Orthotics and Prosthetics, Vol. 31, No. 2, pp. 11–21, June 1977

SEATING AND POSITIONING FOR THE PHYSICALLY IMPAIRED

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The Rehabilitation Engineering Program of the Children's Hospital at Stanford has devoted considerable effort toward the solution of seating and positioning devices for the severely physically impaired because little in the way of habilitation can be realized unless the child can maintain an effective sitting position. The subject of seating and positioning for pilots, astronauts, truck drivers and other equipment operators has been studied extensively by N.A.S.A. (*4*), automobile manufacturers (*1*), and others, but because these studies involve only subjects with normal skin sensations, good protective musculature and skin, and the ability to shift around automatically, the results have been of very little use to us.

The physically impaired must "reeducate" their weight-bearing areas to function in a way that they were not designed to work. The normal function of the skin layer in the seat area has to change from basically a temperature control device and bacteria barrier to a weightbearing surface through which the body weight has to be supported. This function may cause impairment of the circulation and an increase in humidity because of the poor ventilation. These unfavorable conditions may occur 10 to 15 hours per day, day after day, for years. Because of the many complexities and limitations that occur in fitting and fabrication of special seats for the physically disabled, it may be helpful to classify these needs and problems and discuss the features of each.

CLASSIFICATION SYSTEM

Table 1 is a matrix of type-of-patient versus the time the patient is expected to use his chair daily. The type of patient is either "cerebral palsy" or "other than cerebral palsy". The times are "short" (up to 3 hours), "medium" (3–6 hours), and "long" (6–10 hours). Some design criteria are listed also in Table 1.

The primary reason that we believe the cerebral palsy seating systems are different from all others is that people with cerebral palsy do not perceive reclining postures as positions of relaxation. They also need special positioning for reflex pattern inhibition and maximum functioning of the upper limbs. In the near future we hope to show through the use of oxygen consumption measurements that unless the cerebral palsy person is positioned in space as described here he will consume more energy while sitting.

The position of relaxation and comfort for cerebral palsy-type disorders can be defined as follows: (Refer to Figure 1)

1. The head and shoulders should be vertical.
2. The lumbar spine should be rounded.
3. The hips should be flexed 10–30 deg. from the horizontal.
4. The knees and ankle joints should be flexed to 90 deg.
5. The thighs should be abducted.
6. The shoulders should be rounded in the transverse plane.
7. There should be no stimulation over the occipital area.
8. There should be minimal stimulation over the ischial tuberosities and plantar surface of the feet.
9. There should be a general feeling of firmness and security.
10. There should be a general feeling of comfort and relaxation.

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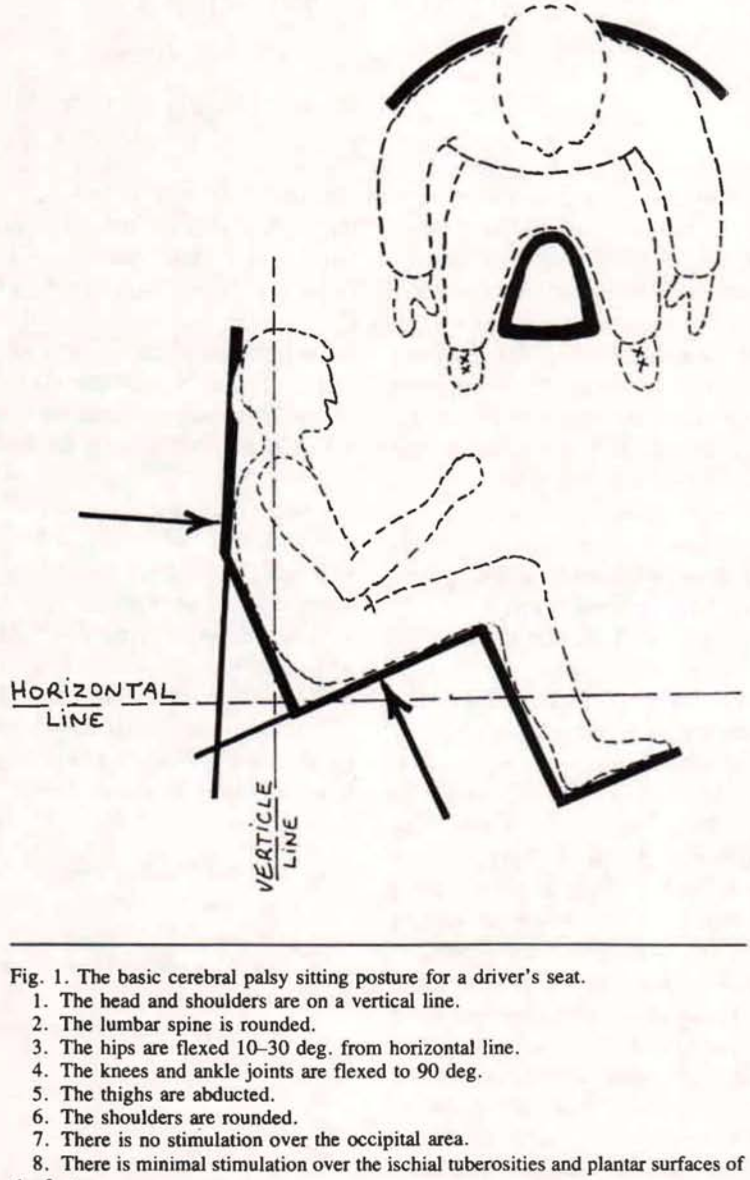

Fig. 1. The basic cerebral palsy sitting posture for a driver's seat.

1. The head and shoulders are on a vertical line.
2. The lumbar spine is rounded.
3. The hips are flexed 10–30 deg. from horizontal line.
4. The knees and ankle joints are flexed to 90 deg.
5. The thighs are abducted.
6. The shoulders are rounded.
7. There is no stimulation over the occipital area.
8. There is minimal stimulation over the ischial tuberosities and plantar surfaces of the feet.
9. There is a general feeling of firmness and security.
10. There is a general feeling of comfort and relaxation.

DESIGN CONSIDERATIONS FOR BASIC CP SEATS

In CP seating the position of the head and shoulders in space plays an important part. The exact location of these two segments in a particular patient can be found by rotating the patient in space and photographically recording the relaxing posture (Figs. 2 and 3). This posture is the sum of the following functions: visual perception of the horizon; the relationship of the head and shoulders in space to provide the balance and resolution that influence reflex patterns like the neck righting reflexes, protective parachute reflex, and proprioceptive sensors; and information from the inner ear that senses the position and movement as well as a great number of positions and reflexes. The most influential of the reflexes seem to be the tonic labyrinthian and the tonic neck and trunk reflexes. Dr. Peiper (*5*) states ". . . the leading reflex is the labyrinthian righting reflex of the head which rights the head in relation to space. Chain reflexes originating from this reflex bring trunk and extremities to the best possible balance under given conditions." In the able-bodied, the equilibrium guarding is done automatically, and, in most instances, is not under the direct voluntary attention of the person. This is not the case in cerebral palsy, where the automatic control has not reached the sophistication of an able-bodied person (*3*). The cerebral palsy person has to voluntarily assess the effect of the force of gravity on his body and process the information to remain seated in an upright position.

Fig. 2. The positioning of the patient in space to locate the most relaxed spacial alignment of body segments. Note the use of a plumb bob for vertical reference line.

Fig. 3. A finished orthopedic seat insert with a clear plastic tray. Note the direct transfer of spacial alignment as seen in Fig. 2 to the finished product.

STATE OF COMFORT

The state of comfort is not found in any one body alignment or position in space. It is, however, the result of changes in position. It is important to point out that significant short term gains in upper-limb function result from firm support (Fig. 4) at the sacrifice of long term tolerance. To prolong the state of comfort in a seating system, it is necessary to investigate articulating systems where the seats, back supports, foot rests, and other parts can be repositioned as needed to sustain the state of comfort.

STATE OF RELAXATION

The state of relaxation is defined as the state of mind that makes us less tense, slackening the

Fig. 4. A CP Type 1 orthopedic seat insert. Right, patient before the fitting. Left, same patient after the fitting.

demands on the overall voluntary control system, and permitting us to concentrate on the task at hand.

PRESSURE AND DISCOMFORT

In CP seating, as in all other seats, prolonged or excessive pressure over any area of the skin can cause problems. The area over protuberances like the occiput and ischial tuberosity require especial attention. In his chapter on "Development of Sensory Function," Peiper (*5*) states ". . . the pain sense is well developed in a newborn. The reactions have the purpose of withdrawing the irritated skin area from the stimulus." Rigid seats can easily cause excessive pressure on the skin and generate pain reflexes that force the hips to extend in order to get away from the pain stimulus. This is not to minimize the importance of the extensor pattern reflex in CP's. Rogers (*2*) in his article on "Tissue Tolerance to Trauma" states that the subtrochanteric areas are much more tolerant to skin pressures than are the ischial tuberosities. In view of this, considering the contour of the seat cushion, the tuberosities must be well relieved to prolong the seating time of the patient. At the same time, the head support must resolve a complex set of reflex influences. Skin protective reactions are best negated by the use of a doughnut-type head rest or a neck support only. The doughnut-type head rest avoids the stimulation of the occipital area and redistributes the pressure over a larger area.

FIRMNESS AND FEELING OF SECURITY

The general feeling of security and firmness of the seating system is not usually emphasized enough. The orthopedic seat insert and all other parts like arm rests, trays, head supports, and foot rests must be attached securely to the wheelchair. This promotes a feeling of security that sets the patient at ease. Peiper (*5*) describes the classic startle reaction that can occur when the seat insert is loosely attached to the chair. He demonstrates this fact by jarring the base on which an infant is lying. This should be proof enough that instability or rocking of the base of support is very distracting and acts as a stimulus to the uncontrollable startle reactions, and thus interfering with activities of function. This is particularly important when the orthopedic seat insert has to act as a driver's seat for an electric wheelchair. Paradoxically, in the electric wheelchair application in this situation, the wheel base must necessarily move. Yet, this movement should not set off the startle reaction to the point that the person loses control.

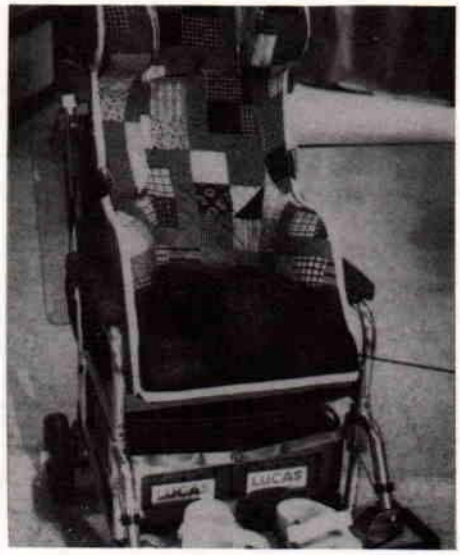

Fig. 5. Front view of upholstered orthopedic seat insert. The seat part is upholstered with vinyl for an incontinent patient; the rest is finished with cloth to provide comfort and keep perspiration to a minimum.

GENERAL FEELINGS OF COMFORT AND SECURITY

The feelings of comfort vary from patient to patient, but the easiest way to assess comfort is to watch the patient. If something bothers him, he will fidget, or become generally less able to concentrate on the task at hand. The patient may become uncomfortable because of presence of excessive perspiration caused by use of a vinyl seat. To minimize this problem we encourage the parents to agree to have the seat upholstered with a heavy-weave cloth, like "Herculon," which allows more ventilation. When the patient is incontinent, the seat part is vinyl and the rest of the seat is cloth (Fig. 5). The use of cloth sometimes necessitates more frequent replacement of the upholstery, but this gives the orthotist a chance to adjust the seat for growth and improvement of the comfort level.

NECESSITY OF A MOCK-UP FITTING

It is common to see a parent or a therapist handle an involved child so that he maintains good posture and relaxation. The problem arises when we need to maintain the same posture and relaxation by using inanimate objects like foam, straps, and plywood. One way to objectively assess the maximum of relaxation and posture available from "non-people" supports is to use a "trial adjustable seat" or to construct a mock-up seat (Fig. 6).

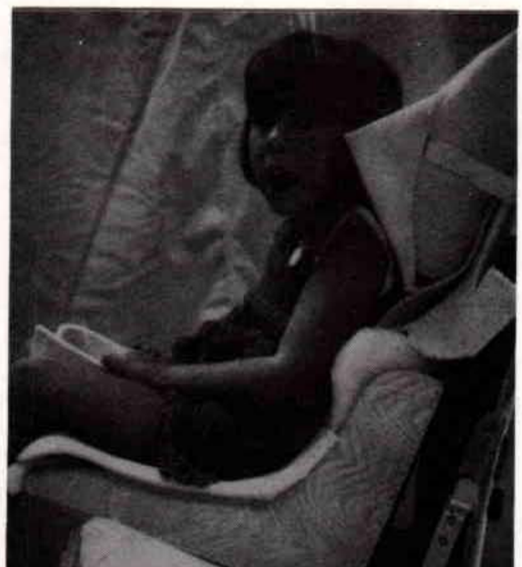

Fig. 6. Mock-up fittings are necessary to confirm the special alignment of the body segments. Much of the relaxing posture possible by handling the patient bodily is not necessarily reproducible with foam and straps.

ORTHOPEDIC SEATS FOR CEREBRAL PALSY PATIENTS

CP seats are prescribed primarily for the following three reasons:

1. To make maximum upper-limb function possible, i.e. create a driver's seat, or position in space for activity for function.

2. To discourage or maintain deformities, i.e. spine deformities and contractures.

3. To provide comfort and means of transportation for extremely severely contracted cerebral palsied individuals who cannot be positioned in a sitting posture. This is often done to facilitate transportation to school.

CP TYPE 1:

Orthopedic seat inserts that make possible maximum upper-limb function (Fig. 4) are based on the previously described philosophy of seating as a method of positioning and relaxation (Fig. 1) and are fitted to severely involved cerebral palsied people who need to control an electric wheelchair, communication device, or environmental control. This type of individual must be provided with a driver's seat that locates him properly in space, minimizes his inadvertent motion, diminishes his startle reflex, and inhibits his extensor patterns. A seat with all of these features is considered for short duration use and is primarily for activities of function, not an all-purpose seat (Table 1).

CP TYPE 2:

In some cerebral palsy cases it is advantageous to provide a well-fitting orthopedic seat insert with good thoracic support (Fig. 7) instead of an orthotic device like a body jacket. Because the seat must be fitted intimately to exert correcting forces on the spine, it fits rather tightly. Therefore, it will need a greater number of adjustments than other seats and may necessitate modification of clothing when it is to be used in colder climates.

As a general rule, the seat insert is considered to be more comfortable and easier to use in everyday activities than a body jacket. The duration of tolerance in this case is usually from medium to long.

CP TYPE 3:

This is a well padded seat (Fig. 8) that allows position changes and shifting around as well as protection to the patient. A seat of this type can often include substantial well padded foot rests, well padded arm rests, and head rests. This seat then is considered a device in which the patient can be placed in the morning and sent on the school bus, stay in the seat during the school hours and return home in the evening. The seat is a long duration item, primarily suitable for teenagers or older children that have severe uncorrectable deformities, and need to spend many hours away from home.

ORTHOPEDIC SEATS FOR OTHER THAN CEREBRAL PALSY PATIENTS

The three types listed in Table I are used as follows:

O Type 1: A general purpose seat to improve sitting stability and trunk balance.

O Type 2: Positioning seat primarily for muscular dystrophy patients.

O Type 3: A seat to improve tissue trauma tolerance primarily for people with desensitized skin i.e. paraplegia, quadriplegia, and spina bifida.

O Type 1

An orthopedic seat insert (Fig. 9) which optimizes sitting posture, security, and stability of the trunk is a base or foundation from which the person functions. The positioning of many patients with deformities of lower limbs, i.e. rigid hip, contractures, pelvic obliquities, and rigid deformed spine can often create difficulties in balancing oneself over the base of support. This type of insert usually consists of a

Fig. 7. Two views of the CP Type 2 orthopedic seat insert. Note the tight fit needed to maintain the spinal deformities and essimetric tonic neck reflex.

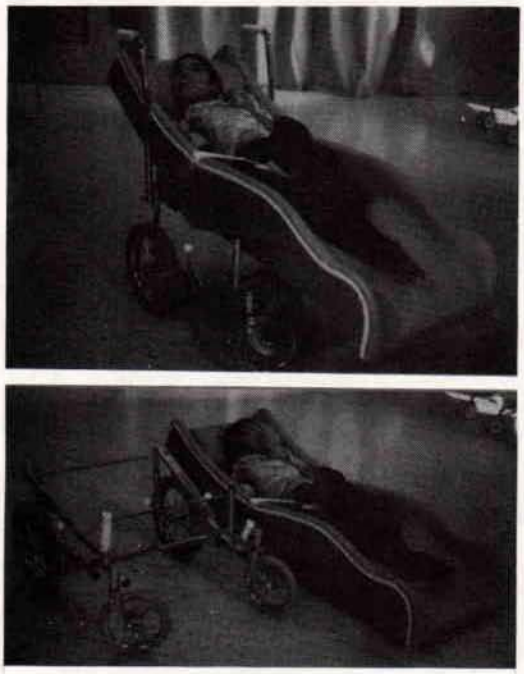

Fig. 8. An example of the CP Type 3 orthopedic seat insert. It is designed to provide comfort during transportation and school attendance.

Fig. 9. A combination of O Type 1 and O Type 3 seats. O Type 1 seat provides this bilateral hip-disarticulation amputee with trunk stability, and the O Type 3 seat redistributes the weight for tissue trauma management.

well-fitting seat portion that locates the patient firmly within the wheelchair and prevents the sliding and instability that is seen on water and jell cushions. This type of seat insert often includes build-ups for spreading of the thighs. It may include abduction blocks to prevent mentally impaired people from sliding out of the chair. It may include side supports as well.

O TYPE 2

An orthopedic seat insert (Figs. 10 and 11) primarily for muscular dystrophy is described by Dr. D. Gibson from Toronto. This type of chair differs from all others by the fact that it is shaped to have good lumbar arching built into the posterior support. The reason for this is that once the lumbar spine is arched, the spinal processes of the vertebrae lock up on each other

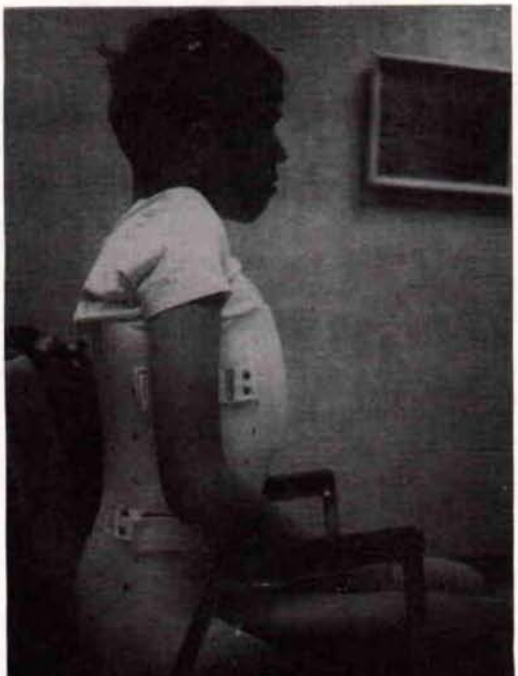

Fig. 10. An O Type 2 orthopedic seat insert for a muscular dystrophy patient. Note the exaggerated lumbar lordosis used to prevent the vertebrae from rotating on each other to prevent spinal curvatures.

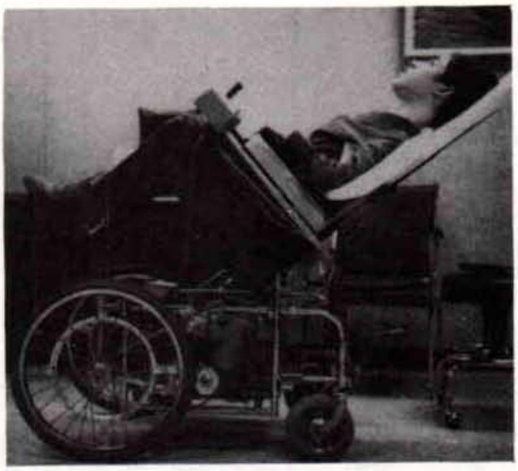

Fig. 11. An O Type 2 orthopaedic seat insert with a power-recliner wheelchair.

and prevent the vertebrae from rotating thus lessening the likelihood of scoliosis. This type of seat often includes reclining features as well as padded sides, trunk supports, and head rests. Frequently, the seat insert is positioned on an electric wheelchair base. Therefore, electric power recliners are recommended. A seat, consequently, needs to be connected to the recliner or be hinged posteriorly to allow for position change and to extend the duration of time for which the patient will be comfortable.

O TYPE 3

These orthopedic seat inserts (Fig. 12) are specially shaped seats that are part of a tissue trauma management routine. They are shaped to redistribute the pressure as evenly as possible over the weightbearing areas and to shift weight from ischial tuberosity and coccyx to other areas which are more tolerant to pressures. Often there are other devices used in this management routine, including suspension seats, height adjustments of arm rest, time sharing of different body areas for weightbearing, and height adjustment of the foot rest. Because the cost of healing a pressure sore can range between \$15,000 and \$30,000, any devices that can be created to eliminate this problem are apt to be extremely cost effective. Tissue trauma may result for many reasons. Most common are excessive pressure, excessive duration of pressure, tissue tension, patient's state of mind, state of health, condition of the skin, condition of the circulatory system, and the shape of the underlying bony protuberances. Of significance is the relationship between the pressure and the time. John Rogers quantitatively described the situation (*2*). It should be noted that as the pressure rises, the acceptable duration gets shorter and vice versa. In the tissue trauma clinic, the permissible pressure discussed is in the order of two pounds per square inch. This roughly rounded off number of two pounds per square inch can be used to describe the magnitude of the problem that a particular patient faces. If we consider a patient whose torso and upper limbs weigh 100 pounds and who is sitting on a 30 square inch area we can calculate as follows:

$$p = {}^{w}/a = \frac{100}{30} = 3.3 \text{ psi}$$

In this case, the patient is exceeding his permissible pressure and thereby limiting his duration of sitting time. This means something rather substantial would have to be done to give him a day's use (8–12 hours) of his seat.

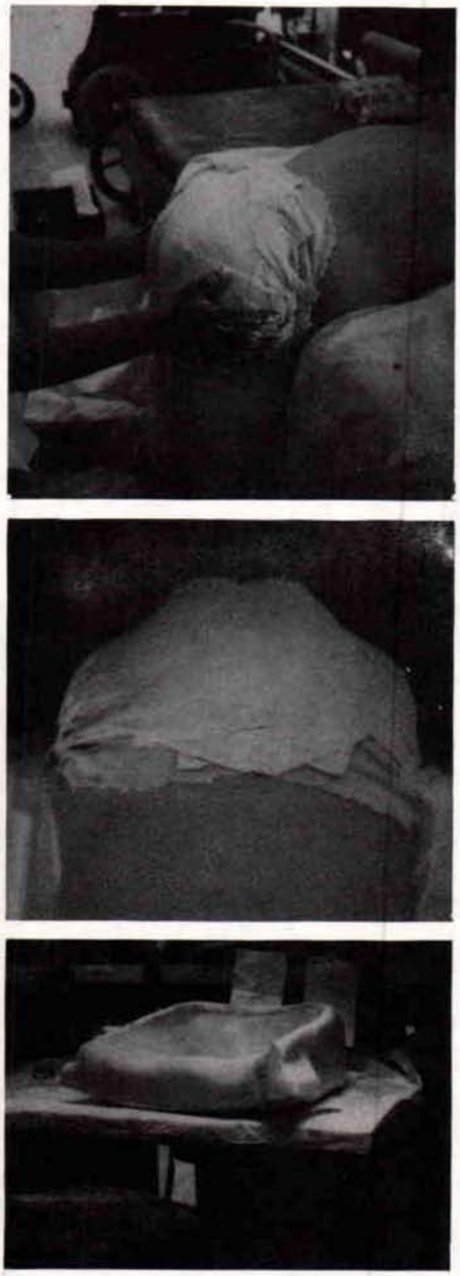

Fig. 12. The O Type 3 orthopedic seat. Top, cast taking technique; center, view showing the extent of protrusion of ischial tuberosities and saubtrochanteric shelf; bottom, finished seat. Note that the contour of the bottom of the seat follows the sag of the wheelchair upholstery.

TABLE 1 CLASSIFICATION OF ORTHOPEDIC SEATS AND SEAT INSERTS

Sitting duration in the seat	*Cerebral Palsy* Orthopedic Seat	*Other* than CP Orthopedic Seats
SHORT Up to 3 hours	(Fig. 4) CP TYPE 1 Purpose: Driver's seat, operator's seat to maximize upper limb functions Fit: Snug, with spacial positioning to enhance the sense of balance and security. Ideal for electric wheelchair use. Growth Adjustments: Fairly frequent (every 1–3 yrs)	(Fig. 9) O TYPE 1 Balance improving seat Purpose: Wheelchair base/foundation from which the person functions. Usually for fused hips or rigid spine deformities, pelvic obliquity, sliding out problems. Fit: Fairly precise, good accomodation of protuberances and deformities. Growth Adjustments: Infrequent (every 2–3 years)
MEDIUM Up to 6 hours	(Fig. 7) CP TYPE 2 Purpose: Deformity Management. Seat like an orthosis for deformities, contractures, sliding our of chair. Fit: Snug only in areas of force application. Growth Adjustments: Frequent (every 8–18 months)	(Figs. 10 & 11) O TYPE 2 Purpose: Positioning of muscular dystrophy patients in lumbar lordosis posture to prevent spinal curvatures. (Toronto M.D. seats) Fit: Medium tight, good side supports, head supports, sometimes the back is hinged to allow power reclining. Growth Adjustments: Frequent (every 8–18 months)
LONG Up to 10 hours	(Fig. 8) CP TYPE 3 Purpose: Comfort and safety for transportation and school use. Fit: Seat well padded, very loosely fitting to allow movement within chair. — Usually reclined to distribute pressure over large area to prolong sitting time. Growth Adjustments: Infrequent (every 2–4 years)	(Fig. 12) O TYPE 3 Purpose: Tissue Trauma Management — Redistribution of pressure —Relocation of weight-bearing areas usually supplemented by other tissue trauma management tools and techniques. Fit: Precise over weight-bearing areas Growth Adjustments: Infrequent (every 2–3 years)

SUMMARY

In summary, orthopedic seat inserts can be considered under six categories. It is important to establish the type of seat to be constructed before the features can be optimized for a particular patient.

ACKNOWLEDGMENTS

The author wishes to extend his sincere thanks to the patients and staff of the Rehabilitation Engineering Center for their kind help in preparation of this article. Special appreciation should go to Mr. Lee Strakbein and Mr. Michael Walsh for their untiring assistance in the seating and mobility program.

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