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THE KNUD JANSEN LECTURE

Education: an investment in everyone's future

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Opening remarks

Frequently one starts a presentation with the expression, "It is a great honour to be here," and thinks of it as little more than a polite form of words. This is not the case for me today. I am very conscious of the honour of giving this lecture and the honour we do to our founding President Knud Jansen. I am grateful to the Executive Board for their support and to the President for selecting me.

I never fail to be surprised when I find myself in a gathering such as this. It is at first sight a far cry from engineering in the Clyde shipyards, where I started my career, to rehabilitation engineering and the field of prosthetics and orthotics. Perhaps this is only a reflection of the changing face of society and the increasing recognition of the contribution which engineering can make in this field. Perhaps also it is a manifestation of happenstance and the vagaries of human behaviour. More likely it is a result of the influence and attraction of those who guided and directed me; engineers such as Kenedi, Radcliffe and Foort, medical practitioners such as Murdoch and Jansen and prosthetists like Lyquist and Kragstrup. I am grateful to them for moving me in this direction and to this Society to which they all belong or belonged.

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Introduction

It is not surprising that ISPO and its forerunner ICPO, the International Committee for Prosthetics and Orthotics have expended, and continue to expend, more effort in the field of prosthetic/orthotic education than in any other area. The fact is that twenty odd years ago just before ISPO was formed there were no universally accepted standards or even guidelines for the education and training of the prosthetist/orthotist. There were few nations with organised programmes and fewer still with any great interest in developing them.

And yet the prosthetist/orthotist enjoys a central position in the treatment of the group of patients with musculoskeletal disabilities. If the clinic team is to function effectively this key figure has to be adequately educated and trained.

If the situation was bad twenty years ago in the industrial world, it was worse in the developing world. Most international agencies displayed little appreciation of the need. Some would say that third world countries could not afford prosthetic/orthotic services and must concentrate on primary health care. Many who did believe prosthetic/orthotic services were necessary thought they could be provided by relatively unskilled workers.

ISPO has made enormous progress in moving thinking forward. Things are beginning to happen. It is astonishing, however, that even yet in the last decade of the twentieth century

there is a key member of the clinic team whose education and training has not yet evolved to a more or less uniformly accepted level.

Historical

Of course it is not surprising that there was a slow beginning. The profession was very much craft-based and medical-led well into the twentieth century. The surgeon had the understanding of the clinical problem and the general education to apply physics to obtain a more or less adequate solution. He then depended on a craftsman to give his solution a physical expression. Ambroise Paré (1575), for example, whose designs of artificial limbs are remarkably similar to many still in daily use, was a sixteenth century military surgeon who worked along with a highly skilled locksmith to produce his sophisticated prostheses.

In many countries the situation changed little and slowly with no formalisation of the place of the limb fitter or maker. Progress was marked by events, such as the development of the famous Anglesey leg, by a London limb maker named Potts who, in 1805, patented an above-knee artificial leg articulated at the knee, ankle and toe-joints. The leg was named after the Marquess of Anglesey, who was the most famous recipient of the device. He lost his leg at the Battle of Waterloo when a grape shot shattered his leg. He is said to have exclaimed to Wellington, who was riding beside him, "By God, Sir, I've lost my leg!". The Duke removed the telescope from his eye, had a look, retorted, "By God, Sir, so you have!" and then returned his attention to the battlefield (Anglesey, 1990).

The first upsurge in the profession in Europe came with the First World War. The scale of the casualty lists was unbelievable. In 1915, in the first two hours of the Battle of Loos, more British soldiers died than the total number of casualties on both sides on D-Day 1944. On the second day of the battle 12 British battalions, totalling just under 10,000 men lost 358 officers and 7,861 other ranks killed and wounded in three and a half hours of fighting (Calder, 1982).

Many of the casualties suffered amputation. By 1915 it became obvious that a large modern hospital was needed in Scotland. The project was pioneered by Sir William Macewan, then Regius Professor of Surgery at the University of Glasgow. The hospital, as was common then, would be under the royal patronage of Princess Louise, Duchess of Argyll. An early indication of rivalry to come between England and Scotland in this field, and American influence lurking in the background, may be gathered from extracts from a letter which Princess Louise sent to Sir William in March 1916:

> "..... I kept back this letter so as to add that I thought it wiser to tell His Majesty, The King, that the Lord Provost had requested me to take an interest in the movement, and he seems very anxious, that nothing should be done, which would, in any way cause a competition with Roehampton .....
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> It seems that the King has been approached, and the hope expressed, that such a Scotch Institution would not be started, which would in any way hinder the success of Roehampton Institution which is the originator. I did say, that I was going to urge you to be in communication with those 3 Americans at Roehampton who are thought to be the only really successful men with the artificial limbs at present ....."

Well, despite the King's reservations, the Princess Louise Hospital was established and, under Macewan's dynamic leadership, flourished, and still exists for disabled ex-service men, though no longer involved in limb fitting. It was of considerable interest to me to discover that the Scottish limbs were designed and built in Clyde shipyards, including the shipyard in which I received my training, and the limb makers were patients trained in the shipyards to make the limbs.

By the 1960's no dramatic change was obvious. Limb makers served an apprenticeship as leather workers, metal workers, or in other related trades. The better were selected to be fitters, but received little in the way of structured training on the route to qualification.

Many countries displayed a similar pattern. The West German system represented a more structured and controlled version of this system. USA led in the way of providing, within the University setting, structured training, while seeking to ensure adequate educational standards. By the 1960's the famous schools in the University of California, Los Angeles, Northwestern University and New York

University, were up and running. There were, however, no universally accepted standards.

Holte

A watershed in the development of training programmes was the so-called Holte Report (United Nations, 1969). This was the Report of the United Nations Inter-regional Seminar on Standards for the Training of Prosthetists, held in Holte, Denmark in 1968 and organised and run by ICPO for the United Nations. Past Presidents George Murdoch, Anthony Staros and Erik Lyquist played key rôles in its organisation and successful conclusion. Experts like Miles Anderson, Helmut John and Joe Traub contributed, and participants were invited from all corners of the globe.

The resulting document was all embracing, specifying everything from the provision of service through job descriptions of the prosthetist/orthotist and the technician, ethical conduct, educational standards, curricula, teaching methods down to terminology and standards. In particular it provided a blue-print for the education and training of the prosthetist/orthotist.

This was a remarkable meeting and a remarkable product. Literally every major educational event since that meeting has been based on the Holte Report. Nearly twenty five years later so far as education and training are concerned the findings still provide a model in continuous use.

Key elements in the proposal as far as training was concerned were

University entry level
Course duration of four years
Identified theoretical subjects
Specified clinical and laboratory practice
Ratio of practice: theory of 4:1

Scotland

The Holte meeting was timely so far as Scotland was concerned. Continuing complaints abour poor service, particularly in regard to prosthetics, had persuaded the Secretary of State for Scotland to set up a Working Party to advise him on "The Future of the Artificial Limb Service in Scotland" (Scottish Home and Health Department, 1970). The life span of this Working Party encompassed the time of the Holte meeting. A major conclusion of its report was that an adequate training scheme for prosthetist/orthotists should be instituted and that the National Centre for Training and Education should be established.

And so twenty years ago we in Scotland found ourselves in the position at which, astonishingly enough, many countries have still not arrived. A system which was not even an apprenticeship had to be replaced by a formal, high level training system with clear educational goals.

A number of circumstances came together and a number of decisions were made, some fortuitous, which combined to produce a good outcome. In retrospect they could be considered sound recommendations for any of the many nations which are currently considering their options. The first and perhaps most important factor is adequate funding for what is an unusually expensive course. The Scottish Home and Health Department accepted this responsibility and have continued to do so. The second was to find an appropriate home for the course. Fortunately, there was an active research group in this field in the University of Strathclyde's Bioengineering Unit and there was consequently a nucleus from which the National Centre might grow. Thirdly, there was a recognition of the appropriate level and content which came with acceptance of the Holte report and a mechanism to incorporate such a course within the national tertiary education system. For any country about to tackle this problem, adequate funding, an appropriate and enthusiastic host institution and proper integration within the national education system are pre-requisites for a successful outcome.

The difficulties were, however, daunting. The information as to what was required might be available, but the problem was how to make it happen. We were very considerably helped by the fact that, in the mid-sixties, Professor Charles Radcliffe had spent a year's sabbatical leave in Strathclyde. Flushed with the success of the Quadrilateral and Patellar-Tendon-Bearing sockets, he ran courses in these techniques for Scottish limb fitters. A number of these traditionally trained fitters who had taken part in the Radcliffe courses, formed the nucleus of the clinical teaching staff in the new National Centre. They were sent on short courses to the American Schools so that they might take part

in the same kind of up-grading activities as had been prescribed for American practitioners.

For the design of the National Centre premises, and for teaching manuals and other material — everthing from sources of supply to lists of machinery — the existing English speaking schools and the school in Oslo, were plundered shamelessly. A special tribute is due to New York University and Northwestern University Prosthetic and Orthotic Schools which were the main sources of information, and to their respective directors, Sydney Fishman and Charles Fryer who, knowing what was being done, so willingly and openly shared their experience.

When the University of Strathclyde prosthetics/orthotics course was initiated in 1973 it led to the award of a Higher National Diploma wihch was a nationally monitored and validated award. It was based on the Holte recommendations but it leant heavily on what were then already well established, respectable and respected courses in USA.

There are two interesting asides which perhaps highlight what was then a dilemma and is also a reflection of attitudes, since changed, which, were entrenched in the traditional University system. Firstly, it was not possible to go directly to a degree qualification — the University community would at that time not have accepted prosthetics and orthotics as a legitimate field of study, especially as it had previously been barely the subject of an apprenticeship. The second relates to the cumbersome title of the Centre where "training" was not enough for the University and was accompanied by "education" to signify a more respectable rôle in academic terms.

In 1986, responding to the perceived needs of the profession and its development within advancing technology the Higher Diploma course was replaced by an Honours Degree Course leading to the award of Bachelor of Science of the University of Strathclyde. This is not quite the same as a Bachelor of Science degree within the American system. To give an international measure of its currency, it represents four years of University study following 12 or 13 years of schooling, i.e. 16 or 17 years of study.

It is a common misconception in Europe to describe degree courses within a University setting as "academic" with the implication that such courses could not contain the necessary elements of practical or clinical instruction. In fact many University courses are strongly vocational and do have all the components to fit the student for a future career — medicine is one of the earlier examples. It is also possible within this framework to satisfy the specification laid down in Holte. The Srathclyde course is a four year course which contains the appropriate theoretical studies, supervised practical instruction and controlled clinical experience.

The first three years take place on the main campus in special purpose-built accommodation. During these three years the students carry out their theoretical studies and undergo training in the fitting and fabrication of prosthetic and orthotic devices working with "professional patients", that is patients acting as subjects for the students and not being fitted as part of their treatment. The normal University year of about 30 weeks is extended by 10 weeks to accommodate the large instructional element.

The final year consists of 46 weeks of clinical practice, 23 weeks in prosthetics, 23 weeks in orthotics, during which students are exposed to a structured broadening of their prosthetic and orthotic experience under appropriate supervision. In effect they are learning to apply to "real patients" the techniques they learned during the first three years. The clinical placements are undertaken in centres which meet specified criteria and have been inspected and approved for that purpose.

It may be mentioned in passing that the National Centre is housed on campus in some 32,000 square feet (3,200 square metres) of purpose-designed classroom, clinical and workshop space. It has a full time staff of about fifty, including ten prosthetist/orthotists. In addition to the Degree Course, it provides each year about 20 short courses, each of one or two weeks duration, for qualified clinic team members, and also operates, in a local hospital, a clinical service unit which provides for the needs of about 400 amputees and a greater number of orthosis wearers.

The Scottish course is one expression within a national context of the ISPO philosophy for the developed world. Many variants are equally acceptable. However, all courses must contain the elements of theoretical studies, closely

supervised practical instruction in both clinical and workshop skills and structured and controlled clinical experience. Any course which does not contain all of these and where they are not all monitored and assessed is inadequate. So far as the theoretical subjects are concerned every course will contain a blend of life, physical and applied sciences to satisfy the diverse requirements of understanding the human body, the device applied to it and their interaction. It is a strongly held personal conviction that one subject may be described as of paramount importance. Mechanics is the study of forces and their effects; biomechanics is the application of mechanics to the human body or, in other words, the study of forces and their effects on the human body. What then is prosthetics and orthotics if it is not applied biomechanics? Any prosthetics/orthotics course which does not have a solid biomechanical foundation is fundamentally flawed.

Although the introduction of new technology, such as computer-aided design and manufacture, may be important for the future, it is no more significant in this field than in many others. The computer is a tool used by many professionals. The undergraduate course must provide the basic theory and principles of practice; it must teach the student to learn and prepare him or her for continued learning throughout a professional career.

It is important to the future of the profession that its development proceeds in what might be described as a normal way. Having established Baccalaureate as the required level of professional qualification, it is only appropriate that some will proceed to higher degrees at Masters and Doctorate level. This is the next step in providing a cadre of individuals who can function at all levels of service, research and education. The National Centre, as part of a continuing programme of responding to the needs of the profession, will this year commence post-graduate degree courses specifically in prosthetics and orthotics.

ISPO and the developing world

A whole series of ISPO meetings and reports since Holte have pondered on the educational needs of the developing world. The first of these in 1974 in Les Diableret (International Society for Prosthetics and Orthotics, 1975), prior to the first World Congress, was a general meeting which attempted to set priorities for ISPO. Entitled, "Needs in Prosthetics and Orthotics Worldwide", it endorsed the Holte Report and emphasised the need for formal long-term degree level courses.

This remains the goal. However, the need in the short-term for compromise has been dictated by the difficulty of fostering educational efforts in the developing world and the need to strengthen and encourage those educational activities which are taking place and influencing a continual raising of their standards.

Of course the use of the term developing world creates the impression of a uniform, homogenous society. It does not take much reflection to realise that Asia, Africa, South America and the islands of the Pacific Rim probably display almost as much disparity within themselves as they do one from the other. They all, however, have crippling diseases which have been eradicated from the industrial world and they all lack resources. This lack of resources led many intergovernmental and international agencies to emphasise primary health care to the exclusion of all else. Where they did think about the needs of the physically disabled they considered they could be met by inadequately trained artisans. This attitude condemned millions to misery and dependence and ignored the consequent enormous cost to society and the individual and his family. ISPO can take considerable credit for influencing the international agencies to change this attitude and to recognise the size of the problem and the priority it deserves.

There are, of course, many conflicting factors. The prosthetist/orthotist in the developing world, like his counterpart elsewhere, needs to understand biomechanics and anatomy, to study materials and how to handle them and to learn the skills of fitting and constructing devices. It could sensibly be argued that with less resources of all kinds, more difficult conditions and probably more difficult clinical problems he needs to be better trained than his opposite number in the developed world. The reality however is that most developing countries cannot yet afford the investment in training to the highest level when this is considered against their many other areas of essential spending. Clearly a compromise is

needed to accept the reality of limited resources while at the same time producing a worker who has adequate skills and understanding to permit him to make a useful contribution in the clinic.

A solution, pioneered mainly by GTZ, the German Agency for Technical Cooperation, is the so-called Orthopaedic Technologist. With entry at 10 years schooling, which is the usual requirement for paramedical education in the developing world and a course of three years duration at lower than Degree level, this individual is clearly less well qualified than the graduate of the higher level schools in the industrial world. In an ideal situation he would always work under the supervision of a high-level, professional prosthetist/orthotist. However, his emergence marks a significant step forward in this field. ISPO has adopted the concept of the orthopaedic technologist, adapted, developed and ratified the syllabus and established a system for inspecting and recognising the educational programmes involved.

In discussion with ISPO and others the World Health Organisation has now agreed and recorded (World Health Organisation, 1990) that this is the minimum level at which developing countries should be aiming and recognised that the long term aim should be for the degree level professional. This is a most significant step forward in the battle for the recognition of the importance of this activity.

Of course the clinical problem is also very much different from that in the developed world — the different causes and incidence of amputation, the continuing presence of such diseases as poliomyelitis and leprosy. This has led to the suggestion of a further development from the orthopaedic technologist philosophy. This would be an emergency measure to produce an orthotics technologist or a prosthetics technologist trained in a single discipline with a consequent reduction in course length and therefore cost. This would permit more people to be trained more quickly with a concentration on greatest regional need.

The challenge or the investment

There are two distinct but related challenges in this field, not surprisingly they correspond to the developed and developing world. They are different because the problems and circumstances are so different, but they are related because the developed world needs to be in a position to provide to the latter, support and assistance and teachers.

The challenge in the developed world and the solution are quite straight-forward.

Government is said to be committed to improving the lot of the disabled among us. For many the prosthetist/orthotist is the key figure in the rehabilitation process. The standards and the revelant training needs are known. The necessity is to provide the appropriate numbers of properly trained professionals and that means to provide appropriate training programmes. Many governments do address the problem of ensuring an adequate supply of doctors, nurses and therapists. It is almost unknown for any government to even consider the supply of prosthetist/orthotists.

Many factors contribute to this situation. In some countries the profession itself has been slow to raise training standards, the numbers involved are small making it difficult for smaller countries to set up viable programmes and of course the training programme is inevitably expensive. Unfortunately government departments are increasingly becoming obsessed by cost. In many countries it has become a maxim that, "Cheap is good". This however is cost consciousness which is not the same as sound economics.

Let us consider some of the numbers involved. Even accepting that they are contentious, it is helpful in putting the problem in perspective. For every one million of population there are about 8,000 disabled in need of prosthetic/orthotic services (that is 0.8%, a figure obtained from Swedish studies (Oberg, 1987) and substantiated by other estimates (Office of Population Censuses and Surveys, 1988). It should be emphasised that this is not necessarily the number who will be provided with service. Government policy, the system of health care provision, and the quality of service available, are all likely to reduce the number fitted in comparison to the number who could benefit from fitting. A useful working estimate of the number of prosthetist/orthotists required to treat these patients is one per 400 patients. So for one million population about 20 prosthetist/orthotists are required. Assuming a working life of about 25 years the training system has to feed into the system about 0.8 prosthetist/orthotist per year per million

population. The cost of training varies widely but let us consider what these figures might mean in a country like USA with a population of 240 million. There would be 1,920,000 disabled, needing the services of 4,800 prosthetist/orthotists. The schools would have to graduate almost 200 new professionals each year. Without going into the details of the real costing it can be seen that the provision of $20 million per year to fund training would only represent about $10 for each disabled individual. This is a trivial cost compared to the real cost of disability to the individual and society and the potential saving from improved fit through the use of better trained professionals, leading to improved function and savings in adjustment and alteration costs. Against that background it is difficult to understand the logic behind the recent attacks on the internationally respected education programmes in USA and the demise of institutions like the New York University School.

Things are not better elsewhere in the developed world. There are twelve countries in the European Community (at the last count). Only four (Denmark, France, Germany and United Kingdom) have what can even broadly be described as "high level" programmes. This means that there is a population of about 200 million, in the most sophisticated part of the developed world, with educational traditions stretching back for many centuries, where a key member of the clinic team is being, at best, inadequately trained and even in some countries not formally trained at all! The situation on Continental Europe has hardly changed in 20 years.

In the developing world the picture is different and certainly not better. Many crippling diseases which have disappeared in the industrial world are still prevalent. The World Health Organisation estimates that despite the efforts to eradicate poliomyelitis, as many as two million children may still get the disease before the year 2000 (World Health Organisation, 1990). The vast majority of these children could remain free of deformities and able to walk if they were provided with orthoses. The number needing devices is further swollen by those still alive who have contracted the disease over the last decades. A recent very cautious estimate of the number of amputees in the developing countries is about 3.5 million. If it is assumed that a prosthesis may last for three years before replacement, the annual production in the developing world would need to be about 1.2 million. There is a special need for orthopaedic footwear in a group of patients, the largest proportion of which has leprosy. It is estimated that, at present, there are 11–12 million people in the world with leprosy. If only 10% of them need footwear every year, this corresponds to a demand for over one million pairs of shoes.

All of these figures are almost certainly underestimates. They give an impression of the size of the problem. A similar analysis to that used above for the developed world puts the problem in context. The present number of adequately trained prosthetist/orthotists and orthopaedic technologists in the developing world is not known, but is estimated to be less than 2,000. A very conservative estimate of the number of people who need prostheses or orthoses would be 0.5% (c.f. 0.8%) of the population. By the year 2000 the combined population of Africa, Asia and Latin America will be approximately 4 billion — so there will be 20 million people in need of orthopaedic devices (World Health Organisation, 1990). To even have only one professional available to serve every 1,000 patients (c.f. 400) requiring devices would need 20,000 trained personnel — ten times that currently available. The need is simply staggering. The output of all the schools which currently exist anywhere in the world could not even scratch the surface of the problem. There is no sign of any dramatic change in the number of training places available worldwide. Indeed, it seems certain that in the developing world the rate of expansion is less than the rate of increase of the world's population.

The challenge in the developing world is then of a different order. We can claim some success in changing attitudes, in providing good and useful information and in being supportive of the programmes which do exist. The situation, however, is catastrophic and worsening. We must be still more active, more responsive and more "diplomatically aggressive". We must encourage and foster new initiatives and seek innovative and, perhaps radically different, solutions. If we are to make an impact on this problem we must change our rate of

achievement. Frankly, what we have done is not enough.

It is suggested in the title of this presentation that education is an investment in everyone's future. There can be no question that, without an investment in training in this field and a dramatic increase in the number of professionals available to practise, for many people the future will have little quality.

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