications and refinements has been made to the basic wheelchair to meet the needs of wheelchair athletes. Development of the lightweight, high-performance, sports chair has led to racing among wheelchair users and has made playing tennis from wheelchairs practical and enjoyable. These chairs have also been found useful in non-competitive recreation, such as camping and mountain climbing. Much that has been learned in developing and using sports chairs has resulted in improved performance and quality of prescription wheelchairs, just as automobile racing has led to improvements in the family car. At the same time, many of the people who have been using conventional wheelchairs are now using sports chairs full-time.

Like the basic prescription wheelchair, the sports chair (Figure 9) has evolved through a series of refinements to where the general configurations of most chairs are strikingly similar. At least 20 manufacturers at this time offer one or more models. Most use 24 inch diameter wheels; some use 27 inch wheels. Weight varies from 16 to 38 pounds, due mainly to material selection and whether or not the chair can be folded. A number of designs incorporate provisions for folding; Others use wheels that can be disconnected (and connected) quickly without tools to make transportation easier.

Nearly all use five inch diameter front castors, except one manufacturer that uses four inch wheels. Two make eight inch castors available as an option. Nearly all, if not all, have a feature that permits a choice of rear wheel axle position with respect to the frame (Figure 10). Only a very few offer arm rests.

Many active wheelchair users prefer to use a sports type chair all the time, and in many instances options are offered that make regular use practical. Many models have adjustable features, and most manufacturers will provide a chair with dimensions to suit a given individual.

A feature found on most sports chair, but not on other types, is the easy adjustability of wheelbase and seat height afforded by the positioning plate for the rear wheels. In many models, the position of the castor wheels can also be adjusted. Such adjustability, of course, permits the user to be seated in a position which puts the muscles in the upper limbs and

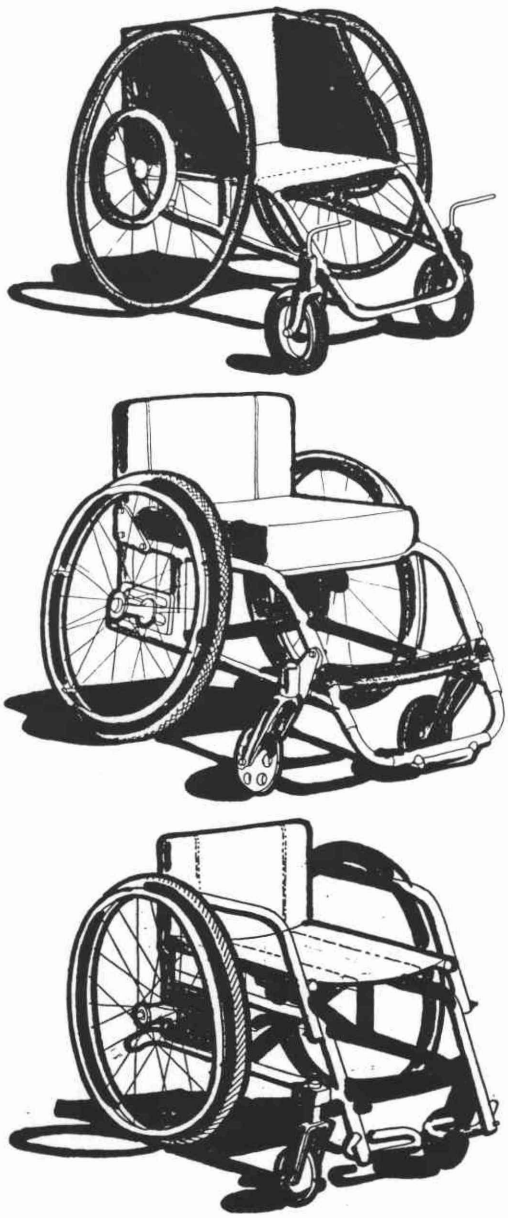

Figure 9. Three types of sports chairs. The one shown at the top is limited primarily for use in racing. The other two are more versatile.

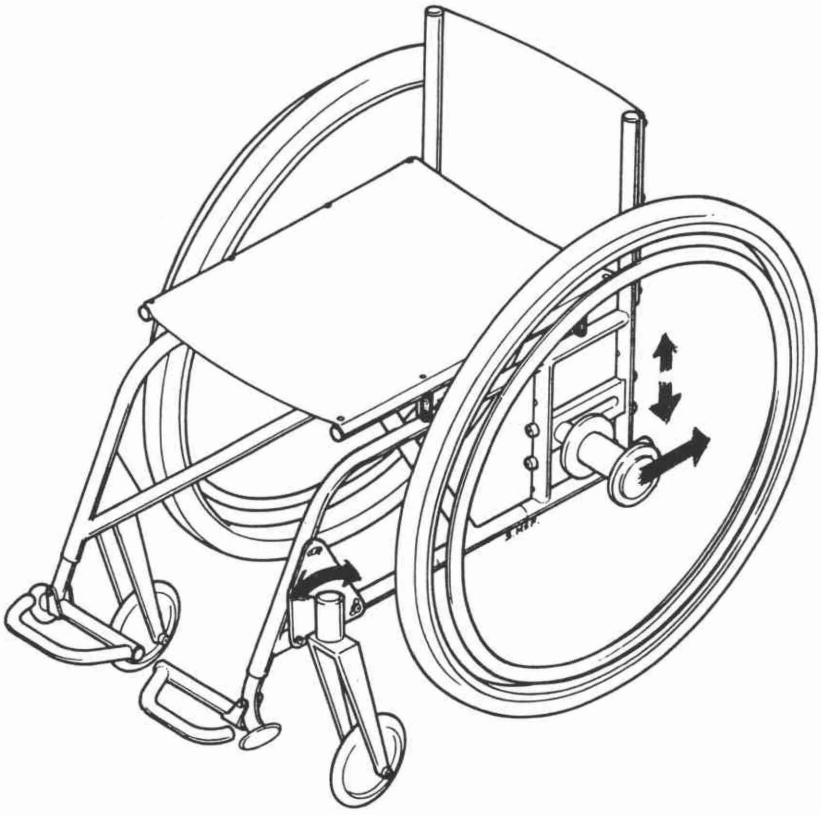

Figure 10. Schematic showing adjustability often found in sports chairs that permit an optimum relationship between position of the user and the wheels.

shoulders in the optimum arrangements for maximum biomechanical efficiency.

Because refinements and advances are being introduced so frequently, the periodical *SPORTS 'N' SPOKES*, published by the Paralyzed Veterans of America, has been devoting one issue each year to sports chairs and their specifications.[3]

SUMMARY

Because of increased competition and refinements brought about by the sports chair movement, paraplegics now have available high quality wheelchairs. No single chair design is apt to meet all the needs of each individual, but careful thought and attention to detail in prescription preparation can result in a chair that meets most of the needs of the paraplegic.

AUTHOR

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