The Journal of the International Society for Prosthetics and Orthotics

Prosthetics and Orthotics International

December 1987, Vol. 11, No. 3

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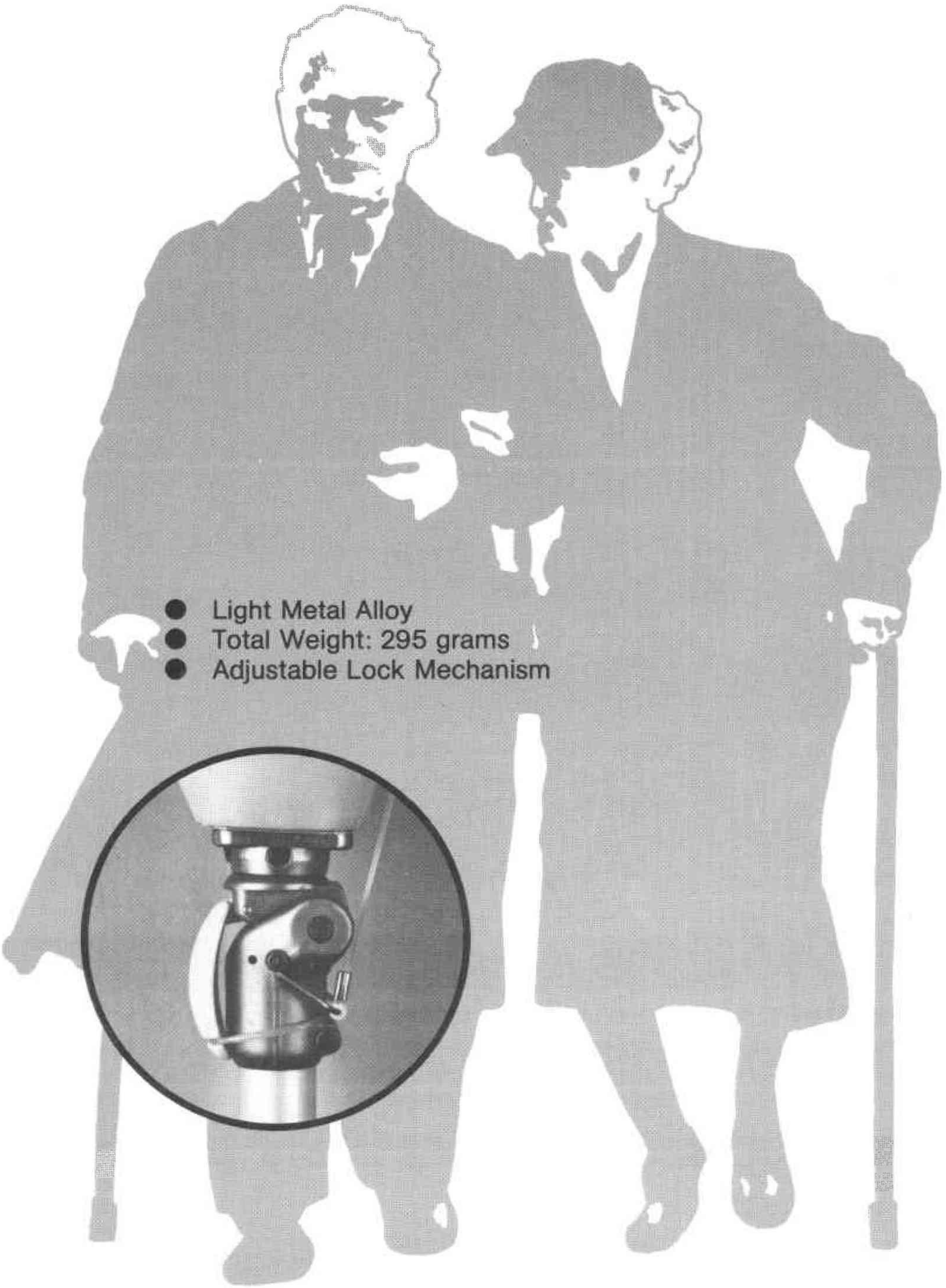

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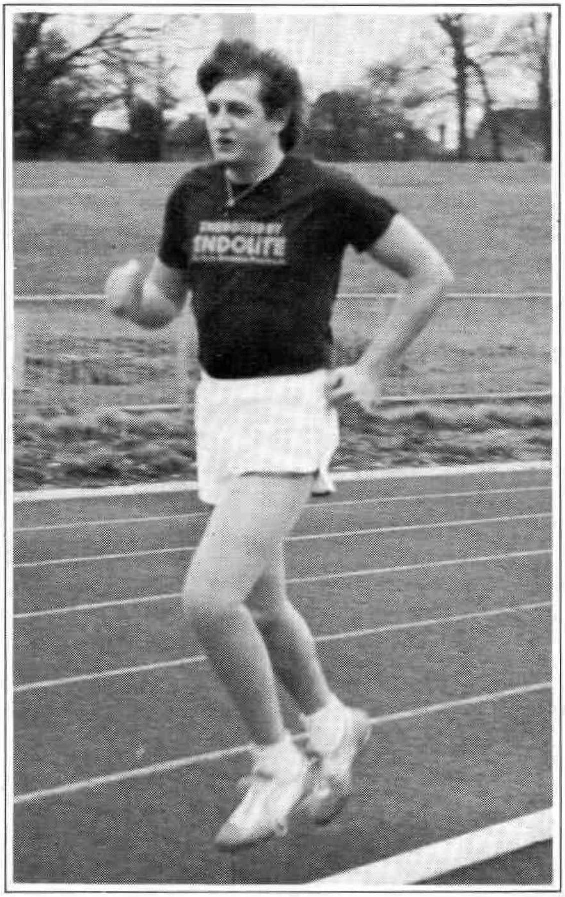

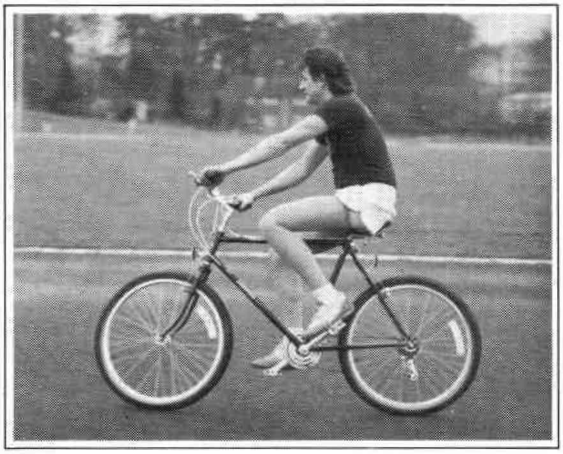

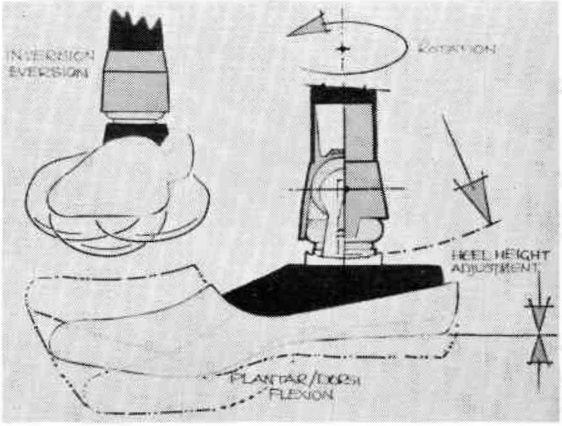

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December 1987, Vol. 11, No. 3

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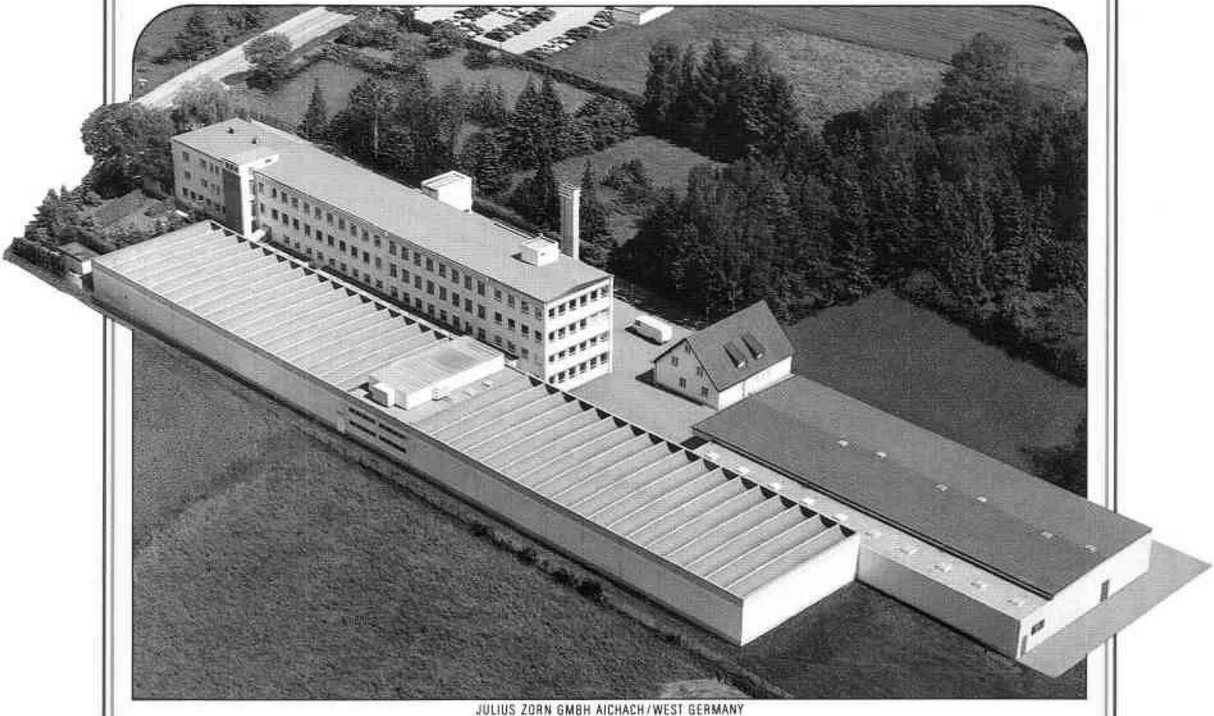
MEDICAL COMPRESSION IN MESHES
A FAMILY TRADITION FOR

75 YEARS

THE SPIRIT BEHIND THE DEVELOPMENT
OF JUZO PRODUCTS: DEVOTION TO SERVICE



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ISPO

Prosthetics and Orthotics International, 1987, 11, 108

Editorial

In its international activities 1987 has perhaps been the most vigorous and diverse year for the Society since its foundation. The main reasons for this are the increasing recognition of the potential of the Society by other international agencies, the development and stabilization of the Society's international and national structures and the formation of an adequate financial base.

In the developing world we have made available a reduced membership fee which provides individual professional Membership, but recognizes the real financial barrier to membership which has existed in these countries. We have agreed to make available through recognised international agencies free copies of the Journal to promote the dissemination of scientific information. We organized a Workshop on Education, bringing together a team of international experts, including representatives of International Agencies, such as the International Committee of the Red Cross, the World Health Organization, World Orthopaedic Concern, and the World Rehabilitation Fund, to consider the problem of upgrading the many "technicians" who have over the years received an inadequate training. This group has, nevertheless, been the main provider of patient treatment in the underdeveloped areas and their upgrading would have an important effect on patient care. A report will be published on this meeting. We also maintained a useful dialogue with many of the important international agencies contributing to, and enhancing, their activities.

In relation, mainly to the industrial world, we held a Workshop on Above-Knee Fitting Techniques, in which the foremost workers in this field examined in detail the various new socket shapes described by such terms as "Narrow Medio-Lateral" and "CAT CAM". Resulting from that Workshop will be a published Report and a Manual on which it is hoped to base an evaluation leading to improved understanding of the options available. Two most successful and important international conferences, in Israel and the Netherlands respectively, focussed on problems of traumatic amputation and on lower limb prosthetics. It is intended to publish the Proceedings from both these meetings for the benefit of those who were unable to attend. Throughout the year the Society also maintained a high level input to the various relevant committees of the International Standards Organization.

It is, of course, also a matter of great satisfaction to see so many of our National Member Societies thriving and enlivening professional activity in their own countries. Nationally, ISPO will often be the only multi-disciplinary society to provide an appropriate forum for the professionals involved in this field to consider and discuss the whole spectrum of activities from research through education to clinical practice. Internationally, it is the only such society, and it is the international aspect of our activities which will provide the continuing stimulus to raising national standards. Our Constitution commits us to promoting high quality care for all people with skeletal and neuromuscular disabilities. Our international activities and communication provide the vehicle for the realization of that ideal.

John Hughes
President

Prosthetics and Orthotics International, 1987, 11, 109–111

Executive Board Meeting

22nd and 23rd June, 1987

The following paragraphs summarize the major discussions and conclusions of the last Executive Board Meeting held in Barcelona. They are based on the draft minutes of that meeting which have not yet been approved by the Executive Board.

Committee, Task Officer and Consultant Appointments

Wyn Beasley was appointed International Consultant for New Zealand. Joan Edelstein (USA) and David Condie (UK) had been appointed as Task Officers for the proposed International Newsletter. An updated list showing these appointments can be seen on page v of this issue of the Journal.

Task Officer Reports

The Honorary Treasurer reported that the accounts for 1986 had been published in the April edition of the Journal. The Executive Board approved the appointment of part-time help in the Central Office in Copenhagen in order to meet the increase in administrative duties which have arisen over the past few years mainly due to the rise in membership numbers and the increase in ISPO activities in general. In addition to this, a new computer system has been installed which will handle all records and work related to the preparation of a professional register of members. The Executive Board agreed that in future all subscriptions and advertising charges for the Journal should be charged in Pounds Sterling due to the fact that the expenses related to the production of the Journal occur in British currency. It was further agreed that for 1988 the subscription rate to the Journal should be £42.00.

Al Muilenberg (USA) had accepted the invitation to fill the vacancy on the Protocol Committee. The Executive Board discussed the recommendations made by the Protocol Committee in relation to the Blatchford Prize and the Forchheimer Prize. Announcements concerning these Prizes appear elsewhere in this issue of the Journal. The Executive Board discussed proposed changes to the Constitution and agreed to recommend them to the International Committee. These proposed amendments can also be seen in this issue of the Journal.

No new National Member Societies have been established recently, but correspondence is currently in progress with members in New Zealand, Pakistan, Korea, Tunisia, Malaysia, Mexico, France and India in this regard. It was also noted that the membership of the Netherlands National Member Society was now over 300.

An ISPO Workshop on ‘Above Knee Fitting and Alignment Techniques’ which examined the narrow mediolateral socket configurations, was held in May of this year in Miami. This was a very successful event and was well attended by professionals from the USA and Europe. The Veterans Administration had separately sponsored attendance from the Prosthetics/Orthotics Schools in the USA. It is anticipated that a full report of this Workshop will be available shortly.

Arrangements were well underway for the Workshop to be held in July in the University of Strathclyde on the ‘Upgrading of Short Course Trained Technicians from Developing Countries’. The Executive Board agreed to collaborate in the meeting organized by the African Rehabilitation Institute (ARI) and the International Labour Organization (ILO) to be held in Cairo in August of this year. The purpose of this meeting was to discuss the production of low cost aids and appliances in the African continent. The report from the Jonkoping Workshop ‘Training and Education in Prosthetics and Orthotics for Developing Countries’ held on 12–16 August 1985 was now published and copies are available to members at a cost of $5 (US) and non-members at $10 (US), available from the ISPO office in Copenhagen.

The Chairman of the Publications Committee hoped that the first edition of the new International Newsletter would appear in the December issue of the Journal. Willem Eisma (Netherlands) retired as Chairman of the Publications Committee and Melvin Stills (USA) was appointed as its new Chairman.

Ernst Marquardt has agreed to chair the Committee on the Limb Deficient Child. The first task for this Committee will be to organize the "ISPO Symposium on the Limb Deficient Child" to be held in Heidelberg from 27th August—1st September 1988.

International Organizations

The President of INTERBOR, Jacques van Rolleghem, reported that arrangements for the INTERBOR Congress in Barcelona were going well. He thanked ISPO for its co-operation during the planning stages and for the participation of ISPO members in the Scientific Programme. Arrangements had been made to hold a meeting of a joint education commission between ISPO and INTERBOR during the Congress.

The International Committee of the Red Cross (ICRC) had indicated that they would be sending a representative to the ISPO Workshop on the 'Upgrading of Short Course Trained Technicians in Developing Countries'. They also indicated that a project had been initiated in Afghanistan which would include a training programme for Afghan prosthetists and invited ISPO's participation in the preparation of the Syllabus. Progress on this project had been delayed due to a number of problems which were now largely overcome and it was anticipated that the project would start in the near future. It was also the intention of ICRC to send an observer to the meeting in Cairo in August organized by ARI/ILO.

The Honorary Secretary reported on a meeting in Geneva in June organized by the World Health Organization (WHO). The purpose of the meeting was to hold informal discussions on how to improve the production and delivery of low cost appliances in developing countries. A report of that meeting will be issued in due course by WHO.

The arrangements for the 16th Rehabilitation International (RI) Congress to be held in Tokyo in September 1988 were well advanced. The President of ISPO would make a plenary presentation on "Technology creating new realities". In addition, ISPO would be responsible for organizing a session on "Changes in prosthetics and orthotics with regard to new technology". Morris Milner is to be RI/ICTA representative on the Executive Board.

The World Rehabilitation Fund (WRF) would send a representative to the meeting on "Upgrading of Short Course Trained Technicians in Developing Countries."

The Honorary Secretary had been in contact with Internationaler Verband der Orthopadie Schuhtechniker (IVO) in order to explore future collaboration between the two organizations.

World Orthopaedic Concern (WOC) would also send a representative to the meeting on "Upgrading of Short Course Trained Technicians in Developing Countries". Rene Baumgartner (FRG) and Georg Neff (FRG) would be delivering papers on the role of ISPO in the Developing World at the WOC session to take place at the Societe Internationale de Chirurgie Orthopedique et de Traumatologie (SICOT) Congress to be held in Munich in August. Ernst Marquardt (FRG) indicated that there would be a separate section on Prosthetics and Orthotics at the SICOT Congress and this was being arranged in collaboration with ISPO.

Congresses

The Honorary Treasurer reported that the Final Accounts for the Copenhagen Congress would be available shortly. Seishi Sawamura (Japan) reported on the progress with regard to the 1989 Japanese Congress. A number of suggestions had been made regarding content, speakers, chairmen etc. for the main topic sessions, panel sessions and instructional courses. The Programme Committee would be contacting individuals in the near future and hoped for an early response. Two invitations to host the 1992 Congress had been received: one from Sweden and the other from USA. The Executive Board discussed these invitations and decided to approach both groups requesting further details.

Future Activities

a) Arrangements for the Symposium on the "Traumatic Amputee" to be held in Herzliya, Israel in September were almost completed. Eight Executive Board members would be participating in the programme and a special meeting was arranged for those members at that time.

b) Willem Eisma (Netherlands) reported that the arrangements for the meeting in the Netherlands from 28th–30th October were nearing completion. He had been working in close cooperation with the National Member Societies of Netherlands, Belgium and Germany with regard to the programme. The President would be performing the Opening Ceremony and George Murdoch would be giving the keynote paper on the state of the art.

c) Planning for the Symposium on the Limb Deficient Child from 27th August–1st September, 1988 in Heidelberg had now begun and the first announcement appears elsewhere in this issue.

d) An International Conference on Wheelchairs and Special Seating is being organized to take place in Dundee from 12th–16th September, 1988. It is being organized by the Department of Orthopaedic and Traumatic Surgery, University of Dundee in collaboration with the Tayside Rehabilitation Engineering Services (TRES) and in association with ISPO.

Tape Slide Set

Melvin Stills (USA) had presented some work on the development of a 'Tape Slide Set' which describes the workings of the Society. When the Tape Slide Set is completed, it is anticipated that copies will be made available to National Member Societies for general use.

Sponsoring Members

The Executive Board agreed to the proposal put forward by the United Kingdom National Member Society that in future, Sponsoring Members should each receive three copies of 'Prosthetics and Orthotics International'.

Fellowships

Jean Vaucher (Switzerland) and Colin Peacock (UK) have been elected as Fellows of the Society and since the Executive Board meeting, Robin Platts (UK) has also been elected as a Fellow of the Society.

Norman A. Jacobs
Honorary Secretary

Prosthetics and Orthotics International, 1987, 11, 112

Proposed amendments to the Constitution

The following amendments to ISPO's Constitution have been formulated by the Executive Board and will be discussed and voted on by the International Committee at their meeting which will be held in association with the World Congress in Kobe, Japan from 12th–17th November, 1989.

The main purpose of the proposed amendments to Clauses 2.4.3 and 2.4.4 of the present Constitution is to take account of the fact that there is no standing Membership Committee. The amended clauses reflect the present practise with regard to the admission of individuals to full membership and the nomination of Fellows.

It is also proposed that Clause 2.3.2 is removed from the present Constitution as there are no Associate Members of the Society.

Before the International Committee discusses these proposals Members and Fellows are invited to comment. Comments should be received by the Honorary Secretary before 1st February, 1989.

The following clauses to the existing Constitution should be deleted:

2.4.3. Applications for admission of individuals to full membership as "Member" are referred for approval to the Membership Committee of ISPO by the representatives in the nation of the applicant or in the absence of a National Committee, by personal application. In the case of any application for Membership that has been rejected, an appeal may be made to the Executive Board for final decision by majority vote. Any individual refused nomination for Membership by a National Committee may approach the Membership Committee directly so that his case may be judged on its merit.

2.4.4 Nomination of Fellows is performed by the Membership Committee on recommendation of a National Member Society or any group of five persons on the International Committee. Any such nomination shall be supported by an appropriate citation. The Executive Board will elect all Fellows by unanimous consent.

The Clauses above should be replaced by:

2.4.3 Applications for admission of individuals to full membership as "Member" are referred for approval to the Secretariat of ISPO by the National Committee in the nation of the applicant or in the absence of a National Committee by personal application. In the case of any application for Membership that has been rejected, an appeal may be made to the Executive Board for final decision by majority vote. Any individual refused nomination for Membership by a National Committee may approach the Executive Board directly so that his case may be judged on its merits.

2.4.4 Nomination of Fellows is performed by a National Member Society or any group of five persons on the International Committee. Any such nomination shall be supported by an appropriate citation. Election requires the unanimous consent of the Executive Board.

The following Clause should be removed:

2.3.2 ASSOCIATE MEMBER: individuals who are interested in joining and supporting ISPO but do not satisfy the requirements of professional membership.

Subsequent Clauses should then be re-numbered accordingly.

Prosthetics and Orthotics International, 1987, 11, 113–116

The influence of smoking on the level of lower limb amputation

C. P. U. STEWART

Limb Fitting Centre, Dundee, Scotland

Abstract

A review of smoking habits of 77 vascular related amputees demonstrated a high incidence of smoking significantly greater for men than in the general population. Male smoking amputees with atherosclerosis related peripheral vascular disease were found to have a high risk of having an above-knee amputation. Those with diabetes mellitus whether male or female, smokers or not, had a significantly greater chance of having a below-knee amputation.

Overall, non-smokers were found more likely to have a below-knee amputation than an above-knee ($p<0.05$).

Introduction

Smoking of cigarettes is still common and causes considerable mortality and morbidity (Balarajan, 1985). While the Tobacco Research Council reports that the smoking habits of the United Kingdom population is decreasing (Lee, 1976), the reduction is more significant in the under 45 year old individuals (The Royal College of Physicians, 1983).

Smoking is considered to be a significant factor in the aetiology of peripheral vascular disease of either atherosclerotic or diabetes mellitus origin (Black 1984). These two diseases are the major cause of lower limb amputations in Europe and the United States of America.

Considerable variation in the smoking habits of amputees is reported in the literature. Malone (1979) records 100 per cent of ex-servicemen smoking. Holden (1982) reported that in a group of 120 primary amputees 50 per cent of the males and 28 per cent of the females smoked whereas Stephen (1983) recorded only 28 per cent of patients admitting to smoking.

The influence of cigarette smoking on the ultimate level of lower limb amputation has apparently not been discussed and this study seeks to clarify this.

Method

In 1983 77 vascular associated primary lower limb amputees consecutively admitted to the Dundee Limb Fitting Centre were asked on admission by the author to state their smoking habits prior to the amputation. They were asked to assess their normal smoking habits in contrast to their current habits which might have been influenced by anti-smoking advice or preamputation stress.

Cigarette consumption was graded as follows:

1. Never
2. 0–5 cigarettes daily
3. 5–10 cigarettes daily
4. 10–15 cigarettes daily
5. 15–20 cigarettes daily
6. 20+ cigarettes daily

In addition basic patient information such as sex, age, causal condition and level of amputation was recorded on a purpose designed chart.

Results

The average age of the 77 patients was 70.1 years. There were 51 male and 26 females. Of these there were 40 per cent (31 cases) at above-knee level and 60 per cent (46 cases) at below-knee level. There was no difference between the sexes in relation to amputation level.

The cigarette consumption level for male and females is shown in Table 1. Overall 65 per cent of the patients smoked. It can be seen that 42 of the men (82.4%) were smokers, 24 of whom (57% of smokers) smoked more than 20 cigarettes a day and that only 8 (30.8%) of the females smoked, 4 of whom (50% of smokers) smoked more than 20 cigarettes a day.

All correspondence to be addressed to Dr. C. P. U. Stewart, Associate Specialist in Prosthetics and Orthotics, Dundee Limb Fitting Centre, 133 Queen Street, Broughty Ferry, Dundee, Scotland.

Table 1. Pre-operative cigarette consumption for male and female patients.

	Cigarette Consumption per Day						
	Non-smoker	0 – 5	5 – 10	10 – 15	15 – 20	20+	Smokers
Male	9	2	5	6	5	24	42
Female	18	1	–	1	2	4	8

Table 2. Pre-operative cigarette consumption by above-knee (AK) and below-knee (BK) amputees divided into principal amputation aetiology.

		Cigarette Consumption per day						
		Non-smoker	0 – 5	5 – 10	10 – 15	15 – 20	20+	Smokers
Athero-sclerosis	AK	6	2	2	4	5	11	24
	BK	10	0	1	1	2	11	15
Diabetes Mellitus	AK	1	0	0	0	0	0	0
	BK	10	1	2	2	0	6	11

The cigarettes consumption levels for those with atherosclerosis and diabetes mellitus related amputations are compared in Table 2. It can be seen that those who had atherosclerosis and were smokers had a much higher risk of having an above-knee amputation than a below-knee one. In those who had diabetes mellitus no such distinction can be made.

The non-smokers in both groups had a significantly greater chance of having a below-knee amputation than their smoking counterparts ($p<0.05$).

Tables 3 and 4 show the relationship between aetiology of amputation and the sex of the patient. No clear relationship was found between the number of cigarettes smoked and either the level or aetiology or amputations.

Although no smoking figures are available for this age group in the general population, a figure was obtained by extrapolation of the results obtained by Heller et al (1983) on the assumption that the decline in cigarette smoking continued. Extrapolating to 1983 provided a predicted smoking level of 50 per cent for those over 60 years of age. Comparison with this figure and the 77 cases studied here revealed that a significantly larger proportion of atherosclerosis related male amputees smoked than in the general population ($p<0.05$).

Table 3. Number of patients and aetiology of amputation-relationship with pre-amputation smoking.

	Smokers		Non-Smokers	
	Male	Female	Male	Female
Athero-sclerosis (55)	33	6	4	12
Diabetes Mellitus (22)	9	2	5	6

Table 4. Level of amputation the sex of patients divided into smokers and non-smokers.

	Atherosclerosis				Diabetes Mellitus			
	Male		Female		Male		Female	
	AK	BK	AK	BK	AK	BK	AK	BK
Non-Smoker	0	4	6	6	1	4	0	6
Smoker	20	13	4	2	0	9	0	2

Discussion

Smoking is considered to be a significant risk factor associated with the development of peripheral vascular disease (Black, 1986). The reports on the smoking habits of primary amputees range from 100 per cent (Malone et al, 1979) to 28 per cent (Stephen, 1983). The present study found an overall smoking level of 65 per cent similar to that reported by Holden et al (1982).

The cigarette consumption of both male and female patients was found to be significantly greater than that recorded by Heller et al (1983) and greater than in the general population. The present study found that 57 per cent of the men and 50 per cent of the women smoked 20 cigarettes or more a day whereas Heller et al (1983) found an average consumption of eight cigarettes per day for men and six for women. In keeping with published figures it was found that more men were smokers (82.4%) than women (30.8%) (Lee, 1976; The Royal College of Physicians, 1983) (Tables 1 and 3).

The evidence shows that amputees represent a group who, being heavy smokers, are more prone to develop peripheral vascular disease leading to a significant degree of arterial compromise requiring amputation of lower limbs. Overall the smoking patients with atherosclerosis had a much higher risk of having an amputation at above-knee level than at below-knee. There was not one non-smoking male with peripheral vascular disease who had an above-knee amputation (Table 4). The non-smoking patients had a greater chance of having a below-knee amputation ($p<0.05$). In contrast diabetes mellitus related amputation levels were uninfluenced by cigarette smoking, the diabetic patient however having a significantly greater chance of preserving the knee than those with atherosclerotic related peripheral vascular disease.

In the case of the diabetes mellitus group there was only one above-knee amputation whereas 21 had below-knee amputations and of these, 10 were non-smokers. It is likely that both factors are related to the lower incidence of cigarette smoking and the vascular pathology which in this case is a small vessel vasculitis. Of the diabetics, 50 per cent smoked involving 64 per cent of men and only 25 per cent of women which is a lower consumption than those who had atherosclerotic related peripheral vascular disease. It was not demonstrated that the actual quantity of cigarettes smoked affected the ultimate level of amputation although 50 per cent admitted to smoking more than 20 cigarettes a day. This may relate to the reluctance of patients to admit their true consumption or it is possible that peripheral vascular disease is exacerbated by cigarettes in any quantity.

Penderson (1968) suggested that the key to the restoration of the elderly person is the preservation of the knee joint. The recognition that knee salvage is vital to the future well-being of the elderly amputee has led to the development of sophisticated vascular assessment methods enabling the surgeon to achieve up to 70 per cent below-knee amputation (Spence et al, 1984). The influence of cigarettes on the ultimate level of amputation has demonstrated that those who do not smoke have a greater chance of preserving their knees at amputation. This further emphasises the need for active encouragement to the anti-smoking campaign. The reduction in cigarette smoking habits in young people is encouraging and it remains to be seen if this influences the incidence of peripheral vascular disease related amputation and amputation level in the future.

Acknowledgements

I am grateful to Professor Murdoch for his valuable comments on the text of this paper and to Mrs Copland for typing the manuscript.

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Prosthetics and Orthotics International, 1987, 11, 117–123

Dynamic testing of below-knee prosthesis: assembly and components

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Abstract
Prosthetic assemblies for lower limb amputees are highly engineered and consist of several components each with its own failure mechanism. This paper describes the dynamic testing of HDPE rotational moulded sockets in a specially designed machine which mimics normal gait. Thus the components are subjected to all main loadings occurring during a stride such as axial loading and A–P bending about the knee and ankle. Machine details as well as the other components of the system are described. SACH feet appear to be vulnerable by rapid wear and structural component failures at less than 100,000 cycles were observed. The sockets are much less vulnerable and stand up to simulated loading of 1350 N for approximately 400,000 cycles. Metal components such as the foot bolt may also fail in fatigue if not properly tightened. References to proposed ISO standards are also included.

Introduction
As part of a test programme on prefabricated sockets for below-knee amputees, a dynamic testing machine was designed incorporating preliminary standards proposed by the International Society for Prosthetics and Orthotics (ISPO) in 1978. The machine was designed to mimic loads under normal walking conditions, with the exception of torsion along the long axis of the limb. The below-knee sockets manufactured by rotational moulding, were made from high density polyethylene (HDPE) and were mounted on an Otto Bock pylon system with SACH feet. During the testing, breakdowns of components other than the sockets occurred. The SACH feet wore out prematurely, or broke, the standard aluminium pipe pylon system failed as well as the ankle bolt. This paper describes the test machine and examines the failures of the different components.

Method
Static ultimate load testing of prosthetic components can be simply done on a tensile and compression loading machine. While this is an important aspect of performance and safety, dynamic testing for fatigue failure of the components must also be executed. In dynamic testing, the frequency of loading usually is high so that the test duration can be shortened. However the maximum load and frequency that

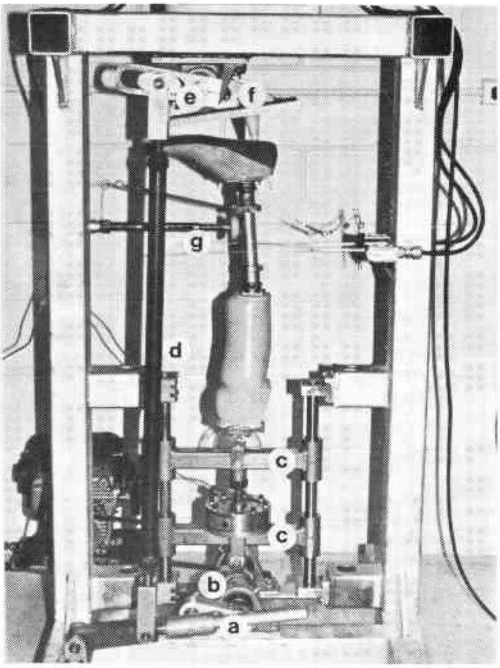

Fig. 1. Dynamic loading machine with cam drive mechanism at bottom, load cell, prosthesis and rocker plate. For explanations of components see text.

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the components can sustain without any effect on its breakdown in fatigue depends on the kind of material tested. This frequency is high for metal components, but usually very low for plastic and rubber parts. For this reason, our test frequency of load cycling was chosen at 1 Hz. The loading machine shown in Figure 1 works on mechanical principles. The prosthesis is positioned upside down in the machine for ease of installation in the test frame. Cam "b" driven by "a" and rocker plate "f" combine to impose the shank-angle and loading for average gait. A commercial load cell sensor at the lower "c" cross bar was built into the slider system. This slider system "c" forces the prosthesis up against the rocker plate at the same time that the plate moves through the cam and linkage bars "d" and "e" providing for a "ground" reaction force at the foot. Stopper "g" with return spring positions the prosthesis at the beginning of the next cycle. The machine is driven by a 110 V synchronous electric motor, through a reduction gearbox, moving the sliders and the rocker plate at one cycle per second.

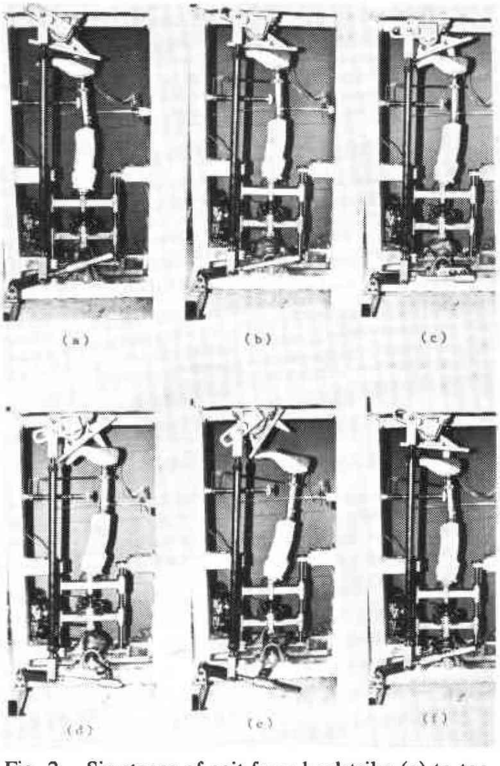
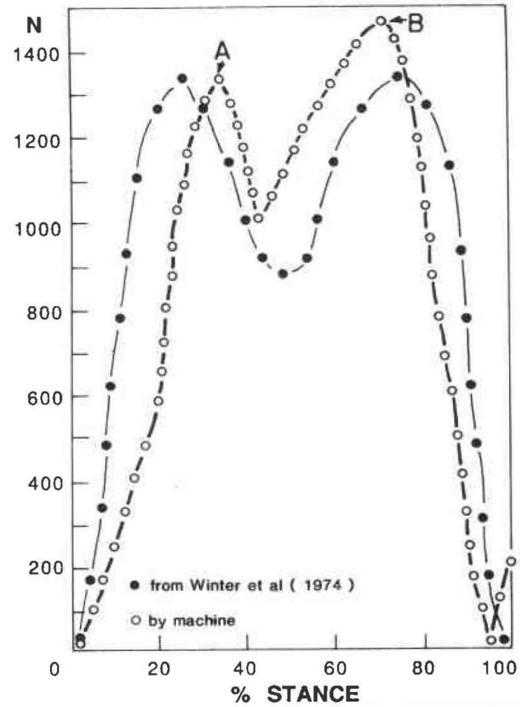


Fig. 2. Six stages of gait from heelstrike (a) to toe-off (e) and the spring activated return to the next stride.

Components of the machine are designed for infinite life. Upon failure of any part of the prosthesis, a micro switch is activated and the machine stops which enabled the researchers to run approximately 80,000 cycles daily.

Required shank angles with respect to the ground were taken from cinematrographic data by Winter et al (1974) and ranged from 17 to 20 degrees at heel strike and 57 to 61 degrees at toe-off. Figure 2 shows a series of successive stages during one gait cycle. The maximum load of 1350 N for cyclic testing was chosen according to the consensus reached at the ISPO Standard Meeting (1978). This maximum load was meant to be applied once per cycle. The resulting load curve applied by the machine as well as averaged data by Winter et al (1974) from the literature are shown in Figure 3. Also shown are the



Moment Nm	Pylon - Foot connection	Socket - Pylon connection
Plantar flexion at A	0	53.3
Dorsi flexion at B	178	99.8

Fig. 3. Desired ground reaction force (black dot) and the machine generated force (open dot) as a function of stance. Maximum moments at indicated points are added.

moments in the sagittal plane at the ankle and the socket pylon connection which inherently result from the loadbearing.

Materials

Sockets were manufactured from HDPE by a rotational moulding technique. The wall thickness was from 3.4 mm to 5.7 mm. The moulding process tended to produce thicker material in corners, thus reinforcing these areas. Figure 4 shows a socket in cross-section.

The pylon system used Otto Bock components for the pylon-socket and pylon-foot connection. The HDPE socket was connected to the pylon by a custom made aluminium-base plate with four threaded screw holes which matched the Otto bock support plate on top of the pylon.

SACH feet from four manufacturers were also tested. The Otto Bock (German) foot had a massive hardwood keel into which a groove was milled to receive a fibre reinforced stiffener (Fig 5, top). The Otto Bock (Winnipeg) foot had a smaller keel and two fibre reinforced stiffeners (Fig 5, bottom). The bottom stiffener was stapled and glued to the wooden keel. Hard rubber was moulded between the stiffeners. The rounded-off keel should also be noted as an important difference from the German design.

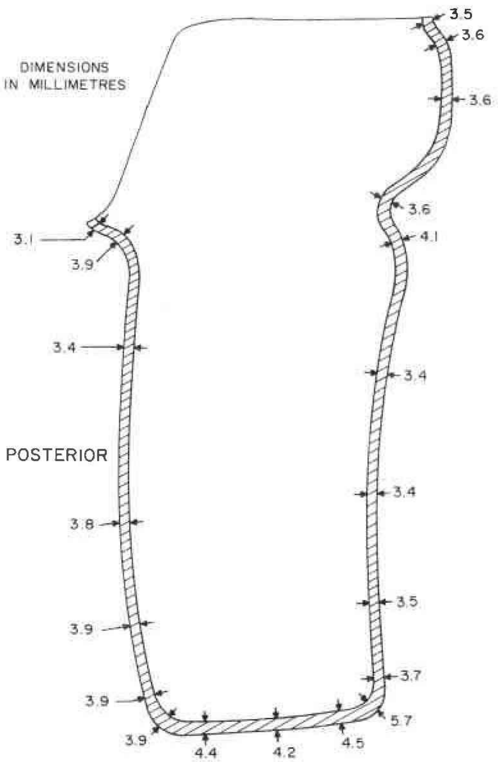


Fig. 4. HDPE rotational moulded below-knee socket in cross-section to show wall thickness at different locations.

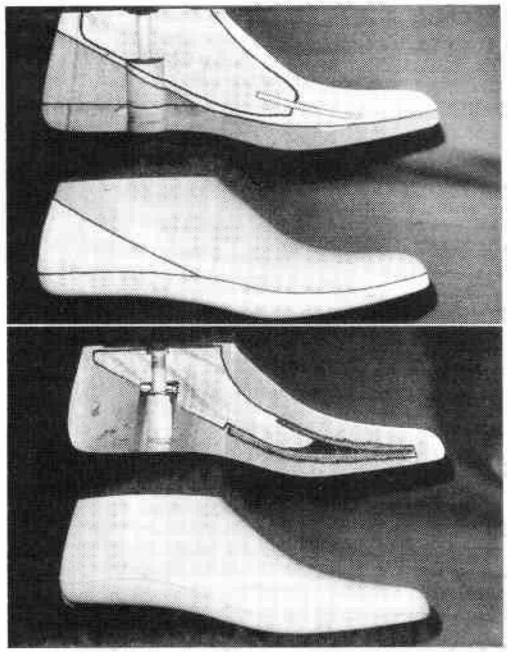


Fig. 5. Top, Otto Bock (German) design with large wooden keel and fibre reinforcement at neutral line. Bottom, Otto Bock (Winnipeg) design with two fibre reinforcements.

The Kingsley design was similar to the previous ones with only one stiffener attached to the bottom of the keel which in turn had a rounded front edge (Fig 6, top). The Kingsley foot had a stiffener moulded into the sole, 3 mm below the surface.

The U.S. Manufacturing foot looked like the Kingsley foot except that it had only one fibre reinforced stiffener which was much thicker than in the other feet (Fig 6, bottom). However, the stiffness of the total assembly was less than that of the Kingsley foot.

Foot, pylon and socket were assembled and aligned by a licensed prosthetist as follows. The sagittal mid plane of the socket was aligned 3 degrees outward from the vertical pylon axis. The socket centre line intersects the base of the foot at 0.33 times the length of the foot measured from the back of the foot. The sagittal mid plane intersects the big toe of the

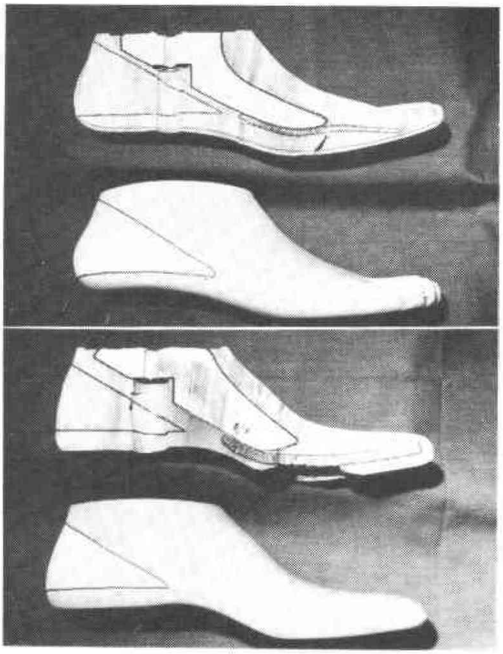


Fig. 6. Top, Kingsley design with round keel tip, well connected fibre reinforcement to keel and imbedded stiffener in sole (shown after testing). Bottom, U.S. Manufacturing Co. design with the section shown after testing. Note thick fibre stiffener.

foot. This assures that the prosthetic system is also subjected to inversion and eversion moments about the ankle. Four samples of each type of foot were tested in a complete assembly.

Results

The fatigue testing of the sockets was continued until micro cracks appeared in the HDPE socket. Micro cracks became visible through "crazing," which turned the normally opaque but glassy appearance of HDPE into a milk white texture in one localized area. If the socket was cycled a little more, the micro cracks would coalesce and form a through the wall crack, which in turn would grow quickly and render the socket useless. Table 1 lists the number of cycles at which the sockets failed. All failures occurred as a result of local bending and buckling at the anterior bottom margin of the socket where it was connected to the pylon.

During the prosthesis testing, the U.S. Manufacturing foot averaged 72,000 cycles (standard deviation 29,825). At an early stage in the testing, the soft rubber sole wore through over the entire width of the foot. This wear also

Table 1. Cycles to failure for rotational moulded below-knee sockets.

Spec. No.	Cycles to Failure
1	400,637
2	370,000
3	460,000
4	436,000*

*test discontinued – no failure

affected the stiffener until two parallel cracks developed beside the stiffener in the rubber of the sole. When the load bearing capacity of the stiffener was exhausted, the feet fractured all the way through.

A hole through the sole of the Kingsley foot wore into the sole stiffener. This in turn decreased the stiffness of the whole foot and cracks appeared in the rubber on the sole and at the instep. This was an indication of the destruction of the inside stiffener which tore after only a few more load cycles. The average life was 105,850 cycles (standard deviation 14,782 cycles).

The Otto Bock (Winnipeg) foot sole wore away after only 25% of the total cycles had been applied. A hole developed through the sole and the underlying rubber into the reinforced stiffener until the remainder of the stiffener broke off. This occurred at an average of 46,000 cycles (standard deviation 7,850 cycles).

During testing the Otto Bock (German) feet first showed a crease at the top of the instep where the keel ended. This crease grew until it spread across the width of the instep. In the later stages, the stiffness of the whole foot decreased, and in the last part of the test a crack appeared in the sole, followed by fracture through the rubber and the fibre reinforcement. The average number of cycles at which this occurred was 43,800 with a standard deviation of 12,900 for the four specimens.

All SACH feet results are listed in Figure 7.

During the testing, two pylons failed in fatigue after 897,600 and 485,900 cycles respectively. The pylons were made from 6.061 – T6 commercial aluminium tubing, Figure 8.

Frequent failure of the standard grade 10.9 ankle bolts occurred at the SACH foot-ankle interface when the bolt was tightened without using a torque wrench. After a torque of 20 Nm (15 ft.lb.) was applied to the bolt upon installation and maintained during testing, no further bolt failures occurred.

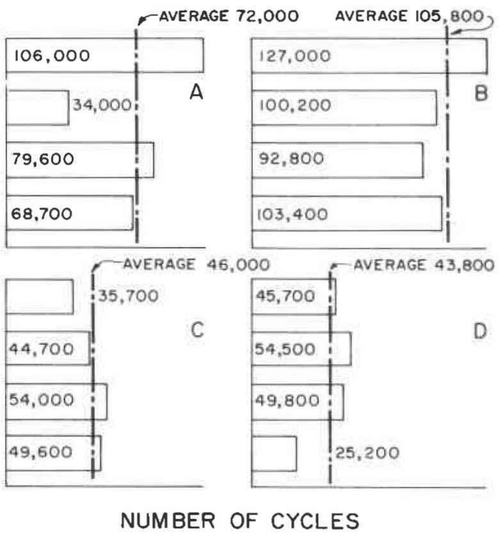


Fig. 7. Number of cycles to breakdown of all SACH feet, U.S. Manufacturing Co. (A), Kingsley (B), Otto Bock (Winnipeg) (C) and Otto Bock (German) (D).

Discussion

Static testing of prosthetic components may assure that ultimate loads of the components or assemblies are well above the loads applied in normal or occasional exceptional use of the prosthesis by the amputee. However, failure can also occur at loads equal to or below those occurring during normal use of the prosthesis. These failures are a result of fatigue or wear. Wear is usually gradual, easily observed, and leads to progressive failure of the prosthesis. Fatigue failure will occur in both metal and plastic components. However, fatigue failure may cause unexpected, sudden breakdown especially in metal components and can be catastrophic. Dynamic testing over a large number of cycles is therefore, necessary. While different testing machines may be used, the load level, frequency of application and load cycle shape are important parameters of fatigue failure. ISPO (1978) recommended standards for fatigue testing which included axial cyclic loads of 1350 N and cyclic AP bending moments about the knee of 120 Nm, as well as ankle bending moments of 140 Nm. These proposals were similar to those set by the Veteran Administration Prosthetic Centre (VAPC) (ISPO, 1978). Current attempts at standardization of performance tests for prostheses by the Japanese Association of Rehabilitation Medicine, (Kakurai, 1984) followed the same method of testing but at a lower load level.

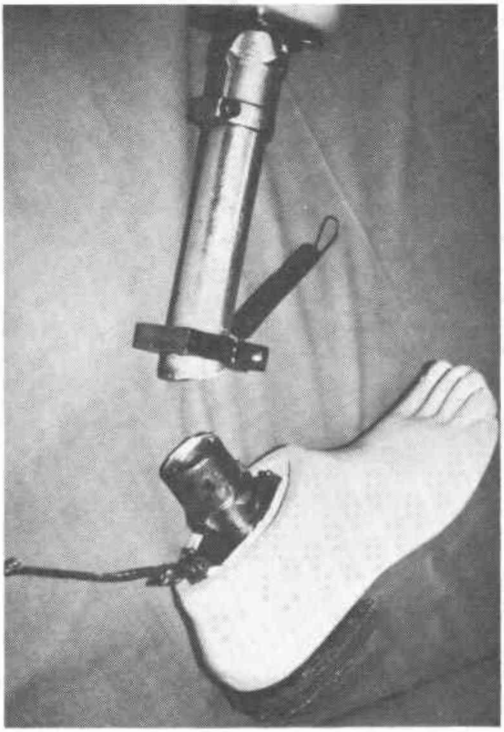


Fig. 8. Pylon fatigue failure at connector-tube interface.

Currently a draft document is being circulated on testing of lower limb prostheses by the International Standards Organization (ISO). It attempts to standardize the testing of lower limb components in their most endangered configuration simulating the forefoot-load situation from the instant of maximum dorsi-flexion ankle moment to toe-off. The loadbearing is a variable, gait dependent, resultant load FR. This force includes pre-load, to eliminate clearances in the test system, and the body weight and the dynamic loading during gait. The application of this force also produces bending moments about the ankle and knee. The authors' test machine applies the loading through the centre of the knee with the loadbearing line between this centre and the foot-ground contact point. The latter varies during gait from heel strike to toe-off as is the case in real life. The vertical machine load is measured in the test set up while the variables defined in the ISO draft are the dependent variables and can be calculated from the load output and shank angle with respect to the ground. It is clear that the sagittal bending moments about the socket-pylon connection point and ankle are most damaging, with respect to fatigue of the pylon and socket system, while the foot-ground contact force ultimately destroys the foot by wear.

Most severe loading conditions occur with mature, heavy and active amputees. However, as illustrated by the fast breakdown of the feet by wear and by fatigue failure of other components in the system, difficulties will be encountered in the design and manufacture of components to match the requirements of $3^{\star}10^{6}$ cycles as proposed by VAPC in the ISPO consensus proposal (1978).

The authors' testing machine was set to produce a peak vertical ground reaction load of 1350 N twice during each cycle which mimicked normal gait. When the maximum axial load had been set, the moments about the ankle and the socket-pylon connection point became dependent variables of the foot dimension and of shank angles at heel strike and toe-off. The slight shift in loading patterns between desired and the one achieved (Fig. 3) is of no consequence to the result of the fatigue failures. Fatigue failure is affected by the root mean square value (RMS), of the loading pattern, Rolfe and Barson (1977) and the RMS values of the achieved pattern were close to the desired value, (994 N versus 1060).

The feet were tested without protective footwear, as it was found that shoes completely altered the characteristics of the feet and the variety of footwear available rendered the observations meaningless. Wear played a role in the destruction of all feet. However, the design features of some feet predisposed them for earlier failure. This was evident with the Otto Bock (German) foot. The fibre reinforcement was positioned approximately at the neutral line of bending which decreased the efficacy of the reinforcement. The stiffness of the foot was achieved by the application of stiff rubbers for the sole and the skin. The fibre reinforcement, furthermore was poorly inserted into the wooden keel and loosened or tore as soon as progressive creasing of the dorsal section of the skin had decreased the foot's resistance to bending. The sharp edge of the keel at the fibre reinforcement insertion site was also a poor design feature. The wear resistance of the sole was very good.

The Otto Bock (Winnipeg) foot utilized the fibre reinforcement much better. While the performance under test conditions was not significantly better, this foot was the lightest of the four designs. The rubber of the sole was not very wear resistant which accelerated kthe destruction in testing.

The Kingsley foot performed significantly better in fatigue testing than the others. The fibre stiffener was larger and was well attached to the heel. There was no sharp transition at the attachment site to the wooden keel. Three millimeters below the sole was an embedded fibre reinforcement. This reinforcement system made the foot stiffer than the other designs. Wear and loss of stiffness were gradual. Final fatigue failure occurred when the main fibre stiffener broke shortly after the appearance of side cracks in the rubber of the skin. This design was the heaviest among the feet tested.

The U.S. Manufacturing Co. foot was very similar in construction to the Kingsley design, although the overall stiffness was less than of the other designs. In order to achieve the required 1350 N loading, larger toe-off angles were required than normal. The sole rubber was soft and wore quickly to expose the fibre stiffener. When the stiffener broke, two large longitudinal cracks developed, at which time the test was discontinued.

The ISPO recommendations are very severe and constitute safety levels for active amputees up to 105 kg load (97.5 percentile of Caucasians, Diffrient et al (1979)). At this level of load many components of the below-knee prosthesis will not stand up to millions of cycles or one to five years if the amputee were to put the maximum load at each cycle. Solomonidis et al (1986) have shown that peak loads of 1350 N were indeed approached during outdoor activities by active amputees and that limited activity patients may at times put on high loads. The majority of prostheses however are used by persons who do not load the limb to these test levels and therefore prosthetic systems will be likely to last much longer than is indicated by this series of tests.

The bolt connection between foot and pylon must be tightened by a torque wrench to the recommended manufacturer's level or to 20 Nm (15 ft.lb.), otherwise premature failure will occur.

Metal fatigue failure may result in unexpected or accidental failure, while plastic and rubber components break down gradually. Therefore, prosthetists should pay close attention to the correct assembly of the metal components as defined by the manufacturer or designer.

Service life of the feet would be increased wearing stockings and shoes. This, however, is difficult to test as the number of parameters becomes large.

The machine loading depended on the design of the drive cam. Loading as a function of shank angles was built in. This is a drawback and for future designs of machines for full length prosthetic limb testing a hydraulic semi-controlled machine would be advisable. While the ISO Working Draft lays the groundwork for much needed standardized total prosthetic system testing, much information can also be gained by testing components only, in load simulating, simpler test machines.

Acknowledgements

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Dynamics of reciprocal gait of adult paraplegics using the ParaWalker (Hip Guidance Orthosis)

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Abstract

Force plate studies with nine adult traumatic complete paraplegics with lesion at thoracic level have shown that, unlike children walking in the Oswestry Hip Guidance Orthosis (ParaWalker) system, they have to apply extra stabilizing forces through the crutches for safe walking. These forces are described and are attributed to an increased crutch force applied to prevent lateral deformation of the orthosis in stance phase.

Introduction

Clinicians and engineers involved in the rehabilitation of paraplegics with thoracic level lesion have long wished to achieve an effective form of ambulation for this heavily handicapped group. Swing through gait using crutches with legs braced in long leg calipers (knee-ankle-foot or hip-knee-ankle-foot orthoses) has been used for many years. However, this method incurs the penalty of high energy consumption. Other devices such as the Swivel Walker (Edbrooke, 1970; Rose & Henshaw, 1972; Stallard et al, 1978) and the Parapodium (Motlock & Elliott, 1966) permit low energy ambulation but are limited to flat, smooth surfaces.

Rose (1979) outlined the principles of the hip guidance orthosis, which was initially designed for children suffering from congenital paraplegia. Over the years design modifications have been made based mainly on clinical experience with these children (Stallard et al, 1986). Lately, with the help of improved understanding of the concept, adult paraplegics have been fitted with the orthosis. Twenty adult traumatic paraplegics have been supplied with the ParaWalker (the name given to the device in routine clinical supply) since 1981. Seventeen of these are still actively using the orthosis. Observation of this group showed that none of them performed as well as junior patients in that they were less confident and ambulation endurance was often limited by pain in the hands. A biomechanical study of their performance was undertaken to see if any reason for this difference could be identified.

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Subjects, method and equipment

Subjects were nine adult traumatic paraplegics with ages ranging from 22 to 33 years and lesions at thoracic level between T4 and T9. All were experienced ParaWalker users and all used elbow crutches.

Each subject was asked to ambulate along the 20′ (6.1m) walkway in the ORLAU Gait Laboratory. A dynamic analysis of their gait was obtained using video recordings from two orthogonally placed cameras and monitoring the outputs of a six channel force platform (Kistler 9261B) mounted in the centre of the walkway. The force platform data was sampled and analysed using a Commodore 4032 Computer interfaced via a 12 bit, 8 channel A/D convertor sampling at 66.67 Hz and presented in a graphical form on a Hewlett Packard plotter.

To enable correlation of the recordings of the events in the gait cycle with the graphical force output, a Real Time Video Vector System was used. It produces a force vector superimposed instantaneously on a television picture of the subject by electronically processing the video signal (Tait & Rose, 1979). The resulting composite signal can be recorded and played back and also contains a display of the video field number.

An inherent limitation of the force platform is that data relating to a specific component or limb segment is invalid if more than one support is in contact with the measuring surface at any one time, or if the support area overlaps the force platform boundary. Hence, using a single force plate, the complete picture of ground reaction forces from two limbs and two crutches requires a minimum of four walks. A walk was considered representative when the subject achieved this without visually detectable hesitation, and with only the limb or crutch in question striking the platform fully. To obtain a complete set of data to represent one gait cycle, subjects were asked to perform a number of walks along the walkway and force platform readings along with video recordings were taken. From these video recordings average time intervals between the events in the gait cycle were determined for each patient. This allowed the average foot and crutch contact times to be established and then the force platform outputs most closely matching these times were selected and temporaly adjusted to exactly fit the time base. This enabled a composite graph to be produced of all ground reaction forces of an average gait cycle for each patient. The graphical results from all nine patients were similar in form and an idealised representation of this is shown in Figure 1.

To ensure acceptable accuracy the total impulse, represented by the summed area under the graphs of vertical force against time for each leg and each crutch during the gait cycle, was measured with a video position

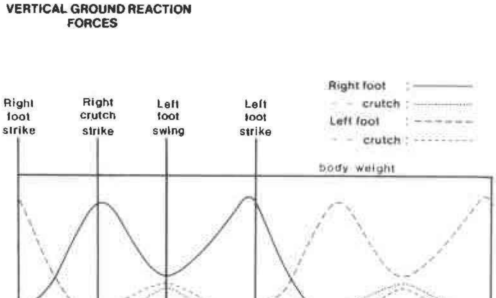

Fig. 1. General form of the graphical results of vertical ground reaction forces against time for adult ParaWalker users. This is an idealized diagram constructed from the general form of all 9 users (see text).

analyser and compared with the product of body weight and duration of the gait cycle. In all patients the difference between the two measurements was less than 5%. The range of forces obtained is presented in the following description.

Description of forces in the gait cycle

Convention

In the following description the forces are those applied by the orthosis or crutch to the ground, not ground reaction forces.

Vertical forces

Phase 1: Right heel strike

When the (R) heel strikes the floor the (L) foot force is beginning to decline after reaching a peak and is approximately 0.8–0.95 BW. and the (L) crutch loading is at a minimum of about 0.075–0.15 BW. The (R) crutch force is very low and is rapidly decreasing as (R) crutch swing approaches.

Phase 2: Right crutch strike
Commencement of body movement to right

At the time of (R) crutch strike the loading on the (R) leg is peaking at approximately 0.83–0.9 BW. and the (L) crutch loading is beginning to increase in order to get the (L) foot off the ground, the load on the (L) crutch reaches approximately 0.28–0.4 BW. and at the same time the load on (R) crutch is also seen to be increasing. It may reach up to 0.28–0.35 BW.

Phase 3: Left early to mid swing and lateral tilt to right

At the beginning of the swing phase vertical loading on both crutches is peaking at approximately 0.32–0.4 BW. and the (R) foot force is at its mid-stance lowest between 0.29–0.47 BW. As the swing phase progresses the crutches begin to unload and at the same time the (R) foot force begins to increase.

Phase 4: Left heel strike

(R) foot force is beginning to decline having reached its peak between 0.8–0.98 BW. and the (R) crutch force is at a minimum of about 0.11–0.18 BW. The (L) crutch force is rapidly decreasing as it approaches (L) crutch swing.

The process continues in the similar fashion with the left leg on the floor and the body moving towards the left until the right heel strikes again.

Horizontal forces

Depending upon the walking style, at the time of foot strike there may be a force directed either forwards (anteriorly) or backward (posteriorly). The reason for this is that some subjects reach their limit of forward leg movement and then allow the foot to swing back and down producing a peak in the posterior direction, whilst the remaining subjects produce an anterior peak because they do not reach their limit of forward movement but bring the foot down whilst it is in forward motion. During the majority of the stance period the horizontal force is predominantly posterior.

The crutch forces in the horizontal direction follow a symmetrical pattern. During the first period the force is anteriorly directed changing to a posterior direction for the second peak producing the forward propulsion.

Transverse forces

Transverse crutch forces do not show medial directional forces at any time during the gait cycle. They are directed laterally throughout the crutch contact.

There is some medially directed force from each foot at the time of footstrike.

Discussion

Dynamic analysis of the force patterns of adult ParaWalker patients has enabled the understanding of the principle of ParaWalker walking to be further advanced. The previous dynamic study of this orthosis (Major et al. 1981) used a subject aged eight years and demonstrated that the crutch vertical force pattern showed only one peak during the later period of crutch contact, whereas the present study with adult paraplegics shows two.

The authors believe that with any large orthosis it becomes difficult to maintain the same relative rigidity as is achieved in smaller devices since bending deformation is proportional to the cube of the length of individual components. With adult patients this deformation may reach such proportions that the swing leg fails to clear the ground. Pushing harder on the crutch has the effect of increasing lateral forces and causing still more deformation in the orthosis particularly in the region of the hip joint (Figure 2b). This can eventually lead to a loss of extrinsic stability

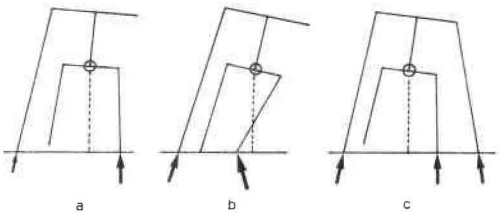

Fig. 2. Diagram showing various modes of ParaWalker crutch use (after Rose 1979). Deformation of the structure is exaggerated for clarity.
a) Ideal situation with a stiff structure enabling a single crutch force to produce foot clearance.
b) Low stiffness in the orthosis allows the stance hip to adduct producing instability as the centre of mass passes outside the support area.
c) Introduction of a force through the remaining crutch restores stability and also reduces loading on the stance foot hence relieving the adducting moment at the hip and restoring more normal geometry.

(Rose 1979). To overcome this problem the patient is obliged to apply large forces through both crutches. Hence two peaks in the vertical crutch force graph occur (Figure 1), the second being the essential force required for normal ParaWalker walking to tilt the body over and clear the swing leg, the first being the force introduced to compensate for instability due to the lack of lateral stiffness in the orthosis (Figure 2c). The forces described here where two peak forces are seen from each crutch and the previous description of forces in which only one peak is seen from each crutch represent two ends of the spectrum of performance of the ParaWalker users. Performance will vary between these two extremes as the relative lateral stiffness of the orthosis changes. Although in theory the stiffness could be increased by the use of larger sections or stiffer materials the scope for improvement in this area is limited since space for the lower hip joint member is restricted as patients need to be able to sit in their wheelchairs and it is difficult to find a material stiffer than steel with suitable failure characteristics.

Consequently alternative methods of compensating for the lack of structural rigidity by means of a hybrid system incorporating both a mechanical orthosis and electrical stimulation of selected paralysed muscles now needs to be investigated. Initial exploratory trials with such a system (Patrick & McClelland, 1985) show promising potential which is worthy of further investigation. The reported study of the dynamics of the mechanical system on the adult patients will provide a useful basis of comparison for trials in Centres undertaking such work.

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Mechanical assessment of polyurethane impregnated fibreglass bandages for splinting

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Abstract
The introduction of polyurethane (PU) resin impregnated fibreglass bandages is likely to have a significant effect on modern orthopaedic practice. The manufacturers of these products claim many improved properties compared to plaster of Paris bandages, such as, high strength to weight ratio, rapid setting time and high radiolucency. This paper reports on a series of mechanical tests designed to assess the strength, flexibility, working time and wear properties of the current range of fibreglass bandages and to compare them with plaster of Paris bandages. The results have clearly demonstrated that the fibreglass bandages are mechanically superior and offer numerous advantages over plaster of Paris for use as the definitive casting material for both weight-bearing and non-weight-bearing casts.

Introduction

The introduction of composite materials technology to prosthetics and orthotics practice offers major advantages in terms of strength to weight ratio and design flexibility. The last few years has seen a rapid growth of resin impregnated fabric bandages, the most common being knitted fibreglass fabric impregnated with a polyurethane resin. The use of a continuous filament fibreglass to produce a fabric which has the strength and flexibility for casting can be achieved by the selection of the appropriate glass fibre diameter and the pattern of the fabric knit. During manufacture the knitted fibreglass roll is impregnated with a urethane pre-polymer resin. The formulation of this pre-polymer resin contributes to the characteristics of the cured polyurethane and hence the properties of the final cast. The bandages are activated by water immersion and wrapped in a similar way to plaster of Paris (POP) bandage.

There is little in the published literature on the properties of fibreglass bandages (Gill & Bowker, 1982; Rowley et al, 1985; Wytch et al, 1987). A series of mechanical tests was devised to supplement the existing knowledge of these materials and to provide a means of comparison of the currently available fibreglass bandages. There are no laid down standards for the properties of these composites but British Standard BS2782: 1978 on the testing of plastics provided guidance for some of the test procedures. Plaster of Paris bandage has been included as a reference for comparison with these materials.

The advantages of casts constructed from PU impregnated fibreglass bandages compared to plaster of Paris (Gypsona) bandages include greater strength, lighter weight, better X-ray transmission, cleaner application and a much faster curing time (weight bearing can be achieved within thirty minutes). The major disadvantages with the PU impregnated fibreglass bandages is their high cost and problems with long-term storage. The resin accumulates in the lowest part of the bandage during storage and

Table 1. Materials studied

Type of bandage	Product name	Activation procedure
100% Knitted fibreglass impregnated with polyurethane resin	Dynacast XR Scotchcast 2 Duraset-lite Zimmer Delta-lite	Immerse in water at 22°C for 5 secs, squeezing 3 times
Plaster of Paris on Leno weave Cotton Bandage	Gypsona	Immerse in water at 25°C for 10 secs squeezing firmly on removal

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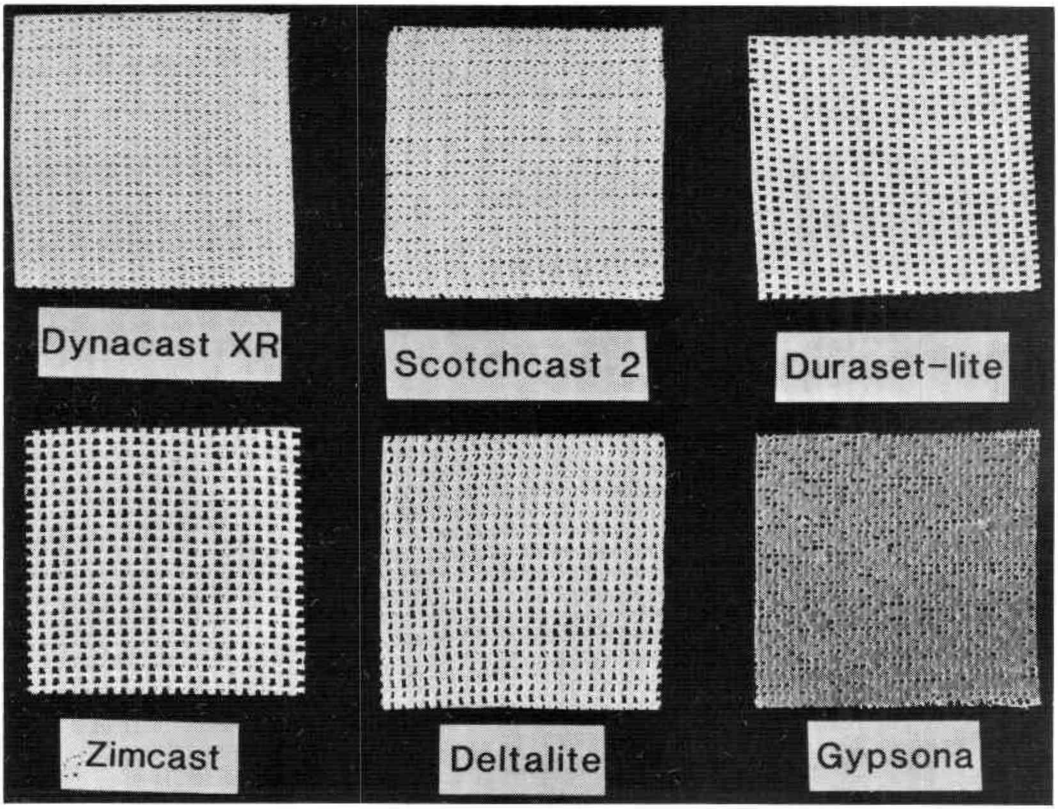

Fig. 1. Samples of PU resin impregnated fibreglass and plaster of Paris bandage. Variation in the knit of the different fibreglass bandages can be seen. Compare the fine knit of Dynacast XR and the coarse knit of Zimcast.

premature polymerisation can occur, the shelf life is therefore limited to about 24 months. The fibreglass bandages do not however have the unrivalled moulding properties of POP bandages (Fig. 1).

Materials and method

A range of mechanical tests was performed on five of the currently available polyurethane impregnated fibreglass bandages and plaster of Paris bandage. In order to minimize experimental errors all sample preparation and testing was carried out by one of the authors. The bandages were conditioned for at least 48 hours at a temperature of 21(±1) degrees Celsius and a relative humidity of 65% (±2%) before use. All bandages were activated according to manufacturers instructions (Table 1).

The eight mechanical tests described below provide a comparison of the currently available fibreglass bandages. However, four of these tests also provide a comparison of the fibreglass with plaster of Paris bandages. An Instron 1195 materials testing frame was used for all except the wear tests. Three types of test sample were used depending on the test method employed, either 50mm or 100mm diameter cylinders, or rectangular specimens of varying dimensions constructed from 100mm (4″) wide bandage. Cylinder diameter, number of layers, deflection and rate of loading were chosen to represent the intended use of the materials under severe conditions. Problems of controlling bandage tension during the preparation of the cylindrical test samples encountered by Gill & Bowker (1982) were overcome using a purpose built test jig. This is explained in the cylinder compression test method below. Mechanical properties of the bandages were obtained using rectangular samples prepared and tested in accordance with British Standard BS 2782 :1976(1986). All tests were carried out on a minimum of six samples of each material and average results are shown below.

1. Cylinder compression test

The aim of the cylinder compression test was primarily to provide a value for the final cast strength of both the fibreglass and plaster of Paris bandages and also provide data on the rate of strength build up of the fibreglass materials. Immediately after bandage activation the 100mm (4″) wide bandage roll was transferred to a toolmaker's jig comprising a base plate supporting two tailstock centres. The bandage core was supported between the tailstock centres and wrapped onto a 100mm diameter motor driven mandrel revolving at a constant speed of 15rpm. This speed maintained a moderate tension in the bandage whilst providing a consistent method of wrapping cylinders from the bandage rolls. Cylinders four layers thick were removed from the mandrel after 30 minutes and transferred to the test jig attached to the Instron shown in Figure 2a.

The cylinders were then compressed diametrically by 10mm, perpendicular to the longitudinal axis of the cylinder, at a rate of 5mm/min and the load recorded. Compression tests were carried out after 30 minutes, 60 minutes, 24 hours and 72 hours. The Gypsona cylinders were not tested after 30 or 60 minutes as they were insufficiently rigid to maintain their shape on removal from the mandrel.

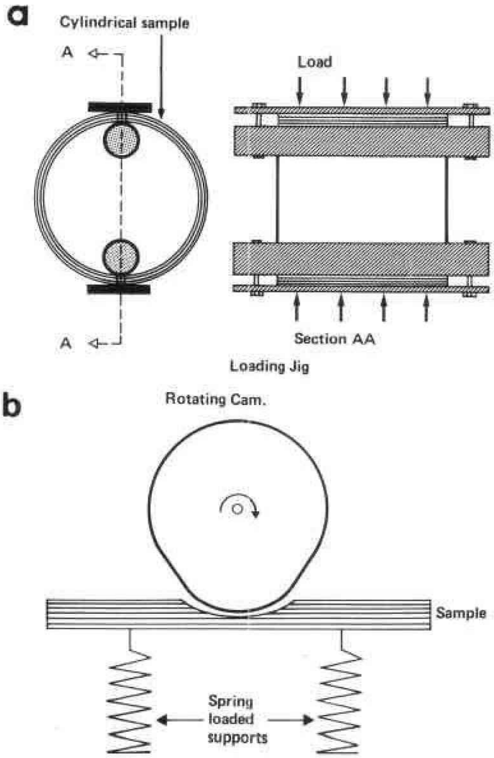

Fig. 2. Schematic of apparatus for: (a) cylinder compression test (b) wear test.

2. Water immersion test

The aim of this test was to determine the effects of water immersion on the strength of the fibreglass bandages. The deterioration of plaster of Paris bandage when exposed to water is well known. Cylinders of each bandage four layers thick were wrapped in a similar fashion to those used in the cylinder compression test and following preparation were allowed to cure for 24 hours in a controlled laboratory environment. They were then subjected to a cylinder compression test. Each sample was then fully immersed in water at 20 degrees Celsius for 60 minutes and re-tested. Subsequent tests were carried out within a 24 hour period after water immersion.

3. Cyclic flexure test

The purpose of this test was to determine the initial rate of strength build up of the fibreglass bandages. Cylindrical samples, 50mm diameter and four layers thick, were prepared in a similar manner to those for the cylinder compression test using the same apparatus but with a smaller diameter mandrel. Each sample was wrapped onto the mandrel and immediately transferred to the Instron test jig. The sample was then subjected to a cyclical loading to produce a deflection of ±2.5mm about the unstressed position using the Instron cycling facility. The load required to produce this deflection was recorded over a 60 minute period.

4. Unrolling tension test

The aim of this test was to provide an indication of the working time for the fibreglass bandages. That is, the time an applicator would have to wrap a bandage before the resin had cured sufficiently to make it difficult to unwrap from the roll. The unrolling tension of the bandage is defined as the time taken for the bandage unrolling force to reach a load of 5N. This value was chosen as manual bandage unwrapping becomes difficult at this load. Bandages were activated in the recommended way and a spindle inserted through the core of the bandage roll. The spindle was attached via a support jig to the load cell of the Instron to record the force required to unwrap the bandage. The free end of the bandage was clamped to the moving crosshead and a constant bandage unrolling rate of 50mm/min. was applied.

5. Rate of lamination strength build up

The purpose of this test was to provide an indication of the time required for the bandage to achieve adequate bond between adjacent layers in a cast. The rate of lamination strength build up was defined as the time at which a delamination load of 50N was reached. This value was chosen since a cured bandage could not be manually unwrapped at this load. The unrolling procedure was similar to the previous test except that the bandage was initially wrapped onto a 50mm diameter mandrel. The bandages were activated and then wrapped onto the mandrel following the same procedure as used in the cyclical flexure test but leaving a 10 cm free end. The mandrel was placed in the Instron and held between tailstock centres so that it was able to rotate whilst the free end of the bandage was firmly clamped and unrolled at a rate of 50mm/min.

6. Three point bend test

The purpose of this test was to determine the flexural modulus and flexural strength of both fibreglass and plaster of Paris bandages. After activation, bandages 100mm (4″) wide were prepared into slabs on a smooth flat surface and covered with a flat board. A uniformly distributed load was placed on top of the board to ensure all slabs were of an even thickness. The slabs were allowed to cure for 72 hours at 22 ($\pm$1) degrees Celsius and were then cut using a bandsaw into samples, 25mm by 100mm and four, five and six layers thick. Samples were tested in accordance with BS 2782 (1978) using a three point loading jig attached to the Instron. The loading rate was 10mm/min. Each material was tested longitudinally and transversely.

7. Tension test

The aim of this test was to determine the fracture stress of the bandage when subjected to a tensile load. Sample preparation was similar to that for the three point bend test except that specimens had dimensions 20mm$\times$150mm and were 2, 3 and 4 layers thick. The test procedure was carried out in accordance with BS 2782 :1976(1986) with a loading rate of 10mm/min.

8. Wear test

The purpose of this test was to determine the wear resistance of fibreglass and plaster of Paris bandages. Bandages were prepared in slab form in a similar way to the three-point bend test to give a sample thickness of 8mm ($\pm$1mm). Slabs were cured for 72 hours before being cut into samples 20mm$\times$170mm$\times$8mm using a bandsaw. Each sample was weighed and measured accurately before and after testing. The test apparatus is shown in Figure 2b. A motor driven cam 25mm wide rotating at 880rpm had abrasive paper attached to the outer surface of the cam prior to each test. Samples of material were clamped to the test jig for five minutes and the sample mass and volume loss determined.

Results and discussion

Variations in bandage mass and width have been included in the results to provide a reliable comparison between specimens. The material strength is therefore defined as the strength per unit mass per unit width of the bandage and has units of N/kg.mm.

1. Cylinder compression test

The results in Table 2 show that the fibreglass materials reached over a third of their final (72 hour) strength within 30 minutes and reached over 90% of their final strength within 24 hours. The results show that the 30 minute strength of the fibreglass bandages exceeded the final strength of Gypsona and after 72 hours they were more than three times stronger. Zimcast was found to be the strongest of the fibreglass materials and also had the greatest 30 minute strength.

2. Water immersion test

The effect of the water immersion on the strength of the fibreglass bandages can be seen in Figure 3. All of the materials showed a decrease in strength after immersion. The

Table 2: Cylinder compression test results

Material	Strength/Mass ratio (N/kgmm)			
	30mins	60mins	24hrs	72hrs
Dynacast XR	7.34	15.84	24.35	25.43
Scotchcast 2	9.08	11.62	22.70	22.70
Duraset-lite	6.04	9.38	20.90	20.95
Zimmer	18.84	21.20	34.25	34.81
Delta-lite	7.27	12.75	29.20	28.95
Gypsona	—	—	4.75	6.09

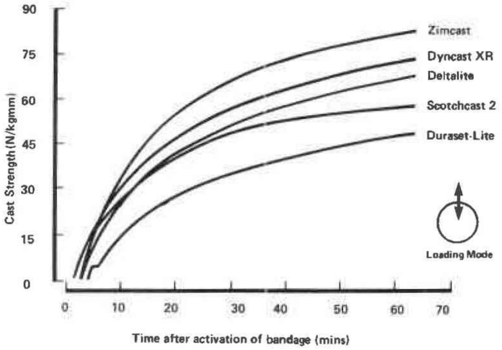

Fig. 3. Water immersion test: effect on strength.

strength of the materials, however, continued to decrease over the next four hours before recovering to 90% of their original strength after 24 hours. The material least affected by water immersion was Delta-lite which at the worst condition lost only 10% of its original strength compared to Scotchcast 2, the most affected, which, at the worst condition had lost 53% of its original strength.

3. Cyclic flexure test

All of the fibreglass bandages showed a rapid increase in strength over the first 20 minutes (Fig. 4). The rate of increase slowed thereafter. Zimcast showed the fastest rate of strength development and Duraset-Lite the slowest. However in practice all materials build up their strength sufficiently quickly to allow weight bearing within 30 minutes.

4. Unrolling tension test

The working time of the fibreglass materials ranged between 3.83 mins. and 2.92 mins. (Table 3). This is more than adequate for applying a bandage of this type.

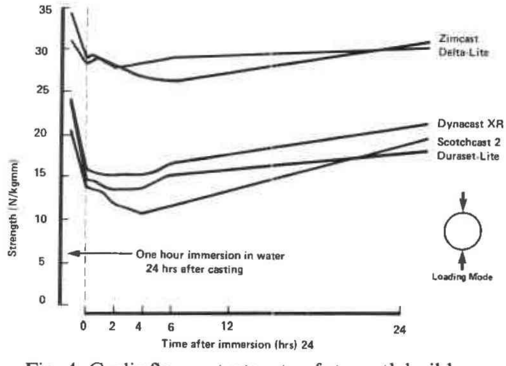

Fig. 4. Cyclic flexure test: rate of strength build up.

Table 3. Critical material times

Material	Working time (mins)	Time to reach bandage lamination strength of 50N (mins)
Dynacast XR	3.28	8.02
Scotchcast 2	3.05	4.77
Duraset-Lite	2.97	8.32
Zimmer	3.83	10.35
Delta-Lite	2.92	5.00

5. Rate of lamination strength build up

Force/time graphs for each material showed large variations in lamination strength between different areas of the bandages. This was due to resin accumulation in the lowest part of the bandage during storage and is one of the disadvantages of this type of material. However if the bandages are regularly turned during storage this problem can be largely overcome. The results in Table 3 show that all the fibreglass bandages reached a satisfactory lamination strength within 11 minutes. This test also showed that all fibreglass bandages reached a lamination strength of over 100N and as much as 200N in the case of Scotchcast 2.

6. Three point bend test

The elastic modulus in flexure (Fig. 5, top) and the flexural stress at maximum load (Fig. 5, bottom) was obtained from a three-point bend test for each material. It was found that these material properties varied significantly when tested in different directions. Samples were therefore tested longitudinally and transversely to the bandage roll. The flexural modulus (stiffness) of the fibreglass materials was greater in the transverse direction than in the longitudinal direction. The opposite was true for Gypsona.

The fibreglass materials were able to withstand higher flexural stresses in the transverse direction than in the longitudinal direction. The opposite was true for Gypsona. The maximum flexural stresses in the fibreglass materials were up to three times greater in the longitudinal direction and up to ten times greater in the transverse direction than Gypsona.

When a below-knee cast is stressed the major bending forces act across the width of the bandage particularly where the calf and foot cylinder meet. It is therefore mechanically desirable to have greater strength and stiffness transversely than longitudinally in the bandage.

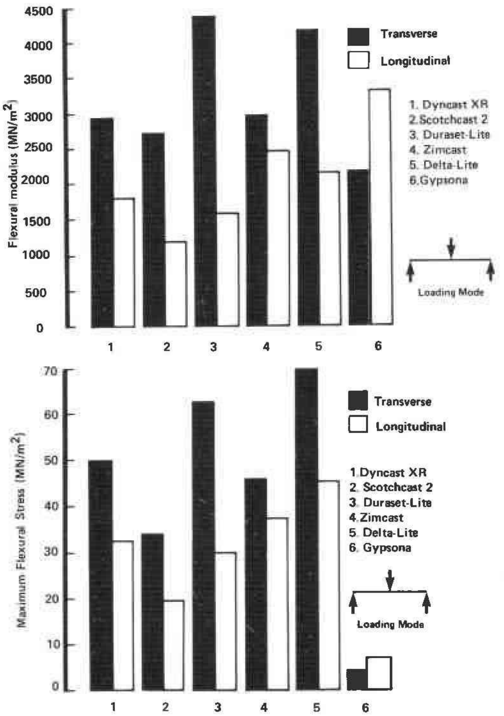

Fig. 5. Top, elastic modulus in flexure: 3-point bend test. Bottom, flexural stress at maximum load: 3-point bend test.

This was found to be the case for the fibreglass bandages.

7. *Tension test*

The difference in properties between the transverse and longitudinal directions can be seen in Figure 6. The fibreglass materials fractured at stresses of up to five times greater than Gypsona in the longitudinal directions and

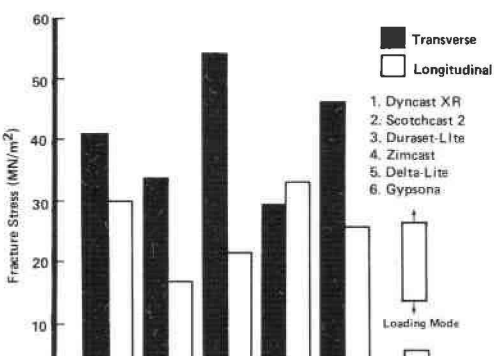

Fig. 6. Fracture stress: tensile test

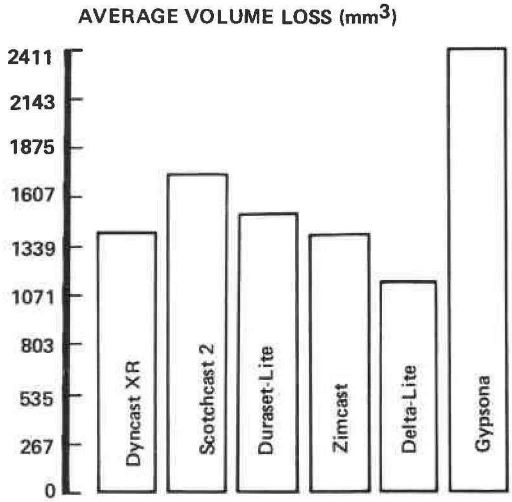

Fig. 7. Volume of material lost during wear test.

up to 20 times greater in the transverse direction. The greatest fracture stress was shown by Duraset-lite in the transverse direction and Zimcast in the longitudinal direction.

8. *Wear test*

The results in Figure 7 show that all of the fibreglass materials were more wear resistant then Gypsona, losing significantly less volume of material during testing. Delta-lite was the most wear resistant fibreglass material being more than twice as hard wearing as Gypsona.

Conclusions

The mechanical tests have shown that the fibreglass materials are mechanically superior to plaster of Paris. They are affected by prolonged contact with water but the effects are not severe and they recover 90% of their strength within 24 hours. The rate of strength build up of the fibreglass materials is rapid enough to allow weight-bearing often only 30 minutes. Gypsona is not recommended for weight-bearing until 72 hours. The bandages have an average working time of over three minutes and reach an acceptable lamination strength after seven minutes.

The fibreglass materials are stronger and stiffer in the transverse rather than the longitudinal direction whereas the reverse is true for Gypsona. This feature being a very important advantage of fibreglass bandages compared to Gypsona when considering the direction of loading in a cast. The fracture stress, typically 22 $MN.m^{-2}$ longitudinally and 32 $MN.m^{-2}$ transversely, of the fibreglass bandages compared to 4$MN.m^{-2}$ and 2$MN.m^{-2}$ respectively for Gypsona demonstrated the mechanical superiority of these materials. The fibreglass bandages were also more hard wearing than Gypsona.

In summary, resin impregnated fibreglass bandages make lighter, stronger and more durable casts than Gypsona and are capable of load bearing within 30 minutes. However, other considerations such as conformability, mouldability, ease of removal and price need to be taken into account when assessing the suitability of these bandages for orthopaedic splinting.

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Prosthetic sockets of polymerized metal: materials, design, technology

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Abstract

The process of fabricating polymerized metal sockets for above-knee and below-knee prostheses is described. The technique is based on pulse stamping of metal blanks over a matrix imitating the negative mould of the stump and subsequent polymeric coating by vibro-vortex spraying.

The monitoring of more than 500 patients fitted with metal-polymer sockets since 1978 is reported.

Introduction

Prosthetic sockets are the most important elements of lower limb prostheses and the selection of materials, their designs and the associated technology development remain urgent problems with respect to patients' comfort as well as the technological and cost aspects of their manufacture.

Physiologically and biomechanically acceptable conditions for stump environment and function are ensured by accurate fitting of the socket and making use of the flexible, thermal, hygienic and other properties of material and design. The required accuracy in individual fitting of the sockets, the cost and complexity of maintaining the equipment, the necessary skills of the personnel, both the active and passive time needed for all operations and other aspects of manufacture are in the end determined by technological feasibility. Prosthetic sockets should be strong and durable enough to tolerate a tensile stress of at least 20 MPa and a flexural stress of at least 15 MPa.

Wide-scale application of homogeneous materials (wood, natural leather, plastics, light metal alloys) clearly indicate that these materials and structures made of them as well as the processing methods employed cannot meet the complexity of up-to-date requirements. Considerable progress was made with composite systems which included materials with a wide range of properties ensuring the desired quality characteristics of prosthetic sockets. Composite systems for prosthetic sockets, developed at present, consist mainly of polymers, thereby causing certain drawbacks in their fabrication and application, e.g., continuous manufacturing time and loss of material strength as a result of aging and other factors.

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Socket fabrication

The authors' approach to developing composite systems is based on the use of a metal former in the basic socket design which is then shaped individually by means of technological operations and finally coated with polymers.

An aluminium alloy, having plastic deformations within the range of 25% is used as a metal former. Polymeric composition is utilized as a non-metal coating.

The technology of fabricating polymerized metal receptacle sockets is based on pulse stamping of metal blanks over the matrix imitating the negative mould of the stump and subsequent polymeric coating by means of vibro-vortex spraying. The main stages of the technological process of fabricating a socket for a below-knee prosthesis will be described.

Initially a negative mould of the stump is made by means of plaster bandages. Woven socks pulled over the stump provide for the required thickness of a metal blank and polymeric coating. The negative mould obtained in this way is placed in a steel box and the space between the mould and the box is filled with a rapidly solidifying substance, for example, a solution of plaster or a mixture of melted paraffin and stearine. The negative mould can be also obtained directly in a plaster solution.

A cylindrical or cone-shaped blank is placed into the inner cavity of the matrix which is then filled with water. The stamping of a blank over the matrix is carried out in the specially designed Pulse Stamping Device — PSD–03.

The operating principle of the device is based on the explosion of a gas charge made up of a stoichiometric mixture of propane or butane with oxygen which fills the power unit of the device, the initial pressure of gases ranging from 0.1 to 0.6MPa. The power unit is a pipe structure, one end of which is shut and has a spark-plug, the other end is open and is sealed with a single use hermetic plug. In the case of the explosion of a gas charge in water, the major portion of energy is concentrated, not in a blast wave, but in a hydraulic flow (up to 80%) which lasts longer than the blast wave, providing slow deformation of the parts being stamped (up to 40 m/sec.). Under these conditions the parts are formed not only due to expansion of the material of the blank but also due to drawing off the excess into the areas of plastic deformation. In this way breakage of blanks and dangerous thinning of the material can be avoided.

The number of stamping cycles is determined depending on the length of the stamped part because the effective pulse loading area ensuring reliable stamping is 10–15mm. Overall stamping time for one socket in a four-cycle operation does not exceed six minutes.

After stamping the part is removed from the matrix, cut off along the upper edge and tried on the patient. At that time the shape of the socket can be corrected easily, if necessary, due to the plastic properties of aluminium alloys, and the required thickness of the polymeric coating is also determined.

In further stages of the technological process the socket is connected with other parts and the polymeric coating is applied on the receptacle module.

For the coating foaming polyethylene has been chosen which is applied on the metal surface by means of vibro-vortex spraying according to Erikson. Adhesion strength is 13–15mm when the metal-polymer system is pressed until ply separation of the plymeric coating occurs with a cross cut. Thickness of the coating can be preset within the range from 0.8 to 6.5mm, thus making it possible to control the accuracy of fitting the socket to the stump. The coating can be removed from metal by means of burning, for example, and then reapplied. That is why when the stump no longer matches the socket volume as, for example, occurs due to atrophy of the soft tissues, it is possible to continue use of the prosthesis after the reapplication of a coating of the required thickness. This technique has proved to be especially effective in early prosthetic fitting.

The forming frames for above-knee sockets were fabricated in 20 standard sizes of aluminium blanks which were corrected with respect to the peculiarities of individual stumps. The high strength of the metal and the sound technological processing permits the manufacture of window sockets and the shaping of convexities capable of weight-bearing over the subtrochanteric area of the femur.

The technology for individual fabrication of the metal frame for an above-knee prosthetic socket by means of the pulse stamping technique is currently being developed. The polymeric coating and the method of its application is the same as for below-knee sockets.

Results

Since 1978 more than 500 patients who were supplied with above and below-knee prostheses with metal-polymer sockets have been monitored. Due to the high accuracy of socket fitting and good hygienic properties of the material the patients concerned did not suffer from those stump disorders which are typical of poor fitting.

Both the weight of the metal-polymer receptacle module (250g for below-knee prostheses, 400g for above-knee prostheses) and their durability are highly appreciated by the patients. In addition, the technological feasibility of the process lends itself to an industrial application for manufacturing the prosthetic sockets.

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Technical note

A low profile paediatric partial foot

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Abstract

A low profile prosthesis was designed using a flexible liner in conjunction with a rigid shell, with a toe extension. Thus far, two paediatric patients have been fitted with the device, at the University of Virginia Medical Center. One patient is a five year old with a Lisfranc level amputation and the other, a sixteen year old with a Chopart level amputation. Both patients have successfully worn their prostheses, full time, for over two years. The prostheses these children have been wearing are comfortable, functional and cosmetic. The prostheses provide excellent suspension, a good weight-bearing surface and an anterior lever arm for push-off during late stance phase.

Introduction

Many of the various types of partial foot prostheses have historically proven to be less than ideal in term of cosmesis. While considerations of comfort and function are quite often met, the partial foot prosthesis is often clumsy and unwieldy in appearance. In an effort to satisfy all three considerations of comfort, function and cosmesis, a low profile prosthesis has been designed using a Dow Corning Silastic Elastomer liner, in a co-polymer polypropylene shell with a toe extension serving as the anterior lever arm.

Method

An impression of the residual limb is taken, with Alginate, under partial weight-bearing conditions. Upon removal of the limb, the negative cast is immediately filled with moulding plaster and a pipe is inserted for ease of handling. Once the plaster has set, the Alginate is removed from the positive model. The positive cast requires very little modification other than light screening to smooth and slight plaster removal to form rectocalcaneo dimples, which aid in the suspension and positive purchase of the prosthesis.

The positive model is then coated with a cast sealer and PVA foil is stretched over the model. A layup of five to seven sewn nylon stockinettes has been used. This may be increased or decreased depending on the size and activity level of the child. An outer PVA bag is applied and the lamination proceeds in the normal fashion, using Dow Corning Silastic Elastomer #382 (Fig 1, top).

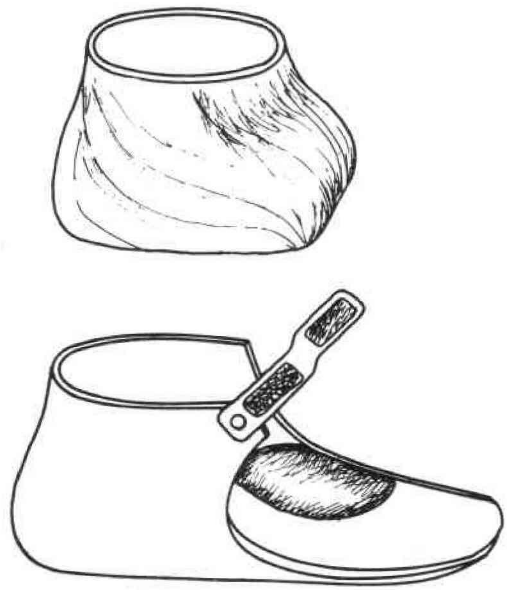

Fig. 1. Top, Dow Corning Silastic Elastomer liner. Bottom, co-polymer polypropylene exterior shell with longitudinal arch pad and elastic suspension strap in place.

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When the laminate has cured, moulding plaster is used to extend the model to match the size and shape of the sound side foot. A nylon stockinette is pulled over the model, to act as a separator, and 3/16″ co-polymer polypropylene is used to vacuum form the exterior shell and toe extension (Fig 1, bottom).

The proximal trimline of the shell is kept low – at or below the level of the malleoli. The medial and lateral trimlines of the toe extension determine the toe break and should be established during fitting. The trimline of the Silastic liner is 0.5 – 1 cm. superior to the co-polymer shell. Plastazote is used to fill the toe extension (Fig. 2, top). After sanding to the proper size, a thin layer of leather is glued and stretched over the Plastazote toe filler. A longitudinal arch pad is cemented in place and a one inch elastic instep strap is attached. The completed prosthesis is shown in Figure 2, bottom.

Donning of the prosthesis is quick and simple. The Silastic liner is pulled over the residual limb. The limb is then pushed into the co-polymer shell and finally the strap is tightened.

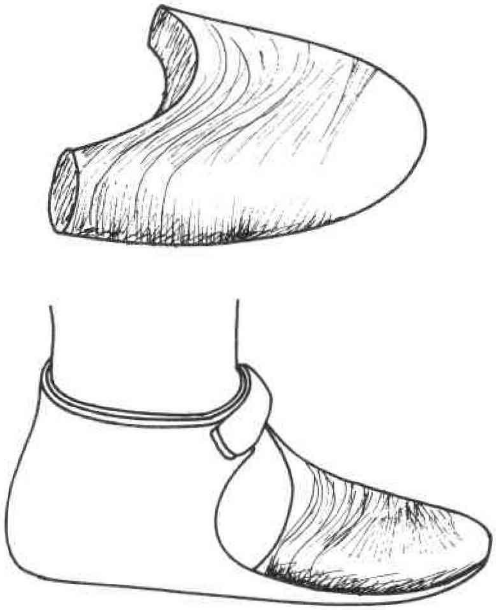

Fig. 2. Top, Plastazote toe filler. Bottom, lateral view of completed prosthesis.

Discussion

The prosthesis has been successfully applied to two paediatric patients. It has met the requirements of comfort, function and cosmesis, as well as having been well received by both the patients and their parents. The low profile design functioned well not only with the Lisfranc level, but also with the Chopart level, which is frequently fitted with a higher profile prosthesis. The thermoplastic toe extension is effective as an anterior lever arm for push-off. The Silastic liner adds a measure of comfort, while the low profile design improves the overall cosmesis. This appears to provide a useful prosthesis for these levels of amputation in children.

Acknowledgement

The author would like to express his appreciation to Richard Rosenberger C.P. (deceased) for his support and guidance in the carrying out of this project.

Prosthetics and Orthotics International, 1987, 11, 139–145

Multifunctional above-knee prosthesis for stairs' walking

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Iwaki Meisei University, Fukushima
**Department of Mechanical Engineering, School of Science and Engineering,*
Waseda University, Tokyo

Abstract

The multifunctional above-knee prosthesis WLP-7R (Waseda Leg Prosthesis – type 7 Refined) described in this study allows amputees to descend and ascend stairs with no external power sources. With the hydraulic circuit mounted in the shank, the ankle joint and the knee joint mutually conterbalance during stance phase in stair walking as well as level walking so that the following performances are obtained. The yielding (flexing) of the knee joint is prevented and smooth advance from stance-phase to swing-phase is realized in level walking. The gradual yielding of the knee joint and the ankle joint while sustaining full body weight is realized in stair descent. Reciprocal stepping with sound and disabled legs during stair ascent is also realised although the powerful extension of the knee joint during stance phase is not possible. The performance of the WLP-7R was examined by a walking experiment in which amputees could descend and ascend the stairs as well as walk on a flat surface after approximately one hour's training.

Introduction

This paper deals with the multifunctional above-knee (AK) prosthesis having the function of permitting stair walking like normal subjects with no external power sources. There have been a few approaches to provide reciprocal walking on stairs (with both lower legs reciprocally advancing and landing on the next stair) by A/K prostheses (Mauch, 1968; Horn, 1972). The knee joints developed in these studies were mechanically locked during stance phase to provide gradual yielding of the knee joints. The fatal problem of these mechanisms lies in the fact that the control of hydraulic flow rate was so difficult that the amputees had to pay undue attention while walking on the stairs (Wagner & Catranis, 1954).

It can be approximately said that a mechanism actuating a knee joint must change its rigidity in three stages (Mauch, 1967). One is the free stage for swing phase, Two is the locking stage and the last stage has the intermediate rigidity of a knee joint for gradual yielding during stairs' descent. However, these stages could be changed continuously or smoothly not suddenly.

In this study a new hydraulic mechanism for above-knee prostheses was proposed and assembled in above-knee prosthesis WLP-7R (Waseda Leg Prosthesis-7 Refined). The proposed mechanism allows the gradual change of the three modes mentioned above. Especially it permits gradual yielding of the knee joint while sustaining full body weight so that the WLP-7R allows amputees to descend stairs in the same way as normal persons and to ascend with reciprocal stepping with no external power source for actuating the knee joint. The WLP-7R is the simplified and refined type of the WLP-7 (Koganezawa & Kato, 1987)

Multifunctional A/K prosthesis: WLP-7R

Figure 1 illustrates the basic structure and the mechanism of the WLP-7R. The most essential mechanism of the WLP-7R is that the cylinder of the knee joint hydraulically connects with that of the ankle joint, by which mutual counterbalance between the ankle joint and the knee joint is realized, which is basically similar to homolateral extensor reflexion. The port B is closed by the ankle piston as the ankle joint

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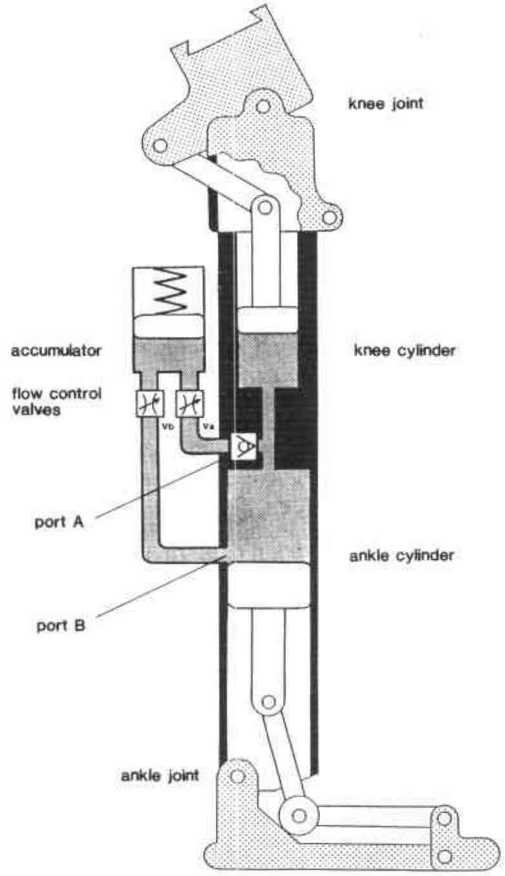


Fig. 1 Structure and mechanism of the WLP-7R.

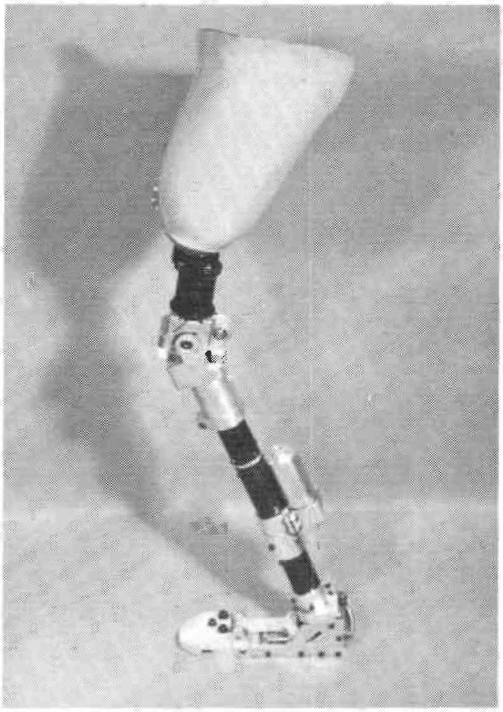


Fig. 2 The WLP-7R.

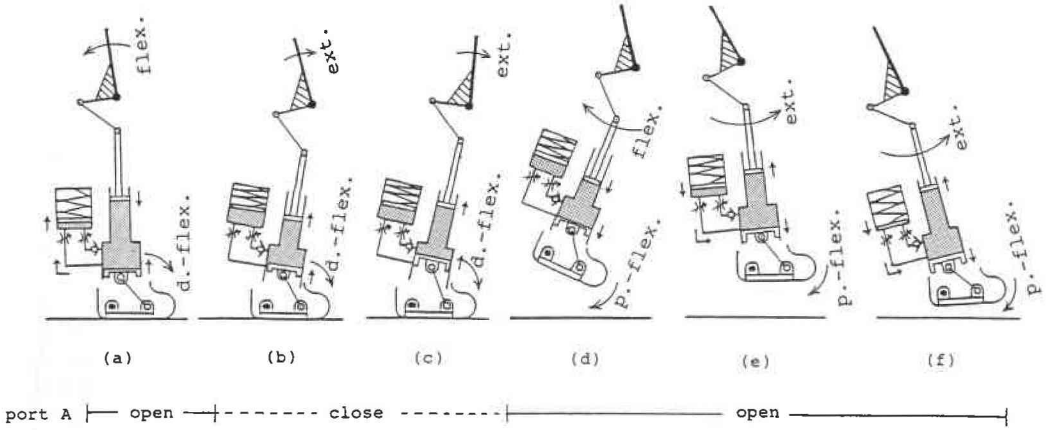
dorsiflexes during a stance phase. Thereafter sudden yielding of the knee joint is prevented by hydraulic pressure which is produced by the dorsiflexion of the ankle joint. At the same time hydraulic energy is stored in the accumulator as spring force. This energy is released for the active extension of the knee joint during the next swing phase.

The appearance of the WLP-7R is shown in Figure 2. The structural material of the WLP-7R is CFRP (Carbon Fibre Reinforced Plastic; black part of the shank in Fig. 2) and duralumin. The weight of the WLP-7R below the knee joint is 2.4 kg which is approximately the same as a conventional A/K prosthesis.

The sequence of the mechanism during walking

(1) *Level walking*

Figure 3 shows the successive movements of the mechanical parts of the WLP-7R, which starts from the time of sole contact (Fig. 3 (a)). The port B is sequentially closed by the ankle piston as dorsiflexion is progressing and the ankle piston is pushed up during the stance phase. Hereafter dorsiflexion of the ankle joint hydraulically pushes the knee piston upward so that yielding of the knee joint is prevented (Fig. 3(b)). At the same time oil gradually flows into the accumulator via port A, of which the flow rate is adjusted manually by the needle valve. Flow rate of the port A determines the rigidity of the knee joint and the ankle joint. After dorsiflexion of the ankle joint is terminated at the end of the stance phase, the knee joint begins to flex gradually so that translation of phase from a stance to a swing is smoothly performed (Fig. 3(c)). The following sequence is consecutively performed after a swing phase starts. The knee joint begins to flex. → The knee piston is pushed down. → The ankle piston is pushed down (Fig. 3(d)). → The port B is opened. → The oil in the accumulator begins to flow back in the ankle and knee cylinders. → The knee joint is actively extended (Fig. 3(e)). → The next sole contact occurs (Fig. 3(f)).



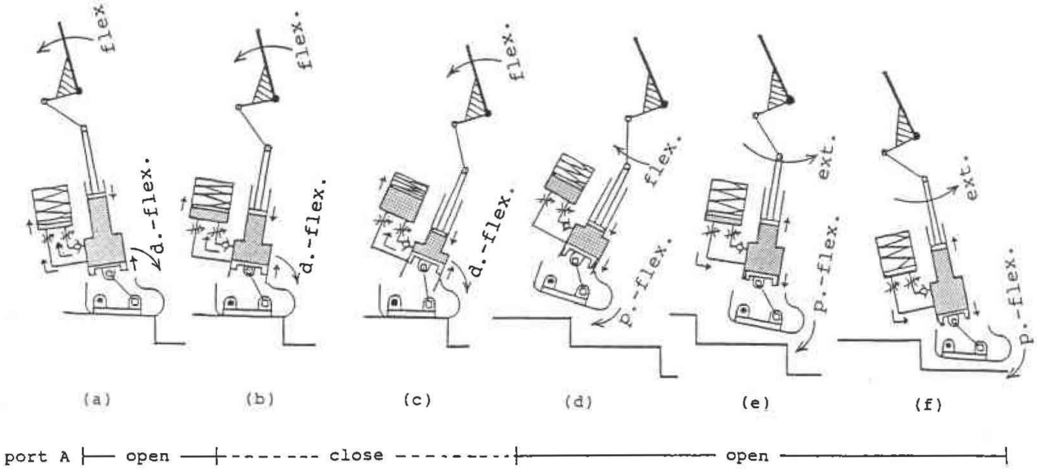


Fig 3. Top, sequential movement of the hydraulic system of the WLP-7R during level walking.

Fig. 4. Bottom, sequential movement of the hydraulic system of the WLP-7R during stairs descent.

(2) *Descending stairs*

The sequence for stairs' descent is basically the same as that of level walking described above. After the port B is closed the ankle joint and the knee joint mutually conterbalance (Fig. 4(b)) so that gradual yielding of the knee joint while sustaining full body weight is realized if the needle valve at the port A is adequately adjusted. Note that automatic stability of attitude, which will be particularly necessary for stairs' descent, is mechanically provided by this hydraulic interaction. For instance, an excessive flexion of the knee joint, which is assumed to occasionally happen, works to plantarflex the ankle joint. The moment of the plantarflexion adversely works to extend or "lock" the knee joint combined with extension moment of a hip joint, so that the excessive flexion of the knee joint will be automatically alleviated. After the sole lifts, the ankle joint starts to plantarflex by spring force, which leads to flexion of the knee joint so that the foot is able to step over the edge of the stairs (Fig. 4(d)). The knee joint starts to extend actively after the port B opens and the oil flows from the accumulator to the knee ankle cylinder (Fig. 4(e)).

Walking experiments by amputees

Walking experiments by an amputee wearing WLP-7R were performed to confirm the prescribed functions of WLP-7R (Fig. 5). After training for about one hour, the amputee (22 years old male amputated at the middle of the left thigh) walked on the flat surface and walked up and down the stairs by reciprocal stepping with his sound leg and his amputated leg wearing the WLP-7R. The needle valve on the channel A was adjusted appropriately according to the amputee's instructions while training. On level walking, he claimed that the knee joint easily yielded if the needle valve was excessively opened, whereas he claimed that it was hard to advance his body forward if the needle valve was unduly closed. The rate of the knee yielding during descent of the stairs was mainly regulated also by the needle valve on the channel A, and by spring force in the accumulator. The amputee started the training to descend the stairs with the needle valve almost closed, so that the yielding rate of the knee was at a slow pace at first. However, the amputee made the yielding rate of the knee faster by gradually opening the needle valve as he accustomed himself to descending the stairs in the same way as a normal person. Finally the opening degree of the needle valve reached the same position as was appropriate for level walking, which means that the amputee could descend the stairs as well as walk on the flat surface with no change of the adjustment of the needle valve.

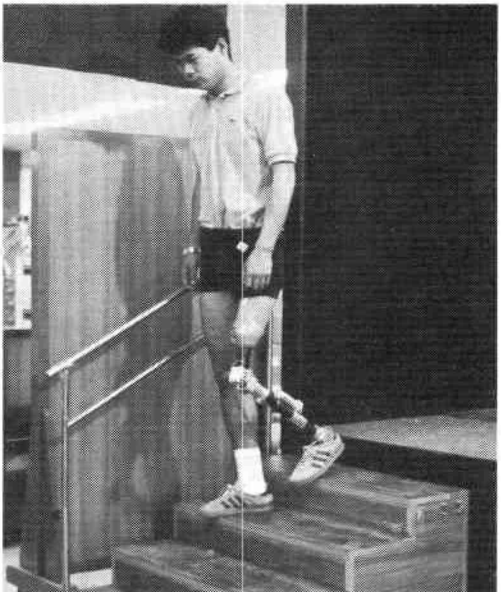


Fig. 5. Walking experiments with the WLP-7R (see text).

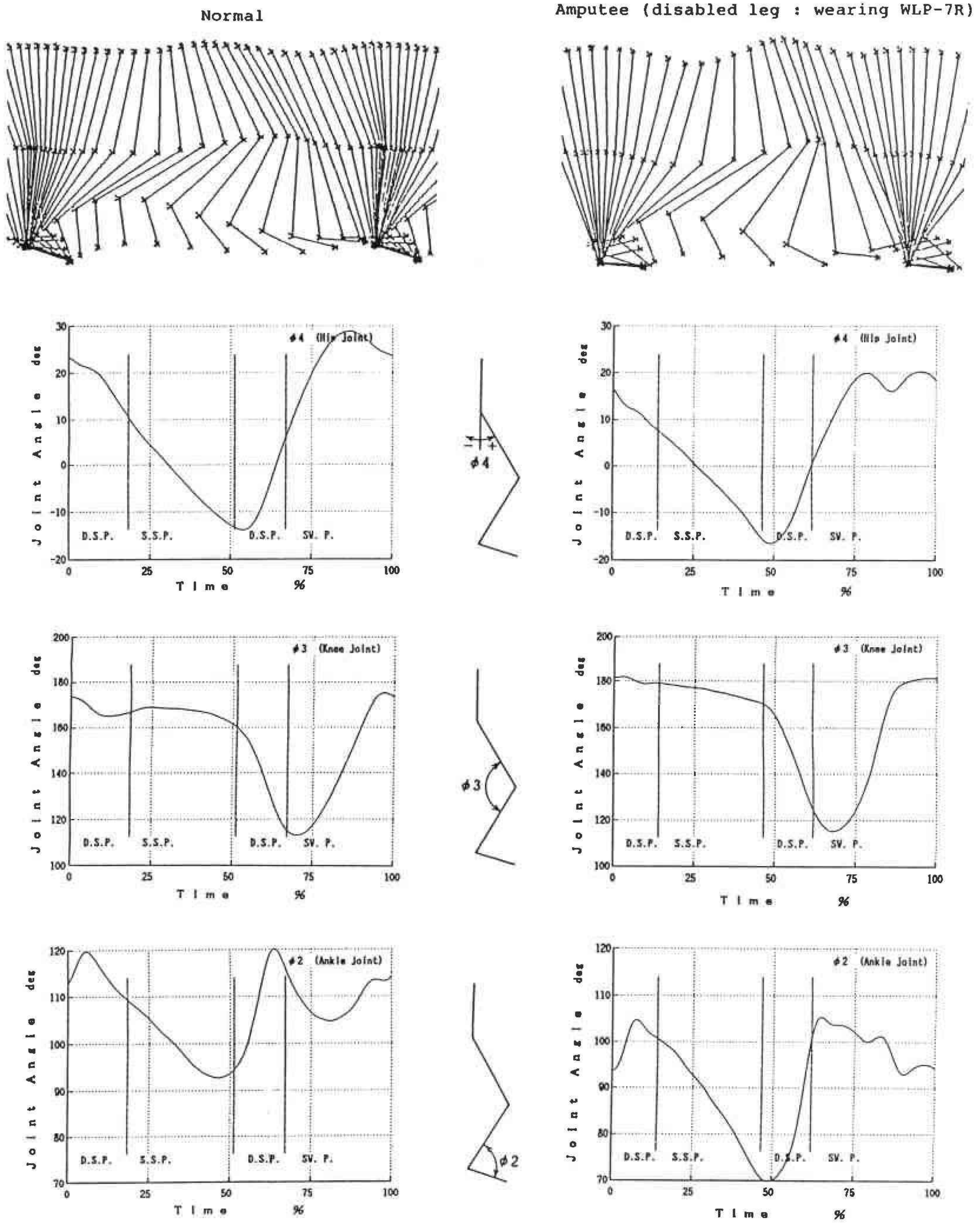
The results of the experiments of walking on a flat surface and of descending stairs are respectively shown in Figure 6 and Figure 7, in which the stick diagrams and the time courses of each joint of the amputee's lower limb wearing the WLP-7R are illustrated in the right columns, while the same results with a normal subject are shown in the left columns for comparison. One of the advantages derived by the proposed hydraulic system, which can be seen in Figure 6, is that the knee joint of WLP-7R was gradually yielding from single supported phase (S.S.P.), so that smooth changing from stance phase to swing phase was achieved. This performance of level walking was similarly shown in descending the stairs, (Fig. 7) that is the gradual yielding of the knee joint of the WLP-7R while sustaining full body weight.

The amputee also tried to ascend the stairs with the WLP-7R. The needle valve was almost closed for ascending stairs. Although active extension of the knee joint and plantarflexion of the ankle joint were impossible because no external actuator was installed, reciprocal ascending with both lower legs (sound and disabled) was achieved, since the mutual counterbalance between flexion of the knee joint and dorsiflexion of the ankle joint almost prevented the yielding (flexion) of the knee joint during the ankle joint's dorsiflexion.

Discussion

It was experimentally verified that a mutual counterbalance between flexion of the knee joint and dorsiflexion of the ankle joint is indispensable not only for descending/ascending stairs but also walking on a flat surface, this is physiologically supported by the fact that each extensor of a lower limb is mutually activated during stance phase. This is termed "homolateral extensor reflexion." Hydraulic power transmission is also necessary for a smooth change between walking phases. Gradual yielding of a knee joint and smooth progression to swing phase were then realized by the "conflict" between joints of the lower limb.

The weight of the WLP-7R (2.4 kg (5.3 lb)) is light enough to be used practically. Further refinement and testing are planned so that the design may be introduced into practical usage.



D.S.P. ; Double Supported Phase
S.S.P. ; Single Supported Phase
SW.P. ; Swing Phase

Fig. 6. Results of level walking experiments. The results for an amputee wearing the WLP-7R are shown in the right hand column with those for a normal on the left.

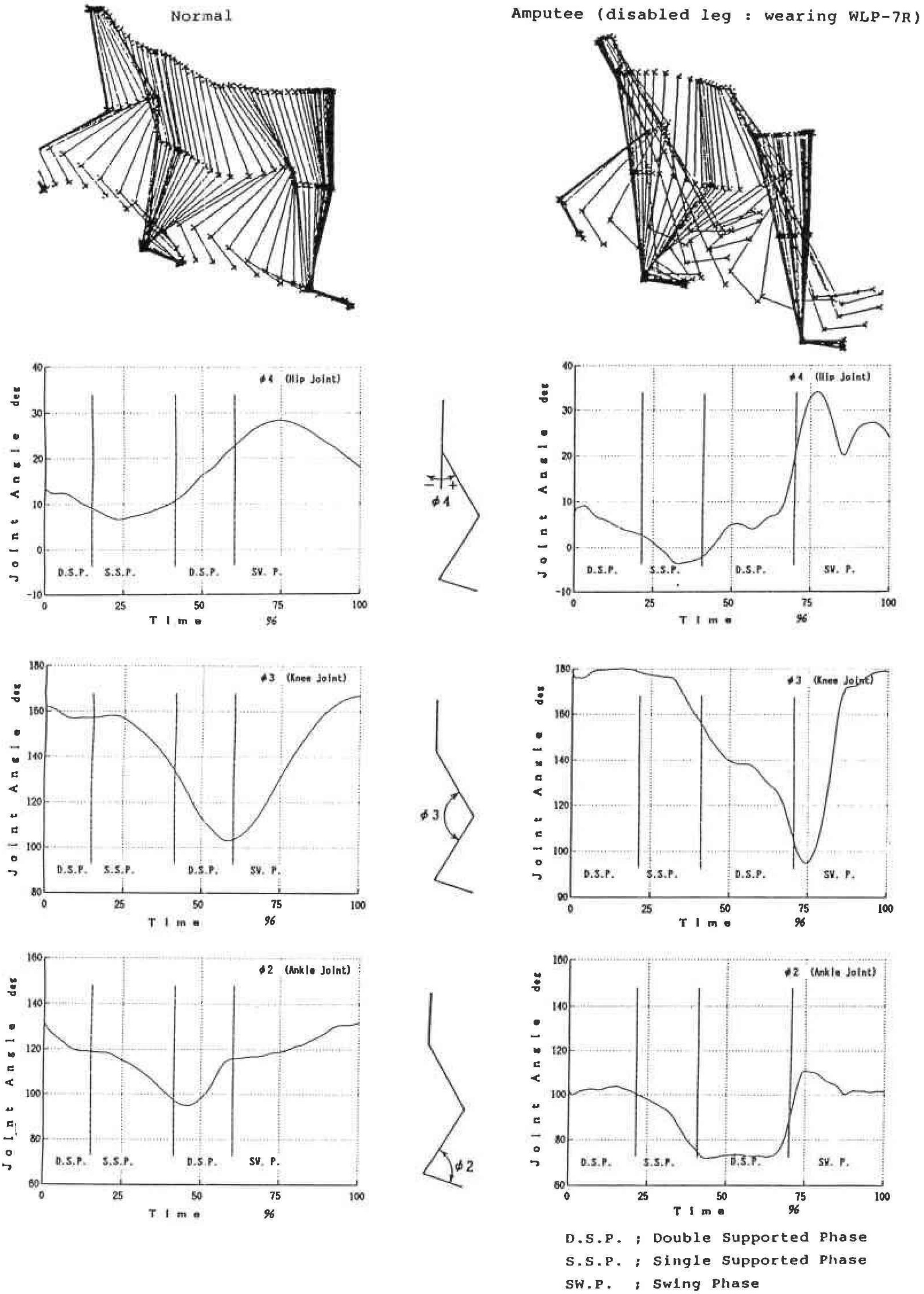


Fig. 7. Results of stairs descent experiments. The results for an amputee wearing the WLP-7R are shown in the right hand column with those for a normal on the left.

Acknowledgment

The walking experiments were performed at Kanagawa Sougou Rehabilitation Centre with much kindness of Mr. Ehara and other staff.

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Prosthetics and Orthotics International, 1987, 11, 146–148

International Newsletter Winter 1987

ISPO members are active participants in professional meetings, instructional courses, and editorial projects. The first issue of the INTERNATIONAL NEWSLETTER features a global sampling of the varied pursuits of our colleagues. Future issues will present additional news, including reports of ISPO national meetings, honours awarded and new appointments of ISPO members, and other information of interest to members. Please forward meeting programmes and other news to David Condie, Co-Editor for European Member Societies, Dundee Limb Fitting Centre, 133 Queen Street, Broughty Ferry, Dundee DD5 1AG, Scotland, or Joan Edelstein, Co-Editor for African, American, Asian and Oceanian Member Societies, New York University, 317 East 34th Street, New York, NY 10016, United States.

Japan National Member Society reports that its membership has increased to 174, including 78 prosthetists and orthotists, 73 physicians, 14 engineers, and nine therapists. The Japan National Member Society presented an instructional course on the ISNY above-knee socket in 1985. Ordinarily, however, other societies, particularly the Japanese Society of Prosthetic and Orthotic Education, Research and Development, founded in 1967, present courses. That organization now has 900 members, consisting of physicians, prosthetists and orthotists, therapists, and engineers; it holds its annual meeting every autumn, and publishes a quarterly Bulletin. At the last annual meeting, held in Osaka, 900 participants heard 90 papers. A symposium on seating problems for the severely disabled was also held. The 1987 Annual Meeting occurred in Sendai on November 28 and 29, when the annual assembly for Japan ISPO members was also held.

Members are also involved in the activities of the Rehabilitation Engineering Society of Japan which is concerned with the application of science and technology in the rehabilitation process. Members include rehabilitation professionals, such as engineers, medical staff, and special teachers; producers, including manufacturers and dealers; and consumers. One purpose is to promote mutual understanding among the groups so that they clearly understand and serve the actual needs of those who can benefit from the application of rehabilitation engineering technology. Conferences attract about 200 participants from a wide geographical area. In 1988, the organization will hold Rehabilitation Engineering International Seminar '88 in conjunction with the Society of Biomechanics and other groups. The National Rehabilitation Center has been the site of postgraduate courses for physicians since 1970, under the auspices of the Japanese Orthopaedic Association, Japanese Association of Rehabilitation Medicine, and the Ministry of Health and Welfare. Approximately 1,100 physicians seeking qualification in prosthetic and orthotic prescription and checkout have attended the two-week courses. A major achievement is the inauguration of a national examination for prosthetists and orthotists in 1988. The examination complements those administered by the Ministry of Health and Welfare for allied health professionals.

On the international scene, the Japan International Cooperative Agency has offered training courses for prosthetic and orthotic technicians from Asian countries since 1981. Dr. Yasuhiro Hatsuyama, National Rehabilitation Center for the Physically Disabled, is the director. Requirements for technicians were determined by means of inspection tours conducted by the staff of the National Rehabilitation Center. Invited trainees are individuals working in public mainstay facilities with at least five years of experience and the potential to become leaders. The four-month programme is taught by physicians, technicians, and engineers. Twenty-nine trainees from 11 countries have completed the programme during the past five years. While the course duration is not sufficient to include all professional techniques, it is useful to promote the international association of people of different customs, languages, and religions. Rendering devoted service are Dr. Hla Pe (Burma), Mr. De Ya (China), Dr. Sim-Fook Lam (Hong Kong), Dr. Handojo Tjandrakusma (Indonesia), Dr. M. S. Moon (Korea), Dr. M. Sivanantam (Malaysia), Dr. J. M. Pujalte (Philippines), and Dr. Thamrongrat Keokarn (Thailand).

The Japan National Member Society of ISPO extends a cordial invitation to all members of ISPO and INTERBOR, as well as to all individuals interested in any aspect of prosthetics and orthotics, to attend the 1989 VI World Congress, November 12–17, at the Kobe Convention Center. This will be the first ISPO Congress held in Asia; consequently, the Organizing Committee will emphasize both the current state of research and clinical experience, and the history of the development of activities in the field by varied Asian countries, thereby illuminating the differences in their cultural and traditional background. By uniting the knowledge and experience of the East and West, the organizers hope to provide a more promising future for all involved in the treatment of incapacitating disabilities. The Organizing Committee has been enthusiastically preparing the programme under the guidance of the International Congress Committee and the Executive Board of ISPO. A more complete announcement will be distributed next summer.

United Kingdom National Member Society held its Annual Scientific Meeting in York University in April. Invited speakers addressed the causes of congenital abnormalities, facial prostheses, bone resorption, and implanted neurological stimulators. A new category of free paper, Clinical Notes, consisted of five-minute papers providing the opportunity for sharing anecdotes on techniques and problem case solutions. The popular innovation will be repeated at the next meeting in Bath University, April 19 and 20, 1988 when special topic sessions on above-knee prosthetics, orthoses for paraplegics, mobility for the disabled, and clinical gait analysis will be featured. Invited speakers will cover rehabilitation services, limb salvage, and the reorganization of the artificial limb service. Following the McColl Report, the government established a special Health Authority in July, headed by Lord Holderness, to administer the Artificial Limbs and Appliance Centres in England, Wales, and Northern Ireland and oversee their transfer to the National Health Service by 1991. The government also instituted a study of the orthotic service in the National Health Service which it is intended to complete by December 1987. Additional meetings scheduled for 1988 include the international conference on wheelchairs and special seating, Dundee, September 12 to 16, and an interdisciplinary symposium on the biomechanics and orthotic management of the foot, Newcastle-upon-Tyne, September 22 and 23. The Society also congratulates its members, Colin Peacock and Robin Platts who have been elected to Fellowship in ISPO.

Hong Kong National Society held the Second Joint Scientific Seminar in cooperation with the Hong Kong Prosthetists and Orthotists Association in July. The seminar drew 70 participants, including physicians, prosthetists, and orthotists who heard speakers consider bracing in the treatment of round back and exaggerated lordosis, management of hip disarticulation at the McLehose Medical Rehabilitation Centre, and prosthetic and orthotic services in Mainland China and Taiwan. Speakers and participants shared their experiences to make the seminar a success.

Australian National Member Society combined its annual scientific meeting held in Melbourne May 25 and 26, 1987 with a three-day course, "Upper Extremity Prosthetics and Orthotics" organized jointly by ISPO and the Central Development Unit. The annual meeting was attended by 130 and the course by 34 participants. The annual meeting featured ISPO overseas guest speakers, Gertrude Mensch from Canada and Joan Edelstein from the United States. Other speakers were from several Australian states, New Zealand, and the United States. Executives for the next biennium are Chairman W. G. Doig, Vice Chairman Margaret Powell, Honorary Secretary Valma Angliss, Honorary Treasurer Martin Masson, and Committee Members Jean Halcrow, Andrew Harding, Raelene Jarvis, and Andrew Nunn. Ms. Angliss and Dr. Doig are the representatives to the International Committee. The next annual scientific meeting will be in Perth, Western Australia, September 30 and October 1, 1988, immediately following the Australian Orthopaedic Association Conference. The Society welcomes speakers and delegates from other ISPO National Member Societies.

United States National Member Society sponsored an international speaker at the recent National Assembly of the American Orthotics and Prosthetics Association in San Francisco. Karl Ruder CPO(C) from Toronto, Canada spoke on "Pelvic Stabilization Socket: West Park Toronto Experience". At the forthcoming Annual Meeting and Symposium of the American Academy of Orthotists and Prosthetists, the United States National Member Society is sponsoring an afternoon devoted to "Expanding Orthotics and Prosthetics Overseas and At Home—Part of Our Mission."

Speakers at the January 1988 convention in Newport Beach, California will include ISPO President John Hughes who will survey "Prosthetics and Orthotics in Developing Countries," and ISPO members J. T. Martin Carlson, CPO discussing "Prosthetics and Orthotics in Madagascar and Nicaragua"; Melvin Stills, CO presenting "Prosthetics and Orthotics in the Pacific Basin"; and Yoshio Setoguchi, MD speaking on "Prosthetics and Orthotics—The Child Population." Other participants will comment on progress in India and with the geriatric population.

Following the very successful ISPO-sponsored workshop on above-knee sockets held in May in Miami, at which invited experts from abroad and throughout the country met in plenary and smaller sessions, a second meeting was held in October to pursue the topic. This meeting, jointly sponsored by United States National Member Society and the American Academy of Orthotists and Prosthetists, brought exponents of the three major socket configurations to Chicago to discuss their differences and to arrive at common principles which are to be practised and taught in the undergraduate and postgraduate prosthetics curricula.

Joan Edelstein, United States National Member Society Secretary-Treaurer, recently completed *Prosthetic and Orthotic Education Aids* which expands upon the *Directory of Films in Prosthetics and Orthotics* she compiled and edited with Ronald Donovan, published by ISPO in 1980. The new directory has been published by the American Academy of Orthopaedic Surgeons. It contains annotated listings of 400 motion pictures, videocassettes, and other productions pertaining to all phases of the field. Listings include the producer, description of the content, format, duration, date of production, and source for free loan, rental, or purchase. Productions are classified according to primary audience, whether clinician or public. Following the alphabetical listing of all productions, the monograph contains a topic index, guiding the user to all aids pertaining to such specialized areas as access, amputee clinical care, hemiplegia, sexuality, wheelchairs, among the many cross-referenced categories.

Joan Edelstein
Co-Editor

Prosthetics and Orthotics International, 1987, 11, 149–152

Calendar of events

National Centre for Training and Education in Prosthetics and Orthotics
Short Term Courses and Seminars 1988

Courses for Physicians, Surgeons and Therapists

NC502 Upper Limb Prosthetics and Orthotics; 25th–29th January, 1988.
NC510 Wheelchairs; 7th–8th March, 1988.
NC511 Clinical Gait Analysis; 14th–16th March, 1988.
NC506 Fracture Bracing; 11th–15th April, 1988. (Also suitable for orthotists and plaster technicians).
NC501 Functional Electrical Stimulation; 3rd–6th May, 1988.

Courses for Prosthetists

NC205 Above-knee Prosthetics; 15th–26th February, 1988.

Course for Orthotists and Physiotherapists

NC217 Ankle–Foot–Orthoses for the Management of the Cerebral Palsy Child; 29th February–3rd March, 1988.

Seminar for Physicians, Surgeons, Therapists and Orthotists

NC717 Orthotic Management in Paraplegia; 2nd May, 1988.

Further information may be obtained by contacting Prof. J. Hughes, Director, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Curran Building, 131 St. James' Road, Glasgow G4 0LS, Scotland. Tel: 041-552 4400 ext. 3298.

North Western University Medical School
Short Term Courses 1988

Courses for Physicians, Surgeons and Therapists

702-B Spinal, Lower and Upper Limb Orthotics; 25–29 April, 1988.
703-B

Courses for Physicians and Surgeons

603-C Lower and Upper Limb Prosthetics; 15–19 February, 1988.
603-D Lower and Upper Limb Prosthetics; 7–11 March, 1988.
603-E Lower and Upper Limb Prosthetics; 11–15 April, 1988.
603-F Lower and Upper Limb Prosthetics; 2–6 May, 1988.

Courses for Therapists

622-A Lower Limb Prosthetics; 18–22 January, 1988
622–B Lower Limb Prosthetics; 18–22 April, 1988

Courses for Rehabilitation Personnel

640 Orientation to Prosthetics; 21–22 March, 1988.

Courses for Pedorthists and Orthotists

801 Pedorthic Management of the Foot; 6–10 June, 1988.

Further information may be obtained by contacting Charles M. Fryer, Director, Prosthetic – Orthotic Center, Northwestern University, 345 East Superior St., Room 1723, Chicago, Illinois 60611. Tel: (312) 908-8006.

22–24 January 1988
Current Trends in the Management of Sports Injuries, Newport, England.
Information: Mr. Graham Smith, Director, Football Association Rehabilitation Centre, Lilleshall, Newport, Shropshire TF10 9AT, England.

4–9 February, 1988
American Academy of Orthopaedic Surgeons Annual Meeting, Atlanta, Georgia.
Information: AAOS, 222 South Prospect, Park Ridge, Il 60068, U.S.A.

19–22 February, 1988
Biannual Conference of the New Zealand Society of Physiotherapists, Wellington, New Zealand.
Information: The Secretary, Conference '88, PO Box 33–031, Lower Hutt, Wellington, New Zealand.

1–4 March, 1988
Intermeditech. International Medical Technology Exhibition and Conference, Glasgow, Scotland.
Information: SEC Exhibition and Conference Centre, Glasgow G3 8YW, Scotland.

2–5 March, 1988
Ontario Physiotherapy Association Convention, London, Canada.
Information: Ontario Physiotherapy Association, 416 Moore Ave., Suite 304, Toronto, Ontario, M4G 1C8, Canada.

6–8 April, 1988
Ste.–Justine Paediatric Orthopaedic Review Course, Montreal, Canada.
Information: Francois Fassier, SPORC, Hopital Sainte–Justine, 3175 Cote Sainte–Catherine, Montreal, Quebec H3T 1C5, Canada.

10–15 April, 1988
10th Congress of the International Federation of Physical Medicine and Rehabilitation, Toronto, Canada.
Information: Secretary, 10th Congress of the International Federation of Physical Medicine and Rehabilitation, 545 Jarvis St., Toronto, Ontario M4Y 2H8, Canada.

12–15 April, 1988
North Sea Conference – Biomedical Engineering (Advances in Rehabilitation Technology), Maastricht, The Netherlands.
Information: Dr. Th. Gerritsen, IRV, Zandbergsweg 111, 6432 CC Hoensbroek, The Netherlands.

12–16 April, 1988
Annual Meeting of the International Society for the Study of the Lumbar Spine, Miami, U.S.A.
Information: Professor Alf Nachemson, Dept. of Orthopaedic Surgery, Sahlgren Hospital, S-413 45 Göteberg, Sweden.

14–16 April, 1988
Second Combined Meeting of Yugolsav and Greek Orthopaedic Associations, Dubrovnik, Yugoslavia.
Information: Professor Dr. Marko Pécina, Chairman, Dept. of Orthopaedics, University of Zagreb, Salata 6, 41000 Zagreb, Yugoslavia.

18–20 April, 1988
ISPO UK Scientific Meeting, Bath, England.
Information: Dr R. G. S. Platts, Institute of Orthopaedics, Brockley Hill, Stanmore, Middlesex HA7 4LP, England.

20-22 April, 1988
British Orthopaedic Association Spring Meeting, Plymouth, England.
Information: Honorary Secretary, British Orthopaedic Association, 35-43 Lincoln's Inn Fields, London WC2A 3PN, England.

25–26 April, 1988
25th Annual Rocky Mountain Bio-engineering Symposium, Colorado, U.S.A.
Information: Dr. Harry L. Valenta, Jr., Research and Engineering, Telectronics Inc., 7400 S. Tuscon Way, Englenwood, CO 80112 Colorado, U.S.A.

May, 1988
5th International Conference on Mobility and Transport for Elderly and Disabled Persons, Stockholm, Sweden.
Information: 5th International Conference Secretariat, c/o Swedish Board of Transport, Box 1339, S–171 26 Solna, Sweden.

5–7 May, 1988
2nd International Symposium on Limb Lengthening and Bone Defects, Utrecht, The Netherlands.
Information: Secretariat, International Symposium on Limb Lengthening and Bone Defects, Obu, Utrecht Congress Bureau, Postbox 14 2 14, 3508 SH Utrecht, the Netherlands.

10–13 May, 1988
Orthopädie+Reha-Technik 1988 International (International Trade Fair and Congress for Orthopaedics and Rehabilitation Technology), Nürnberg, West Germany.
Information: NMA Nürnberger Messe-und Ausstellungsgesellschaft mbH, Objektleitung, Messesentrum, D–8500 Nürnberg 50, West Germany.

18–20 May 1988
2nd S. M. Dinsdale International Conference in Rehabilitation, Ottawa, Canada.
Information: Education Dept., Royal Ottawa Regional Rehabilitation Centre, 505 Smyth Ottawa, Ontario K1H 8M2, Canada.

26–30 May, 1988
Intermedica 88, Paris, France.
Information: CEP, 7 rue Copernic, 75782 Paris Cedex 16, France.

June, 1988
Congress of the World Federation of Occupational Therapists, Australia.
Information: Ms. S. Degilio, Plaistow Hospital, Samson St., London E13, U.K.

8–10 June, 1988
3rd European Conference on Research in Rehabilitation, Rotterdam, The Netherlands.
Information: Office for Post Graduate Medical Education, Erasmus University Rotterdam, PO Box 1738, 3000 DR Rotterdam, The Netherlands.

12–16 June, 1988
Joint Congress of the Canadian Physiotherapy Association and the American Physical Therapy Association, Toronto, Canada.
Information: Congress Secretary, Canadian Physiotherapy Association, 44 Eglington Avenue West, Suite 201, Toronto, Ontario M4R 1A1, Canada.

20–22 June, 1988
American Orthopaedic Association Annual Meeting, Hot Springs, Virginia.
Information: AOA, 222 South Prospect, Park Ridge, IL 60068, U.S.A.

20–23 June, 1988
7th Congress of the International Society of Electrophysiological Kinesiology, Enschede, The Netherlands.
Information: ISEK–88, Congress Secretariat, PO Box 310, 7500 A H Enschede, The Netherlands.

26 June–1 July, 1988
Spinal Disorders, 1988, Gothenburg, Sweden.
Information: Spinal Disorders 1988, Prof. Alf L. Nachernson, Dept. of Orthopaedics, Sahlgren Hospital, S–413 45 Gothenburg, Sweden.

6–13 August, 1988
World Congress on Medical Physics and Bio-engineering, San Antonio, U.S.A.
Information: David T. Kopp, Dept. of Radiology, Univ. of Texas, HSCSA, 7703 Floyd Curl Drive, San Antonio, TX 78284, U.S.A.

27 August–1 September, 1988
ISPO Symposium on the Limb Deficient Child, Heidelberg, Germany.
Information: Mrs. I. Hillig, c/o Stiftung Orthopädische Universitäts Klinik, Abteilung für Dysmelie u. Technische Orthopädie, PO Box 104329, Schlierbacher Landstr. 200 a D-6900 Heidelberg 1, Germany.

5–9 September, 1988
16th World Congress of Rehabilitation International, Tokyo, Japan.
Information: Secretary General, 16th World Congress of Rehabilitation International, Japanese Society for Rehabilitation of the Disabled, 3–13–15, Higashi, Ikebukuro, Toshima-ku, Tokyo 170, Japan.

7–9 September, 1988
Biological Engineering Society Annual Scientific Meeting, Salford, England.
Information: Ms. J. Upton, BES, The Royal College of Surgeons, Lincoln's Inn Fields, London WC2A 3PN, England.

11–14 September, 1988
European Society of Biomechanics Meeting, Bristol, England.
Information: Dr. A. E. Goodship, School of Veterinary Science, Park Row, Bristol BS1 5LS, England.

20–23 September, 1988
Scoliosis Research Society, Baltimore, U.S.A.
Information: Vern Tolo, SRS, 222 South Prospect, Park Ridge, IL 60068, U.S.A.

22–23 September, 1988
2nd Biomechanics and Orthotic Management of the Foot Meeting, Newcastle, England.
Information: Dr. D. J. Pratt, Orthotics and Disability Research Centre, Derbyshire Royal Infirmary, London Rd., Derby DE1 2QY, England.

23–24 September 1988
ISPO Australian National Member Society Annual Scientific Meeting, Repatriation General Hospital, Hollywood, W.A. Information: The Honorary Secretary ISPO, C.D.U., P.O. Box 211, Kew, Vic. 3101. Tel: (03) 862 2944.

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Sixth World Congress

12–17 November, 1989, Kobe, Japan

Time and place

The Sixth World Congress of the International Society for Prosthetics and Orthotics will be held in the Kobe Convention Center, Kobe, Japan from 12th to 17th November 1989. The Kobe Convention Center includes the International Conference Center, Kobe and the Kobe International Exhibition Hall, closely located to each other.

Kobe is located some 30km west of Osaka, with a population of 1,408,000, and serves as the capital of Hyogo Prefecture. It is situated about halfway along the Japanese archipelago facing the Inland Sea, with the scenic backdrop of the Rokko mountains. The city has thrived as an international trade centre since the Meiji Period, and still retains the exotic atmosphere of an international port city. Kobe has a different face from Osaka, Kyoto or Tokyo. The appearance of the city—sophisticated shopping streets, foreign-style architecture preserved from the Maiji Period and the romantic natural setting—accentuates Kobe's unique atmosphere.

Kobe is accessed by the airport limousine bus in about 40 minutes from the Osaka International Airport.

Kobe is actively promoting its new role as a centre of cultural exchange. The city offers a number of well-appointed convention halls and high standard accommodations as well as economy class so called "business hotels" and inexpensive lodging centres for youth.

Congress Structure

Instructional Course Lectures
Main Topic Sessions
Panel Sessions
Free Paper Sessions
Audiovisual Presentations
Poster Presentations
Manufacturers' Presentations and Demonstrations
Scientific Exhibition
Commercial Exhibition
World Assembly
Social Programme

Languages

The working languages of the Congress will be English and Japanese. Simultaneous interpreting between the two languages will be provided in the major rooms.

Instructional Course Lectures

The aim of this lecture series is to present well-prepared, highly informative material representing the state-of-the-art technology in the field of prosthetics and orthotics.

The topics of the courses will be:
- Lower Limb Prosthetics
- Lower Limb Orthotics
- Fracture Orthoses
- Upper Limb Orthotics
- Scoliotic Orthotics
- Management of Stroke Patients
- Amputee Gait Training
- Upper Limb Prosthetics
- Clinical Gait Analysis
- Wheelchairs and Seating for the Severely Disabled
- Neuropathic Foot

Main Topic Sessions

These sessions will feature current trends and recent developments in the undermentioned subject groups, presented by prominent international speakers.
- Environmental Engineering for the Severely Disabled
- Low Back Pain: Surgery and Orthotic Treatment
- Amputation Surgery (Including Traumatic Amputation)
- Sports Injuries and Orthotics
- Upper Limb Orthotics
- Upper Limb Prosthetics
- Neuropathic Foot
- Prosthetics and Orthotics in Developing Countries
- Scoliosis and its Treatment
- Lower Limb Prosthetics: Stump and Socket Interface

Panel Sessions

These sessions will contain lead papers, by experts in the field, combined with appropriate submitted papers. It is anticipated that these sessions will provide ample scope for group discussion.

The topics will include:
- Team Approach in Prosthetics and Orthotics
- Orthotic Treatment for Stroke Patients
- Surgical and Orthotic Treatment for Osteoarthritis and Rheumatoid Arthritis
- Spina Bifida
- Cerebral Palsy
- Historical, Geographical, Climatic and Cultural Considerations in Prosthetic Design
- Management of Spinal Cord Injury
- Functional Electrical Stimulation (FES)
- Communication Aids
- Limb Deficiencies Present at Birth
- Education in Prosthetics and Orthotics
- CAD/CAM in Prosthetics and Orthotics
- Wheelchair and Seating Problems
- Orthotic Treatment in Poliomyelitis

Free Paper Sessions

These sessions will give participants the opportunity of presenting the results of their research work and/or clinical and technological experience, to benefit those who are interested and engaged in a similar field of activity.

Audiovisual Presentations

Great emphasis will be placed on audiovisual presentations, incorporating films, videotapes and tape/slides.

Poster Presentations

There will be ample facilities for the display and discussion of poster presentations.

Scientific Exhibition

Space will be available for scientific exhibits from non-commercial institutions and organizations. As a special feature, we are hoping to arrange worldwide exhibits of traditional prostheses and orthoses using local or modern materials, particularly from Asian countries.

Manufacturers' Presentations and Demonstrations

Time will be available within the Scientific Programme for those taking part in the commercial exhibition to present and demonstrate new products and developments.

Commercial Exhibition

The Commercial Exhibition will be held concurrently with the congress at the Kobe International Exhibition Hall. Participants luncheon area, coffee shop, bar, exhibitors demonstration area and the scientific exhibition will all be accommodated in the same hall with a capacity of 3,000m^2 along with the commercial exhibition.

Other attractions are also being planned for the hall.

Social Programme
To entertain Congress participants and their accompanying persons, particularly those from abroad, a variety of interesting and informative programmes are being planned for the duration of the Congress as indicated below.

Sunday, November 12
Opening Ceremony, Knud Jansen Lecture

Monday, November 13
Japan Night

Tuesday, November 14
Dance Evening

Wednesday, November 15
Kobe Sightseeing, Reception by Mayor of Kobe

Thursday, November 16
Congress Dinner

Friday, November 17
Closing Ceremony

Accompanying Persons Programme
An interesting variety of free or modestly-priced events is now being planned by the Organizing Committee. The Committee will make the utmost effort to entertain accompanying persons with an attractive programme while congress participants are in sessions.

Further announcement and call for papers, exhibits and films
Papers, exhibits and films on prosthetics, orthotics, technical aids, surgery, rehabilitation engineering, rehabilitation management and related subject areas are invited. Please fill out the form, detach and mail promptly.

For further information contact:
Secretariat
VI ISPO World Congress
c/o International Conference Organizers, Inc. (ICO)
Crescent Plaza 1F, 2–4–6, Minami-Aoyama, Minato-ku, Tokyo 107 Japan.

Please complete and return this form as soon as possible to ensure your receipt of the Complete Announcement, which is scheduled to be published in November 1988.

November 12–17, 1989, Kobe, Japan

REPLY FORM

(Please use a typewriter)

(Male/Female)

Name: ________ (First) ________ (Middle) ________ (Last) ________ (Degree)

Affiliation: ________ Professional title (position): ________

Mailing Address: ________

(Please check appropriate boxes and fill in the blanks.)

I will attend the Congress.

I will be accompanied by ____ family member(s).

I would like to offer:

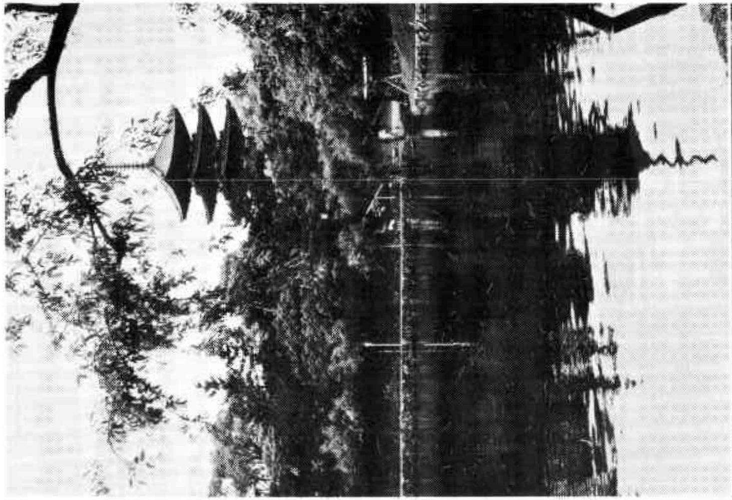
☐ a paper
☐ an audiovisual presentation
☐ a scientific exhibit

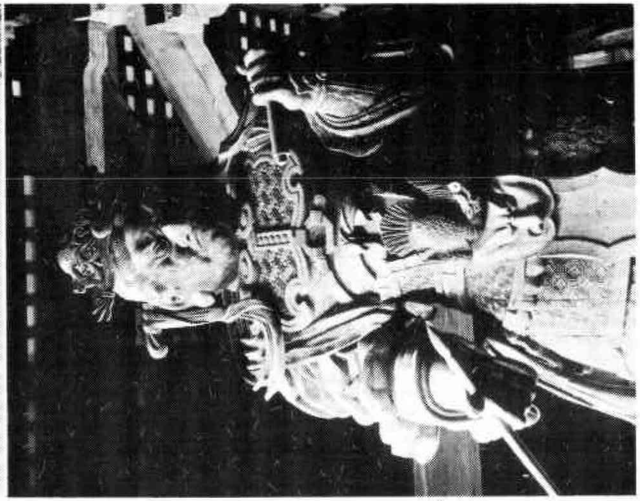
on ________

Note: Closing date for submission of abstract: February 1, 1989
(Abstract forms will be contained in the complete announcement.)

Please send me a copy of the 1st Announcement.

Date: ________





Secretariat
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Crescent Plaza 1F, 2-4-6, Minami-Aoyama,
Minato-ku, Tokyo 107 Japan.

The Brian Blatchford Prize

The Brian Blatchford Prize has been established by the Blatchford family to honour the memory of Brian Blatchford. It will be awarded every three years at the World Congress of the International Society for Prosthetics and Orthotics.

The first Brian Blatchford Prize will be awarded at the Sixth World Congress of ISPO to be held in Kobe, Japan from November 12th–17th 1989. On this occasion the Prize will be £2,000 and will be awarded for the most outstanding innovation in prosthetics and/or orthotics practice over the previous three year period. The innovation should be related to a piece of prosthetic and/or orthotic hardware, or a scientifically based new technique which results in a better prosthesis or orthosis. The innovation should have reached a sufficiently advanced stage to ensure that it can be used successfully on patients.

The applicant or nominator should initially present evidence detailing the innovation, together with a sample of the device if appropriate, and send it to reach the President of ISPO by 31st December 1988 at the following address:

Professor J. Hughes,
National Centre for Training and Education
in Prosthetics and Orthotics,
Curran Building,
131 St. James Road,
Glasgow G4 0LS
Scotland

The innovation shall be presented at the Sixth World Congress and duly published in 'Prosthetics and Orthotics International'.

The President and Executive Board of the International Society for Prosthetics and Orthotics and the Blatchford family reserve the right to withhold the Prize should no suitable application be submitted.

The Forchheimer Prize

The Forchheimer Prize has been established by the Forchheimer family to honour the memory of Alfred Forchheimer. It will be awarded every three years at the World Congress of the International Society for Prosthetics and Orthotics.

The first Forchheimer Prize will be awarded at the Sixth World Congress of ISPO to be held in Kobe, Japan from November 12th–17th, 1989. On this occasion the Prize will be 4000 SEK and will be awarded for the most outstanding paper on 'Objective Clinical Assessment', 'Clinical Evaluation', or 'Clinical Measurement' published in 'Prosthetics and Orthotics International' during the three years prior to the Congress.

The President and Executive Board of the International Society for Prosthetics and Orthotics and the Forchheimer family reserve the right to withhold the Prize should no suitable paper be published.

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Heidelberg, 27 August—1 September, 1988

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*) Clinical Applications of the New International Terminology for the Classification of Congenital Limb Deficiencies by H. W. Kay, InterClinic Information Bulletin, March 1975, Vol. XIV, No. 3, p.1-24.

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Official Language	English (translation into German will be provided)
Call for Presentations	Deadline 31 January, 1988 (Please use only the Abstract Form obtainable from the Symposium Secretariat)
Further Attributes	Industrial Exhibition; Poster, Film and Video Sessions; special Facility Visits
Social Programme	Get-together-Reception; Wine-Tasting in the Heidelberg Castle; Concert Dinner in the Castle of Schwetzingen; Organ Recital in the Heilig Geist Church Heidelberg; Excursions in and around Heidelberg
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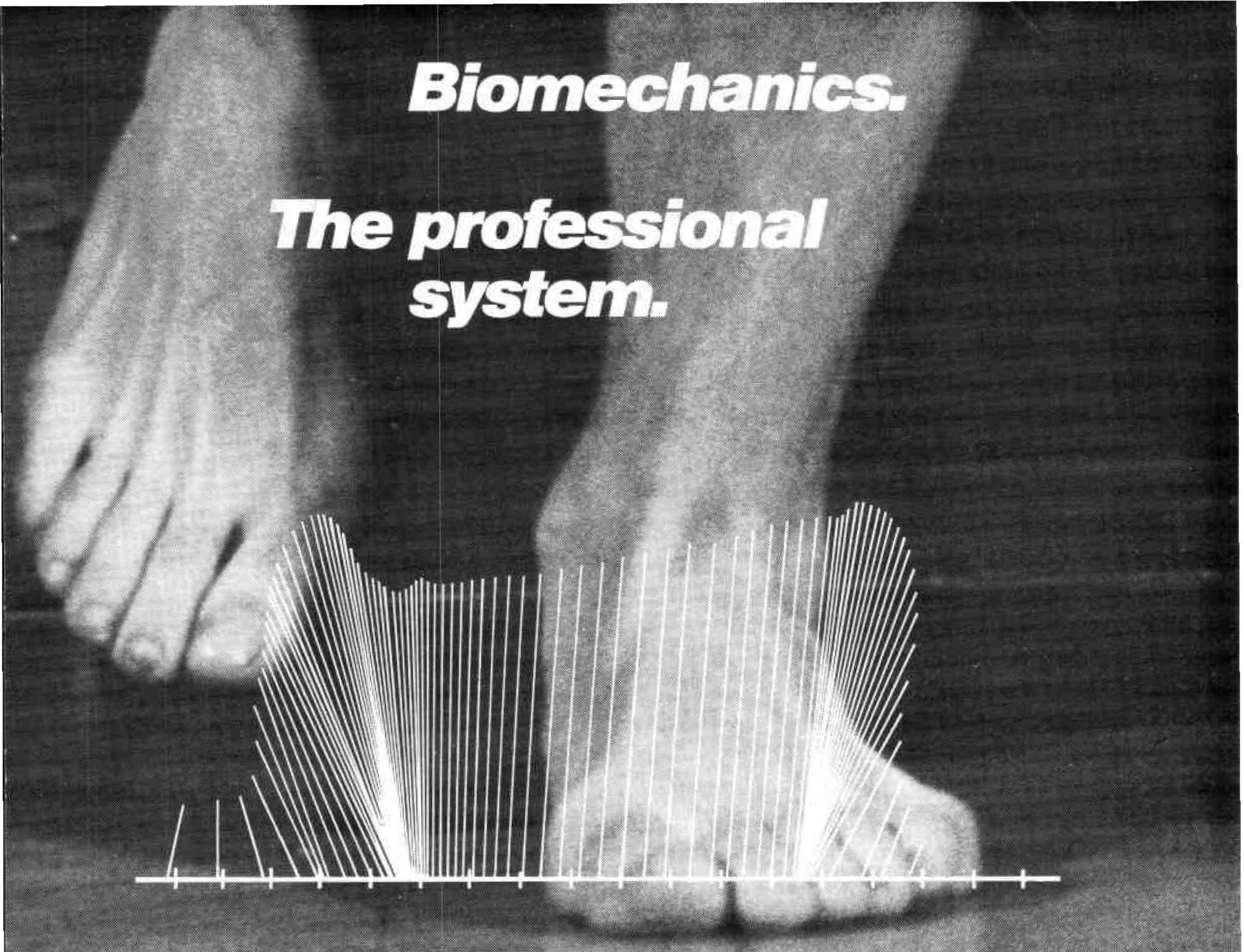
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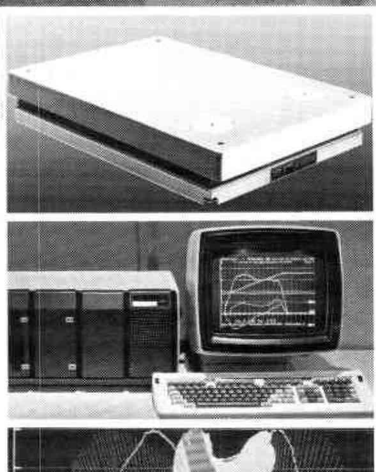

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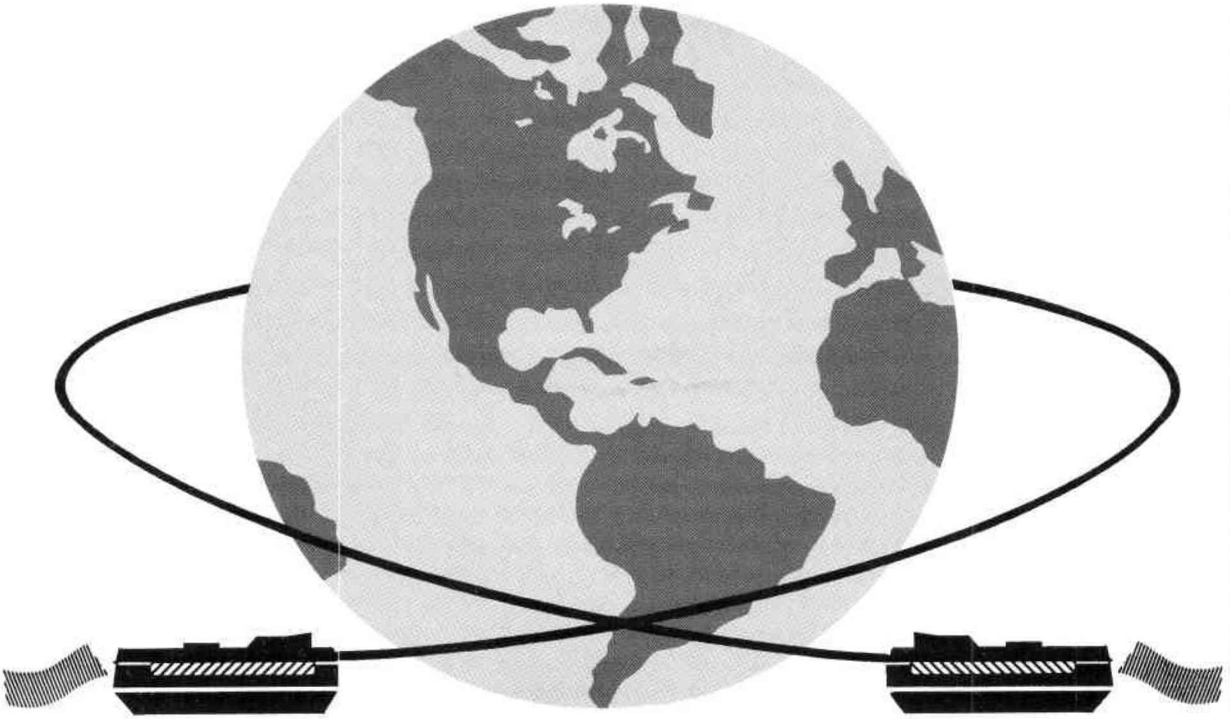

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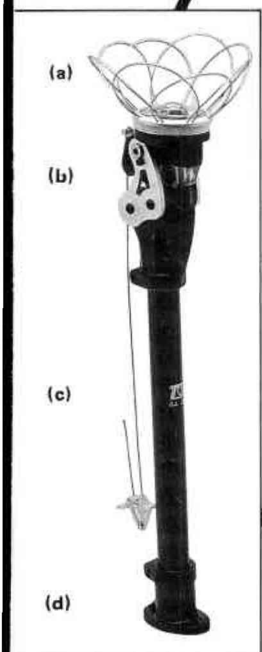

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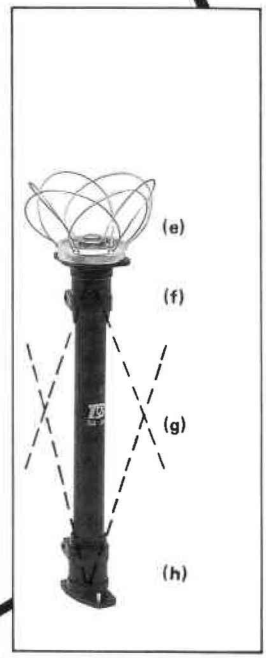

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