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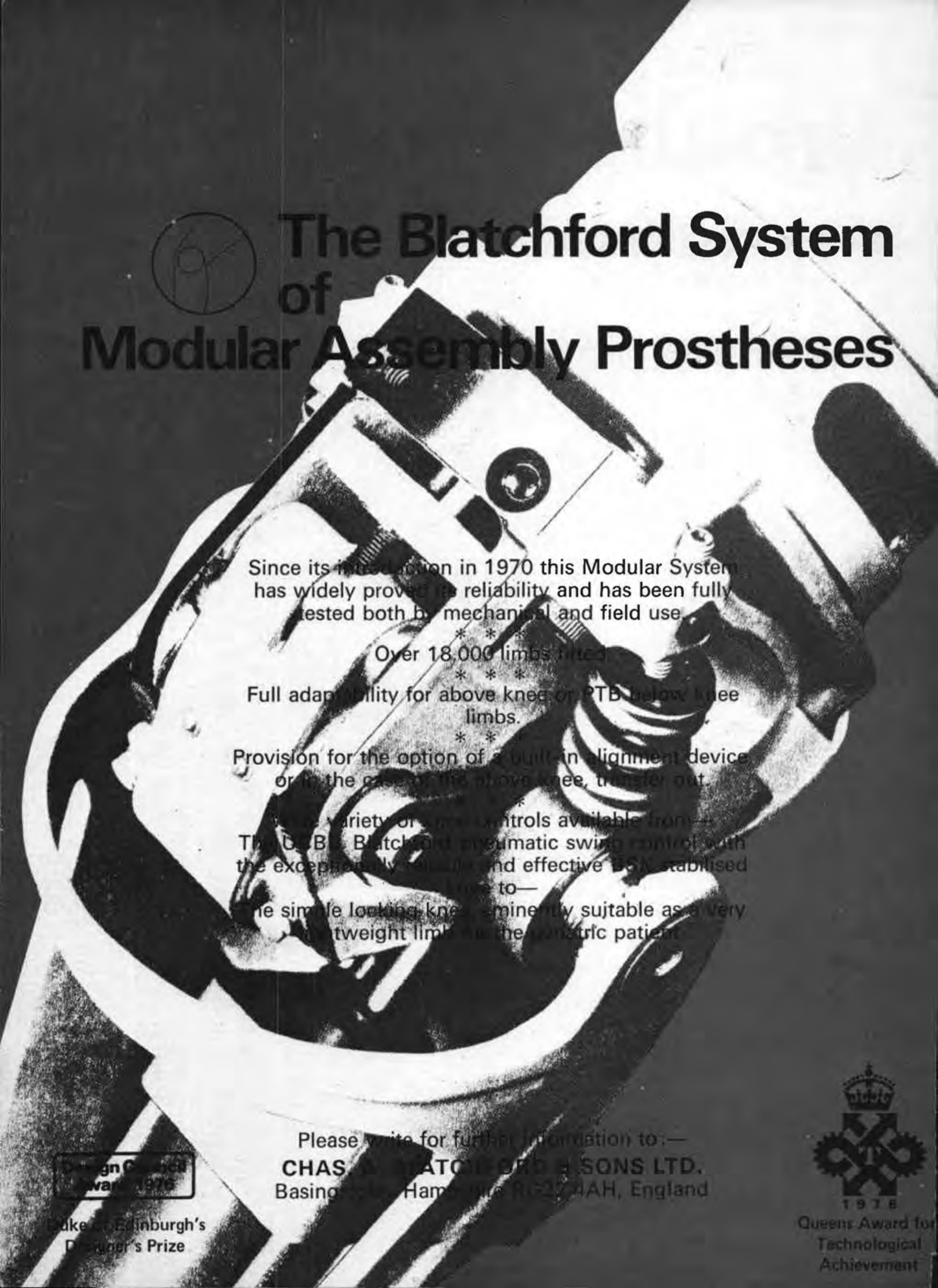
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Executive board of ISPO

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Editorial

The end of another year has seen an Executive Board meeting in Copenhagen in November. At the time of writing, this meeting is in preparation, yet it is already apparent that many important decisions must be made there, some of which will have a decisive influence on the progress of our Society.

It will be necessary to give urgent consideration to the siting of the next World Assembly and Congress. The provisional siting in the Netherlands is now under close scrutiny to ensure that the venue will be of the maximum benefit to the Society and its membership. This is a difficult task when predictions and budgets are subject to the vagaries of the world monetary system and inflation and variations in exchange rates lurk in the background. A definitive decision will be made by the Executive Board at this meeting.

Perhaps the other most important matter to be pursued will be the proposal to organize and effect an international evaluation programme in our field within the organization of the Society. Representatives of a number of government agencies have been invited to meet with the Board at this meeting and a positive decision would permit the Society to accept a central position in the provision of advice in the widest range of services and activities.

The meeting takes place at the time of the International Course on Above-Knee Prosthetics. This course brings together the foremost practitioners in this specialist area throughout the world, not only to pass on information, but also to compare practices and to make judgements and recommendations which have the potential to affect the whole range of activities in this field—from research and development to the provision of clinical service. It is our intention to utilize the content of this seminar to produce a special Symposium Edition of Prosthetics and Orthotics International to effect the widest distribution of this information throughout the world.

It remains relevant at this point to remind the membership, and indeed the readership at large, that the Editorial Board welcomes the submission of new material to the Journal for publication. We believe the publication is increasingly fulfilling the needs of our multidisciplinary society as a forum for the presentation of professional papers. It remains a disappointment to the Editorial Group that the membership are not making use of the Journal in a less formal way for the communication of news, or even the exchange of abuse. We would welcome more active participation.

John Hughes,
Honorary Secretary.

Prosthetics and Orthotics International, 1978, 2, 118–120

Reflections on training in orthopaedic techniques*

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When considering the present state of orthopaedic provision worldwide, crass differences can be observed which can often only be eliminated by the training of suitable personnel. These include those who are needed for medicotechnical measures within the framework of rehabilitation of the physically handicapped and disabled.

In connection with the setting up of comprehensive training programmes, designed to meet the actual situation, three questions are of paramount importance:

a) What type of personnel are required?

b) How many personnel are required?

c) How should they be trained?

In order to answer the first question it is appropriate to divide those employed in Technical Orthopaedics into two groups who differ characteristically with regard to features of their activity.

One group consists of skilled personnel who exclusively or predominantly are employed in the workshop area with the execution of manual tasks connected with the production of orthopaedic-technical remedial aids and do not normally come into contact with patients except in an assisting function. They bear such professional titles as, journeyman, specialist or technician.

The other group is composed of the most highly-qualified people who bear the main responsibility for the execution of all measures concerned with the preparation and fitting of remedial aids, as well as for instruction and training as part of the treatment, and who moreover issue the appropriate instructions to those employed in the workshop area and, if necessary, supervise them. Beyond this they may be entrusted with the training of trainees. Typical professional titles for members of this group are master, prosthetist or orthotist.

This division—about which worldwide agreement exists—reduces the difficulty in answering the first question in the individual case.

With regard to the number of staff required this depends first of all on the total number of physically handicapped and disabled needing provision. Experience shows that in countries with a well-regulated orthopaedic provision the total number of those provided for and the total number of the providers stand in an approximately definable ratio.

In the Federal Republic of Germany for example, for the orthopaedic-technical or medical-technical provision of 700,000 to 750,000 physically handicapped and disabled there are about 7,500 workers available, a ratio of about 100 to 1. A further differentiation of the requirement is possible on consideration of a second factor, namely, the average personnel structure of existing or projected institutions of provision.

If the Federal Republic of Germany is again considered, it can be observed that the numerical ratio of top personnel (e.g. masters, prosthetists or orthotists) to those members of the other group (e.g. journeymen, specialists or technicians) lies between 1:4 and 1:5. This means that around 80 to 85% of the overall required personnel are journeymen, specialists, technicians or persons with equivalent qualifications and "only" 15 to 20% are masters, prosthetists or orthotists.

For a country which has personnel of neither category at its disposal, clear implications can be deduced from this as to training.

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*This is the second lead paper on Prosthetic/Orthotic Education presented at the Second World Congress. The previous paper by John Hughes was published in Prosthetics and Orthotics International, Vol. 2 No. 1.

Measured against the deliberations hitherto the answering of the third basic question as to the "how" of training is comparatively difficult, especially if concepts which deviate from the ISPO philosophy are to be considered in individual training programmes.

However, these differences are clearly distinguishable from differences whose causes are to be sought in national training policy, professional policy, training structure and similar factors not related to the specialisation on the one hand and/or in a differing composition of the patients to be provided for, in differing manufacturing techniques or in a more or less strong specialisation of individual personnel, and which in my view must be tolerated.

In this view of the situation a satisfactory similarity is apparent in the various training programmes for the group of journeymen, skilled workers and technicians, from which may be deduced that on a worldwide scale extensive agreement must exist about features of employment and resulting demands.

Variations exist primarily in the choice of the place of training and the fixing of the duration of training. The recognisable limits offer a scope for centrally, as well as dually organised training courses with a duration of between one and three years.

The situation in the field of training of top personnel is fundamentally different. The differences presented here stem to a considerable degree from concepts which deviate from one another, which becomes especially clear on consideration of the two extremes, i.e. manual training and the training at university level.

Without going into great detail it may be observed that one of the basic points of the discussion is the level of training necessary to provide the master, prosthetist or orthotist with all the essential technical knowledge and skills.

Representatives of the manual skill take the view that, besides the skills which are basically essential for looking after patients and co-operating with medical partners, manual skills are of prime importance, and theoretical knowledge need not go beyond that necessary for the understanding and execution of these procedures.

Therefore manual training up to master or state technician level is accomplished by further training of the best of that group who have qualified themselves for the workshop area and have gained professional practice of several years in private workshops or clinics. This further training is carried on centrally or dually in terms of courses of varying duration which are constantly being adapted as technology develops.

An expert, for example, trained at the specialist school in Frankfurt, although he has no academic title, possesses nevertheless an extensive knowledge which enables him to carry out efficiently the medical-technical rehabilitation procedures expected of him, as well as comprehensive knowledge and expertise for the management or co-ordination of all that goes on in the workshop.

The road to this goal is long; it lasts at least $5\frac{1}{2}$ to 6 years. It is open to everyone to judge whether this is to be interpreted as lack of efficiency or thoroughness.

The representatives of a university training, as also envisaged by the ISPO philosophy, proceed on the assumption that only the intellectual mobility needed for the exploitation of technological progress and the degree of theoretical knowledge required for this justify this level of training. In this they represent the view that these conditions are scarcely compatible with the tradition of manual work, since manually employed workers are inclined to go on indefinitely applying what they have once learnt without much sign of readiness to change.

This reasoning, when one applies objective criteria, is not valid even from the viewpoint of an academic. If it were, all manually orientated provision would be in a desolate state. However, even under critical examination the situation in the Federal Republic of Germany proves the opposite to be the case.

Therefore the neutral observer cannot escape the conclusion that with the introduction of this training course possibly other reasons have played a part, for example the adapting of the training level of the prosthetist/orthotist to that of the other rehabilitation personnel in order to promote his recognition in this circle as a most important condition for the realisation of the clinic team concept.

This conclusion is further supported by the fact that prosthetist/orthotists according to the ISPO philosophy are presented as paramedical personnel and thus predominantly associated with the medical sphere.

This leads on to the second main point of the discussions: the categorising of top personnel.

In Germany the master is unambiguously graded as a technical specialist and thus associated with technology. Employment in the health service is made clear by the addition of medical experience—as with the bio-engineer who is categorised in Germany according to the same viewpoints.

It is easy to recognise the advantages and disadvantages of the one or the other association and the consequent training guidelines, if one sees the master, prosthetist or orthotist, as a key figure between medicine and technology. If both specialist areas are to be combined through him, he must be in the position to fill completely the borderline region between them in his capacity as an expert and as a human being. If he is not capable of this or if his capacity is restricted in the sense of one-sidedness then a gap will arise either between him and medicine (i.e. the rehabilitation team) or between him and technology (i.e. those employed in the workshop area) a gap which can lead to problems in communication, co-operation, loss of authority and other disturbing influences which can have a negative effect on the rehabilitation programme and on the patient.

Depending on the character of the training course the risk of such a gap will be found on one side or the other; in the case of university orientated training between prosthetist/orthotist and workshop and in the case of manual training between master and medical specialist staff. Examples from practice prove the correctness of this hypothesis.

Some ideas about training in orthopaedic technology have been put forward. It is clear that we are still a long way from applying an international training system as recommended by ISPO.

The reason for this lies in the fact that differing national conditions and demands must be taken into account. It is one thing to recommend the establishment of recognised training schemes which are related to educational levels, it is quite another to implement them in countries where the required educational levels are limited or do not exist.

Since it is unlikely that the appropriate ministries of countries thus concerned will change an entire national educational system, just because a few specialists in technical orthopaedics so wish, one ought perhaps in future, before the establishment of training programmes, to give rather more careful thought to determining the peculiarities of individual national educational systems.

Prosthetics and Orthotics International, 1978, 2, 121–124

National programme of prosthetics and orthotics in Japan*

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As part of the progress made in the rehabilitation of the physically handicapped in Japan, an increasing interest has been given to prosthetics and orthotics over the past ten years.

The national associations in prosthetics and orthotics can be seen in Table 1.

Table 1
National associations in prosthetics and orthotics

1939: Japanese Association of Prosthetic and Orthotic Industry. (President Mr. Tasawa.)
1968: Japanese Society of Prosthetic and Orthotic Education, Research and Development.
1971: Committee of Prosthetics and Orthotics in the Japanese Association of Rehabilitation Medicine. Chairman S. Sawamura M. D.
1973: Committee of Prosthetics and Orthotics in the Japanese Orthopaedic Association. Chairman H. Tsuchiya M.D.
1974: Japanese National Member Society of ISPO. (President T. Amako M.D.)

The Japanese Association of Prosthetic and Orthotic Industry, founded in 1939, consists of 300 manufacturers, of which the total number of prosthetic and orthotic technicians are estimated to be 5,000.

In 1968 doctors, engineers and technicians got together to form the Japanese Society of Prosthetic and Orthotic Education, Research and Development. This society, having 500 members, holds meetings twice a year and publishes a journal.

In 1974 a branch of ISPO was founded in Japan, and this has led to an active exchange of information with foreign countries. To date its members number about 80.

On the medical side committees of prosthetics and orthotics were formed; firstly in 1971 within the Japanese Association of Rehabilitation Medicine and secondly in 1973 within the Japanese Orthopaedic Association.

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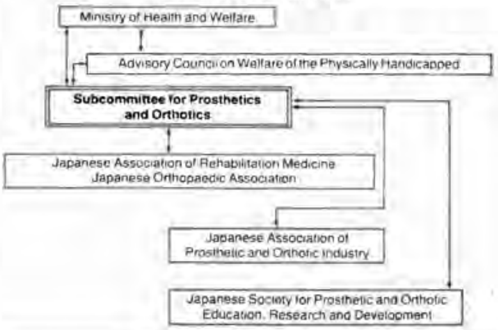
Table 2
Government activity in prosthetics and orthotics

1949: Legislation for the welfare of the physically handicapped.
1956: Short-term course for prosthetic technicians. (2–3 weeks, Supervisor Mr. U. Iida).
1970: Long-term course for prosthetic and orthotic technicians (2–3 years).
1973: Revised legislation on the Fee, Title and Kind of Prosthetics and Orthotics.
1973: Postgraduate training course for medical doctors (2 weeks).
1974: Subcommittee for prosthetics and orthotics.
1975: Trade skill test for prosthetic and orthotic technicians.
1976: Committee for prosthetics. (Ministry of Labour) (Chairman: Dr. Amako).

In addition to the activities taking place in the various societies, the Ministry of Health and Welfare has also been active in the field of prosthetics and orthotics (Table 2). It now conducts training courses for prosthetic and orthotic technicians and, at the same time, a training programme in prosthetics and orthotics for doctors is organized by them every year in co-operation with the Japanese Orthopaedic Association and the Japanese Association of Rehabilitation Medicine.

Table 3
Relationship of Subcommittee for Prosthetics and Orthotics to Ministry of Health and Welfare and National Associations



*Based on a paper presented at the Second World Congress, ISPO, New York, 1977.

Table 4

Number of physically handicapped

	Total number of the physically handicapped (A)	Number of handicapped in limb or body (B)	B/A	Rate of (A) to 1,000
1955	785,000	476,000	60%	14·4
1960	829,000	486,000	58%	13·7
1965	1,048,000	610,000	58%	15·7
1970	1,314,000	763,000	58%	17·9
1975	2,005,000	1,303,000	64%	19·2

Starting in 1976 the Ministry of Health and Welfare founded a Subcommittee for Prosthetics and Orthotics within the Advisory Council on Welfare of the Physically Handicapped (Table 3) in order to reflect the public trend. It holds meetings about twice a year to discuss various problems, some of which are outlined below.

Number of physically handicapped

The number of physically handicapped adults in Japan continues to increase every year, the ratio of those who are handicapped in limb or body is shown in Table 4.

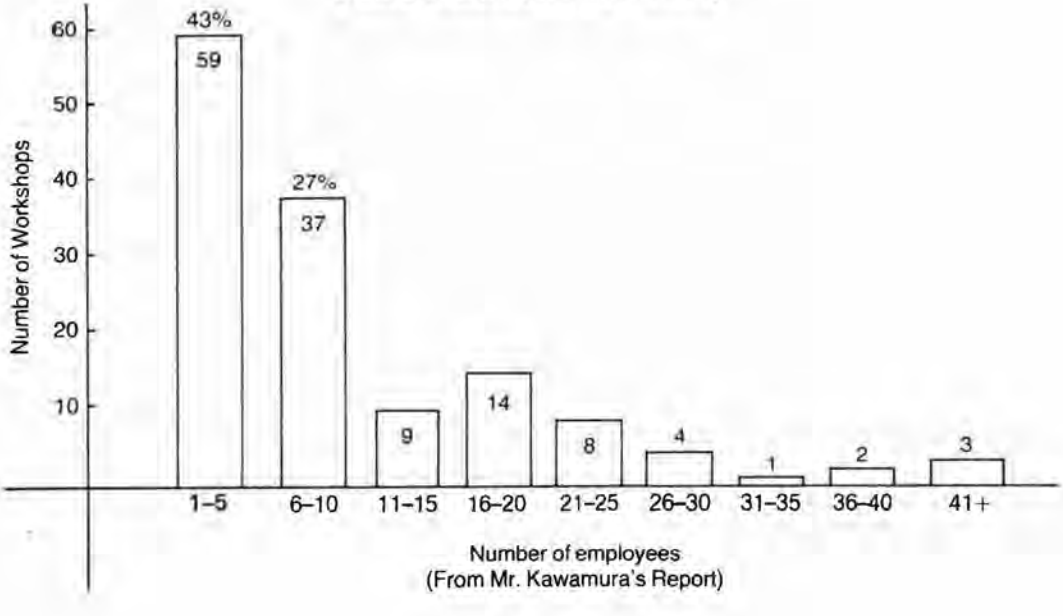
In 1975 the Japanese Medical Society of Rehabilitation, headed by a group of doctors who belong to the prosthetic and orthotic committee and assisted by the prosthetic and orthotic technicians, carried out a fact finding survey of the amputees. The result demonstrated that the total number of amputees operated on that year was 1,394, out of which the number of arm amputees was 441 and that of leg amputees was 953.

Males overwhelmingly outnumbered females in both arm and leg amputation by the ratio of 3·5:1 and 4·9:1 respectively. Eighty per cent of the arm amputees were skilled male labourers and farmers, who suffered trauma.

As for the leg amputees, a large proportion were found to be elderly, with 50 per cent over 50 years. Seventy per cent of leg amputations

Table 5

Number of employees in each workshop



(From Mr. Kawamura's Report)

were due to trauma, for example, accidents at work and injuries received during the war.

Amputations due to the disturbance of blood circulation occupied only 8·5% of the male amputees and 2·5% of the female amputees, which is quite different from those of other countries.

Problem of qualification of prosthetists and orthotists

While the statistics gathered by the Ministry of Health and Welfare show an increase in the number and cost of prosthetic and orthotic appliances provided, qualification of prosthetic and orthotic technicians has not yet been standardized. Many of the factories are operated on a small scale, with no more than 5 workers (Table 5). As for educational background, high school graduates occupy 44%, and college graduates occupy only 6% (Table 6) of the total number of technicians working in the prosthetic and orthotic industry. Under the current situation most employees work under apprenticeship, living in the master's house, after they have finished compulsory education.

Table 6
Educational background of prosthetic and orthotic technicians

	College Graduate	High School Graduate	Primary School Graduate
Japanese Association of Prosthetic and Orthotic industry (1973)	83 (6%)	613 (44%)	715 (50%)
Public Institutes	2 (3%)	35 (46%)	39 (51%)

(From Mr. Kawamura's Report)

With the increase of information coming from abroad, there is a growing demand for the training of manufacturers of prosthetic and orthotic appliances and the government is now studying a system of qualification.

Since 1976 the Ministry of Labour gives a certificate examination for the prosthetic and orthotic technician. This examination is given at two levels, each including a written test and a skill test.

In the meantime, the establishment of a training school for prosthetists and orthotists, along with the qualification problem, is under discussion. A course of about three years to be given to high school graduates is being considered, however, it is likely to take a little time before it takes a concrete shape.

Standardization of prosthetic and orthotic appliances

In Japan no institution which evaluates the standards and performance of prosthetic and orthotic appliances has been established. For the past three years, the Ministry of International Trade and Industry has taken a leading part in the standardization of parts of prosthetic and orthotic appliances.

As for technical terms, unification has been tried out, in prosthetics in 1976 and in orthotics in 1977, and a draft is now under way.

Establishment of limb fitting centres

As the actual situation in the field of prosthetics and orthotics has become clear, a plan to establish limb fitting centres has been proposed and is now under discussion. Firstly, Japan is divided into several regions and a centre is to be set up in each region. It is to be provided with sufficient staff and equipment to distribute prosthetic appliances, to check and examine the fitting and to follow up the result. This project is considered to be one of the most important projects in this field.

Development of prosthetic and orthotic appliances

Japan falls behind many other countries in the development of prosthetic and orthotic appliances. However, for several years, prosthetic appliances of modular type have rapidly come into wide use. For the externally-powered upper limb prostheses, besides the YM Hand reported at ISPO, upper extremity prostheses of the total arm type using voice control and microcomputer are being manufactured for trial and an attempt to put their various parts into practical use is in progress. A motorized wheelchair is also under active development. While such developments are under way, 80% of hooks used for upper limb prostheses are imported. The same is also true of knee mechanisms of lower limb prostheses of the modular type. Moreover, the method of distributing these foreign-made prosthetic appliances leaves much to be desired.

Recently, besides prosthetic and orthotic appliances, the development of various equipment for the physically handicapped, such as a telephone for the blind and a total environment control system, is being pursued on a large scale.

It is anticipated that some of the problems outlined above will be solved in the near future.

Prosthetics and Orthotics International, 1978, 2, 125–136

Vulcanized rubber foot for lower limb amputees

P. K. SETHI, M. P. UDAWAT, S. C. KASLIWAL and R. CHANDRA

S.M.S. Medical College and Hospital, Jaipur, India

Introduction

A prosthetic workshop was started some years ago at the S.M.S. Medical College Hospital, Jaipur, to meet the growing demands of the local population. Unlike the premier limb-fitting centres in India which still cater for the more affluent sections of society, it was decided that this centre would also look after the poor rural amputees. It soon became apparent that a disturbing number of amputees from the villages were unhappy with their prostheses and discarded them after their initial enthusiasm waned. No flaw could be detected in the fabrication or fitting of these limbs to account for this rejection. An enquiry was then instituted to find out the reasons for non-acceptance of these prostheses. Several factors emerged out of this study.

Shoes and Indian amputees

The average rural Indian does not wear shoes. He has to walk on a rugged terrain and through water and mud. This is not kind to shoes which break down with a frequency which the urban population cannot imagine. Even the urban amputees do not wear shoes inside their homes, in the kitchen and in places of worship. On formal occasions footwear frequently takes the form of an open sandal, this practice being related to the hot climate where closed shoes are uncomfortable. Shoes not only raise the initial cost of a limb considerably but the frequent need for renewal imposes a financial burden which most amputees find impossible to meet. In short, the requirement for a shoe to be worn with a lower limb prosthesis raises economic and cultural problems and it was felt that the shoe should somehow be dispensed with.

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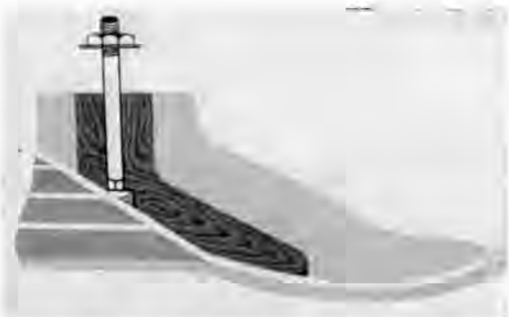

Fig. 1. The SACH foot, see text.

Once the outer casing formed by the shoe is removed, the bare footpiece is revealed to the onlooker and it therefore becomes important to give it the shape of a normal foot for obvious psychological reasons.

The SACH foot

The functional design of a conventional footpiece also posed some problems. For instance, it is customary for Indians to squat (sitting on haunches) or sit cross-legged on the floor. Squatting requires a range of dorsiflexion which is scarcely available in a single axis ankle joint and totally absent in a SACH foot (Fig. 1). Sitting cross-legged on the floor is a complicated manoeuvre. The forefoot rests on its outer border and is deflected into adduction, together with an element of supination twist; the hindfoot is inverted. A SACH foot has a rigid keel which does not allow this freedom of movement and if an amputee tries to sit cross-legged on the floor with a SACH foot, a combination of a twist and adduction strain is transmitted via the shank to the socket and an unbearable pressure is felt on the stump. When it is realized that social etiquette as well as the majority of vocations involve sitting or squatting on the floor, it was felt that this matter also needs to be looked into.

There are other objections to a SACH foot. This foot was designed for amputees walking on level ground and the rather limited range of inversion and eversion by compression of the heel pad has so far been considered adequate for the Western amputee. It is when SACH feet are used in rugged terrain for rough outdoor activities that their structural and design weaknesses are revealed. Even in the West, where the material used for SACH feet is far superior to that used in Indian SACH feet, complaints of frequent breakdowns have been voiced by amputees who want to lead a vigorous outdoor life (Harris, 1973).

The presence of a rigid keel does not permit any transverse rotation of the foot in relation to the leg; the importance of this movement is receiving increasing recognition in recent descriptions of gait analysis. But more important than any of the foregoing drawbacks is the inability of the foot to adapt readily to uneven surfaces. The ground reactions are transmitted and magnified by the length of the shank to the stump, consequently many amputees felt very uncomfortable when walking on rough and uneven ground.

Peg legs and rural amputees

The general philosophy of most Indian surgeons has been to follow a double standard. For the well-to-do urban amputee who can take to a Western style of living, that is walking on level ground, sitting on chairs and using Western type of toilet seats, a conventional prosthesis is provided. For the poor rural amputee a peg leg is prescribed. While it is true that a peg leg is simple and inexpensive, even the rural amputee of today would reject it on cosmetic grounds. In addition, there are numerous biomechanical drawbacks which are commonly overlooked. The point of support is too small; a peg leg sinks in sand or mud. The impact of heel-strike cannot be cushioned adequately because of the lack of an ankle and knee mechanism (Saunders, Inman and Eberhart, 1953). The forward transfer of the point of support from the heel to the metatarsal heads which is so necessary for knee stabilization during take-off is not possible in a peg leg; an above-knee peg leg prosthesis cannot have a knee mechanism. The inability to shorten and lengthen the limb during the gait cycle leads to a characteristic vaulting gait (Murphy, 1960).

Formulation of objectives

Based on the foregoing observations, the requirements of the footpiece were roughly formulated as follows:

1. It should not require a shoe, and consequently, should have a certain degree of cosmetic acceptance by the amputee.
2. The exterior should be made of a waterproof, durable material.
3. It should allow enough dorsiflexion to permit an amputee to squat, at least for short periods.
4. It should permit a certain amount of transverse rotation of the foot on the leg to facilitate the act of walking as well as to allow cross-legged sitting.
5. It should have a sufficient range of inversion and eversion to allow the foot to adapt itself while walking on uneven surfaces.
6. It should be inexpensive.
7. It should be made of materials which are readily available.

Muller solid rubber foot

Muller, working in Ceylon, was faced with the problem of providing limbs for amputees working in paddy fields with legs immersed in water. His major objective was to render the prosthesis waterproof. He chose vulcanized hard rubber for this purpose and used it to cover the wooden leg piece (Muller, 1957). A solid L-shaped prolongation simulating a foot was added to improve the function of the limb. One can conceive of the Muller limb as a large skin-tight gum boot in which the shoe portion was replaced by a solid rubber footpiece (Fig. 2). This was an improvement on the peg leg and Muller expressed considerable satisfaction with his design.

Muller's choice of vulcanized hard rubber as a material for a footpiece appeared to be very apt. Natural rubber has a combination of several properties which, in many ways, is unique. Its durability, resilience, resistance to abrasion and to cuts and tears are not present in any of the available plastics. Moreover, natural hard rubber is readily available in India because of an extensive trade in retreading worn out automobile tyres. Almost every town in India has retreading shops and local craftsmen know how to handle this material.

Fig. 2. Muller foot with solid rubber footpiece. The footpiece offers biomechanical advantages over a peg leg.

Fig. 3. Top, die prepared from plaster replica of normal foot. Bottom, cosmetically acceptable footpiece of solid rubber.

The first step in this project was therefore to borrow Muller's idea but improve on its appearance. A plaster of Paris replica of a normal foot was made and a die was prepared from it (Fig. 3 top).

Rubber was packed into the die and vulcanized by heating it in an oven. A foot such as is shown (Fig. 3 bottom) was obtained.

While the cosmetic features of this solid rubber foot were quite pleasing, it was too heavy and very stiff and it lacked the selective resilience and rigidity at appropriate places which are desirable in a foot and ankle mechanism.

Rubber enclosed SACH foot

In order to make the foot lighter, a SACH foot was placed in the die and enclosed in hard rubber, a much lighter foot with all the desirable design features of a SACH foot was obtained (Fig. 4). This foot was like having a built-in rubber shoe over a SACH foot with the external appearance of a normal foot. The external hard rubber enclosure served as a protection as well as a screen to the underlying SACH foot. While this footpiece was considerably lighter than a solid rubber foot, the compressibility of the heel pad was diminished because of the much stiffer hard rubber enclosure.

Mid-tarsal break

Having achieved the initial requirement of dispensing with the shoe, and providing a footpiece with acceptable appearance, durability and being waterproof, the objective of allowing an amputee to squat was pursued. The solid wooden keel of a SACH foot does not allow any dorsiflexion. To allow this movement a wedge was removed from the keel, based dorsally and located approximately in the midtarsal region. The space created by the removal of the wedge was filled with a soft grade of sponge rubber. It was argued that a closure of this wedge would simulate dorsiflexion. However, when a foot with this mid-tarsal break was used, only a very limited range of dorsiflexion was achieved. Apparently the size of the wedge was too small. Also, the foot bent at the wrong place; it was odd to witness an amputee develop a rocker-bottom foot while trying to squat.

Fig. 4. Rubber enclosed SACH foot, see text.

Fig. 5. Initial design of Jaipur foot.

Evolution of the Jaipur foot

Efforts so far had been concentrated on developing the design of the SACH foot to provide additional ranges of movements. Larger and larger wedges were removed till almost nothing was left of the proximal section of the keel where the carriage bolt for fixing the shank to the foot could be securely held.

It was at this stage that a total departure was made from the SACH foot and a completely new design was worked out (Fig. 5). The solid wooden keel was dispensed with. Instead, two completely separate wooden blocks were used. A proximal wooden block, which roughly represented the lower end of tibia, was used for securing the carriage bolt. A distal wooden block occupied the area normally represented in a foot by the distal row of tarsus and the metatarsals. The intervening space was filled with layers of sponge rubber, glued together. This represented the mobile section of the ankle, subtaloid and mid-tarsal joint complex. This large sponge rubber block could now act as a universal joint with freedom of movements in all directions. Dorsiflexion, plantarflexion, inversion, eversion, abduction and adduction were all possible. In addition the foot as a whole could now rotate on the leg.

Initial mistakes

A number of initial mistakes were made. In our first attempt the proximal wooden block was placed directly over the sponge rubber block. This resulted in the wooden block sinking at every step and the sponge rubber was quickly damaged. To protect the sponge rubber, a platform or shelf of hard rubber was interposed between the proximal wooden block and sponge rubber. While this succeeded in protecting the sponge rubber, the interface between the distal wooden block and the sponge rubber developed a pseudarthrosis because of stresses accumulating at this joint (Fig. 6 left). Gradually, the idea of enclosing the entire sponge rubber block in a closed shell of hard rubber emerged (Fig. 6 right). This protects the sponge rubber so effectively that we have had no subsequent structural failure of this region in spite of gross abuse of the footpiece by farmers over a period of years.

In order to allow free dorsiflexion, too much sponge rubber was used and the amount of hard rubber in front of the ankle region was deliberately thinned out. This permitted the amputees to squat with ease but led to instability in walking, where, during the latter half of the stance phase the leg would suddenly buckle forward, causing an excessive flexion of the knee. The gait resembled a typical calcaneus limp. We had then to curb our enthusiasm and pack in more hard rubber in front of the ankle to control instability in walking.

Fig. 6. Left, the proximal wooden block sinks into the unprotected sponge rubber causing damage during weight bearing. Right, enclosure in a shell of solid rubber protects the sponge rubber block; no subsequent structural failures have been encountered.

Reinforcement by cord lining

To determine the strength of these feet, loading tests were conducted in a universal testing machine and the foot was found to break at a vertical loading of two tons. This was felt to be a satisfactory figure. However, when field trials were held, a number of amputees came back with cracks which were mainly located around the distal edge of the proximal wooden block. There was apparently a concentration of stresses in this region and the wooden block gradually worked its way through these cracks. It was then suggested that reinforcement with cord lining should be used as is done in automobile tyres. The various structural components of the foot were bound with a cord lining (Fig. 7). The breaking load figure rose to a value of six tons. Further field trials were conducted and the locations of these cracks were carefully plotted. These vulnerable areas are specially reinforced and now these feet are really strong and durable.

Fig. 7. Top, components of the Jaipur foot. Bottom, rayon cord, used in automobile tyres, reinforces and binds the components. Structural failures are now rare.

Fig. 8. Jaipur foot. Note the laminated proximal wooden block. The lighter colour of the dorsal surface is provided for cosmetic reasons; it is made of soft, resilient, lightweight cushion compound. The dark sole is made of tread compound to provide toughness and durability.

Analysis of present design

Figure 8 shows a sagittal section of the footpiece which has been finally adopted. It can be seen that the overall structure reproduces broadly the basic functional components of the human foot.

Initially the toes were made of solid hard rubber and these sometimes fractured. The toes are now filled with sponge rubber inserts which not only provide a soft cushion-like feel but also render them more resilient and less liable to break away. Usually the individual toes are not separated, it being unnecessary cosmetically and functionally. A slit, however, is provided between the great and the second toes to allow insertion of the strap of a sandal if the amputee desires to wear one.

The space normally occupied by the distal row of tarsal bones and the metatarsals is represented by a single wooden block. This provides rigidity to the forefoot which is so essential for an efficient take-off. As compared to the wooden keel of a SACH foot, the anterior limit of the forefoot is located further distally where normally the metatarsal heads lie. The roll-over is much more natural and theoretically speaking, knee stabilisation should be more effective.

The main function of the proximal wooden block is to provide anchorage for the carriage bolt. There is no movement of the carriage bolt in a SACH foot because the wooden keel is a one-piece structure. In the present design, however, the carriage bolt moves with the wooden block in various movements. There must be some stresses generated around it since in many of our earlier feet, the wooden block split along the grain of the wood around the bolt. Hence this block is now made by joining several pieces of wood with their grains at right angles to each other, based on the principle in plywood. This enormously strengthens the structure and no further breakdowns have been encountered.

The sponge rubber universal joint is the most important design feature of the foot. Several layers of sponge rubber are glued together to form this large block. The entire block is enclosed securely in a closed shell of hard rubber. It is a self-contained unit and very simple to fabricate. In addition to providing freedom of movement in all directions, it is noiseless, requires no lubrication and no structural failure has so far been encountered.

During the course of this study, skiagrams were taken to demonstrate the structure of the foot and to study its behaviour during different movements (Fig. 9). The first skiagram revealed that the different layers of sponge rubber, which were so carefully glued together, had come apart. Apparently the heating during vulcanization had caused the glue to give way. This was a little unsettling and a search began for a suitable heat proof adhesive. However, while studying the movements in a cut section of the foot, it was apparent that because of this separation these layers were able to glide on each other, thereby adding to the overall mobility. In other words, the unwitting separation of these layers during vulcanization actually conferred an advantage. To prove the point, a sponge rubber block made out of a large single piece of identical material was used in a foot and the mobility was shown to be significantly reduced.

Fig. 9. The separation of the layered structure of the sponge rubber joint is shown in this skiagram, see text.

Another advantage of these separate layers seems to lie in the dissipation of stresses along the lines of cleavage, thereby protecting the sponge rubber from breaking up. An analogy of the joints which are deliberately made when laying a concrete floor to allow cracks to be dissipated along these joints can be offered.

External vulcanized hard rubber enclosure

A layer, approximately 2 mm thick, of hard rubber covering encloses the main structural components of the footpiece. In the initial stages of this work too much hard rubber was used; this increased the weight of the foot and also reduced its suppleness. Suitably coloured, this vulcanized rubber exterior offers a durable and waterproof cover of acceptable cosmetic appearance. While the rest of the foot is enclosed in a softer, lighter and more resilient grade of rubber, known as rubber cushion compound, the sole is made of a tougher material which is used on the external facing of an automobile tyre, known as rubber tread compound. This tread compound has far greater resistance to abrasion, tears and cuts but is stiffer and heavier. Its use is therefore restricted to the sole of the foot and can be compared to the thick plantar skin of a normal foot. The cushion compound is then comparable to the thinner skin of the non-weight bearing areas of the foot.

Observations

These feet have been tested in the laboratory as well as in field trials over a period of eight years in more than a thousand amputees.

The cosmetic features are satisfactory. The amputees are pleased with their appearance and from a distance it is difficult to detect that the foot is artificial. When new, the foot looks a little shiny and smooth but with use, the surface acquires a matt finish and wrinkles appear which, with a layer of dust which inevitably covers it in barefoot walking, gives it a very realistic appearance. The problem of colour matching exists. Three shades of coloured rubber have been used to match dark, medium and fair skinned individuals and this seems to serve the purpose reasonably well. The use of waterproof paint was tried; a more pleasing colour matching could be achieved but the paint started peeling in a few weeks. While repainting could be done by the amputees themselves, there is little doubt that coloured rubber offers a much better solution.

These feet are heavier than conventional SACH feet. There is no reason why this drawback cannot be overcome by rubber technologists. It must be made clear, however, that the combined weight of a SACH foot with the overlying shoe is more than this rubber foot.

The feet are durable; some farmers have

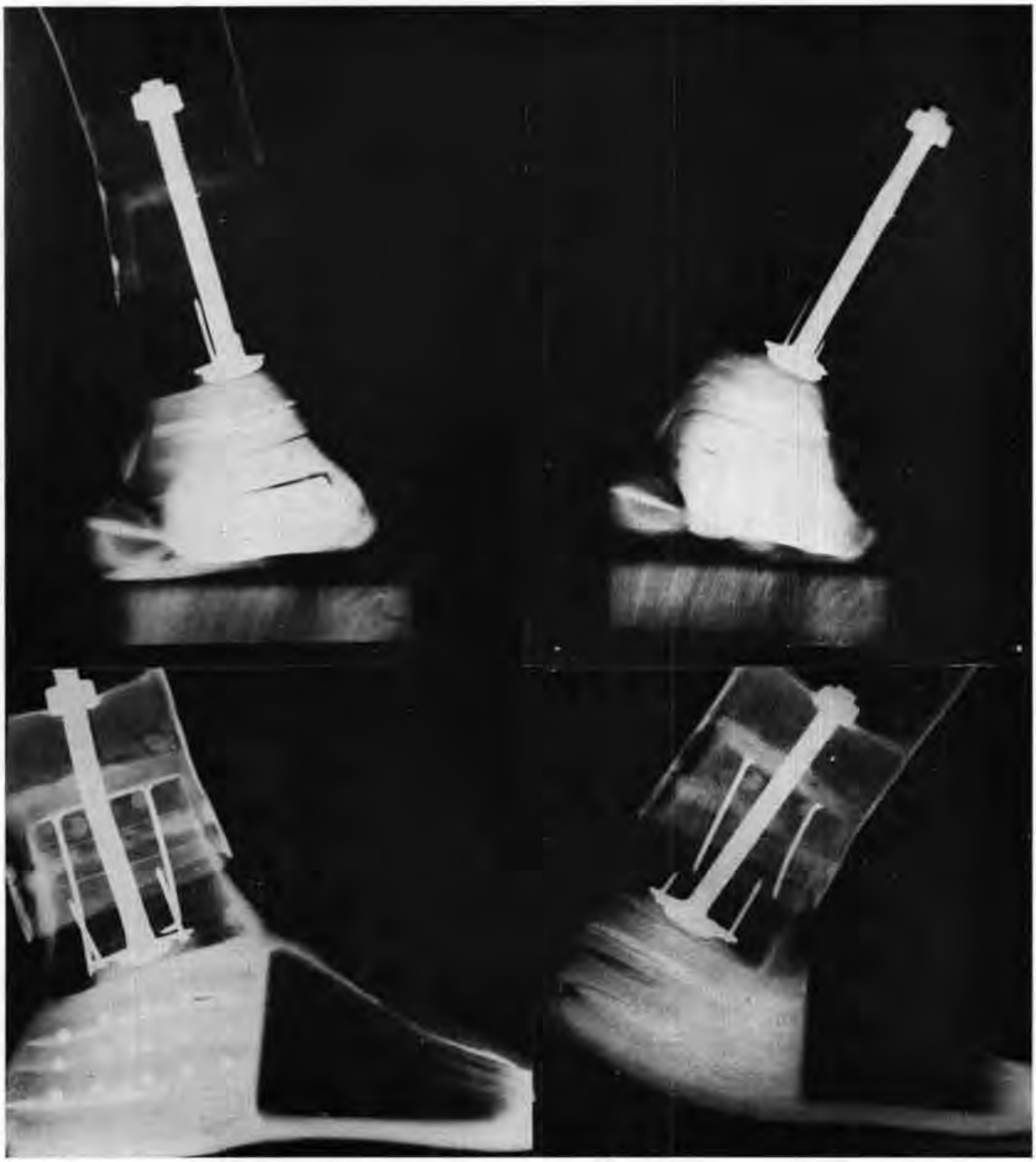

Fig. 10. Radiographic demonstration of range of movement. Top left, inversion. Top right, eversion. Bottom left, plantarflexion. Bottom right, dorsiflexion.

been using them in the environment of Indian villages for as long as 3 years without breakdown. The addition of a cord lining has significantly increased the strength as well as the durability.

The cost of production is reasonable. The initial expense of making a die is soon nullified by the number of feet which can be produced. With the current cost of labour and raw materials in India these feet cost only about £2.00 (sterling). This is as much as a pair of shoes would cost to the amputee.

There is some freedom of movement in all directions. The skiagrams reproduced here (Fig. 10) show the range of movement, with the carriage bolt utilized as an indicator.

The advantages of having a universal joint became apparent in our field trials. The amputees can sit cross-legged on the floor comfortably; no discomfort is felt in the stump as is the case when SACH feet are used (Fig. 11 top). Squatting is possible because of the range of dorsiflexion available (Fig. 11 bottom). There was an apprehension that this range of dorsiflexion might lead to a feeling of insecurity, especially in above-knee amputees. This, however, is not so. If one observes an amputee with this foot during the process of squatting, a very interesting fact emerges. The initial phase of squatting is carried out slowly, as if the foot is not yielding into dorsiflexion. As the effort continues, the foot is found to yield increasingly easily and the last phase of squatting is performed smoothly. This feature is based on the property of hard rubber which bends slowly at first but as the deforming load persists, the curve of bending rises steeply. This explains why, in spite of possessing a range of dorsiflexion which can allow squatting, there is no feeling of insecurity in ordinary walking; the small range of dorsiflexion needed in the gait cycle meets with a fair degree of resistance.

Fig. 11. Top, the range of inversion and adduction of the foot allows cross-legged sitting. Most Indians adopt this position at work. Bottom, the range of dorsiflexion permits squatting.

Walking on rough ground is performed remarkably well. The foot adapts itself readily to uneven surface with the result that the ground reactions are not easily transmitted to the socket-stump interface. To compare the performance characteristics of a SACH foot to the present design in a rugged terrain, an experiment was conducted. Two identical feet were prepared, one having a SACH foot inside and the other having the present design with a universal sponge rubber joint. The patient chosen for the trial was an intelligent farmer. He was asked to use each foot during his outdoor work and his subjective reactions as well as the condition of the stump were recorded after a day's work. The limb having an enclosed SACH foot was found to be very uncomfortable and the stump, at the end of the day, was painful and bruised. With the present design, no adverse reaction was noticed.

Transverse rotation

The significance and value of transverse rotation of the leg in relation to the foot during the gait cycle is being increasingly realized. Lamoreux and Radcliffe (1977) reiterated the need to incorporate this movement in lower limb prostheses and presented a new design to allow passive rotation of 20 degrees in either direction with a centring spring—the UC-BL axial rotation device. The Jaipur foot provides the same range of rotation in either direction.

Pneumatic joint

In an attempt to reduce the weight of the foot, it was suggested that instead of containing layers of sponge rubber, the hard rubber housing of the joint should be left hollow. It would then resemble a closed rubber ball containing air and could reasonably be labelled as a pneumatic joint. The idea seemed attractive and a foot was constructed and fitted to an amputee. It was observed that while the heel strike was very comfortable, the amputee felt a recoil on the stump when the heel was lifted off the ground. This was presumably due to the property of bounce which air conferred on this joint. The compressed heel expanded too rapidly when pressure was removed and the thrust was transmitted proximally. Thus another valuable property of sponge rubber was revealed; slow controlled recovery after deformation.

Weight bearing surface

A rather surprising observation was made that the amputees felt very secure in these feet from the beginning and required almost no gait training. The limb was fitted and they walked off. This was in contrast to our earlier experience with SACH feet where it took some time for the amputee to learn to walk confidently. This appears to be related to the very large area of support offered by these feet. A walking foot print is almost indistinguishable from a normal human foot print (Fig. 12). A SACH foot, on the other hand, has a solid ankle and requires a rockered sole for a smooth heel to toe gait. A rockered sole provides a relatively small area of support and consequently the amputee requires to learn to balance himself on it. For Indian villagers the ability to climb trees is also an important asset and amputees fitted with the Jaipur foot have had no difficulty in performing this feat due to the grip afforded by the rubber sole and the adaptability of the foot (Fig. 13).

Fig. 12. Left, a walking foot print reveals the large weight bearing area of the Jaipur foot. Right, compare the sole of the normal foot with a Jaipur foot which has been used for some months; such a broad flat sole is only successful if there is mobility available at the ankle.

Fig. 13. The adaptability of the foot permits tree climbing; this is a valuable asset in rural India.

Maintenance and repairs

There are no metallic joints which require maintenance. Being made of waterproof material, the feet can be washed daily without harm. The colour is built-in and no fading occurs with time.

Some feet develop superficial cracks. These are seen less often now since the incorporation of a rayon cord lining. Most are in any case attributable to faulty fabrication, since they are still being hand made with primitive technology. However, any cracks can easily be repaired by sticking a patch of rubber over the crack with vulcanizing cement and re-vulcanizing the foot, in much the same way as one repairs a puncture in a bicycle tube.

Modifications for Syme's and partial foot amputations

After seeing some of these feet in use in the villages, many amputees requested identical feet. Some of them had Syme's amputation and even though the original design was not meant to cater for their needs, their insistence led to modifications which have been very successful for Syme's stump (Sethi, 1971) (Fig. 14). This would form the subject of another communication.

Fig. 14. Jaipur Syme's prosthesis.

Discussion

Even though the present study was undertaken with certain limited objectives to meet the specific needs of Indian amputees, with their peculiar cultural and functional requirements, the footpiece so evolved has design features which make it suitable for use anywhere. Because of the preoccupation of the prosthetic profession with several exciting developments in the field of socket design, modular systems, knee mechanisms and the availability of new raw materials, the problem of the footpiece has been somewhat neglected. There seems to be a fairly widespread dissatisfaction with the conventional designs and there is definite scope for fresh ideas in this field.

There is little doubt that SACH feet do not stand up to rough use in vigorous outdoor activities. The material used in SACH feet is not durable enough. The use of a vulcanized hard rubber enclosure, reinforced with cord lining, provides a really strong, durable and waterproof enclosure which can withstand more rough handling than any other material. Even if the external shape of a SACH foot is retained, reinforcement with vulcanized rubber or some suitable substitute can enormously strengthen these feet.

The idea of using a foot and ankle assembly which can provide a universal freedom of movement appears to be very desirable. It is not for nothing that nature has evolved the complex joint mechanism in the ankle, subtaloid and mid-tarsal region. The ability of the foot to adapt to uneven ground is not only kind to the foot itself, but it also protects the more proximal segments of the limb by dampening the ground reactions. This protective role of the joints of the foot in saving the knee and hip from excessive ground reactions has probably not received the attention it deserves. This is presumably because it would take a long time for a knee joint to reveal excessive wear if the ankle and foot were stiff. In an amputee, however, it is the stump which becomes vulnerable to ground reactions and adverse effects are more readily observed. For the comfort of the stump, it is not only accurate fitting of sockets and correct alignment which are necessary but the provision of a universal joint in the foot assembly is equally important; this has been repeatedly proved in this study. The mobility of the footpiece has allowed us to employ many poorly made sockets and imperfect alignments without any adverse effects on the stump.

From time to time, this need had been recognised and designs have been put forward to allow more freedom of movement (Fulford and Hall, 1968).

It is felt that, in general, metallic joints are unsuitable for this purpose. They require a high degree of engineering precision in manufacture, are bulky and heavy and raise problems of lubrication; they also need to be sealed from the environment, especially in wet conditions. Repairs would involve replacing the entire unit which necessarily would be expensive and such repairs cannot be undertaken everywhere.

Many designs have, therefore, relied on rubber for providing mobility (Murphy, 1960). Probably one of the most applauded designs is the Griesinger foot, which is more versatile but the accuracy with which this needs to be made and the quality of the rubber ring would seem to be critical and require a perfection of manufacture which would not be available everywhere. It has not been possible so far to obtain a Griesinger foot to compare its performance characteristics with the Jaipur foot design.

As compared to the foregoing attempts, the design of the joint mechanism in the Jaipur foot has a basic simplicity which is attractive. It is very easy to fabricate: the large size of the sponge rubber block gives it a very substantial range of movement. This is enhanced by the presence of layers in the sponge rubber block which can slide on each other. The enclosure of this unit in a shell of hard rubber provides virtual immunity from breakdowns. Prolonged and extensive field trials under the most adverse conditions have proved the basic sturdiness of this joint.

The forefoot wooden block represents the rigid section of the foot. This provides a lever arm for take-off which gives it a greater mechanical advantage than the relatively short keel of a SACH foot. Because of the presence of the large sponge rubber joint and the rubber toes, it is unnecessary to provide any toe-break and so the full advantage of this lever arm can be exploited. The idea of replacing the single forefoot block with separate metal links which could simulate metatarsals has been discussed but this has so far not been tried. The complexity of such a design and the fear of making the footpiece heavy has acted as a damper to this idea. It is possible, however, that in barefoot walking this device could increase adaptability of the forefoot.

The external skin made of vulcanized rubber not only lends strength to the foot but also serves to modulate the range of mobility. The final range of movement is thus a resultant of the intrinsic mobility of the sponge rubber block and the restraining effect of the external skin. It will be recalled that earlier attempts were hampered by the stiffness of the hard rubber which had to be reduced in thickness. What appeared originally as a drawback has now been harnessed to control the mobility and by increasing or decreasing the thickness of the hard rubber in front of or behind the ankle, one can get any desirable degree of suppleness in the foot. No other existing design is known which has made use of such a control mechanism.

The value of a large area of support provided by the plantar surface has not received any attention by the limb designers so far. This is surprising because this is also an important anatomical feature and makes the amputee feel more secure. This may prove to be particularly useful for the elderly amputees in the West who may find balancing much easier. It may be stressed that a broad flat plantar surface is directly linked with the provision of mobility in the foot mechanism; a stiff ankle would demand a rockered sole to allow a smooth heel to toe action. The area of support in a rockered sole is a relatively small one and consequently the amputee requires some time to learn to balance himself on it. It is also possible that a large area of plantar surface may result in a more effective sensory feedback to the stump. Although this seems plausible no means were available of testing this hypothesis.

The gait with these feet is very natural. Farmers are able to walk on uneven ground with remarkable ease.

The cosmetic features of the footpiece naturally assume importance in all countries where closed shoes are not ordinarily worn. This is perhaps true of most of the warm countries in the Asian, African and South American continents. It is obvious that a very large proportion of the amputee population of the world would require this feature. The social and cultural background also cannot be ignored. Natrajan (1971), in Madras, recognised this need and has tried to reshape a SACH foot to make it resemble a normal foot by carving toes, modifying the heel contour and painting the exterior to match the skin colour. Lest the "Natrajan Foot" be confused with the "Jaipur Foot", it must be made clear that he has not made any alteration in the basic design of a SACH foot and the footpiece is made of sponge rubber. It cannot withstand the rough exposure during the outdoor activities of an Indian peasant. It does not match the strength and durability of the "Jaipur Foot" nor does it have the range of mobility present in the latter.

There is considerable scope for improvement in the "Jaipur Foot". It should be realized that this work was carried out with the help of local craftsmen with primitive facilities, supervised by orthopaedic surgeons with no formal background in prosthetics.

It is felt that even the Western amputee would appreciate a more natural looking artificial foot. There is no reason why a really life-like foot which is light and more durable cannot be produced with the help of the advanced technology in the West. It is envisaged that the entire range of foot sizes in different shades of colour could be produced on an assembly line basis so that they could be taken "off the rack" to suit any amputee.

REFERENCES

FULFORD, G. E. and HALL, M. J. (1968). Amputation and Prostheses. p. 38. Bristol, John Wright & Sons.

HARRIS, W. R. (1973). Personal Communication.

LAMOREUX, L. W. and RADCLIFFE, C. W. (1977). Functional analysis of the UC-BL shank axial rotation device. *Pros. Orth. Int.* **1:2,** 114–118.

MULLER, G. M. (1957). A simple prosthesis for rural amputees. *J. Bone Joint Surg.*, **39-B,** 131.

MURPHY, EUGENE F. (1960). Lower extremity components in Orthopaedic Appliances Atlas Vol. 2. J. W. Edwards, Ann Arbor, Michigan.

NATRAJAN, M. (1971). Personal Communication.

NORTH, J. F., GOVAN, N. A. and HUGHES, J. (1974). Performance measurement of the Sethi foot. Paper presented at the First World Congress Prosthetics and Orthotics, Montreux.

SAUNDERS, J. B., INMAN, V. T. and EBERHART, H. D. (1953). The major determinants in normal and pathologic gait. *J. Bone Joint Surg.*, **35-A,** 543–568.

SETHI, P. K. (1971). A modified Syme's prosthesis. Paper presented at the Annual Conference of Indian Orthopaedic Association, Vishakhapatnam.

SETHI, P. K. (1972). A rubber foot for amputees in underdeveloped countries. *J. Bone Joint Surg.*, **54-B,** 177.

SETHI, P. K. (1974). Lower limb prosthesis for amputees in rural areas, in Surgical Rehabilitation in Leprosy. Edited by McDowell, F. and Enna, C. The Williams & Wilkins Co., Baltimore.

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HRC adjustable pneumatic swing-phase control knee

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Abstract

Since 1972 the Hyogo Rehabilitation Centre has been developing a variable-resistance-type pneumatic control device, the HRC Adjustable Pneumatic Swing-Phase Control Knee. Successful field tests have been carried out on 20 cases with Model IV since 1973 with only a limited number of mechanical troubles.

This paper introduces the HRC adjustable pneumatic swing-phase control knee with follow-up studies.

Objectives

Recently pneumatic swing-phase control devices providing improved control of the knee over wide ranges of walking speeds have been developed. Pneumatic control knees such as those produced by Blatchford or Hosmer have been commercially available (Veterans Administration Program Guide, 1973) which have shown superior swing-phase characteristics (Radcliffe and Lamoreux, 1968; Lewis, 1971). Because of the difference in the way of life between western countries and Japan, it is not only expensive for the amputee to get these pneumatic knees from other countries, but also difficult to get follow-up services. In designing the HRC unit, two major points have been taken into account.

1. The need to speed up the prosthetic gait whenever the amputee requires a faster, safe speed such as when crossing a busy road. To this end adjustability of the speed of prosthetic gait by the amputee himself is desirable.
2. The desire to reduce the terminal impact which is caused by increased speed in gait.

To fulfil those major points for a pneumatic swing-phase control unit, the following three independent functions are necessary (Radcliffe, 1973):

i. Resistance to excessive heel rise between toe off and the instant of maximum knee flexion.

ii. Voluntary adjustment of the acceleration by amputee himself from maximum knee flexion to maximum forward velocity.

iii. Reduction of terminal impact.

Since September 1972, the Centre has built 6 models, the latter 4 with the technical aid of the Nippon Air Brake Company. Model I realized the desired kinematic behaviour of the pneumatic knee, and in Model II the outside bypass was modified by incorporating it within the piston-rod. Adjustable resistance for a sliding mechanism and a cushion mechanism for a terminal impact were added to Model III and in Model IV a check valve was added in the piston to increase the walking speed. Field tests were performed with Model IV and V (Fig. 1).

Description of Model IV unit

The HRC pneumatic control unit Model IV consists of the following; a pneumatic cylinder, a knee block, and a wood shank which contains

Fig. 1. Left, HRC Model IV. Right, HRC Model V.

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the cylinder. The attachment of the unit to the knee block is by a pin passing through the piston rod head into bushes 3 cm. posterior to the knee bolt. The movement of air is limited by the piston. The rate of leakage between upper and lower cylinder can be varied by a needle valve which is contained within the piston rod. It is adjusted by operating an adjustment screw in the head of the piston rod and located to the rear of the knee joint. This mechanism enables the amputee to adjust the slide resistance of the piston in a natural manner without any supplementary devices.

Inside the cylinder head, there is a small air chamber A (Fig. 2) which can act as an air cushion mechanism as the knee comes into full extension. When the largest part of the piston-rod (ϕD) comes to the cushion seal in the cylinder head, the air of the chamber A is trapped and a cushion effect can be obtained because the rate of air-release through the cushion valve is very small. This cushion valve is also adjustable. With this system, the reduction of terminal impact was much more pronounced than without it (Nakamura and Sawamura, 1973).

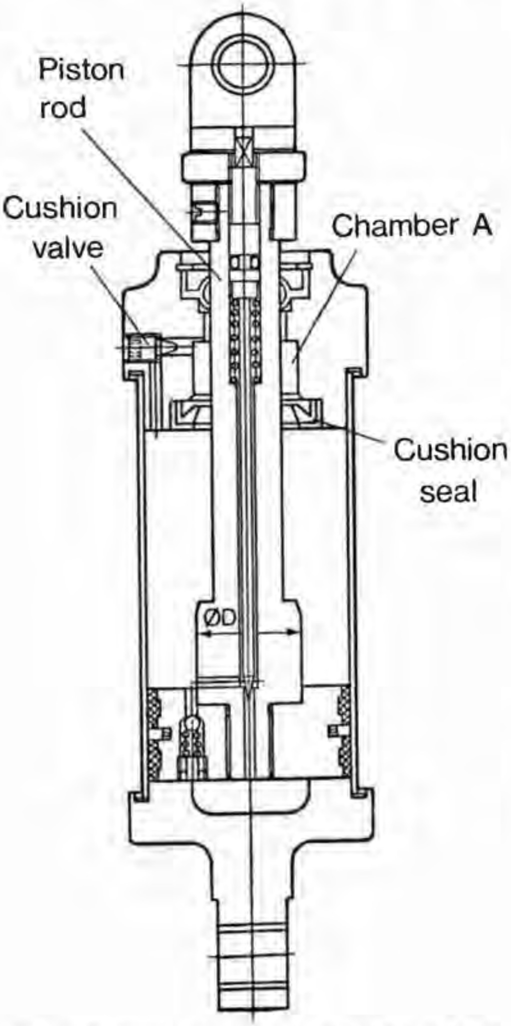

Fig. 2. Sectional drawing of Model IV cylinder.

Operation speed	30 mm/sec in both directions
Frequency	14 times/min
Total no. of cycles	2×10^5

Fig. 3. Frictional durability test conditions.

A frictional durability test of the pneumatic cylinder was performed and Figure 3 shows the test conditions. During this test temperature and size of the parts were not affected (Nakamura and Kayatani, 1974). Figure 4 shows the material of the cylinder.

Part	Material
Cylinder tube	A6063
Piston	Al, compound rubber
Piston rod	A2B4–T6
Cover	A 4C–T6
Cushion seal	Compound rubber
Rod packing	Compound rubber
Needle valve	SUS 27

Fig. 4. Model IV cylinder parts and materials.

Field test and evaluation

After obtaining a successful result in the mechanical durability test, a field test of Model IV was performed for 20 cases. The evaluation programme consisted of three groups as follows.

1. Objective evaluation tests by physical therapist.
2. Subjective evaluation to check the acceptability by the amputee.
3. Biomechanical tests with measuring instruments. Details of the test programme are shown in Figure 5.

A. Objective evaluation	B. Subjective evaluation	C. Biomechanical test
1. Gait speed	1. Gait speed	1. Maximum knee flexion angle during swing-phase
2. Cadence	2. Easiness of acceleration	2. Inner pressure of the pneumatic cylinder
3. Stride	3. Waiting time during swing-phase	
4. Knee flexion angle	4. Terminal impact	
5. Weight	5. Weight of toe	
6. Noise	6. Total weight	
7. Gait appearance	7. Noise	
8. Stability	8. Stability	

Fig. 5. HRC pneumatic knee evaluation programme.

Age	Number
15–19	3
20–29	7
30–39	5
40–49	2
50–59	2
60–69	1
	20
Range: 17–62	
Mean: 32	

Fig. 6. Age of test subjects.

No. of years	Number
0–3	10
4–7	2
8–11	5
12–15	3
Range: 3 mo.—15 yr.	20
Mean: 5.3 yr.	

Fig. 7. Length of time prosthesis worn.

Group	Level	Number
H	Hip-disarticulation	3
K	Through knee	4
S	Short A/K stump	6
M	Medium A/K stump	3
L	Long A/K stump	4
		20

Fig. 8. Amputation level.

The 20 amputees participating in the study have been wearing the test unit since 1973. They were classified into 5 groups, H, K, M, S and L, according to the amputation levels. Details of test subjects as shown in Figures 6, 7 and 8. Average gait training period was 3 months.

The results of objective evaluation test are shown in Figure 9. The abbreviations C and N are used to represent the results of the pneumatically *controlled* knees and *non-controlled* knees respectively. The difference between C and N can be regarded as an effect of the characteristics of the HRC knee because the tests were performed under the same conditions, that is, same fitting and same alignment, except for attaching the pneumatic cylinder to the knee joint. Each figure in Figure 9 represents the average value of each group, the total average value in each test being given in the final column.

From the normal gait speed test it can be seen that the control unit improves 16 seconds on average for the amputee to walk 100 metres; Groups M and L are dominant in improving their gait speed among the 5 groups. The dominance of Groups M and L holds in 100 metre fast gait speed test as well as in the cadence test. The double-stride test indicates that with this control unit amputees could make their double-stride 12 cm longer. However the unit has no particular merit for slopes and stairs.

In the gait analysis of Figure 10, excessive heel rise and terminal impact are greatly improved. It may seem strange but lateral bending of the trunk is reduced by using this unit. According to the table, symmetry of the strides is lost but this means that the stride of the affected side is nearly 1 cm longer than the unaffected side. The average total weight of the

C: Control N: Non-Control

		Hip (H)	A/K (S)	A/K (M)	A/K (L)	T/K (K)	Ave.
Gait Normal (100m)	Speed	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.	min. sec.
	N	1 56	1 51	2 06	1 51	1 32	1 53
	C	1 50	1 39	1 39	1 33	1 31	1 37
	C–N	–6	–12	–27	–18	–1	–16
Fast (100m)	N	1 45	1 22	1 44	1 33	1 21	1 33
	C	1 42	1 14	1 27	1 22	1 18	1 23
	C–N	–3	–8	–17	–11	–3	–10
Cadence	N	86	94	93	92	98	93
	C	84	95	101	101	98	96
	C–N	–2	1	8	9	0	3
Double-Stride		cm	cm	cm	cm	cm	cm
	N	120	125	112	121	112	118
	C	135	132	129	125	129	130
	C–N	15	7	17	4	17	12
Slope		sec.	sec.	sec.	sec.	sec.	sec.
Up	C–N	0	0	1	0	0	0
Down	C–N	1	0	2	0	1	1
Stair							
Up	C–N	2	–1	2	4	2	1
Down	C–N	–1	5	1	4	0	2

Fig. 9. Results of the objective test.

above knee prosthesis was about 4 kg and the pneumatic cylinder unit weighed 400 gm.

In the subjective evaluation test programme, many of the amputees under test felt they were able to walk more easily and faster than before (Fig. 11). The pneumatic control unit did not provide any stance-phase control, however many amputees felt that the stability of the knee was improved at the beginning of the stance-phase.

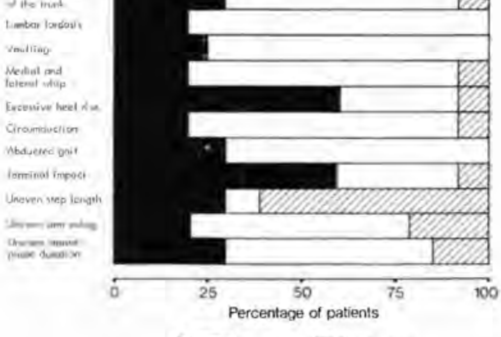

Fig. 10. Gait appearance.

The knee flexion angle during prosthetic gait was measured with a high-speed camera, film motion analyser, and PDP-12 mini-computer. The maximum knee flexion angle during swing-phase in each group reached normal value except H Group (Fig. 12). To measure the inner pressures of the pneumatic

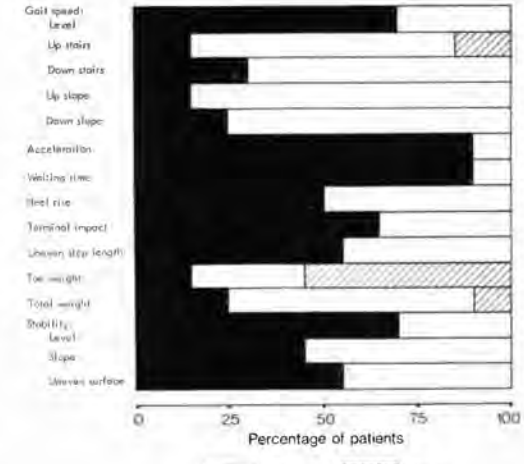

Fig. 11. Subjective test.

		Hip(H)	A/K(S)	A/K(M)	A/K(L)	T/K(K)	Av
Maximum knee flexion angle (degrees)	N	132	115	98	105	105	109
	C	140	122	109	123	119	122
	C−N	8	7	11	18	14	13

Fig. 12. Maximum knee flexion angle during swing-phase.

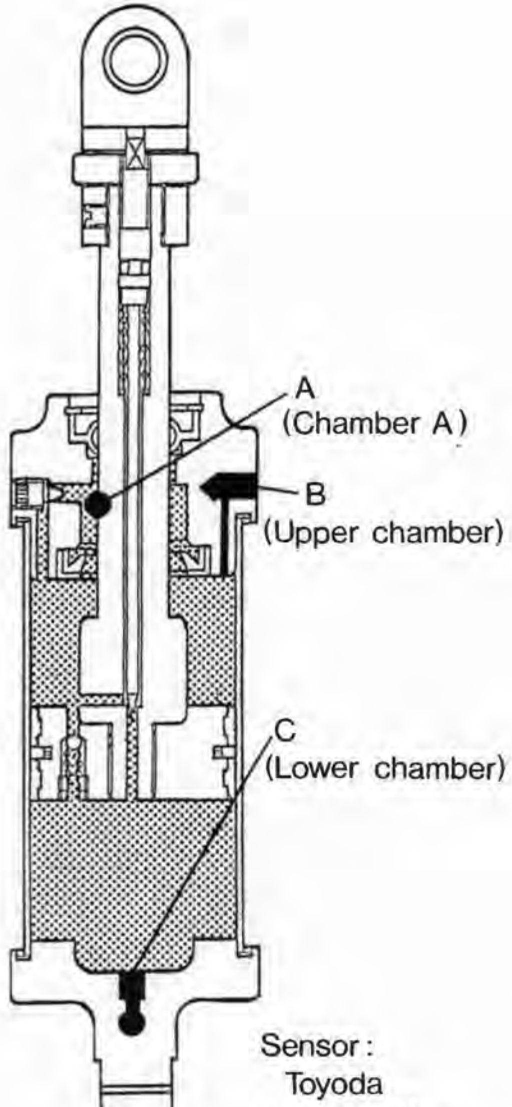

Fig. 13. Position of pressure transducers.

cylinder miniature type pressure transducers were attached to points A, B, and C as can be seen in Figure 13. Typical pressures are shown in Figure 14. Negative pressures in chamber A and the upper cylinder contribute to reduction of excessive heel rise and acceleration of the shank. Positive pressure in the chamber A is used to reduce the terminal impact.

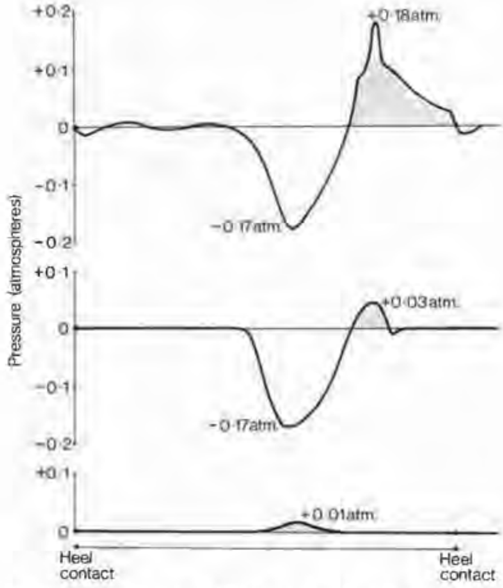

Fig. 14. Pressure within each chamber of the cylinder. Top, A. Centre, B. Bottom, C.

Mechanical problems

During this field test several types of mechanical troubles were experienced in a limited number of cases.

Trouble occurred at the needle valve with Model IV in 3 cases out of 20 . When the wearer revolved the adjustment screw too tightly, the needle valve was inserted too firmly into the hole in the piston and did not work well.

The problem of noisy joints was solved by using Oiles no. 80 bushes.

Breakdown of the cylinder rod-head occurred in 2 cases with Model IV which resulted in the wearer suffering a violent fall. Another case of breakdown was in a through knee prosthesis; as the knee joint hyperextended repeatedly, the cylinder rod-head broke down after 2 years.

Trouble has occurred in one case out of 50 with Model V. The bakelite of the bearing at the knee joint wore out and would not work after 2 years of constant use. To avoid these problems the models were changed 3 times. The last type is the Model VI (Figure 15) and field test of it started in May 1977.

Fig. 15. HRC Model VI.

Summary

The amputee can voluntarily change the acceleration at the beginning of swing-phase by adjusting the rate of air leakage of the pneumatic cylinder without any supplementary devices. This unit furnishes the mechanism for reduction of terminal impact. Voluntary acceleration and reduction of terminal impact provides an amputee with smoother and faster gait on level walking. This improvement is dominant especially in the case of long and medium length above knee stumps.

The 20 cases of Model IV and 50 cases of Model V have been field tested successfully except for a limited number of mechanical troubles. Negative reaction of test subjects are non existent, they all want to wear the unit.

To solve the mechanical troubles experienced during the field tests with Model IV and V, Model VI was developed.

Acknowledgement

The authors wish to thank the Nippon Air Brake Co. Ltd. and Mr. K. Amemori for their technical support and Mr. S. Suzuki, RPT and Mr. M. Nishioka, RPT for their help to evaluate these units clinically.

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REFERENCES

Lewis, E. A. (1971). Clinical evaluation of a pneumatic knee system. The University of California Biomechanics Laboratory Swing-Control Unit. *Bull Pros. Res.*, **10–15,** 85–94.

Nakamura, S. and Sawamura, S. (1973). Development of pneumatic swing-phase control knee. Proc. 16th Joint Conference on Automatic Control in Japan, **16,** 329.

Nakamura, S. and Nishioka, M. (1973). Evaluation of HRC pneumatic swing-phase control knee. *Jap. J. Phys. Ther. and Occ. Ther.*, **8,** 253.

Nakamura, S. and Kayatani, F. (1974). Development of pneumatic gait-control device. *Jap. J. Hydraulics and Pneumatics*, **12,** 53.

Radcliffe, C. W. and Lamoreux, L. W. (1968). UC-BL pneumatic swing control unit for above-knee prostheses. *Bull Pros. Res.*, **10–10,** 73–89.

Radcliffe, C. W. (1973). Biomechanics of swing phase control in prosthetic knee mechanisms. Proc. 1st International Congress on Prosthetics Techniques and Functional Rehabilitation, **4,** 275.

Veterans Administration Program Guide (1972). Selection and application of knee mechanisms. *Bull. Pros. Res.*, **10–18,** 90–158.

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Prosthetic principles in bilateral shoulder disarticulation or bilateral amelia*

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Abstract

Following a brief survey of the historic development of pneumatic prostheses the actual principles of prosthetic management in bilateral shoulder disarticulation or bilateral amelia are explained.

The active functions are restricted to active pronation and supination, active gripping of the terminal device "hook" or "hand", combined with pneumatic locking of free swinging shoulder and elbow joints in one artificial arm; the cosmetic arm provides only space for the power package in the resin socket of the upper arm. Both arms are suspended on a Simpson frame.

Thus optical control is concentrated on the movements of the functional arm. The reduction of valve control makes prosthetic training and use easier.

Recently hybrid systems came into use because electric power proved superior to pneumatic power for pronation and supination and gripping, whereas CO_2 is still necessary for locking the elbow and the shoulder joint. The accumulator can be recharged daily at a plug socket, the CO_2 container need only be refilled after one or two weeks ensuring more independence for the disabled. The advantage of such a prosthesis is the better appearance in public combined with a certain functional use.

However only intensive foot training without prostheses provides independence in daily activities, because even sophisticated prosthetic systems cannot make up completely for body loss.

Introduction

Whereas an amputee with shoulder disarticulation and one healthy upper limb generally finds a cosmetic prosthesis without active functions adequate, there is an obvious problem in the fitting of cases of bilateral disarticulation or congenital absence of both upper extremities with functionally satisfactory prostheses. No unexplored possibilities remain for the body powered positioning of artificial arms and for opening and closing the terminal device "hook" or "active hand"; so external power for a functional prosthesis becomes indispensable.

In 1948 the first experiments with CO_2 driven pneumatic prostheses were undertaken by Häfner and Weil; CO_2 was used as a safe, easily controllable, easily applied and at the same time cheap propellant. In 1957 Marquardt and Häfner first fitted a child with bilateral amelia of the upper limbs with pneumatic prostheses.

The initial aim of the most extensive motorisation possible of both prostheses rapidly proved itself inexpedient. The absence of suitable body parts for operating the control valves and the limited capacity of co-ordination, even in the most intelligent patients, was opposed to the increasing number of necessary control signals. The insufficient sensory "feedback" necessitated an exclusively optical control over the actions of the terminal devices. The independent use of each prosthesis at the same time beyond a small, optically controllable area was bound to fail for this very reason. The heavy weight and increasing energy consumption required finally led to reflection on the practicability of such "fully motorised" prosthetic systems. As a consequence there was a step by step reduction to the necessary functions and the improvement or new development of better suitable fittings.

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*Based on a paper presented at the Second World Congress, ISPO, New York, 1977.

Present practice

Partly manufactured by the industry and partly handmade in our own workshops the following pneumatically driven modular parts are available today:

—a hook for children,

—a hook for teenagers,

—the pneumatic Otto-Bock-system hand,

—joints for pronation and supination,

—an active pneumatic elbow joint with lock,

—a free mobile elbow joint with pneumatic lock,

—for children, a free swinging shoulder joint manufactured from a standard modular elbow joint with pneumatic lock and extremely small CO_2 consumption combined with a friction joint for abduction,*

—for older children and teenagers a free swinging shoulder joint with pneumatically lockable forearm linkage.*

The philosophy of prosthetic fitting of such seriously disabled patients, as described by Marquardt, is based on the idea that the prosthesis is only to be prepositioned, that is, a rough adjustment is obtained and held. Fine co-ordination is achieved by body movements, for example by bringing the mouth to the cup or to the spoon, which is already prepositioned with the prosthesis within the range of the body movements (Fig. 1).

Connected with this is the reduction of prosthetic technique to the minimal yet indispensable functions. The dominant side is provided with a functional arm for active use. The opposite side is fitted with a cosmetic arm without active functions; in the moulded resin socket of its upper arm the CO_2 storage cylinder is accommodated. The functional arm has at its disposal:

—a free swinging, pneumatically lockable shoulder joint,

—either a free or pneumatically movable elbow joint, in both cases pneumatically lockable,

—a pneumatic joint for active pronation and supination,

—a pneumatic "hook" or a pneumatic "system hand" (if possible interchangeable) for active gripping.

The cosmetic arm of the opposite side has only a free swinging shoulder joint and a passively adjustable elbow friction joint. Occasionally the hand of the cosmetic arm may be additionally pneumatically activated to allow a certain amount of hand to hand co-ordination. Both artificial arms are suspended on a Simpson frame (Fig. 2), which has replaced our former frame constructions (Fig. 3) due to its reduced weight and superior comfort in wearing.

The individual functions are controlled by means of valves. For locking or unlocking of the free swinging shoulder and the elbow joints, flip-flop valves have proved successful since in these the pressure points are clearly defined. The pronation and supination of the forearm is controlled by means of a doublepoint pressure valve, situated above the acromion, or by a doublepoint traction valve, operated by a shoulder strap while lifting the shoulder (Fig. 4). The opening and closing of the gripping device is effected by activation of a flip-flop valve in front of the shoulder.

* Developed by H. Krämer, Research Lab. of the Dept. for Dysmelia and Technical Orthopaedics, Heidelberg University.

Fig. 1. Prepositioned prosthesis permits the patient to bring the mouth to the spoon.

Fig. 2. Prosthetic system with active arm on the right side with pneumatically lockable shoulder and elbow joint, pneumatic pronation and supination and pneumatic hand; on the left side, a free swinging shoulder and elbow friction joint, and built-in CO_2 storage cylinder in the upper arm. Both arms are suspended on a Simpson frame.

Fig. 3. Former frame construction for pneumatic prostheses for a child with phocomelic upper limbs.

Fig. 4. Detail of doublepoint pressure valve in front of the shoulder and doublepoint traction valve fitted to the Simpson frame.

The few active functions can be easily controlled and, in general, learning problems in prosthetic training do not occur. The optical control is directed exclusively towards the activity of the functional arm. Energy consumption is limited, the contents of a CO_2 container, corresponding to about 500 actions, is sufficient for a normal day's use, as shown by experience. The weight of such a complete prosthetic system for a 10 year old child is about 1750 g with a pneumatic hook and about 1950 g with an Otto-Bock-system hand.

One thing which remains unsatisfactory, is the dependence on refilling the CO_2 storage container carried in the prosthesis from a stationary CO_2 pressure cylinder by means of a reduction valve and a special adaptor. With regard to this inconvenience electrical power from batteries or from rechargeable accumulators has proved superior to CO_2 pneumatics.

On this account we changed over to electromechanical prostheses. The first patients were children with phocomelic upper limbs; their forearmlike prostheses were attached to a modified "Ringbandage" instead of the uncomfortable stiff frame, permitting maximum freedom of movement (Fig. 5). The phocomelic limbs were fitted into the moulded resin sockets in such a way as to give the impression of an actively movable elbow joint and to enable the fingers to operate microswitches which in turn controlled the electromechanically driven hands (Fig. 6). The result was an improvement upon wearing comfort, cosmetic appearance and function.

For the reasons mentioned above it seemed sensible to convert also the prostheses for patients without arms to electrical power. So far, however, no comparably efficient electromechanically lockable shoulder and elbow joints have been developed. Thus in the meantime, we are developing hybrid systems which exploit the advantages of the pneumatic as well as of the electrical external power (Fig. 7).

The shoulder and elbow joint of the functional arm is pneumatically lockable as before. The CO_2 consumption for these actions is extremely small; the volume of the container carried in the prosthesis is now sufficient for one or two weeks, according to the amount of use, assuring greater independence from the station-

Fig. 5. Recent prosthetic fitting of a phocomelic girl with electromechanical prostheses and suspension on a modified "Ringbandage"; Hosmer outside locking for elbow joints. Extreme right, cosmetic result.

Fig. 6. Microswitch which is operated by the movements of the one finger phocomelia.

ary energy reservoir at home. The energy consuming functions, such as pronation and supination and gripping movements, are electrically driven. The accumulator can be recharged at the nearest, most convenient plug socket or, with little interruption in prosthetic use, it can be exchanged for a charged second accumulator. In our experience this hybrid system can be most recommended.

Discussion

In spite of these improvements excessive enthusiasm concerning the extent of functional use of such prostheses in daily life is out of place. Their actual value lies in the indisputable "normalisation" of the patient's appearance in public (one should perhaps say: *for* the public), combined with an optimizing of the functional possibilities of such prostheses by exploiting the technical knowledge available today. Therefore an intensive training in daily activities without prostheses is also essential. Besides simple technical aids, as for example, an eating aid attached to and moved by the leg, foot training is of the

Fig. 7. Hybrid prosthesis in bilateral amelia with pneumatically lockable shoulder joint (controlled by valves in the left side) and pressure and traction microswitches for gripping and forearm rotation. Built-in accumulators fitted to the frame of the right upper arm.

Fig. 8. Result of self-care foot training, independence from prostheses in daily activities at home.

utmost importance, especially for overcoming daily recurring problems not only in toilet use, dressing and undressing, washing (Fig. 8), combing hair, teeth cleaning, but also in eating, drinking and in writing (with or without typewriter). Not only can many things be *handled* better with the feet but functional independence of (meaning freedom *from*) the prosthesis—at least at home in privacy—releases the patient from the unpleasant feeling to be capable of living only as a "perfect operator of a sophisticated prosthetic robot". This consideration should be uppermost in the mind while prescribing such a costly aid: it protects against the over-evaluation of technology and the concomitant under-evaluation of the individual, whom the technology should serve.

BIBLIOGRAPHY

MARQUARDT, E. and HÄFNER, O. (1956). Technische Bewahrung und prakhische. Anwendung der Heidelberger pneumatische Prothese. *Archiv fur Orthopadische und Unfallchirurgie* **48,** 115–135.

MARQUARDT, E. (1957). Muskelsteuerung von pneumatischen Unter-und Oberarmprothesen. *Archiv. fur Orthopadische und Unfallchirurgie*, **49,** 419–426.

MARQUARDT, E. (1965). Erfahrungen mit pneumatischen Prothesen. *Verh. Dtsch. Orthop. Ges.*, **52,** 346–352.

MARQUARDT, E. (1974). Pneumatische Prothesen, Eigenkraft-prothesen und technische Hilfen für schwere Armfehlbildungen in: [10] *Jahre Entwicklung und Erprobung von Hilfen und Hilfsmitteln für behinderte Kinder*. Hrsg.: AG Technische Orthopädie und Rehabilitation, R. Schunk Verlag, Königshofen.

NEFF, G. MARQUARDT, E. (1977). Stand der Versorgung mit pneumatischen Prothesen in: *Amputation und Prothesenversorgung beim Kind.* Ed.: R. Baumgartner, F. Enke Verlag, Stuttgart.

NEFF, G. (1978). *Prinzipien der prothetischen Versorgung nach beidseitiger Schulterexartikulation oder bei beidseitiger Amelie Orthopädie-Technik*, (In press.)

SIMPSON, D. C. and KENWORTHY, G. (1973). Design of a complete arm prosthesis. *Bio-med. Eng.*, **8,** 56–59.

SIMPSON, D. C. and KENWORTHY, G. (1973). Entwurf eines vollstangigen Amersatzes (Teil 2) *Orthopädie-Technik*, Feb. 41-44.

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A new approach to the management of wounds of the extremities Controlled environment treatment and its derivatives

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Abstract

Controlled Environment Treatment is a new approach to wound management—for the first time it provides the surgeon with the means of controlling and optimizing the wound environment for the duration of the healing period.

Equipment is commercially available and the technique is now being applied internationally; the technique has been established for the treatment of limbs—application to the trunk requires further investigation and development.

Spin-offs have already occurred, one being the control of certain types of lymphoedema by the patient in their own home; the other concerns the application of plaster of Paris to produce casts having significantly superior physiological characteristics using minimal manipulative skills. The former is known as Pressure Environment Treatment, the latter is known as Controlled Pressure Casting; equipment is commercially available internationally.

The treatment and healing of wounds on the limbs

General philosophy

The rate at which a wound heals is governed by the metabolic processes in the adjacent tissues; in ideal conditions the healing time becomes a minimum, but external conditions can impair the local metabolic processes which in turn will result in delayed healing. A wound management system should therefore endeavour to provide a wound environment which does not impair the natural processes.

Ideally, a wound management system should permit an adequate tissue response to the stimulus of injury and actively prevent any over-response such as excessive oedema. The system should not interfere with the normal vascular and lymphatic circulation; indeed it is advantageous if these circulations are positively assisted. The system should prevent bacterial cross-infection and should control the proliferation of the skin-borne bacteria. It should prevent the occurrence of complications such as the formation of a haematoma. Visual observation of the wound and palpation of the tissues without disturbing the environment, would permit the early detection of complications and the implementation of relevant remedial action. When healing is complete, the system of treatment should not retard the resolution of the side effects of the mechanisms of tissue repair; this is of special importance in relation to the persistence of residual oedema which may cause considerable delay in the final rehabilitation of the patient.

Present methods of wound management usually entail the application of a clinical dressing held in place by a soft bandage, a pressure bandage, or a rigid plaster cast. The effect of these dressings on the wound and on the adjacent tissues, and also on the conditions of the environment surrounding the wound, is very dependent upon the skill and experience of the person applying the dressings; furthermore, these conditions can be radically changed—for instance by a change in tissue volume. Once applied, the conventional dressings are passive; any attempt to readjust the influence of the dressing requires removal and re-application with consequent mechanical disturbance and exposure to cross-infection. Bleeding and wound exudate establish moist warm conditions which favour bacterial proliferation. The inability to observe the wound until the dressing is removed may result in complications remaining hidden until other symptoms indicate that all is not well at the wound site; remedial measures are consequently delayed.

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The concept of the gaseous dressing

The Biomechanical Research and Development Unit at Roehampton has developed a wound management system which is unique; it is known as Controlled Environment Treatment (CET) and it complies with most of the requirements of what should constitute an ideal system of wound management. By containing the bare limb within a transparent plastic film bag, and by using a pressurized gaseous environment in direct contact with the limb, a form of wound management has been devised which has the following clinical advantages:

a. The wound is maintained in an environment which is protected from bacterial contamination.

b. The low relative humidity of the environment militates against the proliferation of the indigenous skin-borne bacteria. Additionally, the low relative humidity maintains the wound and adjacent tissues in a dry state.

c. By varying the air pressure in the "dressing" in a predetermined cyclic fashion, the circulation of blood and lymph can be modified with beneficial results.

d. The pressures imposed on the tissues are uniform within the "dressing" and can be set to predetermined levels and will be maintained at these levels, regardless of change of size or shape of the traumatized limb. A tourniquet effect is impossible.

e. The temperature within the "dressing" can be set to a predetermined level.

f. Direct contact between the skin/tissues and the gaseous environment permits the normal gaseous and water exchange mechanisms of the skin to remain viable and functioning.

g. Clinical assessment of the wound can be made both visually and by palpation at any time and without disturbing the environment.

h. There is no interference with the normal nursing and rehabilitation procedures.

i. The treatment is simple to set up and maintain.

Fig. 1. Controlled Environment Treatment (CET). Top, application to surgical case. Bottom, sterile treatment bag enclosing the limb.

The apparatus for this treatment (Fig. 1) consists of a control console containing an air compressor, feeding bacterially free air via pressure, timing, and temperature control devices and a lightweight flexible hose to the sterile treatment bag which encloses the limb. The pneumatic circuit system is shown in Figure 2. Figure 3 shows the console with its controls. The treatment bag, Figure 4, is a flexible transparent "open bag" with the air hose connected to the closed distal end. The open proximal end incorporates a self-adapting pleated type of air seal used within the hovercraft industry. Following surgery, the limb is inserted into the sterile bag by passing it through the pleated seal. No dressings are applied to the wound which is therefore clearly visible through the transparent wall of the bag; the limb rests on a soft open-cell plastic foam pad attached to the inner wall of the bag. The

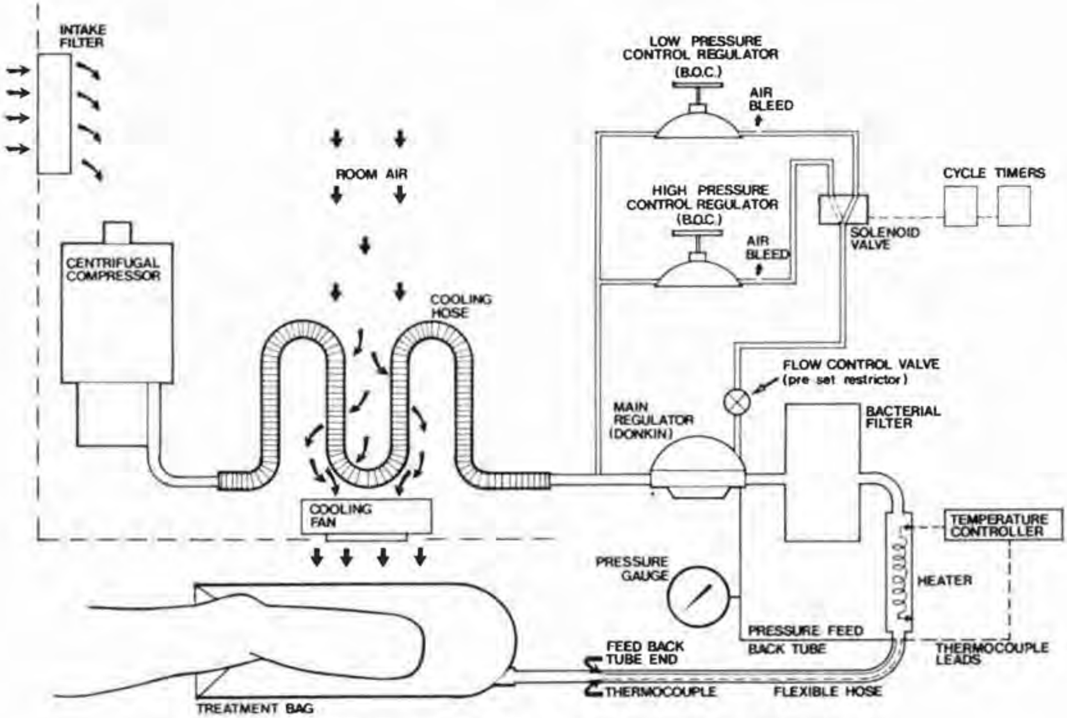

Fig. 2. Block diagram of pneumatic circuit system.

bag is held on the limb by means of a simple retention harness made from flexible webbing. The pressure and temperature conditions in the treatment bag can be preset via the controls on the console; the air pressure will be cycled automatically, typically 50 mm Hg for 30 seconds followed by 10 mm Hg for 10 seconds. The temperature control is normally set to supply air to the bag at about normal skin temperature (33 ± 3°C). The fit of the seal around the limb cannot exert a pressure on the underlying tissues which is greater than the air pressure in the bag, and thus there is no risk of a tourniquet effect. The seal is not air tight, and is organized to permit a specific leakage of air from the bag to atmosphere at all times; this


Fig. 3. Air control console.


Fig. 4. The treatment bag showing pleated self-adapting seal.

air leak allows a continuous passage of air through the bag enabling both temperature and humidity to be controlled. This controlled air leak is provided by a single layer of knitted stockinette which is placed over the limb in the region of the bag seal; it is important that this stockinette is in place. Additionally this prevents the seal vibrating and emitting an undesirable raucous noise. The positive pressure gradient that is maintained at all times between the inside of the bag and the outside atmosphere, prevents the re-entry of any non-sterile air past the pleated seal. The control console does not incorporate a preset relative humidity control, but raising the temperature of the ambient atmosphere to bag temperature produces a relative humidity within the bag of about 20%—which has a significant drying effect.

The treatment is maintained for 24 hours a day for the duration of the healing period.

By the early part of 1974, sufficient clinical experience had been accumulated in the U.K. at Queen Mary's Hospital, Roehampton, and by the Prosthetic Research Study at Seattle, U.S.A., to indicate that the Controlled Environment Treatment offered significant clinical advantages over the current/classical wound management technique in the fields of amputation and hand surgery.

The use of the equipment was extended, and by 1975 5 Centres in the U.K. and 5 Centres in the U.S.A. were using it in the fields of:

a. Amputations of the leg for
   i. Vascular disease including diabetic gangrene
   ii. Non-vascular causes

b. Hand surgery for
   i. Dupuytren's contracture
   ii. Re-implantation surgery
   iii. Syndactyly
   iv. Arthroplasty

c. Burns of the extremities

d. Post-traumatic oedema of the extremities
   i. Acute } Closed
   ii. Chronic } trauma

e. Chronic obstructive lymphoedema

f. Ulceration of the lower limb
   i. Gravitational (varicose)
   ii. Diabetic

In order to compare the performance of this form of treatment over conventional forms of wound management several independent colleagues were involved in the conduct of a formal trial. After attempting to collect information for a twelve month period, experience clearly indicated that the combined effects of (i) limited equipment availability, (ii) small sample population, (iii) inability to stabilize the surgical, the nursing and the range of physiological conditions, and (iv) the problems of attempting to quantify such qualitative parameters as pain and oedema, have made rigorous statistical analysis difficult and of debatable value.

The generation of clinical opinion based on clinical experience was however much more positive and generally convinced most colleagues that this form of treatment was beneficial. Since 1976 a much wider and more extensive background has been accumulated and may have regularized its use. Success is not universal and there is a minority of cases where enthusiasm is either lacking or is muted; nevertheless—to the best of our knowledge—there is no instance of the treatment adversely affecting the progress of the patient.

A summary of clinical opinion could be stated as:—

(i) In all applications CET is effective in the reduction of pain and oedema;

(ii) in hand surgery, it presents no obstacle to the early mobilization of the joints and consequently appears to result in a more rapid restoration of function;

(iii) in amputation surgery, the stump at the end of the healing period is more mature and dimensionally stable;

(iv) both (ii) and (iii) above have implications in the cost of subsequent rehabilitation;

(v) provides the additional aid to circulation/healing processes thereby promoting healing of "marginal" cases which, having healed, do possess adequate circulation to maintain tissue viability (Fig. 5).

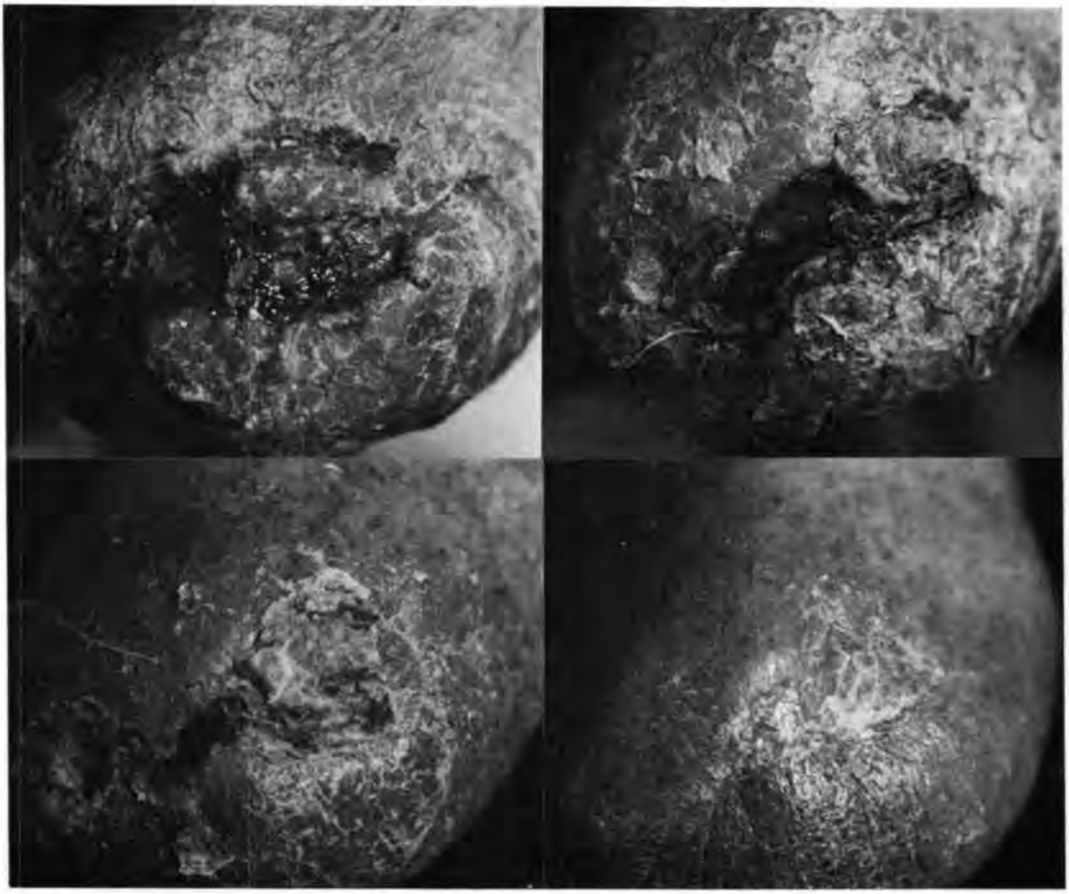

Fig. 5. Response from a chronic ulcer remaining after amputation 14 months earlier. Top left, stump at start of treatment. Top right, stump after 2 weeks. Bottom left, after 4 weeks. Bottom right, after 6 weeks.

(vi) improvements have been noted in the orthopaedic field, but these are too limited in number to be detailed;

(vii) in relatively clean wards it is difficult to make any statement about the avoidance of cross-infection (a single case at Roehampton involving both legs clearly demonstrated this protection);

(viii) very little work has been done in the field of burns, what has been done was disappointing, but there is every reason to continue to investigate revised techniques;

(ix) the technique and equipment presented no major difficulties to the nursing and physiotherapy staff; the fitting and adjustment of the harness proved troublesome to the uninitiated —new and simpler forms of harness are available.

The equipment for this form of treatment is now commercially available throughout the world and is now in use in the U.S.A., Canada, Russia, Japan, Australia.

The control of limb volume

Oedema is a natural consequence of damage to the tissue; the damage may be direct as in the case of surgery or accident, or it may be physiological such as interference with the tissue fluid transfer mechanisms. Whatever the cause, the presence of oedema can interfere with the fluid exchanges which maintain the tissues in a normal state.

The oedema resulting from closed trauma can result in surgery being delayed until the oedema has significantly subsided. Oedema resulting from damage to the lymphatic mechanism can produce a chronic state which may result in serious restriction of joint movement and loss of muscle power coupled with the encumbrance of an overweight and oversize limb.

Whilst the Controlled Environment Treatment can be used for the treatment of these cases, it was realised that this equipment was unnecessarily complex for this category of patient, and a simplified version (and hence cheaper) was designed. This equipment provides the pressure cycling facility and is known as Pressure Environment Treatment (PET); limited adjustment of the cycle is possible but only after access to controls locked away inside the equipment. There is no temperature control, but the air is warmed to a comfortable temperature; there is no bacterial filter. The equipment was designed for use in the patient's home; safety and simplicity of operation were of paramount importance. Figure 6 shows the equipment which is commercially available; the treatment uses the same bags and harnesses as the CET equipment.

Fig. 6. Demonstration of Pressure Environment Treatment (PET) air control equipment..

From a clinical point of view it is relatively easy to demonstrate the effectiveness of this form of treatment since the non-existence of a wound enables the volume of the affected limb segment(s) to be measured by direct water displacement methods. Such a case is depicted in Figure 7. This patient had chronic lymphoedema of her dominant arm rendering the hand almost immobile together with an oversize and overweight arm. A phlebogram produced normal results, but a lymphangiogram showed no functional lymphatic channels. This was the first patient to be fully documented and to whom this form of treatment was offered as a serious alternative to the possibilities of the grossly disfiguring and somewhat unsatisfactory process of the excision of skin and subcutaneous tissue with subsequent grafting (the Charles operation), or amputation. Treatment by elevation, massage, exercises, or compression treatment using a commercially available pneumatic double walled splint-type treatment bag inflated by a small air pump, all failed to produce any significant response. Figure 7 shows the normal and abnormal arms immediately before treatment. Alternating pressure treatment using the PET type of equipment resulted in a dramatic response after 24 hours of continuous treatment. Continuous treatment was applied for several days before an attempt was made to restrict treatment to a limited daily

Fig. 7. Patient with lymphoedema. Left, immediately before treatment. Right, following 24 hours continuous treatment. See text and Figure 8.

	Pressure	Time	Pressure	Time	Duration
A	50mm	10sec	10mm	10sec	24 Hrs/day
B	50	10	10	10	12 Hrs/night
C	30	10	10	10	12 "
D	55	10	10	10	24 Hrs/day
E	55	30	10	10	12 Hrs/night
F	30	30	20	10	12 "
G	55	30	10	10	12 "
H	55	22	10	8	12 "
I	55	18	10	12	12 "
J	55	20	10	10	10 "
K	Treatment discontinued				
L	55	20	10	10	8 Hrs/night
M	55	10	10	20	8 "

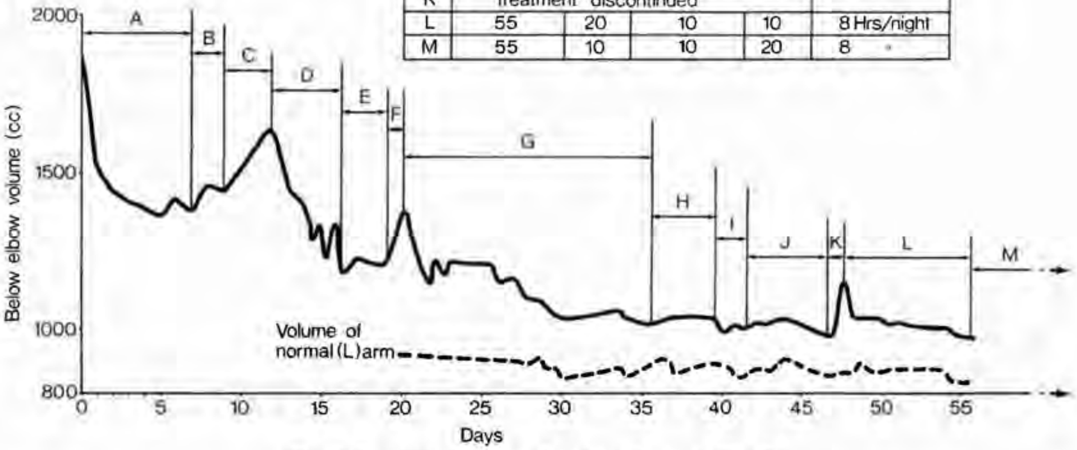

Fig. 8. Response to PET of patient shown in Fig. 7.

period; being very early in the experimental phase, progress was not uniform—as the graph depicts (Fig. 8). Furthermore, the patient was detained in hospital for other reasons and hence became a "long stay" captive subject. As will be seen from the graph, the arm volume became virtually normal, and with the aid of physiotherapy, the muscle and joint functions were completely restored. The patient continued the treatment on a nightly basis in her home; although it could only be offered as a palliative treatment, it was found two years later that treatment was no longer necessary and the arm remained normal in all respects.

This is not a unique case—as Figure 9 shows. This is not a fully documented case but the before and after photographs show clearly the dramatic response. Treatment continues in the patient's home.

Several patients suffering from arm lymphoedema subsequent to mastectomy have been treated—with varying degrees of success. The effectiveness of the treatment is governed by the extent of the lymphatic damage and also by the way and extent to which the patient judges and values the response.

Many other applications have been and are still being explored by colleagues; it is being seriously used for the immediate treatment of injuries to the limbs on the sports field thereby preventing the build-up of oedema before detailed examination and other remedial treatment can be undertaken. (There is serious interest in the athletic world in its use to assist in the removal of metabolic products from tissues subsequent to prolonged physical exertion.)

As indicated earlier, there are a number of pneumatic compression devices available on the market, and unlike the CET and PET, use double walled splint-type treatment bags; it should not be assumed that comparable results can be obtained using these less sophisticated and cheaper forms of treatment.

Controlled pressure plaster casts

Where the preferred treatment is the mechanical support of the whole of the limb (or limb segment) or the immobilization of the muscle groups, the conventional way of obtaining such states is either by the application of pressure/support bandages or by plaster casts. The

Fig. 9. Patient with lymphoedema. Top, condition at start of PET. Centre, after 2 days. Bottom, treatment maintained at night only in patient's home.

hazards of bandaging have been mentioned earlier; plaster casts can also introduce hazards because the fit of the cast is dependent primarily upon the skill of the operator whose task varies widely because of the variable mobility and distortion characteristics of the tissue/bone structure of the limb segment. As is well known in practice, regions of excessive pressure over bony prominences and zero pressure in re-entrant areas are not uncommon. Non-uniform pressure distribution around the circumference of the limb can invoke a variety of responses including the generation of pressure areas; non-uniform pressure distribution along the axis of the limb can constitute a tourniquet and invoke general oedema.

The concept of pressure air "dressings" has been extended to the application of a uniform

Fig. 10. Controlled Pressure Casting (CPC) equipment.

pressure fluid plaster dressing which subsequently solidifies in that precise form. This technique is known as Controlled Pressure Casting (CPC); the equipment shown in Figure 10 is commercially available.

The technique can be readily understood by reference to Figure 11. A length of tubular knitted stockinette is placed over the segment to be encased in plaster. Strips of wet plaster bandage are placed longitudinally on the surface of the stockinette using enough strips to cover the limb to a depth of two or three layers. Placing the plaster strips longitudinally ensures that they cannot apply any pressure to the tissues—as would be inevitable if the plaster bandage was wrapped on in the conventional

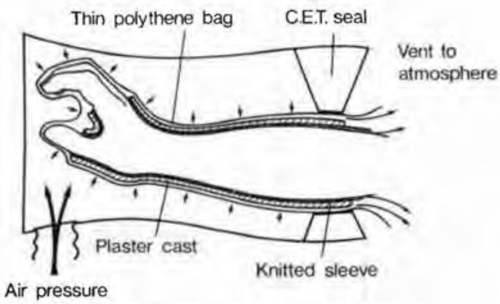

Fig. 11. Principles involved in CPC.

way. The wet, unset assembly is now placed inside a thin walled plastic film bag and the whole pushed into a CET treatment bag; it is imperative that the open proximal end of the plastic film bag and the stockinette must extend through the fluted seal of the CET bag and be free to atmosphere. Inflation of the CET bag with air to the desired pressure will result in air being expelled to atmosphere from the wet plaster/stockinette assembly, and because the plaster is still fluid, the plaster strips and plaster will be held against the tissues at a pressure equal to that of the air in the CET bag. This state is maintained until the plaster has set, whereupon the limb with its shell cast can be removed from the inner plastic film bag. This shell is strong, but it is advisable to reinforce it with plaster bandage wound on in the conventional way until an acceptable thickness is achieved.

This process involves transfer of pressure from one medium to another and it is absolutely essential that the plaster is quite fluid and has not started to set before air pressure is applied. It is also essential that the inner plastic film bag is free from leaks and pinholes.

The fit of the plaster to the tissues is entirely governed by the air pressure applied to the CET treatment bag; a pressure of 50 mm Hg will correspond to a tight fit, 10 mm Hg will correspond to a snug but light fit.

Experience has indicated that the use of cold water to soak the plaster bandage is advantageous and leaves adequate time to complete each stage without the need for unseemly haste.

Patients who have had experience of both conventional casts and CPC casts have commented on the firm and unique fit of the CPC cast. This controllable and superior fit has been employed to stabilize a tibial fracture sufficiently to enable the knee and ankle joints to remain free. The finer details of the technique are still being established, but the clinical experience to date is demonstrating a successful technique with obvious clinical advantages.

Acknowledgements

In conclusion we would like to acknowledge the help and support given to this project by

(i) The Consultants and Staff of the various National Health Service Hospitals in the United Kingdom and the British Royal Army Medical Corps.

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(iii) Colleagues in the Biomechanical Research & Development Unit, and the Limb Fitting Centre at Roehampton.

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BIBLIOGRAPHY

BERLEMONT, M., WEBER, R., and WILLOT, J.P. (1969). Ten years of experience with immediate application of prosthetic devices to amputees of the lower extremities on the operating table. *Pros. Int.*, **3:8**, 8–18.

BURGESS, E. M., ROMANO, R. L. and ZETTLE, J. H. (1969). The management of lower extremity amputation. Veterans Administration Report 10–6.

BURGESS, E. M., TEDEGANA, L. R. (1977). Controlled environment treatment for limb surgery and trauma (A preliminary report). *Bull. Pros. Res.*, **10–28**, 16–57.

MURDOCH, G. (1969). Immediate post surgical fitting: an editorial. *Pros. Int.* **3:8**, 2–7.

REDHEAD, R. G. (1973) The problems of the post-operative and stump/environment interface. 1st International Congress on Prosthetic Techniques and Functional Rehabilitation, 65–73, Egermann, Vienna.

REDHEAD, R. G., SNOWDON, C., BURGESS, E. M. and VITALI, M. (1974). Controlled environment treatment for the post-operative management of wounds of the upper and lower limbs including amputation stump. 1st World Congress ISPO, Montreux.

REDHEAD, R. G. and SNOWDON, C. (1977). A new approach to the management of wounds of the extremities; controlled environment treatment and its derivatives. Scientific Symposium, British Trade Fair, Tokyo. Copies from BRADU Library, Roehampton, London.

VITALI, M. and REDHEAD, R. G. (1967). The modern concept of the general management of amputee rehabilitation including immediate post-operative fitting. *Annals Royal Coll. Surg. Eng.*, **40**, 251–260.

VITALI, M. and REDHEAD, R. G. (1972). Wound healing in the ischaemic limb. Symposium on the Healing of Wounds, Smith & Nephew Ltd., Birmingham.

WEISS, M. (1965). Psychologic, social and physiologic effect and significance of an immediate application of prosthesis. Report from Medical Academy, Warsaw, Institute for Rehabilitation, Konstancin, Poland.

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Rehabilitation engineering as the crow flies*

PART V—A PROBLEM-SOLVING METHOD FOR REHABILITATION ENGINEERING

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This paper, the fifth of a series, deals with dynamic group problem-solving and shows how this can give radical solutions to problems and at the same time enhance group cohesiveness.

Dialogue:

Steve: You might think that the usual unstructured method of attacking problems works fine. I've not found it satisfactory on a number of counts, but rather than go into that I feel we should examine the alternative way and build a case for it. Mainly, I feel that engineers should follow procedures for problem-solving that make it attractive—that is efficient—to have engineering procedures applied to problems in rehabilitation. For that, the solutions must unfold in an attractive way and lead to an obvious advantage in the shortest possible span of time for the least amount of money spent. Ultimately our responsibility to patients and the recipients of our talents requires that we use the best methods available to us.

Jim: As an old-timer in the field, I look back on my various attempts to solve problems by a hit and miss method and feel a bit ashamed when I compare the impulsive launching of projects on quickly formulated ideas to what we have been doing latterly. How can we convey the improvements I have experienced to others so that more groups can make what they do more effective.

Richard: Let us show how we generate innovative solutions and, in the process, show how that brings people together. Perhaps we can do that best by first outlining what happens in most problem-solving encounters, highlighting the faults and pitfalls and then using an example from our own experience to show how it could be. Steve, tell us how it is.

Steve: Usually participants at a meeting consciously or unconsciously perceive the encounter as a competition between the members of the group. A winner infers a loser. So right away a part of a person's energy is directed away from solving the problem to protecting himself.

Jim: That's right. Often when I have made suggestions intended to get the ball rolling people have taken it as a threat to themselves and have dumped the idea before it had a chance to get started. Also, I have felt attacked for not giving "complete" solutions when proposing ideas which seemed nebulous or even off the track. Looking back on it, what I would have appreciated was a leg up toward the solution so that I could have felt that I had made a contribution toward a solution. The sharing of the solution would also have made me feel appreciated and made me appreciate more the other members of the group.

Richard: Yes, I've often seen group leaders using their power unwisely so that free thinking was inhibited. The aim should be to examine as many alternatives as possible in order that the most suitable can emerge.

Steve: We have all seen group leaders who do that. Every participant brings two characteristics to a meeting: *sensitivity* and *aggressiveness*. These really can detract from the efficiency of generating solutions. You see this all around in daily life too. The job of the group leader is to direct these feelings toward solving the problem.

Jim: You are getting onto *how* it *could* be Steve. Could you summarize that for us?

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Steve: I would like to see group interactions relieve people of the burden of self-protection. This could be done by *building* on speculative concepts that initially seem unworkable, such as some of the suggestions you have made in the past and which you would have liked to see developed, Jim. That would be my first point.

My second point would be to have group interactions ensure that each idea has a *hearing* and is given support and consideration. No one loses and everyone gains.

My third point would be that creative aggressiveness be directed to build on both the negative and positive aspects of an idea.

Richard: Now I see the leader as the servant of the group. He creates an atmosphere of security where all ideas are considered worthy. Can we have an example of the value of what we are suggesting?

Steve: Sure. One key to generating solutions is good *listening*. Remember the crazy sessions we had on fracture bracing?

Jim: As a matter of fact, those sessions really stand out vividly in my mind. It seems to me that more ideas came out of those short sessions than I've been used to experiencing in a month of Sundays.

Richard: Let's review it using the flowchart we prepared Steve. What was the *problem as given* by the orthopaedic surgeon?

Steve: We were asked to improve fracture bracing We redefined the problem to mean "distribute the forces optimally on given locations of the skin". This became the *goal as understood*.

Richard: We generated a number of goals as understood before we selected the final one, remember. These were:

1. Optimize force on the skin
2. How do we make the skin determine the force
3. How do we make the location optimize the force on the skin
4. How do we make the force responsible to the skin
5. How can the skin choose the location of the force application

The fourth one appealed to us most and became the goal as understood which we selected.

Jim: The next part of the process, selecting *paradoxical book titles* really seemed crazy to me at the time when we first tried this method. Now I can understand the value of diverting our thoughts from the problem.

Richard: Yes, that is the objective—to *divert* our minds from the problem so that we are freed from the preoccupation with the immediate problem. That leads us to see the problem from unexpected viewpoints.

Steve: Remember the fun it was developing the list of paradoxical book titles in the fracture bracing experience. They were so far from the point they were on the face of it quite ridiculous.

Jim: I remember we chose "Steady Uncertainty" as the paradoxical book title which would lead us away from the immediate problem. I could certainly see that it did, but what bothered me at the time was what would lead us back!

Richard: You were in a hurry to get to the point! We took the example of geology as the topic we would discuss in relation to the paradoxical book title so that we would get even further away. From that we tried to *force fit* the *example* of geology to the book title in the hope that a solution would emerge.

Jim: This was the most interesting part of the problem-solving method to me. We were able to very quickly generate fifteen paradoxes in geology that were parallel to the idea of steady uncertainty. The Theory of Evolution was one. What appears to be steady is constantly changing.

Richard: That's where we got our ideas for corrugations—like scales of fish, or the shells of armadillos, or the scales of snakes and so on.

Jim: Again, I was tempted to break into fracture bracing at that point, but we went on to other examples of steady uncertainty.

Richard: Many possibilities must be considered to see how often a similar solution suggests itself. The idea of corrugations recurred in discussions we had on erosion, and on crystal formations. The most striking analogy for me was comparing the cross section of the world (Fig. 1) at the equator with a cross section through the thigh. The core was like the femur, the mantle like the soft tissues and the crust of the earth as the skin. Around this floated the

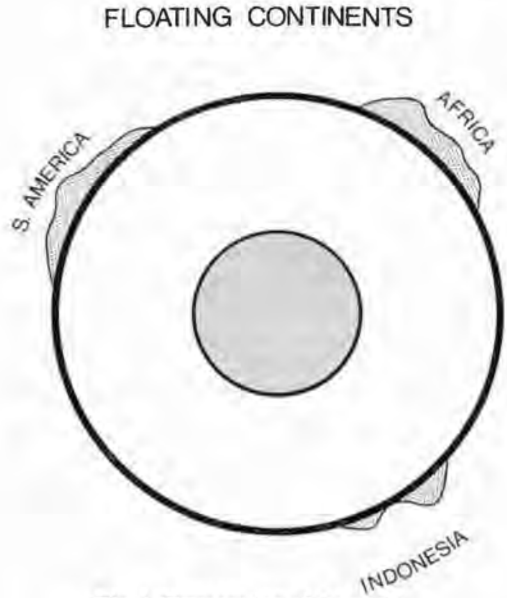

Fig. 1. Cross section of the world.

Fig. 2. Golf ball model around the thigh. Left, end view. Right, side view.

Fig. 3. Bead-cylinder model.

continents, seemingly steady, but uncertain. From this we went straight to the golf-ball model we made. (Fig. 2).

Jim: And from that Steve came to the beautiful working model he made in England which I believe will set a new direction in the making of all sorts of support surfaces, even sockets and brace cuffs as well as seats and fracture brace support surfaces. (Fig. 3).

Steve: This process which leads to force fit of seemingly remote ideas has taken us a long way from plaster of paris and hinged irons. We are on the road to modularized support surfaces for prosthetics and orthotics.

Discussion

You can see how good listening can lead to graphic generation of a radical solution. Good listening means setting aside your usual critical analytical urges so that you can get the fullest possible picture of the new idea emerging into your mind leaving aside any ambiguities or worries about incompleteness. Behind those first hesitant words lie intentions, feelings and intuitions. By disciplining your negative concerns about a new idea, holding them back, you can release a neglected capacity to contribute, to advance, to add to the creative sum of an emerging idea.

The emerging idea has in it a spectrum of good and bad points. In most meetings people at times focus on and discuss the bad points. This is natural because the bad points loom threateningly in the forefront of your mind. But when you indulge this natural tendency, you pay a large price in teamwork, in involvement, and in the probability of developing solutions. People protest that it is unrealistic and a waste of time to pursue an idea that has fatal flaws. However, in the early stages of an emerging idea no one can know with certainty that a flaw is in fact really fatal. It seems universal that the faults in an idea will take precedence in your mind, so don't fight it; simply do not voice the faults. You will get to them in good time. Then temporarily focus your intellect, your feelings, your intuitions on that small portion of the idea that is worthwhile. Then talk about it. Now you have earned the right to bring out the faults, but choosing your words not to prove a negative point but rather to help in finding a solution.

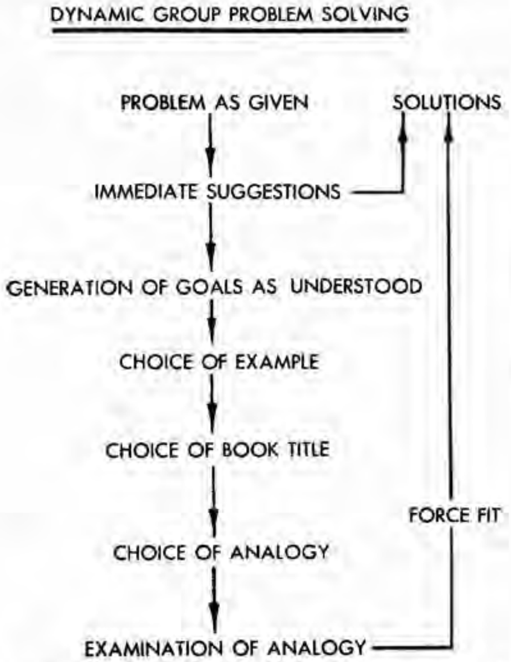

Fig. 4. The flowchart provides a model that can be modified to suit the needs of the group.

Comment

We view the procedure outlined above as a way of developing an attitude and approach to problem-solving and not a rigid, inflexible system. You will find that this approach to problem-solving can be easily adapted to a given group and may not follow the flow chart at all.

Old methods not emphasising positivity will more than likely result in run of the mill solutions. A radical change in attitude is needed from what one usually finds if remarkable innovations are to result.

FURTHER READING

George M. Price (1970) *The Practice of Creativity, a Manual for Dynamic Group Problem-Solving*, Harper and Row.

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Analysis of variability in pylon transducer signals*

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Abstract

A pylon transducer has been used to provide force and moment data relating to the stance phase of gait of below-knee amputees fitted with modular types of PTB prostheses.

The data has been collected and modified using digital processing systems with particular interest in quantifying shape differences in the loading information curves. Earlier tests illustrated the need for more data to provide statistical support for conclusions. However, the requirements for more data greatly increased the data handling and storage problems. A method was devised whereby those features considered significant from an information point of view could be extracted from the transducer signals and then combined. The statistical combination of features was made to allow objective comparisons of strides for a particular subject.

Introduction

To formulate a useful locomotion study it is necessary to answer several fundamental questions:

a) What data should be collected in the study?

b) How will it be collected?

c) Which part of the collected data constitutes *information* valuable to the aims of the study?

These three elements are mutually dependent. Unfortunately, the problem of extracting useful information from masses of data often seems to be treated as an "after thought" in spite of our enthusiasm in data acquisition. The evidence of this enthusiasm can be seen in many locomotion laboratories where mountains of computer output lie unused.

Data which is collected, but not essential for the success of a study is commonly referred to as "redundant". Shannon (1948) defined the concept of redundancy as: "That fraction of a message which is unnecessary and hence repetitive in the sense that if it were missing the message would still be essentially complete; or at least could be completed".

The study to be described attempts to reduce the redundancy amongst collected pylon transducer data. The nature of the required information is controlled by the aims of the study.

Aims of the study

Previous pylon transducer studies have attempted to examine the effects of, for example, prosthetic alignment changes upon the loading signals, without first establishing that these signal patterns exhibit statistical consistency under conditions of fixed alignment.

At the University of Strathclyde the stride to stride loading signals obtained from pylon transducer tests were examined with a view to quantifying the stride to stride differences. With the signal variability established, this would form a basis for comparison once the conditions of the prosthetic experiment differ.

The mechanism of redundancy reduction

The details of data acquisition is given later but it is convenient to note at this time that the conversion of the analogue transducer signals to their sampled data equivalents was conducted at a sample rate of 200 samples per second upon each channel.

Two simple observations of the data are helpful:

a) Any single stance phase period will, at the

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*Based on a paper presented at the Second World Congress, ISPO, New York, 1977.

acquisition stage, be represented by many samples of the original continuous-time signal.

b) Successive stance phase periods may occupy significantly different total times.

The first point raises worries over the amount of labour needed in a sample to sample comparison of successive stance phase periods, whilst the second point poses doubts as to whether that process would be valid.

An approach that could be used for data reduction involves the fitting of mathematical functions with orthogonal properties to the successive stride data. The best known of these methods involve polynomial expansion, Taylor series or Fourier series approximations.

Jacobs and Skorecki (1972) examined the differences in the vertical force records from a force plate, amongst subjects exhibiting both "normal" and "pathological" (in appearance) gaits. Comparisons were made by using the Fourier series spectra of the stance period data. A problem with the method arises with a loss of all phase information. Also the use of this type of representation, termed "Periodogram", can provide unreliable spectral magnitude data when only a limited signal record is available (Jenkins, 1961; Tukey, 1967; Richards, 1967; Rayner, 1971).

The examination of curvature to define a shape has received much support.

Attneave (1954) demonstrated that information sufficient for the recognition of familiar shapes was contained in a knowledge of the points of maximum absolute curvature on the boundaries of those shapes and their location and connectivity. Many others have employed these concepts (Zahn and Roskies, 1972; Tomek, 1973 and 1972).

Macfarlane and Lawrie (1972) used a function termed the "Spatial velocity" to recognize wave patterns in ECG signals. If, for example, a force vector described by its X, Y and Z components in an orthogonal reference frame changes direction by an amount SX, SY, SZ in dT seconds then the spatial velocity is given by:

$$SPV = [(SX/dT)^2 + (SY/dT)^2 + (SZ/dT)^2]^{1/2}$$

The SPV function was chosen to provide an indication of a significant event within the time history of the loading information. The supposition is that the shapes of the load signals are being examined for similarity.

Instrumentation

The pylon transducer used has been described previously (Berme *et al*, 1975). Prior to these tests the dynamic behaviour of the transducer was examined using impulse response and Fourier Transform methods. The results for transverse and longitudinal impulse forces imply (Fig. 1) that if the activities monitored by the pylon have no significant frequency components higher than 600 Hz, then the transducer will be adequate from a dynamic viewpoint.

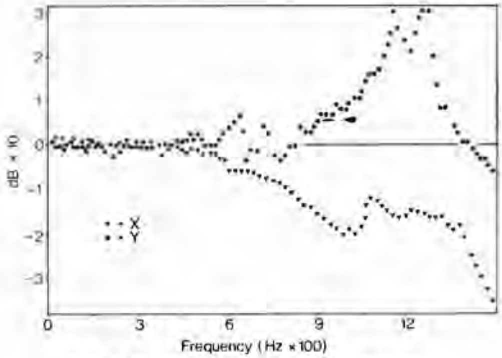

Fig. 1. Response to X and Y impulses.

Data acquisition was performed using a 12 bit A–D converter operating at 200 samples per second on each channel. A PDP–12 computer was used as a preprocessor for an ICL 1904s computer system. Prior to data reduction all data was filtered using a 4th order Butterworth-equivalent digital filter with a 3 dB down frequency of 20 Hz. Filtered data was corrected for phase distortion.

Subject data and testing

The subject to be considered was a heavy (96 kg), active below-knee amputee with a conventional cuff type suspension PTB prosthesis. A Berkeley adjustable alignment unit was used to set up dynamic alignment to the satisfaction of the prosthetist. The alignment and shoe type were constant throughout the test series.

On each visit by the subject, six level walking periods were conducted whilst pylon transducer and knee goniometer signals were recorded. Each level walking period consisted of 20 seconds of free level walking. The subject chose his own walking rate and this was measured.

Data reduction strategy

1) The number of strides needed to represent a particular walking occasion were determined.
2) The SPV function graph was produced for the representative strides. The ankle force vector components were used here (FXA, FYA, FZA).
3) The points of local extrema in the SPV function were noted. These points were considered to indicate a significant feature in the time history of the force vector. Each of the Fi "features" (i=1 - - -N) occurs at some time Ti from the start of the data record. These occurrence times were noted (Fig. 2).
4) By noting the values of the FXA, FYA and FZA components at times Ti the essential characteristics were determined.

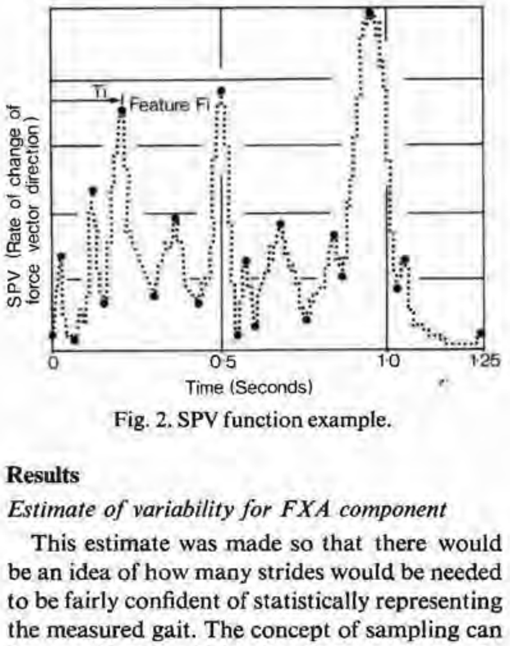

Fig. 2. SPV function example.

Results

Estimate of variability for FXA component

This estimate was made so that there would be an idea of how many strides would be needed to be fairly confident of statistically representing the measured gait. The concept of sampling can be considered within the framework of the common sense notion that if all the strides collected during a walking session were absolutely identical then only the data for one stride would be needed to completely describe that session. If on the other hand all the stride data were completely dissimilar then it becomes useless to describe that walking session other than with consideration of an extremely large number of strides.

In the case under examination a range of numbers of strides (n=4, 8, 16 and 32) were combined and the statistical population estimates for each of the groups were compared (Fig. 3).

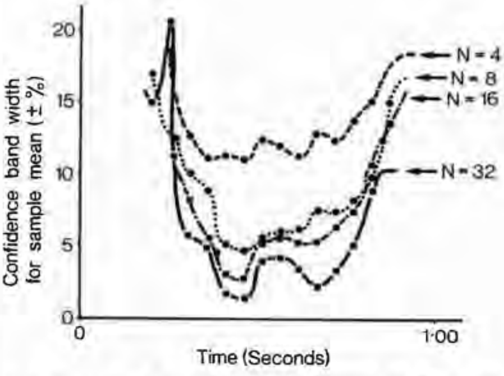

Fig. 3. How n affects the confidence of $\overline{X}$ as an approximation to μ.

Not surprisingly as n increased the confidence of $\overline{X}$ (the particular sample mean) as an approximation to μ (the time population mean) improved. However, the amount of work required also increased with n without a proportionate increase in information. As a compromise, for the level walking tests, 8 stance periods were considered sufficient to describe an individual walking session.

Stride variations in force vector within a level walking session

Eight consecutive strides were extracted from a level walk conducted by the subject. Each stride was examined, processed and a set of features produced for each. Observation of the SPV function for these strides provided 16 features. The times of the feature indicators from the start of the stance periods were recorded, along with the values of the force components FXA, FYA, FZA at each feature time.

The eight sets of sixteen "critical" values were combined for these components. Figure 4 shows these components synthesized from their feature values, their time occurrences and their 95% confidence intervals from the mean values.

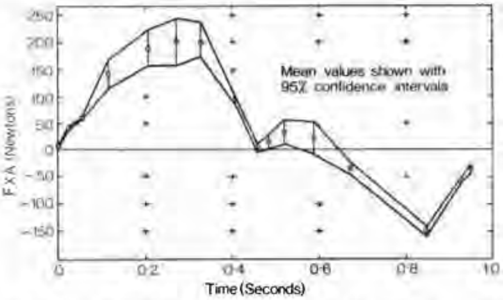

Fig. 4a. Synthesized for eight strides with the features of FXA (16 features used).

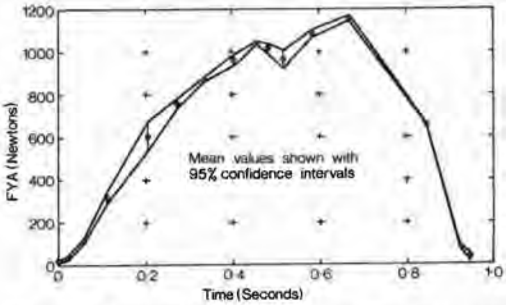

Fig. 4b. Synthesized for eight strides with the features of FYA (16 features used).

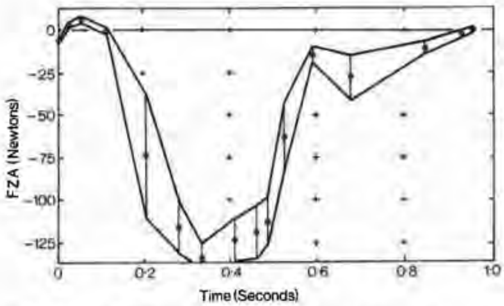

Fig. 4c. Synthesized for eight strides with the features of FZA (16 features used).

A representation of the magnitude confidence intervals versus feature number is given in Figure 5. This shows rather more clearly the places and values of the confidence limits for each of FXA, FYA and FZA. Considering the FXA set, the widest confidence interval is seen at the 6th feature time and has a value of ± 42N. From an initial low variability close to heel strike the variability increases rapidly between the 3rd and 4th features and then decreases to

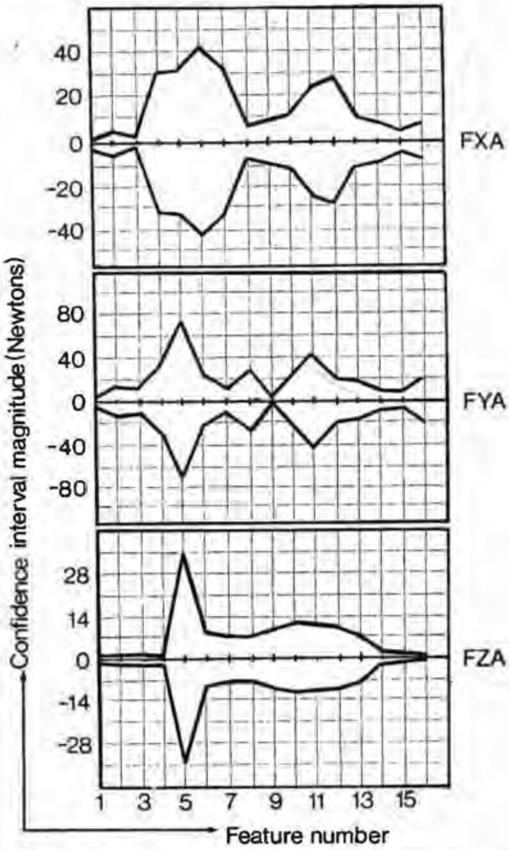

Fig. 5. Confidence interval variation during stance period.

less than ± 10N at midstance. During the roll over period the variability increases to a peak at feature 12 of ± 28N before decreasing again toward toe off.

For the FYA set the peak variability at feature time 5 was such as to allow a confidence interval of ± 70N about the sample mean. The characteristic twin peaks were present with confidence intervals of less than ± 20N at each peak. The trough between these peaks showed evidence of a local region of higher variability with a confidence interval of ± 40N.

The FZA set exhibits one strong peak of ± 35N interval width at feature time 5, rising from a region of low variability at feature time 4. The rest of the period shows a fairly even variability distribution without the local high spots of FXA and FYA.

Overall the region of features 5 and 6 displays the largest stride to stride variability.

Variations from walking session to walking session

Figure 5 may now be considered to be related to the variability of the pylon transducer data during a single walking session. For that session, at each feature Fi, the population mean $\mu 1$ is estimated by the calculated mean $\bar{x}$ with a confidence interval computed from the sample variance SX^2 (which itself is an estimate of the population variance OX^2).

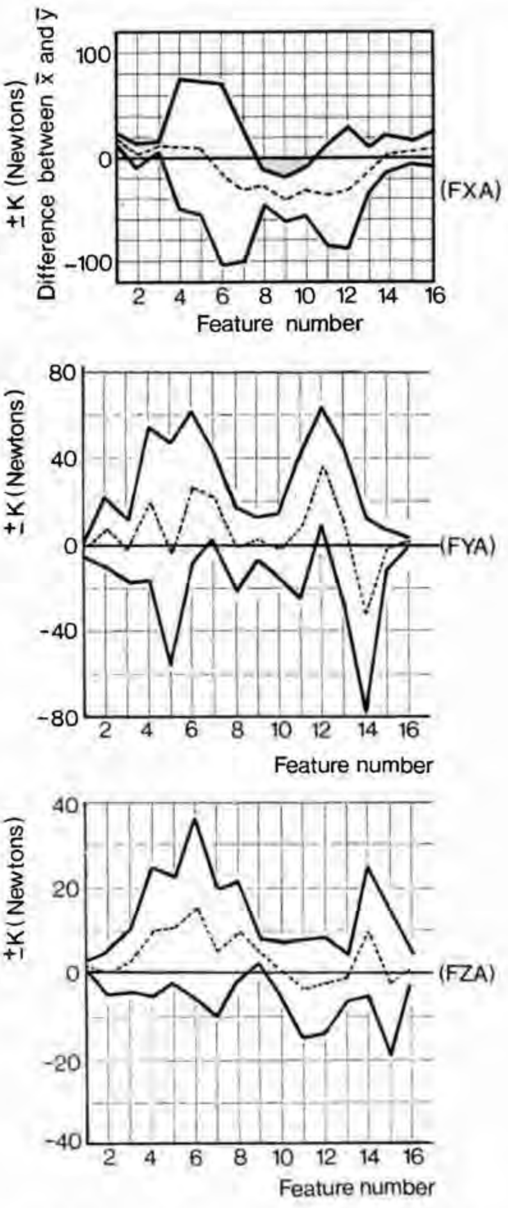

Fig. 6. Comparison between two level walking sessions.

Considering a 2nd walking session with again the averaging being computed over 8 stance phase periods. This time at the Fi values, the population mean $\mu 2$ is estimated by a calculated mean of $\bar{y}$ with a variance estimate of SY^2 (being an estimate of the true variance σy^2).

A test may then be made for the assumption that the data from these two level walking sessions belong to the same statistical population (that is, that the difference between $\mu 1$ and $\mu 2$ at the Fi is insignificant).

Taking $\bar{x}$ and $\bar{y}$ as the estimates for the two population means:

$\bar{x}-\bar{y}$ will be Normally Distributed with a mean $\mu 1-\mu 2$ and a standard deviation of $\sqrt{(SX^2+SY^2)/8}$.

The 95 % confidence intervals are given by:

$$(\bar{x}-\bar{y}) \pm 1{\cdot}96\sqrt{(SX^2+SY^2)/8} = (\bar{x}-\bar{y}) \pm K$$

If these limits do not include zero then the difference is said to be significant at the 5 % level.

Figure 6 shows the result of the comparison of two walking sessions conducted with the subject, expressed as a display of $\pm K$ as a function of feature number. Those areas shaded black correspond to the areas of significant differences between the information upon the two walking sessions.

Summary

The variability in pylon dynamometer data acquired during level walking tests has been examined. The information upon variability has been considered to lie within the shapes of the loading signals. The extraction of this information from the data was performed as indicated by the local extrema of a spatial velocity curve. For the study example given no significant differences could be found for the subject's gait between time separated walking sessions (with constant experimental conditions). Data reduction has provided a statistical template representing the subject's gait on a particular occasion. This template may then be used in comparison with templates produced under different experimental conditions (that is, alignment or footwear changes).

REFERENCES

ATTNEAVE, F. (1954). Some informational aspects of visual perceptional. *Psychology Review*, **61:3,** 183–193.

BERME, N. *et al* (1975). A shorter pylon transducer for measurement of prosthetic forces and moments during amputee gait. (Submitted for publication) Engineering in Medicine. The Institute of Mechanical Engineers.

JACOBS, N. A. and SKORECKI, J. (1972). Analysis of the vertical component of force in normal and pathological gait. *J. Biomech.*, **5,** 11–34.

JENKINS, G. M. (1961). General considerations in the analysis of Spectra. *Technometrics*, **3:2,** 133–166.

LAWRIE, T. D. V., and MACFARLANE, P. W. (1972). Routine automated electrocardiogram interpretation. *Biomed. Eng.* May, 176–180.

RAYNER, J. N. (1971). An introduction to spectral analysis. Pion Ltd., London.

RICHARDS, P. I. (1967). Computing reliable power spectra. IEEE Spectrum, 83–90.

SHANNON, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, **27,** 379.

TOMEK, I. (1972). A clustering technique in the classification of almost periodic waveforms. *Computers in Biomedical Research*, **5,** 621–628.

TOMEK, I. (1973). Two quantitative measure of similarity of one class of waveform. *Computers in Biomedical Research*, **6,** 499–508.

TUKEY, J. W. (1967) An introduction to the calculations of numerical spectrum analysis. In Spectral Analysis of Time Series, 24–46. Ed. Harris, B. Wiley and Sons.

ZAHN, C. T. and ROSKIES, R. Z. (1972). Fourier descriptors for plane closed curves. *IEEE Transactions on Computers*, **C21:3,** 269–281.

Prosthetics and Orthotics International, 1978, 2, 167–172

Audiovisual organization for conferences*

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Abstract

Factors related to conference size, complexity, location and communication between the conference organization, contributors and support staff are identified and discussed.

An audiovisual organization is described of which the main features are; the appointment of an audiovisual specialist to coordinate the organization, preview and controlled delivery of audiovisual material to support staff, and the use of an events chart as an aid to forecasting and identifying problems.

Introduction

The audiovisual aspects of conference organization are seldom accorded the importance they deserve and only rarely does a conference committee include an audiovisual specialist. We have all sat through the embarrassing hiatus when the sound does not work or the picture does not appear, or the image is too large, too small, out of focus or upside down. These errors are often the outward manifestation of an inner confusion as behind the scenes an inadequate organization struggles to cope with demands for facilities, the need for which has not been foreseen.

However, it is significant that while incidents like these do happen, they are seldom the fault of the support staff, i.e., the projectionists, sound recordists and television engineers. In most cases the blame can be placed squarely upon a lack of experience, communication and foresight on the part of the conference organizers. Over many years the writer has observed and experienced the delights and the disasters of numerous conferences as projectionist, delegate, contributor and organizer. He has made all the mistakes—many of them more than once—and the audiovisual organization which will be described has evolved out of an analysis of these mistakes.

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It is the view of the writer that the most vulnerable areas of conference organization lie in:

1. Communication between contributors and the conference organization.
2. Communication between the conference organization and the host institution.
3. The handling of audiovisual materials.

The audiovisual coordinator

The cornerstone of the suggested organization is the appointment to the conference committee of an individual who is given complete responsibility for coordinating the audiovisual arrangements. For convenience this individual will be referred to hereafter as the audiovisual coordinator (AVC).

The AVC should be chosen carefully. It is vital that he exhibits a high degree of competence in the operation and conditions of use of the range of audiovisual equipment which is likely to be encountered in any conference situation. Additionally, the coordinator must possess considerable organizational ability and the capacity to control staff. In short he must be an able communicator in every sense of the word.

Preparation

No two conference situations are alike, therefore it is not possible to lay down a precise sequence of events; indeed the provision of audiovisual facilities remains an open-ended situation for the duration of a conference. One of the AVC's first tasks is to correspond with contributors. As papers are accepted he will write to the contributor, identifying himself as the individual responsible for all audiovisual matters. He will explain the audiovisual arrangements, state the facilities which will be provided and suggest that other facilities can be made available by arrangement. He will enclose a response sheet on which the contributor can list his audiovisual requirements. The result of this initial contact is that some time in advance

*Reprinted from J. Audiovisual Media in Medicine, 1978, 1.

of the conference the AVC will know who the speakers are, he will have an indication of the use that is likely to be made of the facilities that are offered and he will also have some idea of any additional requirements.

It is unlikely that he will receive a 100 per cent response. Some speakers are incredibly casual about their presentation and will ignore all letters. Others will respond, then change their minds—usually in favour of a more sophisticated presentation—without notifying the AVC.

At some time, well in advance of the conference, the AVC and other members of the committee will visit the conference location. The primary purpose of this visit is to meet the staff of the host institution and inspect the reception, exhibition and social areas and the lecture theatres and seminar rooms. The coordinator will take this opportunity to meet the person in the host organization who is concerned with the provision of audiovisual facilities and support staff. At this early stage in the conference planning the AVC will ensure that the facilities which are listed on the response sheet, to be sent to contributors, can be provided. He will also discuss the provision of additional facilities which may be requested by contributors. It will be necessary for the AVC to maintain the contact thus established with the host institution, and he may return to the conference location for further discussions.

Assessing the requirements

It is useful to identify and consider briefly those factors existing in a proposed conference situation which will dictate the scope of the audiovisual organization required and most influence the demands made upon it.

The first factor to be examined is *conference size*, i.e. the number of delegates expected. If the conference is to take place solely in plenary session, the AVC will be concerned that the lecture theatre is satisfactory in terms of seating capacity, public address system, projection arrangements, lighting and ventilation. A multilingual conference may involve the AVC in the provision of suitable facilities for interpreters.

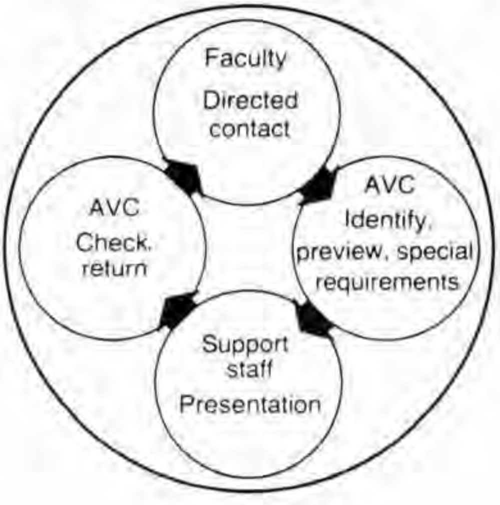
The *duration of the conference* is not a major factor although a lengthy meeting, which includes concurrent sessions, may impose considerable and continuing strain upon the audiovisual staff. Account must be taken of this when estimating the number of support staff required.

The *number of contributors* is of great importance; the larger the faculty the greater will be the volume of audiovisual material to be identified, checked, presented and returned. Moreover a large faculty will probably require a wide variety of audiovisual facilities.

Concurrent sessions are a major factor in audiovisual organization, not least because conferences which include these sessions tend also to have a large number of contributors. Complex organizational problems occur when several events, each requiring audiovisual facilities, are presented simultaneously—sometimes in widely separated areas. It is necessary to channel the correct material and equipment to the right room at the proper time. While the variety of audiovisual equipment used during concurrent sessions may not be wide, the number of units in operation will be much increased over those required for plenary sessions and additional support staff must be made available.

The final factor to be considered is the *location of the conference*. If it is to take place on the AVC's home ground then, irrespective of other factors, the problems are much simplified. The AVC will be familiar with the lecture theatres and seminar rooms to be used. He will know what equipment is available in the area and whether it may be borrowed or must be hired. The AVC will be acquainted with the audiovisual staff who may be colleagues or friends and, hopefully, this will guarantee their co-

Fig. 1. Schematic diagram of flow of audiovisual material.



operation. The problems inherent in providing an efficient audiovisual organization are greatly increased by distance. In the case of a distant conference location the advisability of early reconnaissance and contact with responsible individuals in the host institution cannot be overstated. If the conference is to take place in a country where English is not the first language, the problems already outlined are complicated by difficulties of communication in a foreign language and by unfamiliar customs and attitudes.

Setting up

The AVC will spend the immediate pre-conference period at the venue. The length of this period is governed by the location and complexity of the conference. The AVC will supervise the setting up of the audiovisual facilities and prepare his own organization, the outline of which is shown diagrammatically in Figure 1. Contact between the AVC and the faculty will be made and maintained by initial and subsequent correspondence as already described and by providing an area in the conference reception where the contributors can be intercepted by a member of the conference secretariat acting as audiovisual receptionist or by the AVC. The contributors' requirements are confirmed and checked off against the events chart, which is described later.

Previewing

An appointment is then made for the AVC to preview contributor's material with the contributor present. Previewing is carried out as soon as possible after the contributor arrives and, in any case, not later than one half-day before he is due to speak. It may be necessary to conduct previews immediately for the benefit of late arrivals. The ideal situation for the preview room is in proximity to the conference reception area and the main lecture theatre. However, the layout of the conference venue may not permit this. If a choice must be made, the preview room should be sited close to the latter area to allow previewing at the last moment for contributors who bypass the reception area and proceed directly to the lecture theatre.

The preview room should be equipped with examples of all the audiovisual equipment requested. Cupboard space should be provided for storage of material which has been previewed or is awaiting preview.

Handling the audiovisual material

Experience has shown that a convenient arrangement for handling the film, slides etc., is to divide a table top into areas, one area corresponding to one conference day. Each area is further divided into four sections, each of these sections being identified with sessions which take place between normal breaks in the programme. The first section corresponds to the period between the start of the day and the morning break, the second section between the end of the morning break and lunch, and so on. Material for presentation is stored in time order in the appropriate section. An identification slip (Fig. 2) accompanies each item and, in addition, a label is affixed to each magazine, box or reel (Fig. 3). Contributors may request a rehearsal of their presentation and the AVC should be prepared to arrange this. Indeed when the contributors' intentions become known it may be the AVC who insists that a rehearsal is necessary.

For plenary sessions the AVC will deliver the previewed and labelled material for the forthcoming session to support staff and, if appropriate, collect material which was presented during the previous session. This arrangement is reversed for concurrent sessions when support staff will collect material from the preview room, returning it when the next batch is collected. The advantages of this system are:

1. Support staff are responsible only for material for the current session, consequently the projection area is kept tidy and there is less risk of confusion.
2. Because the material is supplied in a batch, the senior projectionist can evaluate the work load which is helpful in arranging staff supplementation or relief.
3. Support staff can be confident that they are not required to show material that has not been checked.

One further aspect of the system is that the AVC acts as a buffer between a demanding faculty and busy staff who are now free to work without interruption. At the same time the faculty are accommodated by the provision of free access to audiovisual facilities for preview and rehearsal.

Fig. 2. Slip which accompanies material to support staff. It should be of adequate size to accommodate instructions to the projectionist.

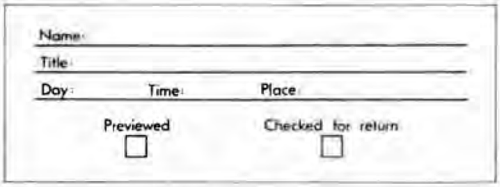


Fig. 3. Adhesive slip attached to magazine, reel or container. Blick (or similar) labels in sizes 72 × 24 mm and 48 × 24 mm are particularly suitable.

Events chart

The organization is incomplete without some means of recording conference events. This is done by employing a display chart (Fig. 4) which is divided into columns. The chart is of a convenient size to be written on with felt tip pen and is posted prominently at the audio-visual reception point. The first group of columns, which should be completed before the conference starts, is headed from left to right as follows:

Time (of presentation).

Speakers name. (It may be useful to include the title of the presentation.)

Place (of presentation).

Staff. (In a multisession conference it will be necessary to assign staff to particular locations.)

Session executive.

The session executive is part of the AVC's team. He may be a member of the host institution or, more probably, a conference participant who is known to the conference organizers and who has been persuaded to volunteer his services. The session executive may have little to do beyond looking after the session

Fig. 4. Events chart. A multisession conference of long duration will demand the preparation of a separate chart for each day.

THURSDAY 10th													
time	name	place	support staff	session executive	slides	film	other	received	previewed	to support staff	from support staff	checked	returned
FRIDAY 11th													

chairman and checking the room in advance. This is done from a check list supplied by the AVC which includes such details as blackboard, chalk, eraser, water, glasses, seating, lights, ventilation and audiovisual facilities, On the other hand he may be required to act as projectionist, recordist or microphone handler or to assist at the audiovisual reception desk. The use of session executives provides essential back-up to the organization. They are regarded as a form of insurance which an audiovisual co-ordinator dispenses with at his peril.

The second group of columns indicates the material to be presented. Some of this information can be listed in advance from the response sheets:

Slides—the columns may be divided to show format or multiprojector presentations.

Film—subdivisions may be used to indicate gauge and mute/sound.

Other—depending upon the variety of material to be shown additional headings may be added for overhead projection, microprojection, epidiascope, video.

The final group of columns relates to material handling:

Received

Previewed—time and date of appointment for preview is listed under this heading.

To support staff

From support staff

Checked

Returned

If the layout of conference facilities requires that the preview room be separated from the audiovisual reception desk, the chart is posted in the preview room which is close to the main lecture theatre and is the area in which the AVC will spend much of his time. In this instance the receptionist will accept material and check it off against a list prepared from the response sheets. It is essential that the receptionist and the AVC maintain close liaison, and it is useful if a telephone or intercom link is set up between the preview room and the reception area.

The chart is easily maintained and provides an ongoing picture of conference activities as they affect the audiovisual organization. The AVC is able to identify in advance problems related to facilities, space or staff. For example, empty spaces under 'Received' or 'Previewed' indicate gaps in information which may demand priority of action.

It must be remembered that the audiovisual organization is only one part of the conference and is subject to constraints which are beyond the control of the AVC. Presentations may be cancelled or their place in the programme altered. Extra sessions may be introduced or locations changed. When these things happen it is usually for good reasons but always without much notice, therefore the audiovisual organization must be flexible enough to cope without breaking down.

Briefing the staff

The AVC has two more tasks to fulfil before the conference begins and if possible they should be carried out on the same occasion. He will call a meeting in the main lecture theatre to which will be invited support staff, session executives, audiovisual receptionists. Session chairmen are normally briefed by conference committee but any chairmen who are available should be invited. Introductions are made and responsibilities outlined. When the audiovisual organization is described it is common for support staff to react with polite disbelief. However, it has been the author's experience that scepticism turns quickly to enthusiasm when the advantages of the system are realised and it is perceived that it will not interfere with normal working practices. Finally the AVC ensures that all staff have programmes, meal tickets and, when appropriate, access to conference bars and social events. This meeting is important not only for the dissemination of information, but because it helps to promote a team identity without which the audiovisual organization will be less successful.

Following the briefing the group will carry out a check of all audiovisual facilities. Whenever possible equipment should be duplicated because it is easier to change over equipment than to locate a fault under pressure. The equipment is tested and the picture size is checked as is the provision of lenses and condensers to permit format change. Controls for lights, screens, blackboards and ventilation are tested. The public address system is switched on and the position of microphones, including wander microphones, is confirmed. The location of the sound recordist, if any, will be examined to ensure that he can see platform and audience simultaneously. Two-way telephone communication between chairman and projection area is checked.

Whenever possible facilities should be provided for the rapid production of slides and overhead projector transparencies. A final check is made of a myriad of small details such as spare lamps, fuses, reels, magazines and slide mounts.

Summary

This examination of the audiovisual organization for conferences has identified particular aspects which are considered to be of importance. These are:

1. The appointment of an audiovisual coordinator (AVC) to coordinate the organization.
2. The importance of early contact between the AVC and contributors, and between the AVC and the host institution.
3. Preview and controlled delivery of audiovisual material.
4. Use of an events chart as an aid to forecasting and identifying problems.
5. Employment of session executives.
6. Adequate briefing of audiovisual staff.

The system which has been outlined reduces many of the tasks of running a conference to a routine, thereby allowing difficulties and unexpected problems to be managed without causing undue disruption.

Prosthetics and Orthotics International, 1978, 2, 173–175

Calendar of events

National Centre for Training and Education in Prosthetics and Orthotics

Short Term Courses

NC 203 Knee-Ankle-Foot and Hip-Knee-Ankle-Foot Orthotics for Orthotists; 15–26 January, 1979.
NC 302 Lower Limb Prosthetics for Therapists; 29 January–2 February, 1979.
NC 206 Upper Limb Orthotics for Orthotists; 12–16 February, 1979.
NC 102 Lower Limb Orthotics for Physicians and Surgeons; 19–23 February, 1979.
NC 208 Patellar-Tendon-Bearing Prosthetics (supra-condylar suspension) for Prosthetists; 5–16 March, 1979.
NC 207 Spinal Orthotics for Orthotists; 19–30 March, 1979.

Further information may be obtained by contacting Mr. J. Hughes, Director, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, 73 Rottenrow, Glasgow G4 0NG, Scotland. Tel.: 041-552 4400, extension 3298.

New York University Medical School

Short Term Courses

Courses for Physicians and Surgeons

741C Lower Limb Prosthetics, 26 February–2 March, 1979.
751B Lower Limb and Spinal Orthotics, 26–31 March, 1979.
744B Upper Limb Prosthetics and Orthotics, 2–6 April, 1979.
741D Lower Limb Prosthetics, 30 April–4 May, 1979.
751C Lower Limb and Spinal Orthotics, 7–12 May, 1979.

Courses for Therapists

745A Upper Limb Prosthetics, 22–26 January, 1979.
742C Lower Limb Prosthetics, 5–16 February, 1979.
752B Lower Limb and Spinal Orthotics, 26–31 March, 1979.
742D Lower Limb Prosthetics, 16–27 April, 1979.
752C Lower Limb and Spinal Orthotics, 7–12 May, 1979.
757B Upper Limb Orthotics, 21–25 May, 1979.
745B Upper Limb Prosthetics, 4–8 June, 1979.

Courses for Orthotists

753 Lower Limb Orthotics, 15 January–2 February, 1979.
758 Upper Limb Orthotics, 29 May–8 June, 1979.
756 Spinal Orthotics, 9–20 July, 1979.

Courses for Prosthetists

746 Upper Limb Prosthetics, 2–12 January, 1979.
743 Above Knee Prosthetics, 11–29 June, 1979.

Course for Rehabilitation Counsellors

750B Prosthetics and Orthotics, 14–18 May, 1979.

Requests for further information should be addressed to Professor S. Fishman, Prosthetics and Orthotics, New York University Post-Graduate Medical School, 550 First Avenue, New York, NY 10016, U.S.A.

1979

Latin American Association for Rehabilitation Medicine (AMLAR), Guatemala, 1979.
Information: Asociacion Guatemalteca de Medecina Fisica y Rehabilitacion, Cuidad de Guatemala, Guatemala, C.A.

1979

Meeting to consider the Peto System of Conductive Education, Budapest, Hungary, 1979, and a seminar on "Pediatrics and the Child with Cerebral Palsy", Ibadan, Nigeria, 1979.
Information: International Cerebral Palsy Society, 5a Netherhall Gardens, London NW3 5RN, U.K.

6 February, 1979

Engineering in Medicine and Biology as a Career.
Information: Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1, U.K.

2–4 April, 1979

Bioengineering 79, Southampton.
Information: K. Copeland, University College, Gower Street, London WC1, U.K.

2–6 April 1979

4th International Conference on Legislation Concerning War Veterans and War Victims, London, U.K.
Information: World Veterans Federation, 16 rue Hamelin, Paris 16e, France.

18–21 April 1979

British Orthopaedic Association—Spring Meeting, Exeter, U.K.
Information: Hon. Secretary, British Orthopaedic Association, Royal College of Surgeons, 35–43 Lincolns Inn Fields, London WC2A 3PN, U.K.

22–27 April, 1979

6th Pan Pacific Conference on Rehabilitation, Seoul, Korea.
Information: Dr. Pyung K. Moon, President, Korean Society for Rehabilitation of Disabled, 15-Sau, Sinchon-doug, Sudaemoon-ku, Seoul, Korea.

6–8 June, 1979

Canadian Association of Therapists, Ottawa.
Information: M/s. D. Campbell, 67 Nanook Crescent, Kanata, Ontario, Canada K2L 2B2.

17–21 June, 1979

International Congress on Electromyography, Stockholm.
Information: Dr. A. Persson, Huddinge Syjukhus, S–141 86 Huddinge, Sweden.

21–22 June, 1979

The Plastics and Rubber Institute—Third International Conference on Plastics in Medicine and Surgery, Twente University, The Netherlands.
Information: Mr. J. N. Ratcliffe, Sec. Gen., The Plastics and Rubber Institute, 11 Hobart Place, London SW1W 0HL, U.K.

22–29 June, 1979

23rd Annual Meeting American Association for Rehabilitation Therapy/Association of Medical Rehabilitation Directors and Co-ordinators.
Information: M. Abelson, Box 218, Yonkers, New York, 10705, U.S.A.

July 11–13, 1979

International Conference on Emotional and Sexual Needs of Handicapped People, Surrey University, Guildford, U.K.
Information: Committee of Sexual Problems of the Disabled, (SPOD), 49 Victoria Street, London SW1H 0EU, U.K.

19–24 August, 1979

Medical and Biological Engineering Conference, Jerusalem.
Information: P.O. Box 16271, Tel Aviv, Israel.

27–31 August, 1979

7th International Congress on Ergonomics.
Information: Organising Committee, 7th. I.C.E., ul Gornoslgska, 20, 00–848, Warsaw, Poland.

2–9 September, 1979

Ninth European Rheumatology Congress, Weisbaden, West Germany.
Information: Dr. (Med.) G. Josenhans, IX European Rheumatology Congress, c/o Deutsche Geseleschaft für Rheumatologie E.V., 2357 Bad Braunstedt, Falkenweg 7, West Germany.

24–27 September, 1979

International Conference on Riding for the Disabled, Warwickshire, U.K.
Information: Riding for the Disabled Association, Avenue "R", National Agricultural Centre, Kenilworth, Warwickshire CV8 2LY, U.K.

November, 1979

Third International Congress on "Improving the Quality of Life of the Handicapped with Assistive Devices", U.S.A.
Information: World Veterans Federation, 16 rue Hamelin, Paris 16e, France.

1980

4th World Congress of the International Rehabilitation Medicine Association, Stockholm
Information: International Rehabilitation Medicine Association, CH–7310 Bad Ragaz, Switzerland.

24–28 March, 1980

Aids for the Disabled, Dusseldorf.
Information: International Trade Fairs Ltd., 2 Old Bond Street, London W1, U.K.

7–9 May, 1980

Engineering Aspects of the Spine, London.
Information: Institution of Mechanical Engineers, 1 Birdcage Walk, London, SW1, U.K.

23–27 May, 1980

8th International Congress of Physical Medicine and Rehabilitation, Stockholm.
Information: Dr. W. Moritz, Sydsvenska Sjukgymnast Institutet, 5–220 05 Lund 5, Sweden.

22–27 June, 1980

Rehabilitation International 14th World Congress, Winnipeg, Canada.
Information: Mr. Jack Sarney, Canadian Rehabilitation Council for the Disabled, Suite 2110, Yonge Street, Toronto, Ontario M5E 1E8, Canada.

* * * * *

The use of lumbosacral corsets prescribed for low back pain. Prosthetics and Orthotics International, Vol. 2, No. 2.

We have been asked by the authors to point out that the investigation reported in the above paper was conducted at the Department of Orthopaedic Surgery, Kärnsjukhuset, Skövde, Sweden.

List of advertisers

Information for Contributors

Contributions should be sent to Prosthetics and Orthotics International, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, 73 Rottenrow, Glasgow G4 0NG. In the meantime considerable difficulty and delay is entailed in processing contributions in languages other than English. Authors are asked to provide three copies of text, tables and figures. Papers are accepted on the understanding that they may be subject to editorial revision and that no substantial part has been, or will be published elsewhere. Subsequent permission to reproduce articles must be obtained from the publishers. Manuscripts should be typewritten in double line spacing on one side of paper only with margins of 25 mm. Papers must commence with an abstract not exceeding 250 words. On a separate sheet must be:

(1) Title and short title. The short title should appear at the head of each page and should not exceed forty-five characters including spaces.

(2) Authors' names, initials and titles. The present address of any author if different from the place where the work was done, may be shown as a footnote.

(3) Department(s) in which the work was done.

(4) The name and full postal address of the author to whom correspondence and requests for reprints should be directed. This will appear as a footnote.

Illustrations

All illustrative material should be lightly marked on the back in pencil with the figure number in arabic numerals, title of paper, authors' name and a clear indication of the top of the figure. The approximate location in the text should be marked. Figure captions should be typed on a separate sheet. Tables should be used only when necessary to clarify important points. Each table should be typed on a separate sheet and numbered consecutively in arabic numerals.

References

References in the text should follow the author/date system for example: Peizer (1971). If there are more than two authors—Solomonidis *et al.* (1974). References at the end of articles should be listed on a separate sheet in alphabetical order of (first) authors' name, as follows: Marx, H. W. (1974). Lower limb orthotic designs for the spastic hemiplegic patient. Orthotics and Prosthetics, 28(2), 14–20. Journal titles must be given in full.

References to articles in books should include author, year of publication, article title, book title, edition, editor (if different from author) first and last pages, publisher and place of publication. For example, Hughes, J. (1975). Recent developments in prosthetics and orthotics. Recent Advances in Orthopaedics (2) Ed. McKibbin, B., 196–216, Churchill Livingstone, Edinburgh.

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