

## **Statistical analysis of amputations and trends in Korea**

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### **Abstract**

Epidemiological research on amputees is being continued extensively world wide, but there are different epidemiologic reports from country to country. This study undertakes an epidemiologic report of the medical records of amputees in Korea which has developed very rapidly, when compared with other countries. This study included 4258 amputees who either had an amputation and/or received prosthetic training at Yonsei University College of Medicine, Severance Hospital from January 1970 to June 1994. The most common cause of amputation was trauma (66.7%), and the second most common cause was peripheral vascular disease. While amputations due to infection or trauma were the most common in the 1950's, amputations due to peripheral vascular disease have gradually increased until they now make up 23.5% of all amputations in the 1990's. Lower limb amputation, more common than upper limb amputation, accounted for 68.7% of all amputations. Multiple amputation accounted for 9.3% of all amputations, and the occurrence rate of multiple amputation was relatively higher in cases of burn injuries, train accidents, frostbite, and Buerger's disease than in cases brought about by other causes. The various amputation causes change according to the circumstances of the times, as can be seen in this study.

### **Introduction**

Amputation is one of the most ancient of all surgical treatments, and the history of

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amputations is as old as that of the human race. Early in the 16th century Ambroise Paré was the first to use ligatures to control bleeding after amputation and also designed relatively sophisticated prostheses. Later, with the development of tourniquet's aseptic surgical procedures and anaesthesia, amputation technique was developed radically by people such as Lisfranc and Syme as Tooms (1992) has described.

The increase in amputees today is due to the improvement of transportation methods, as the development of mechanical civilisation, the prolongation of life, etc. Epidemiological research on amputees is being continued extensively in many countries all over the world. After studying the cause of amputation of young men from Illinois in the USA, Lambert and Sciora (1959) found that trauma was the most common cause, accounting for 52% of all amputations, Warren and Kihn (1968) have reported that 76% of 1964 amputees who received treatment at the Veterans Administration Hospital were amputation cases caused by vascular insufficiency. Later, Hansson (1964) reported that as a result of studying 586 amputees who received amputation surgery in Sweden from 1947 to 1963, 85% of lower limb amputations were because of peripheral vascular disease, and that the rate of amputations due to peripheral vascular disease yearly. Pohjolainen and Alaranta (1988) reported that of the 750 lower limb amputees studied, 43% were because of Diabetes Mellitus. Still later, Stewart and Jain (1993) reported that the majority of amputations in Scotland were caused by peripheral vascular disease, especially arteriosclerosis.

Putting these reports together, it is possible to

conclude that in the industrial world most amputation cases are caused by peripheral vascular disease, but in Asia, where the number of developing countries is large, there are different findings.

According to reports by Chan *et al.* (1984), a retrospective study undertaken on 1821 amputees who were treated over a period of 24 years at the Prosthetic and Orthotic Unit of Kowloon Rehabilitation Centre in Hong Kong showed that the most common cause of upper limb amputation was trauma, and that in cases of lower limb amputation the leading cause was disease. Hla Pe (1988) of Burma has made a somewhat different report, saying that trauma was the most common cause in both upper and lower limb amputations, accounting for 87% and 47% of amputations respectively. Later, Al-Turaiki and Al-Falahi (1993) performed a retrospective study on 3210 amputees who received treatment at the Riyadh Medical Rehabilitation Centre from 1977 to 1990, and found that 86.9% of upper limb amputations were due to trauma, and that 52.9% of lower limb amputations were also due to trauma, making trauma the leading cause in both cases.

As Korea differs from many other countries in having experienced the devastating 1950 Korean War; the dispatch of troops to Vietnam during the Vietnam War; rapid industrial development and improvement of transportation methods, it seems that the epidemiological statistics of Korea would be different.

Therefore, the object of this study is to investigate the basic available statistics in Korea which include the cause of amputation; the site of amputation; the distribution of age groups, and to examine the aspects that differentiate Korea from other countries, and to compare their parameters according to the changing times.

## Methods

### Subjects

A retrospective study has been carried out of patients who have received an amputation or went through the process of prosthetic prescription, fitting and training at Yonsei University College of Medicine, Severance Hospital from January 1970 to June 1994, a span of 24 years and 6 months. Among these patients are excluded those for whom it was not possible to provide precise data because of

insufficient or lost medical records, and also those who received rotation plasty because definite classification was not possible. Therefore, 4665 cases including multiple amputations from 4258 amputees, were the subject of this study.

### Data collection

The data that was thus selected was reviewed through medical and prosthetic records. These records include the demographic factors and general characteristics including age and sex of the amputee, the amputation cause, the operation date, bilaterality, etc. The records were reviewed by medical doctors for the purposes of this study.

### Amputation age and cause

The amputation age was determined on the basis of the last operation date, and the point of congenital limb deficiency at the time of birth. The amputation cause was classified according to the primary cause only. The large categories of amputation causes were classified into trauma, peripheral vascular disease, infection, malignancy, and congenital anomaly. The category of trauma included amputation caused by machinery, industrial injury, traffic accidents, explosions, train accidents, and burn injuries. The category of peripheral vascular disease was subdivided into diabetes, arteriosclerosis, ischaemic disease, Buerger's disease, and frostbite. The category of congenital anomaly included congenital limb deficiency and polydactyly or syndactyly. The amputation site was determined by classification provided by ICD-9 (1978), and the amputation and disarticulation of fingers and thumbs was included in the hand category. The amputation of toes and feet was included in the foot category.

### Data analysis

All data was analysed through descriptive statistics of the SPSS statistic analysis programme.

## Results

### Amputation age and sex

The amputation age ranged from 1 month to 83 years, and the most common amputation age group was the twenties, a time of vigorous social activity; then the teens; and then the

Table 1. Age and sex distribution of amputee

Age (years)	Male	Female	Total	M/F Ratio*
0 - 9	411 ( 8.1)	243 (18.1)	654 (15.4)	1.7
10 - 19	662 (19.8)	165 (23.3)	827 (19.4)	4.0
20 - 29	944 (28.4)	146 (21.2)	1090 (25.6)	6.5
30 - 39	722 (21.9)	83 (12.5)	805 (18.9)	8.7
40 - 49	373 (11.3)	70 (10.8)	443 (10.4)	5.3
50 - 59	209 ( 6.3)	46 ( 7.1)	255 ( 6.0)	4.5
60 -	139 ( 4.2)	45 ( 7.0)	184 ( 4.3)	3.1
Total %	3460 (81.3)	798 (19.7)	4258 (100.0)	4.3

Values are given as number (%)

\*M/F ratio of men to women.

thirties. These younger age groups accounted for 63.9% of all amputees. There were more male amputees than female with the overall ratio of men to women being 4.3 to 1. In the age group under 9, little difference existed between genders, but in the thirties age group male amputees vastly exceeded female amputees at a rate of 8.7 to 1 (Table 1).

#### Amputation cause

In this study, trauma was the most common

amputation cause, accounting for 72.3% of all cases. The next most common cause of amputation was peripheral vascular disease. Among the acquired amputations excluding congenital anomalies, amputation due to trauma made up the largest share of all amputation cases (85.9%) in the 1950's, but have gradually decreased to 58.3% in the 1990's. Amputation due to peripheral vascular disease has gradually increased until it accounts for 23.5% of all amputations in the 1990's. Infection was the

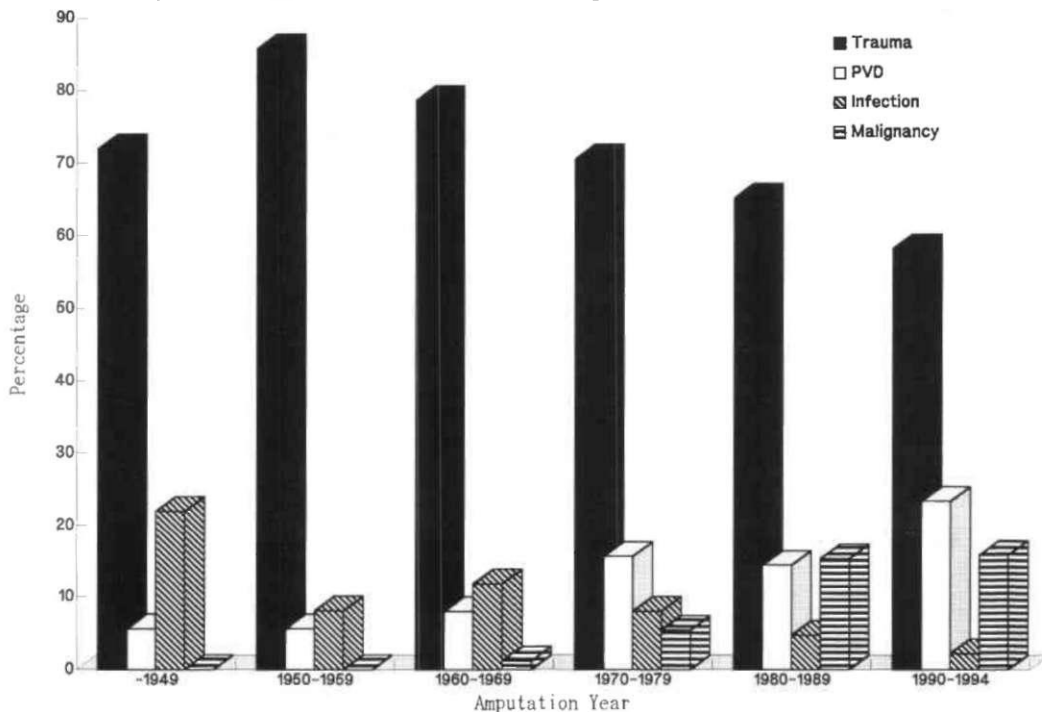


Fig. 1. Change in acquired amputation causes according to the time interval.

Amputations due to trauma have decreased gradually but cases of PVD have increased. Amputations due to congenital anomaly were excluded.

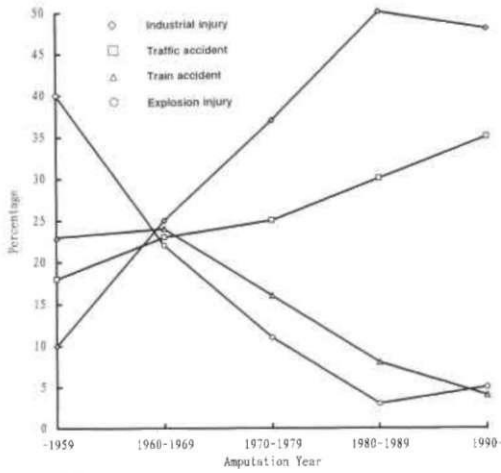


Fig. 2. Distribution of trauma subtypes according to time interval. Amputations due to industrial injury, traffic accident have increased, but cases of explosion have abruptly decreased.

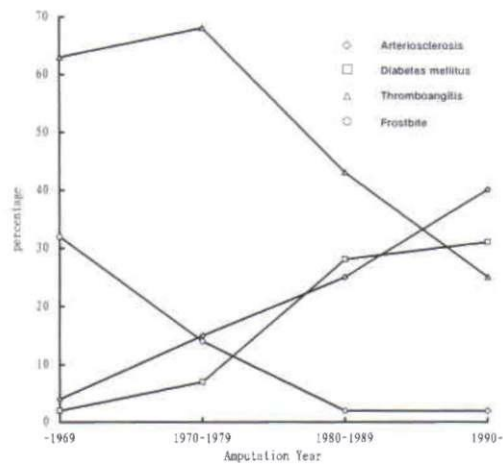


Fig. 3. Distribution of peripheral vascular disease subtypes according to time interval. Amputations due to diabetes or arteriosclerosis have steadily increased, but cases of Buerger's disease have gradually decreased.

second leading cause of amputation in the 1950's, but has dwindled until it has become the least common cause since the 1980's (Fig. 1).

Cases of amputation caused by trauma due to industrial injury have increased since the 1950's until the rate stabilised in the 1980's (50%) and 1990's (49%); while causes due to traffic accidents have increased steadily until they made up 35% of all amputation cases in the 1990's. Amputation caused by explosives has decreased abruptly since the 1950's (Fig. 2).

Cases of amputations caused by peripheral vascular disease due to Buerger's disease have decreased gradually from the high point of 63% in the 1960's. Cases due to frostbite have also decreased gradually from the point of 32% in

the 1960's, but cases due to diabetes or arteriosclerosis have gradually increased until they respectively made up 31% and 42% of all cases in the 1990's (Fig. 3).

The leading cause of amputation was trauma in all age groups except those in the sixties. In each of the younger groups from the teens to the thirties, amputation due to trauma accounted for more than 70% of all amputations. Cases of amputations caused by peripheral vascular disease tended to increase along with the increase in age. In the group over 60, peripheral vascular disease (51.5%) was a more common cause of amputation than trauma (30.4%). Of the 269 amputees who received amputation surgery due to malignancy, 72 were in their

Table 2. Distribution of amputation causes according to age

Amputation age (years)	Trauma	PVD	Infection	Malignancy	Congenital	Total
0 - 9	343 (52.4)	5 ( 0.8)	21 ( 3.2)	14 ( 2.2)	271 (41.4)	654 (100.0)
10 - 19	643 (77.8)	23 ( 2.8)	63 ( 7.6)	72 ( 8.7)	26 ( 3.1)	827 (100.0)
20 - 29	859 (78.7)	78 ( 7.2)	91 ( 8.3)	40 ( 3.7)	22 ( 2.1)	1090 (100.0)
30 - 39	571 (70.9)	134 (16.6)	53 ( 6.6)	44 ( 5.5)	3 ( 0.4)	805 (100.0)
40 - 49	253 (57.1)	98 (22.1)	47 (10.6)	43 ( 9.7)	2 ( 0.5)	443 (100.0)
50 - 59	117 (45.9)	72 (28.2)	29 (11.4)	36 (14.1)	1 ( 0.4)	255 (100.0)
60 -	56 (30.4)	94 (51.5)	13 ( 7.1)	20 (10.9)	1 ( 0.6)	184 (100.0)
Total	2842 (66.7)	504 (11.9)	317 ( 7.4)	269 ( 6.3)	326 ( 7.7)	4258 (100.0)

Values are given as number (%)  
PVD: peripheral vascular disease.

Table 3. Distribution of amputation causes according to amputation level

Amputation age (years)	Trauma	PVD *	Infection	Malignancy	Congenital	Total
Shoulder	22 ( 0.7)	0 ( 0.0)	1 ( 0.3)	15 ( 5.6)	0 ( 0.0)	38 ( 0.8)
TH	343 (11.1)	3 ( 0.5)	5 ( 1.5)	8 ( 3.0)	0 ( 0.0)	359 ( 7.7)
TR	439 (14.2)	12 ( 1.9)	13 ( 3.8)	3 ( 1.1)	11 ( 3.2)	478 (10.2)
Hand	341 (11.0)	24 ( 3.9)	8 ( 2.3)	12 ( 4.4)	199 (58.7)	584 (12.5)
Hip	45 ( 1.5)	3 ( 0.5)	8 ( 2.3)	61 (22.6)	1 ( 0.3)	118 ( 2.5)
TF	823 (26.6)	151 (24.3)	150 (43.8)	137 (50.7)	9 ( 2.7)	1270 (27.3)
TT	1023 (33.1)	357 (57.5)	151 (44.2)	24 ( 8.9)	15 ( 4.4)	1570 (33.7)
Foot	57 ( 1.8)	71 (11.4)	6 ( 1.8)	10 ( 3.7)	104 (30.7)	248 ( 5.3)
Total	3093 (100.0)	621 (100.0)	342 (100.0)	270 (100.0)	339 (100.0)	4665 (100.0)

Values are given as number (%)

PVD: peripheral vascular disease; TH: trans-humeral and elbow disarticulation; TR: trans-radial and wrist disarticulation; Hand: hand and finger; TF: trans-femoral and knee disarticulation; TT: trans-tibial and Syme; Foot: foot and toe.

teens, making this group the majority in this category. Most of the cases due to congenital anomaly received treatment or amputation before the age of 9 (Table 2).

#### Amputation site

With the exception of hip disarticulation and foot amputation; for all amputation levels, trauma was the most common cause of amputation. Malignancy was the most common cause of hip disarticulation (61 out of 118 cases). Peripheral vascular disease was the leading cause of amputation in cases of trans-tibial amputation, and, in cases due to congenital deformity, hand or foot amputation was the most common procedure performed (Table 3).

There were more cases of lower limb amputation (68.7%) than upper limb amputation. Peripheral vascular disease, infection, and malignancy occurred more often in the lower limbs than in the upper limbs, and only congenital deformity was more common in the upper limbs (Table 4).

#### Multiple amputation

Multiple amputation accounted for 9.3% of all amputations. The occurrence rate of multiple amputation was relatively higher in cases caused by burn injuries, train accidents, frostbite, or Buerger's disease than in cases due to other causes (Table 5).

#### Discussion

Statistics on amputations differ because of factors such as the population of the subject group, the method of research, and the social conditions of the country. This is a hospital based, retrospective study in Korea, which has experienced dramatic social changes including rapid industrial development literally from the ashes of the Korean War in 1950.

In this study the younger age groups from the teens to the thirties accounted for 63.9%, thus making up the leading amputation age group. This grouping is different from other reports. Kerstein *et al.* (1974) reported that the average age of amputation was 56.8, and Warren and Kihn (1968) also reported that the majority

Table 4. Comparison of upper and lower limb amputation causes

	Trauma	PVD	Infection	Malignancy	Congenital	Total
ULA	1145 (37.0)	39 ( 6.3)	27 ( 7.9)	38 (14.1)	210 (61.9)	1459 (31.3)
LLA	1948 (63.0)	582 (93.7)	315 (92.1)	232 (85.9)	129 (38.1)	3206 (68.7)
Total	3093 (100.0)	621 (100.0)	342 (100.0)	270 (100.0)	339 (100.0)	4665 (100.0)

Values are given as number (%)

PVD: peripheral vascular disease; ULA: upper limb amputation; LLA: lower limb amputation

Table 5. Comparison of multiple amputation rates according to causes

Cause	No. of MA/AA	Rate (%)
Trauma	287/2842	10.1
Burn	37/ 149	24.8
Train accidents	112/ 447	25.1
Others	138/2246	6.1
PVD	94/ 504	18.7
Frostbite	32/ 67	47.8
Buerger's disease	52/ 252	20.6
Other	10/ 185	5.4
Infection	6/ 317	1.9
Malignancy	3/ 269	1.1
Congenital	6/ 326	1.8
Total	396/4258	9.3

Values are given as number (%)

No. of MA/AA: number of multiple amputation per all amputation; PVD: peripheral vascular disease.

were over 60. On the other hand, Seiler and Richardson (1986) who only investigated traumatic amputees reported the average amputation age as 31.5, and Al-Turaiki and Al-Falahi (1993) reported that their hospital based study showed the younger age group took the majority. The age of the amputee in this report is younger than in others due to the fact that most amputations were due to trauma, which occurs frequently to younger people who lead active lives. There is also, the fact that the age group from the teens to the thirties makes up about 60% of the whole population of Korea.

Reports on the causes of amputation differs from country to country. Stewart and Jain (1993) reported that peripheral vascular disease was the leading cause (80%), and that amongst those cases arteriosclerosis accounted for 60%. Kerstein *et al.* (1974) reported as the results of an exclusive study on lower limb amputees that 85% of the cases were due to peripheral vascular disease. But Al-Turaiki and Al-Falahi (1993) reported in their study in Saudi Arabia that trauma accounted for 60%, and disease for 30% of all cases. Hla Pe (1988) in Burma reported that the leading cause of amputation is trauma. In this study amputation caused by trauma accounted for 66.7% of all cases, while peripheral vascular disease accounted for 11.9% and infection for 7.4%, making trauma undoubtedly the primary cause of amputation.

The leading causes of amputation in different countries is influenced by the degree of industrialisation, the transportation system, and the medical care available in each country. In the case of Korea, it seems that trauma is the leading cause of amputation because of factors such as the 1950 Korean War; explosion injuries from the Vietnam War where Korea sent troops in the 1960's; the rapid development of an industrial and mechanical civilisation since the 1960's, and the increase of the volume of traffic, along with increased speeds. This is similar to Banerjee's report (1982), which said that trauma, infection, and Buerger's disease were the three leading causes of amputation in developing countries, and except in times of war, peripheral vascular diseases such as diabetes and arteriosclerosis were the leading cause of amputation in developed countries.

The leading cause of amputation has changed with time. Amputation due to trauma decreased to 58.5% in the 1990's from 85.9% in the 1950's, and amputation due to infection has decreased until it has become the least common cause of amputation. This appears to be a result of the improvement in treatment techniques brought about by the development of medical science and antibiotics. But cases of amputation due to peripheral vascular disease increased greatly from 5.7% in the 1950's to 23.5% in the 1990's. This fact may be related to a surprising gradual increase in the intake of a high protein, high fat diet, and the fact that the population of senior citizens over the age of 65 is increasing 5.4% every year. If one looks at reports on the change of peripheral vascular disease with time. Hansson (1964) says that while 2% of all people using prostheses in 1926 received amputation surgery because of peripheral vascular disease, that percentage increased to 57% in 1955. Hierton and James (1973) reported the rate of amputation due to peripheral vascular disease increased from 69% in 1947 to 73% in 1957, and to 93% in 1967-1969, and that this was because of the increase in the number of advanced age citizens in the population. But Buchanan and Mandel (1986) reported as the result of a study on amputation cases performed through institutions offering prosthetic services throughout Canada that the rate of amputation due to trauma increased from 33.6% in 1960 to 43.1% in 1980. They gave the contradictory opinion that this could be because amputation

cases due to disease decreased thanks to the improvement of treatment methods of internal diseases while the rate of amputations due to trauma increased correlatively.

Looking at the cause of amputation according to age, Kerstein *et al.* (1974) reported that peripheral vascular disease occurred mainly in the senior age group and that it especially occurred frequently in the fifties age group. These reports are consistent with this study, and show that cases where amputation was performed because of accidents occur relatively more often in the younger age groups while cases due to peripheral disease are more frequent than cases due to accidents in the sixties and older age group and that the occurrence rate of these peripheral vascular disease related cases increases with age. Cases of amputation due to malignancy were most common in the teen age group compared to the other age groups. This seems to be because of the speciality of osteogenic sarcoma which is a malignancy that occurs mainly in the teens and twenties age groups as Tebbi *et al.* (1985) have reported.

Lower limb amputation accounts for 68.7%, which is a larger percentage than that of upper limb amputations. This is a similar result to the report of Tooms (1972) saying that upper limb amputations make up about 15-20% of all amputations, and the report of Al-Turaiki and Al-Falahi (1993) saying that lower limb amputations account for about 65%.

Looking at the various sites of amputation according to the cause, cases due to accidents or peripheral vascular disease were more common in lower limbs than in upper limbs, and among those lower limbs amputations the most frequent site of amputations was trans-tibial amputation including Syme amputation. In amputation cases due to malignancy, however, trans-femoral amputation occurred most frequently. This is because the distal portion of limbs are generally more likely to be injured, and surgeons tend to amputate as distally as possible to enhance functional activity.

As for the frequency of multiple amputations, Hansson (1964) reported 16.9%, Stewart and Jain (1993) 18%, Al-Turaiki and Al-Farahi (1993) approximately 5%, and Kerstein *et al.* (1974) 3.4%. The rate of multiple amputation in this study is 9.3%, which is similar to other reports. In cases where the cause of amputation

was electric burns, train accidents, frostbite, or Buerger's disease, the occurrence rate of multiple amputation was relatively high. This is because in cases of electric burns, there is an entrance and exit area as in gunshot wounds as Baxter (1970) has reported. In train accident cases, the reason seems to be that train accidents tend to be more severe than other traffic accidents. As Buerger's disease is not a localised disease involving only one limb, the recurrence rate is high as Ohta and Schionoya (1988) have reported. Therefore, it seems that in these cases there would be a higher multiple amputation relative risk compared with other causes. La Borde and Meier (1978) reported that the multiple amputation rate of electrical burn injury patients is 50%, and Kegcl *et al.* (1978) have reported that most multiple amputations were caused by peripheral vascular disease.

#### Conclusion

Putting the results of this study together, we arrived at statistics similar to those of other Asian countries. Unlike developed countries, trauma was the leading cause at present. However, the amputation cause according to the circumstances of the times changed dramatically as can be seen in this study as the amputation cases due to peripheral vascular disease have increased gradually and the cases due to trauma have decreased gradually.

It is hoped that this study on amputees in Korea will help in the efforts to provide more comprehensive rehabilitation treatment by predicting the course of future amputation patterns and being used as basic data in setting up plans in the developing countries.

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## INVITATION

### UPDATE COURSE ON AMPUTATION AND PROSTHETICS HELSINGBORG, SWEDEN

ISPO has arranged an Update Course on Amputation and Prosthetics 11-14 April 1997 at Marina Plaza Hotel in Helsingborg, Sweden. The course is directed to orthopaedic surgeons, vascular surgeons, rehabilitation doctors, physical therapists, orthopaedic engineers and other specialists involved, preferably teams including surgeon, therapist and prosthetist. Both advanced teams and beginners are welcome.

The course will cover both upper and lower limb amputations and prosthetics and the subject matter will be presented by faculty from Denmark, Germany, Hungary, Scotland and USA as well as Sweden.

The rapid development within prosthetics with new components, new materials and aggressive rehabilitation programmes with sports etc. makes an update course valuable both as a forum for discussion and teaching. The update course is planned for about 100 participants.

The course fee is 400 US\$. Preliminary application should be sent to secretary May-Christine Friberg, Dept of Orthopaedics, Helsingborg Hospital, S 251 87 Helsingborg, Sweden.

Fax nr +46 42 102450. We will then distribute a complete programme and list of faculty, hotel information and application form.