

LOWER EXTREMITY BRACING IN PARAPLEGIA— A FOLLOW-UP STUDY

By J. K. COGHLAN, M.B., F.R.C.P. (C),* C. E. ROBINSON, M.D., F.R.C.P. (C),†
B. NEWMARCH‡ and G. JACKSON, B.Sc.‡

* *Physical Medicine and Rehabilitation Department, G. F. Strong Rehabilitation Centre, Vancouver, Canada;* † *G. F. Strong Rehabilitation Centre;* ‡ *University of British Columbia*

Abstract. This retrospective study of 98 paraplegics was carried out to determine the utilisation of long leg braces prescribed during their rehabilitation training.

An analysis of their age, duration of disability and physical status was done. Other factors such as work status, decubiti, bowel and bladder functions were also considered.

Key words: Paraplegia; Rehabilitation; Braces.

Introduction

At the Centre there has been an awareness for some time that many patients with paraplegia who are provided with long leg braces for walking either abandon them or use them only sporadically. Prescription of braces has always caused a lot of controversy among doctors and various articles (Long & Lawton, 1955; Kaplan *et al.*, 1966; Hahn, 1970; Hussey & Stauffer, 1973; Stauffer, 1974; Rosman & Spira, 1974) have been written on this subject. Rosman and Spira gave an excellent review of the literature in their survey.

In this follow-up study we are attempting to define what use is made of long leg braces, what benefits are gained by their use and whether there is any significant difference between those who use braces and those who do not.

Method

Review of the medical records of the G. F. Strong Rehabilitation Centre indicated that between 1953 and 1976, 163 paraplegics had been supplied with long leg braces and discharged. Letters were sent to see if they were willing to participate in the survey and a follow-up telephone call was made if necessary. One hundred and three of these patients agreed to participate in the study, but five were excluded because they could walk using less aids than long leg braces. The remaining 98 patients were interviewed either in their homes or at the Centre, using a detailed questionnaire.

Questions were asked concerning braces and their use; skin status; bladder, bowel and sexual function; social status; and the patient's evaluation of the rehabilitation received. Following this, a physical examination pertinent to the study was performed if the patient was agreeable (Coghlan *et al.*, 1977). This paper presents information relevant to the bracing aspects of the data collected.

Address reprint requests to: Dr C. E. Robinson, Medical Director, G. F. Strong Rehabilitation Centre, 4255 Laurel Street, Vancouver, British Columbia, V5Z 2G9.

Results

Seventy-nine of the 98 were males, giving a male to remale ratio of 4 : 1. The average age at time of injury was 27 (Table I). The average time since the injury was $6\frac{1}{2}$ years (Table II). On the basis of answers given to the questions on bracing, it was found that 57 did not use their braces at all, that six used braces for standing only, that 19 used them for standing and exercise walking, that three used them for occasional functional walking, and that 13 used them for functional walking. Functional walking was defined as the daily use of braces for practical mobility. Occasional functional walking was defined as the use of braces on a less than daily basis for practical mobility.

As part of the study, the attitudes of patients towards the prescription of braces was determined. Of the 41 using braces, 38 felt they should have been prescribed. One patient considered them to be of psychological value only, two were against the prescription of braces, one because of fear of falling, and the other because he felt they were of no value. Of the 57 non-brace users, 38 felt that braces should have been prescribed and 19 were opposed to their prescription. The reasons of the latter group in descending order of importance were: braces were not practical; had difficulty in brace use and/or balance; spasms were made worse; and braces were a waste of money. Ninety-five of the 98 felt that every patient should have a trial of gait training. They were asked, if they had been given a trial of gait training and had been told to come back in 6 to 12 months for permanent braces, would this have been acceptable: 71 felt that this would not have been acceptable.

TABLE I
Age at time of injury

Age	No. of patients
0- 9 years	1
10-19 years	26
20-29 years	35
30-39 years	20
40-49 years	11
50-59 years	5
Total	98

TABLE II
Number of years since injury

Years since injury	No. of patients
1- 5 years	46
6-10 years	24
11-15 years	25
16-20 years	2
21-25 years	1
Total	98

The 57 non-users were specifically asked why they were not using them, and they gave multiple answers. The common answers in descending order of frequency are given in Table III. Those using braces were asked also if they obtained any benefits other than increased mobility and these are listed in Table IV.

After reviewing the physical examination data, it was decided that the most accurate way to categorise the patients was based on the presence or absence of muscle power. The patients were divided into six groups (Table V, Parts A and B). Of the 98 patients included in the study, 11 refused physical examination or allowed only partial examination, which did not give enough information to categorise them. Part A of Table V deals with the 87 who did have a complete physical examination and Part B deals with the 11 who did not.

The patients also were divided into spastic and flaccid groups. In groups I, II and III of Table VA, there were 34 spastic and six flaccid patients; there was no significant difference in their walking status. In groups IV, V and VI of Table VA, there were 22 spastic and 25 flaccid patients; there were no significant differences between these two groups. However, if one left out the functional walkers in each group, the spastic group of patients tended to be exercisers, whereas the

TABLE III

Reasons for not wearing braces (multiple answers from 57 non-brace wearers)

Reason for not wearing braces	No. of patients
Easier to get around in a wheelchair	24
Takes too much time to put them on and take them off	15
Not practical	12
Walking in them uses too much energy	12
Do not feel safe on them	8
Pressure sores	7
Make spasms worse	6
Braces don't fit properly	5
Make pains worse	3
Broken hip or leg	3
Terrain in the community unsuitable for use of braces	2
Sore shoulder	1

TABLE IV

Benefits from wearing braces (multiple answers given)

Benefits from wearing braces	No. of patients
Means of physical exercise	23
Feel good being upright/psychological value	21
Improved bowel/bladder function	15
Independence/allows extra activity	6
Control of spasms	5
None	3
Other reasons	5

TABLE V
Physical status correlated with walking status

Part A Of the 98 patients, 11 refused physical examination and the remaining 87 were divided into the following groups:

Group I No abdominal musculature
 Group II Upper abdominal musculature only
 Group III Upper abdominal and leg musculature (grade II+)
 Group IV Full abdominal musculature and back extensors to T12 at least
 Group V Full abdominal musculature and lumbar back extensors (grade III+) and hip hikers (grade III+)
 Group VI Full abdominal musculature, back extensors, hip hikers, and hip or knee musculature (grade II+)

Group	Total	Functional walkers	Occasional functional walkers	Exercise walkers	Standing only	Non-brace users
Group I	21	—	—	3	3	15
Group II	18	1	—	4	—	13
Group III	1	—	—	—	—	1
Group IV	2	—	—	1	—	1
Group V	26	6	3	6	2	9
Group VI	19	6	—	4	—	9

Part B Of the 11 people who did not have physical examinations, the following information was obtained from hospital records.

Group	Total	Functional walkers	Occasional functional walkers	Exercise walkers	Standing only	Non-brace users
Group I	1	—	—	—	—	1
Group II	4	—	—	—	1	3
Group V	3	—	—	1	—	2
Group VI	2	—	—	—	—	2

flaccid group tended not to use their braces at all. These figures were not statistically significant. Walking status was also correlated with hip proprioception; half of the functional walkers had some hip proprioception present, compared to 33 per cent of the exercisers and standers and 38 per cent of the non-brace users.

To cross-correlate walking status with other functions, the functional walkers and occasional functional walkers were combined into one group. A second group was composed of the exercise walkers and standers. A third group consisted of non-brace users. These three groups were then compared in relationship to job status, diazepam usage, occurrence of decubitus ulcers and bowel control (Table VI). Good bowel control was defined as the non-use of any aids, either drugs or mechanical stimulation. Bladder drainage status was also cross-correlated with functional walking status, but in this cross-correlation only males were considered as females at present have no adequate external drainage comparable to condom drainage (Table VII). It was found that functional walkers had a statistically significant lesser incidence of decubitus ulcers. There was a statistically significant

TABLE VI

Walking status correlated with job situation, diazepam usage.
Major decubitus ulceration and bowel control

	Total	No job	Full-time job	Part-time job	Student	Retired	Diazepam usage	Decubitus ulcers	Bowel control: no aids used
Non-brace users	57	21	23	8	4	1	21	34	9
Use braces for exercise or standing	25	12	9	4	—	—	9	10	5
Use braces for functional walking	16	3	7	2	4	—	4	*5	4
Totals	98	36	39	14	8	1	34	49	18

* Statistically significant at the $P \leq 0.05$ level.

TABLE VII

Walking status correlated with urinary drainage status in males only

	Total	Use catheters or ileal loops	Use condom	Voiding without aids
Do not use braces at all	46	9 = 20%	28 = 60%	9 = 20%
Use braces for exercise or standing	19	1 = 5%	14 = 74%	4 = 21%
Use braces for functional walking	14	2 = 14%	2 = 29%	8 = 57%

increased number of functional walkers who were catheter and condom-free compared to the rest of the groups. None of the other figures for any of the three groups were statistically significant (Tables VI and VII) at the $P \leq 0.05$ level.

Discussion

The vast majority felt that braces should be prescribed for individuals with their level of injury. Even the non-brace users felt that the braces should have been supplied even though they did not use them. The reason for this attitude may be social compliance, unwillingness to admit their own physical shortcomings, or a very positive attitude to the concept that each patient has the right to at least try brace walking. Up to now this desire to walk with braces has been culturally appropriate and may continue to be so for some time. In an individual case, the doctor and patient together have to decide if bracing is feasible and to what extent ambulation or exercise is practical.

The main reason for not using braces was that they were not practical in terms of functioning in the home environment. The reasons for not using braces were similar to those of Kaplan *et al.* A large group of the non-brace users did not have the physical capability to become functional walkers, especially in groups I and II of Table V. In other cases, there was no encouragement to maintain func-

tional walking in their home environment. This may happen also in the hospital environment if an individual uses a wheelchair for mobility outside of his gait training sessions. If one of the goals of treatment is for an individual to become a functional walker, then one should not discharge that person until he is functioning without the use of a wheelchair for at least 8 hours a day. Once a patient is discharged, conditions in the community tend to reinforce wheelchair mobility as it is faster and more in tune with the pace of modern living. In some cases, patients stopped using their braces due to mechanical and physical problems (Table III). This might not have happened had there been adequate follow-up after discharge from the Centre.

If one looks at bracing as a therapeutic regime and the subsequent use as an index of therapeutic response, 16.5 per cent had a good result, *i.e.* used braces for functional walking; 25 per cent had a fair response, *i.e.* used braces for standing and exercise walking; and 58 per cent had a poor response. Efforts must be made to improve these results as it is an expensive form of treatment especially in terms of the cost of hospitalisation. Patients often have to be retained in hospital specifically for gait training.

Correlating walking status with physical status, one sees that there is only one individual with less functional musculature than is the case for those in Group 5—this group being comparable to a T₁₂ intact paraplegic. These results are comparable with previous studies (Kaplan *et al.*, 1966; Hahn, 1970; Hussey & Stauffer, 1973; Rosman & Spira, 1974) and reinforce the belief that hip hikers, full abdominals and lumbar back extensors are the minimum requirements for functional walking by paraplegics, other than the exceptional person.

Additional musculature across the hips and/or knees does not increase the chances of an individual becoming a functional walker with long leg braces (see Groups V and VI of Table V)—this is contrary to the suggestion of Hussey and Stauffer in their report. This study does not support their claim that hip proprioception was a useful prognosticator of an individual's brace walking ability.

Our results conclude that having a spastic or a flaccid lesion makes no difference to whether one becomes a functional walker or not. In this study we did not measure the degree of spasticity and therefore cannot comment on the effect that the degree of spasticity has on walking ability. The functional walkers tended to be younger, were more likely to be employed, used less diazepam and had fewer decubitus ulcers. They were less likely to use catheters or condoms than those in other groups. Functional walking makes little difference to bowel control. On statistical analysis, the only trends that were significant at the $\alpha = 0.05$ level were that functional walkers have fewer decubitus ulcers and more were condom- and catheter-free. These benefits are certainly worth attaining in any paraplegic.

There were no statistically significant differences between the exercise walking and standing groups and non-brace users. Table IV shows that some individuals feel there is benefit, other than walking, to be obtained from the use of their braces. This table includes the responses of the functional walkers as well as the exercisers. Brace walking as a form of exercise is the major benefit described. The use of braces for exercise only can hardly justify their prescription as doing push-ups in a wheelchair is an adequate alternative form of exercise. However, in an individual case the psychological benefits of being upright during exercise may justify the exercise. It is important to consider what is anticipated when the braces are prescribed and certain indices can help with this decision, *e.g.* motivation of patient, premorbid behaviour, age and level of paralysis with full abdominal muscle power and grade III hip hikers being the minimum for functional walking.

For individuals with the ability to become functional walkers, prescription of the standard knee-ankle orthosis is advisable. For those individuals who do not have the potential to become functional walkers and are willing and able to finance the cost of bracing for exercise, the brace prescription could be simpler. Double uprights without knee joints could be prescribed. Whether an ankle joint with fixed anterior and posterior stops and sole plates is necessary depends on the individual's stability and whether he exercises in parallel bars, with a walker or with crutches. As an alternative for this group, a pneumatic long leg orthosis with or without plastic short leg braces may be practical (Silber *et al.*, 1975; Ragnarssen *et al.*, 1975; Lehmann, 1977).

Considerable costs for these cases could have been saved by modifying gait training to exclude stair climbing, managing ramps and rough ground.

This study did not clarify the natural history of the use of braces after discharge. Some individuals did mention that they used their braces for some years but as they got older they used them less. A study of the natural history of brace usage is indicated.

SUMMARY

The study was carried out to determine the use of long leg braces by paraplegics after discharge from the G. F. Strong Rehabilitation Centre. The patients were interviewed in their homes or at the Centre. A physical examination was performed to assess their present status. Sixteen of 98 used their braces for functional walking, 25 used them for exercise walking or standing and 57 did not use braces at all. Cross-correlations were made between physical status and brace usage. For functional walking it was necessary to have Grade III or greater muscle strength in the hip hikers, abdominal musculature and back extensors. Proprioception in the hip or knee region was not necessary for an individual to become a functional walker. Having a spastic or a flaccid lesion did not enable prognostication on the eventual use of braces in this group.

RÉSUMÉ

On a essayé de savoir quel usage faisaient, de leurs longs supports à jambes, les handicapés après leur sortie du Centre de Réhabilitation G. F. Strong.

Les patients furent interviewés chez eux ou au Centre.

Un examen physique a été fait pour évaluer leur état actuel. Seize parmi 98 employèrent leurs supports pour marcher; 25 les employèrent pour s'exercer à marcher ou se tenir debout, et 57 ne les ont pas employés du tout.

Pour pouvoir marcher, il fallait avoir 'grade III' ou une force musculaire plus grande grande dans les hanches, la musculature abdominale et les 'extensors' du dos.

La 'proprioception' dans la hanche ou la région du genou n'était pas nécessaire pour qu'un individu puisse se être capable de marcher.

Le fait d'avoir une lésion 'spastic or flaccid' ne permet pas un pronostique sur l'éventuel emploi de support dans ce groupe.

ZUSAMMENFASSUNG

Das Studium wurde durchgeführt um den Gebrauch der langen Beinprothesen nach der Entlassung von G. F. Strong centre zu finden. Die Patienten wurden in ihrem Haus oder in dem 'Centre' befragt. Eine physikalische Untersuchung wurde durchgeführt um ihren gegenwärtigen Stand zu beschätzen. Sechzehn von 98 benutzten ihre Prothesen für funktionelles Gehen, 25 gebrauchten sie zum Exerzieren oder Stehen und 57 verwendeten sie überhaupt nicht mehr. Wechselbeziehung zwischen physikalischen Stand und Prothesengebrauch wurde gemacht. Für 'funktionelles Gehen' Grad III oder

groessere Muskelstaerke in den Hueft 'flexors', Unterleib Muskelatur und Ruecken Streckmuskelen war noetig. Empfindungsnerven in der Huefte oder Knie Gegend war nicht noetig, fuer eine Person ein 'funktioneller Geher' zu werden. Man konnte keine Voraussagung ueber den schliesslichen Gebrauch der Prothesen in Gruppen von 'spastic' oder 'flaccid' Verletzungen machen.

Acknowledgements. This study was funded by the Vancouver Foundation, to whom we are indebted.

REFERENCES

- COGLAN, J. K., ROBINSON, C. E., NEWMARCH, B. & JACKSON, G. (1977). Paraplegia—a follow-up functional review. *B.C. Med. J.*, **19**, 386–389.
- HAHN, H. R. (1970). Lower extremity bracing in paraplegics with usage follow-up. *Paraplegia*, **8**, 147–153.
- HUSSEY, R. W. & STAUFFER, E. S. (1973). Spinal cord injury: requirements for ambulation. *Arch. Phys. Med. Rehabil.*, **54**, 544–547.
- KAPLAN, L. I., GRYNBAUM, B. B., RUSK, H. A., ANASTASIA, T. & GASSLER, S. (1966). A reappraisal of braces and other mechanical aids in patients with spinal cord dysfunction: results of a follow-up study. *Arch. Phys. Med. Rehabil.*, **47**, 393–405.
- LEHMANN, J. F., STONEBRIDGE, J. B. & DELATEUR, B. J. (1977). Pneumatic and standard double upright orthoses: comparison of their biomechanical function in three patients with spinal cord injuries. *Arch. Phys. Med. Rehabil.*, **58**, 72–80.
- LONG II, C., LAWTON, E. B. (1955). Functional significance of spinal cord lesion level. *Arch. Phys. Med. Rehabil.*, **36**, 249–255.
- RAGNARSSON, K. T., SELL, G. H., MCGARRITY, M. & OFIR, R. (1975). Pneumatic orthosis for paraplegic patients: functional evaluation and prescription considerations. *Arch. Phys. Med. Rehabil.*, **56**, 479–483.
- ROSMAN, N. & SPIRA, E. (1974). Paraplegic use of walking braces: a survey. *Arch. Phys. Med. Rehabil.*, **55**, 310–314.
- SILBER, M., CHUNG, T. S., VARGHESE, G., HINTERBUCHNER, C., BAILEY, M. & HIVRY, N. (1975). Pneumatic orthosis: pilot study. *Arch. Phys. Med. Rehabil.*, **56**, 27–32.
- STAUFFER, E. S. (1974). Orthotics for spinal cord injuries. *Clinical Orthopaedics and Related Research*, **102**, 94–96.