Prosthetics and Orthotics International, 1989, 13, 39–41

Development of a universal wheelchair narrower

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Abstract

A wheelchair user's mobility may be hampered by narrow doorways and restricted turning spaces. Mobility may be improved by undertaking expensive building alterations in the wheelchair user's own home and work environment. However, other environments, including modes of public transport, may still present considerable difficulties.

One way of improving mobility is to reduce the overall width of a wheelchair with the occupant still seated within it. This is achieved by using a clamp, known as a "wheelchair narrower" which can be fitted and operated either by the wheelchair user or an attendant. The narrower takes advantage of the inherent design of a wheelchair which permits folding for storage.

A universal wheelchair narrower was manufactured and tested at Tayside Rehabilitation Engineering Services. It was designed to be used on 69% of wheelchairs issued through the National Health Service in Scotland. Tests revealed that wheelchairs could be narrowed by between 38 and 127 mm depending upon the type of wheelchair. Active wheelchair users reported that the device was particularly useful when travelling.

Introduction

The architecture of the environment is generally not suitable for wheelchair users. Mobility is frequently hampered by narrow doors and corridors through which wheelchairs cannot manoeuvre.

A typical house builder in Scotland uses two sizes of doorway based on British Standard doors of widths 726 and 826 mm, the former being more common. After allowing for fitting tolerances and after deducting the thicknesses of the door-stop plate and the doors themselves when in the fully open position, the clearances are about 685 and 785 mm, respectively. The Scottish Housing Handbook Bulletin Number 3 advises home architects to allow for a wheelchair width of 635 mm. The majority of wheelchairs issued in the U.K. have widths less than this specification (Table 1) and therefore no difficulties should be expected. In practice, however, access can still be impeded by obstacles in the path of travel and by restricted turning spaces. Moreover, the overall width of bathroom doors in some modern houses can be 635 mm and toilet areas in particular can be very restricted. Expensive building alterations may be necessary to adapt a wheelchair user's home for his or her use and these may in some cases delay discharge from hospital. Mobility problems may still arise when visiting other homes and when using modes of public transportation such as ferries, trains and aeroplanes.

One method of improving mobility is to reduce the overall width of a wheelchair by taking advantage of its inherent design which permits folding for storage. This can be achieved by using a clamp, known as a "wheelchair narrower", which can be fitted and operated either by the wheelchair user or an attendant. The clamp draws the seat frame towards the armrest, tending to fold the chair with the occupant still seated in it, thus narrowing its overall width. Such clamps are available on a limited scale commercially but it appeared that a universal clamp which fitted the principal adult chairs issued through the United Kingdom National Health Service did not exist.

There are approximately 5,000 wheelchairs issued annually in Scotland (population about

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5.5 million) and 21,000 are currently in use; 69% of these comprise the U.K. Department of Health and Social Security models 8BL and 8L (both self-propelled), 9L (attendant propelled) and the Everest and Jennings self-propelled and attendant propelled wheelchairs. It was decided to develop a wheelchair narrower which could be fitted to these wheelchairs thereby improving accessibility. The criteria which were applied to its development were;

a) the narrower should be capable of fitting to the 8BL, 8L, 9L and the Everest and Jennings wheelchairs
b) no modifications should be made to the wheelchairs themselves
c) active wheelchair users should be able to apply and operate the narrowers easily without assistance
d) the narrowers should be robust and reliable
e) they should be cheap and easy to manufacture.

Method

It was found that the overall widths of used wheelchairs which had been returned to stock, marginally differed from the specified widths given in Department of Health and Social Security's specifications (Table 1). The principal reason for this was wear in joints and hinges. Accordingly, the narrower was designed to fit a sample used stock.

A wheelchair narrower was designed and manufactured. It comprises two hollow cylindrical tubes which telescope together. The small diameter tube has a threaded insert welded at one end and a hardened steel hook at the other. The curve of the hook matches the 19 mm diameter steel tube used in the construction of the seat chassis. The large diameter tube has a flat steel plate brazed onto its side and a brass bush is pressed into the top end. The end of the steel plate is shaped so that it will hook over the armrest. The plate is also reinforced with a strut to prevent bending when loaded. A length of M8 studding is inserted through the brass bush to engage with the threaded nut in the small diameter tube. The upper end of the studding is attached to a small lever, on the end of which is a plastic handwheel. When the lever is turned, the two tubes telescope together through a total distance of 70 mm. Thus the unit functions by drawing together the armrest and seat (Fig. 1).

Tests were performed on each of the differing types of wheelchair. The overall maximum widths of the chairs before and after using the narrower were recorded (Table 1).

The required structural strength of the narrower was determined by inserting a modified load cell between the narrower and a wheelchair armrest. The clamping force required to collapse a chair with a 70 kg occupant was recorded whilst the narrower was used on various surfaces. Tests were performed on an 8L chair with partially deflated tyres. The clamp was then loaded to destruction in a tensile testing machine and the load at failure compared with the recorded functional tests.

Twelve further prototypes were constructed and ten active home-based wheelchair users

Table 1. The reduction in overall wheelchair width which can be achieved with the use of the wheelchair narrower when it is shortened by 70 mm. Actual narrowing may be limited in practice by the width of the wheelchair occupant's pelvis which restricts the drawing together of the seat supports

Chair type	Wheelchair narrower proving test. Specified and measured distances between outer edges of wheelchair wheels							
	DHSS specification		Measured fully open		Measured fully clamped		Narrowing achieved	
	mm	in	mm	in	mm	in	mm	in
8BL small adult self-propelled	584	23.00	578	22.75	540	21.25	38	1.50
8L standard adult self-propelled	629	24.75	629	24.75	578	22.75	51	2.00
9L attendant propelled	660	26.00	641	25.25	572	22.50	69	2.75
Everest and Jennings self-propelled junior	648	25.50	705	27.75	578	22.75	127	5.00

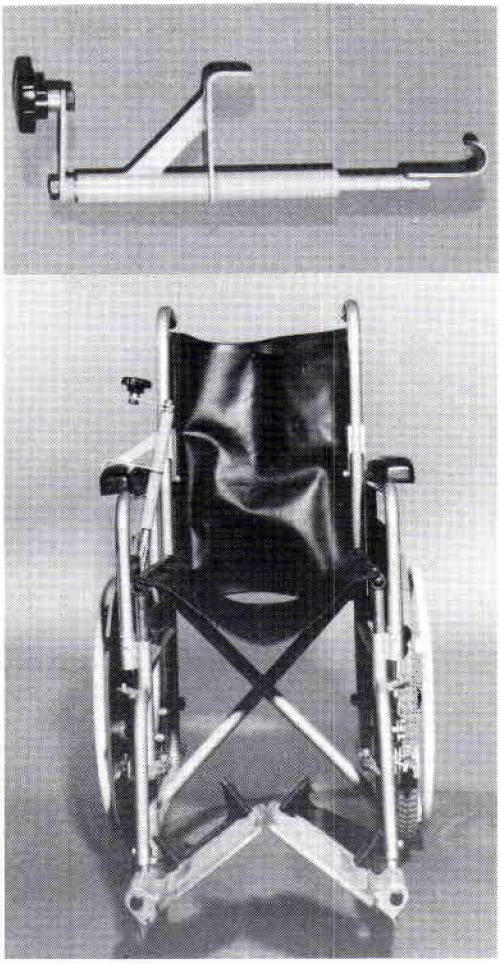

Fig. 1. Top, the wheelchair narrower. Bottom, the narrower fitted to a standard self-propelled wheelchair.

were supplied with the clamp. The users were asked to use it as often as possible for six months and then complete a questionnaire.

Results

It was found that the chairs could be narrowed by between 38 and 127 mm depending upon the type of chair (Table 1). In practice however, the limitation in the extent of narrowing occurs when the two tubular steel frames which support the canvass seat compress the pelvis of the wheelchair occupant.

Table 2. Maximum force recorded: 1,000 Newtons

Force required between wheelchair armrest and main chassis to clamp an 8L wheelchair on a variety of surfaces (test performed with occupant weighing 70 kg-average of three readings)

Surface	Clamping force Newtons
Rough tarmac	834
Coir mat	800
Thin pile carpet	784
Linoleum	684
Smooth concrete slope inclined 15° (left to right)	616
Gravel	600

The forces exerted between the clamping points ranged between 550 Newtons and 1,000 Newtons. Rough tarmac and coir matting were found to require the greatest force and gravel the least (Table 2). The destructive test performed upon the clamp resulted in failure at a tensile force of 2,600 Newtons, giving a safety factor of 2.6.

The patient trial revealed two specific points. The device fulfilled its purpose and it was so successful that the narrowers were not returned to the Centre, the users wishing to retain them.

Discussion

The clamp has been shown to fulfil its design purpose and has been successfully used by wheelchair users. The narrower provides wheelchair users greater mobility in their homes. Active users found the device useful when travelling. Bathroom doors are frequently found to be insufficiently wide and the narrower enabled easier entry.

Ferry, train and aircraft cabin doors and corridors have similarly been found to be accessible with the device which gives wheelchair users more confidence when travelling.

Conclusion

A wheelchair narrower has been designed to fit 69% of U.K. Ministry issue wheelchairs. The device can be operated by both the occupant or an attendant. Further details of the device can be obtained from Tayside Rehabilitation Engineering Services.