Late Sequelae of Amputation*

THE HEALTH OF FINNISH AMPUTATED WAR VETERANS

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PART II

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Findings in the Back and Spine

Back pain constitutes the commonest complaint among amputees. Table 16 gives the history of back symptoms causing temporary unfitness for work or repeated marked disturbance which has occurred for a minimum period of half a year.

TABLE 16

CHIEF SITE OF BACK PAIN

Group	Cervical spine %	Thoracic spine %	Lumbar spine %
AE	8	2	48
BE	8	4	33
AK	—	—	65
BK	1	1	73
C	1	2	35

It was found that in lower limb amputees pain in the lumbar spine was highly significantly commoner than in the control group and in upper limb amputees. In upper limb amputees pain in the cervical spine was commoner than in the other groups.

Postural scoliosis often occurs in order that the balance be maintained when the centre of gravity has been displaced as a result of the loss of an upper or lower limb. Table 17 lists the cases of scoliosis occurring in the present series calculated as a percentage of the number of cases of each group.

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TABLE 17

SCOLIOSIS (AS A PERCENTAGE OF THE NUMBER OF PERSONS OF EACH GROUP)

(Site of greatest scoliotic curvature)

Group	Thoracic spine		Lumbar spine	
	Clinical	Radiological	Clinical	Radiological
AE	92	46	19	21
BE	67	42	17	17
AK	20	28	50	28
BK	24	29	32	22
C	1	22	5	16

The clinical observations were made while the patient was standing, the lower limb amputees with prosthesis and shoes on, the upper limb amputees generally without their prosthesis. As a rule, the scoliosis seemed to become corrected when the patient was lying down. However, radiograms showed that there were also numerous cases of scoliosis in the control group, even when the person examined was in the recumbent position. Radiologically demonstrable deviations of 5 mm were regarded as scoliosis. The thoracic scoliosis in the upper arm amputees was always directed towards the side of the stump. In one-eighth of the forearm amputees with thoracic scoliosis it was directed towards the healthy side. In one-fifth of the cases of lumbar scoliosis in amputees with an amputated thigh, the scoliosis was directed towards the intact side and, correspondingly, almost one-quarter of the cases of lumbar scoliosis diagnosed in the lower leg amputees were convex towards the intact side. In thigh amputees the direction of the scoliosis seemed clearly to depend on a poor, mostly short and tender, stump or on a poor prosthesis and this also seemed to be the reason in many of the cases of lower leg amputation.

It can be concluded that clinically established thoracic scoliosis is statistically highly significantly commoner in upper limb amputees than in the control group.

Clinically, the difference is also highly significant between upper and lower limb amputees, clear enough to allow the statement that clinically demonstrable thoracic scoliosis is typical of upper limb amputees. Likewise radiologically thoracic scoliosis is significantly commoner in upper limb amputees than in other groups ($P < 0.05$). With regard to the incidence of thoracic scoliosis the lower limb amputees hardly differ radiologically from the control group, while the upper limb amputees clearly do so.

The frequency of clinical lumbar scoliosis is significantly higher in lower limb than in upper limb amputees.

Radiologically there is no significant difference in this respect between upper and lower limb amputees, although, reckoned in per cent, lumbar scoliosis is commonest in thigh amputees, and in all groups of amputees commoner than in the control group. Borgmann observed lumbar scoliosis radiologically in about 45 per cent of thigh amputees and Arens in about 80 per cent of lower limb amputees.

It should be mentioned for the sake of comparison that Moreton and others (1958) in a pre-employment radiological examination demonstrated scoliosis of the lumbar spine in 1.3 per cent of 13,000 (non-amputated) men

whose average was 26 years. Here a deviation of 10 mm was considered a scoliotic curvature. In Crow and Brogdon's (1959) series of 936 air force cadets aged 17 to 27 years, scoliosis occurred in 0.5 per cent. It should be noted that in this series a deviation of over one inch was considered scoliosis.

Other changes in the curvature of the spine were changes in the degree of thoracic and lumbar curvature. A deviation from the normal is difficult to establish and to classify reliably. An increase of the normal thoracic curvature was clinically estimated to be present in 13 per cent and radiologically in 5 per cent of the lower limb amputees, and clinically in 19 per cent and radiologically in 12 per cent of the upper limb amputees, clinically in 37 per cent and radiologically in none of the patients with two stumps, and clinically in 7 per cent and radiologically in 1 per cent of the controls. A reduced thoracic curvature was present clinically in 12 per cent and radiologically in 2 per cent of the lower limb amputees, clinically in 21 per cent and radiologically in 4 per cent of the upper limb amputees, clinically in 12 per cent and radiologically in 0 per cent of patients with two stumps, and clinically in 1 per cent and radiologically in 2 per cent of the controls.

The lordosis of the lumbar spine was considered to be increased in lower limb amputees clinically in 8 and radiologically in 11 per cent of cases, in upper limb amputees clinically in 1 and radiologically in 27 per cent of cases, in amputees with two stumps clinically in 0 and radiologically in 3 per cent of cases, in the control group clinically in 2 and radiologically in 3 per cent of cases. The lumbar lordosis was flattened in lower limb amputees clinically in 18 and radiologically in 2 per cent of cases, in upper limb amputees clinically in 21 and radiologically in 0 per cent of cases, in amputees with two stumps clinically in 25 and radiologically in 0 per cent of cases and in the control group clinically in 8 and radiologically also in 8 per cent of cases. Radiography of the spine was carried out with the subject to be examined in a recumbent position.

It will be observed that changes in the shape and carriage of the spine are commoner in amputees than in uninjured persons. This phenomenon does not, however, seem to follow any rules that could be clearly correlated, with, for instance, the type of amputation, the stump, the use of a prosthesis or the occupation. Evidently the change in posture necessary for the maintenance of balance, the quality of the prosthesis and the exceptional movement that is necessary force the trunk, when upright, into a changed position which depends on many factors, different in each individual case, and this changed position may be manifested as an abnormal curvature of the spine.

The results of radiological examination of the spine are also given in tables 18—20.

TABLE 18

RADIOLOGICAL FINDINGS IN THE CERVICAL SPINE

Group	Flattening of a disc %	Osteochondrosis %	Spondylarthrosis %
AE	15	10	27
BE	21	21	17
D	6	—	—
C	21	4	18

TABLE 19

RADIOGRAPHIC FINDINGS IN THE THORACIC SPINE

Group	Spondylosis deformans %	Spondyl-arthrosis %	Scheuermann's kyphosis %
AE	21	15	17
BE	50	4	—
AK	31	20	8
BK	32	13	20
D	42	—	24
C	25	16	9

TABLE 20

RADIOGRAPHIC FINDINGS IN THE LUMBAR AND SACRAL REGIONS OF THE SPINE

Radiographic finding	Upper arm amputees %	Forearm amputees %	Thigh amputees %	Lower leg amputees %	Double amputees %	Control group %
Osteochondrosis	—	12	9	10	—	5
Spondylosis deformans	27	50	31	34	35	14
Flattening of the intervertebral disc	—	4	9	12	6	8
Scheuermann's kyphosis	6	—	2	4	6	8
Spondylarthrosis	12	—	9	13	12	9
Sacrum horisontale	2	—	—	1	6	1
Spondylolisthesis	8	—	2	—	—	—
Arthrosis of the sacro-iliac joint	—	—	5	3	—	2

There do not seem to be any significant differences in the frequency of flattening of an intervertebral disc or the other abovementioned changes between the control group and the upper limb amputees. In all groups a flattened disc is commonest in the two lowest intervertebral spaces of the cervical spine. In the remaining cases the condition occurred in the spaces C3 to C5 or in several simultaneously.

Osteochondrosis of the cervical spine was commoner in amputees than in the control group. There was no difference between the groups in regard to localization. The percentage of spondylarthrosis was higher for amputees than for the controls.

It will be seen from the table that spondylosis deformans was commonest in the group of forearm amputees. The difference as compared with all other groups, however, was not statistically significant There are no significant differences between the frequency values for spondylarthrosis.

In the literature, the following incidences of Scheuermann's kyphosis have been reported: Söderberg and Andrén (1955) 23—33.5 per cent, Crow and Brogdon 20.7 and Rübe and Hemmer (1962) 20.18 per cent. In some groups of our series the frequency of Scheuermann's kyphosis is of the same magnitude.

The radiographic findings given in table 20 were absent in 10 upper arm amputees, 6 forearm amputees, 16 thigh amputees, 26 lower leg amputees, 3 amputees with two stumps and 20 subjects of the control group.

Spondylosis deformans was clearly commoner in amputees than in the control group. In the groups of upper and lower limb amputees the percentage of cases is about equal. Spondylosis deformans occurred in about 52 per cent of the thigh amputees investigated by Borgmann.

Fritz and Aufdermaur (1950) describe a case in which clear spondylosis deformans and scoliosis developed in a thigh amputee within a few years. These authors believe that a prosthesis of the wrong length may cause scoliosis and spondylosis deformans on the side of the concavity of the lumbar spine.

Statistically significant differences between the different groups are not demonstrable in osteochondrosis of the lumbar spine, flattening of the disc, Scheuermann's kyphosis and spondylarthrosis.

When these results are compared with the results obtained in investigations on non-amputated persons it should be mentioned that in Allen and Lindem's (1950) series of 3000 men degenerative changes in the lumbar spine were present in 13 per cent of cases, while changes indicative of disc degeneration occurred in 1.13 per cent of cases only. Chrom (1945) found osteochondrosis in patients with back pain in about 15 per cent of cases and in less than 2 per cent in healthy persons. Tammia (1940) demonstrated osteochondrosis in about 6 per cent of cases, Hanraets (1959) found spondylarthrosis in 60 per cent of persons over 50 years old and in 50 per cent under 40 years old. In Runge's (1954) radiological investigation, which comprised over 4000 workers in heavy industry, some pathological finding was made in the lumbar spine in 25 per cent of cases.

In amputees, lack of symmetry in the tonus of the back muscles is often observed (Solonen and Aho, Lindemann and others 1963). Table 21 gives the deviation from the normal observed at clinical examination of the muscles of the back in the present material.

TABLE 21

ASYMMETRIC TONUS OF THE ERECTOR MUSCLES OF THE TRUNK

Group	Increased muscular tonus	
	On the intact side %	On the side of the amputated limb %
AE	—	92
BE	—	92
AK	23	63
BK	22	54
C	5	

Muscular tonus, motility of the back and level of shoulders were determined while the patient was standing upright (lower limb amputees with prosthesis and shoes, upper limb amputees with prosthesis) as relaxed and symmetrically as possible. Even though a result obtained by palpation might seem unreliable, the variation in muscular tonus was often considerable and even clearly visible.

Estimation of the movements of the back solely by eye is inexact. The following observations were made (table 22).

TABLE 22

LIMITATION OF MOVEMENTS OF THE BACK (FORWARD BENDING, LATERAL BENDING AND/OR ROTATION IN BOTH DIRECTIONS)

Group	Limitation of movement (in per cent of group)
AE	46
BE	33
AK	23
BK	31
D	41
C	28

From this we can only conclude that in amputees with two stumps and in upper arm amputees the motility of the lumbar spine may more often be limited than in the other groups.

Clear changes in the motility of the cervical spine were not observed even in upper limb amputees. In the present series there were hardly any diseases traceable to irritation of or pressure on nerve roots or bundles of the region of the cervical spine.

Drop shoulder is often observed in amputees. Observations in this respect in the present series are given in table 23.

TABLE 23

ASYMMETRIC HEIGHT OF SHOULDERS
(in per cent of the no. of persons in each group)

Group	Higher on the amputated side	Higher on the non-amputated side	
AE	90	4	
BE	71	8	
AK	23	15	
BK	17	15	
		Right	left
C		17	10

It should be mentioned that in the control group the asymmetry observed was insignificant and, as a rule, less marked than in amputees. In upper limb amputees the shoulder on the amputated side is often pushed forward (Solonen and Aho). In the present series this occurred in about 70 per cent of upper arm amputees and in about 30 per cent of forearm amputees. We did not determine the degree of this hunching. It was demonstrable when the patient's shoulders were observed from above, with the patient standing on the floor and the examiner on a platform. This phenomenon has been described by Loeschke in kyphotics (1914).

Findings in the Lower Limbs

The following observations were made on the motility of the hip joints in thigh amputees: In the amputated limb there was marked limitation of

motility in about 39 per cent and flexion contracture of at least 10 degrees in about 15 per cent of cases. In the hip joint of the intact lower limb limited motility was observed in one case only. In the control group there was limited motility of the hip joint in only one case. In leg amputees there was full motility of the hip joint on the amputated side in all cases, while flexion was limited in two cases in the intact limb. The radiographic findings in the hip joint are given in table 24.

TABLE 24

RADIOGRAPHIC FINDINGS IN THE HIP JOINT

Group	Arthrosis coxae		Protrusio acetabuli	
	Amputated side %	Non-amputated side %	Amputated side %	Non-amputated side %
AK	31	38	2	2
BK	15	17	1	2
	right	left	.	—
C	13	15		

In the above table the arthrosis deformans has been stated to occur on that side on which the arthrotic changes were more clearly demonstrable. In about half the cases arthrosis was also observable more or less clearly on the other side.

There is no significant difference in the incidence of arthrosis between the group of leg amputees and the control group. In the hip joints of the intact limb in thigh amputees there is a slightly higher incidence of arthrosis than in the hip joint on the amputated side, but in both there is significantly more arthrosis than in the hip joint of persons of the control group.

Protrusion of the acetabulum was rare in both groups of lower limb amputees. This radiographic finding was not made in the control group.

No significant limitation of the motility of the knee could be observed in the groups of thigh and lower leg amputees or in the control group. Chondromalacia of the patella was a common finding (cf. Kallio 1947), as shown by table 25.

TABLE 25

CHONDROMALACIA PATELLAE

Group	Intact lower limb %	Amputated lower limb %
AK	75	.
BK	62	57
C	53	.
	(right and left)	

The diagnosis was based on the common clinical symptoms of this disorder. Chondromalacia of the patella is commoner in the group of lower

limb amputees than in the control group while there is no clear difference between thigh and lower leg amputees.

The radiographic findings in the knee joint are given in table 26.

TABLE 26

RADIOGRAPHIC FINDINGS IN THE KNEE JOINT

Group	Arthrosis genus		Arthrosis genus bilateral %
	Amputated limb %	Intact limb %	
AK	.	25	.
BK	22 right	27 left	17
C	21	21	23

There is no statistically significant difference between the different groups.

In the whole series of lower leg amputees there was but one in whom marked arthrotic changes in the knee were observed. All the other cases of arthrosis in both the control group and the amputees were slight. Heine (1927) found at autopsy that arthrosis was considerably commoner in the intact knee of thigh amputees than in non-amputated persons.

The motility in the talocrural joint of the intact leg was clearly reduced only in one case of thigh amputation, in three lower leg amputees and in one subject of the control group. There was clinical reason to suspect arthrosis of the intact ankle joint of three lower leg amputees and one thigh amputee.

The radiographic findings are seen in table 27.

TABLE 27

RADIOGRAPHIC FINDINGS IN THE ANKLE JOINT

Group	Talocrural arthrosis %
AK	15
BK	10
D	6
C	2

According to table 27, there was significantly more talocrural arthrosis in leg and thigh amputees than in the control group ($P < 0.05$).

Flat-foot

The frequency of flat-foot in lower limb amputees and the control group is given in table 28.

Flat-foot was highly significantly commoner ($P < 0.001$) in lower limb amputees than in the control group. The deformity was, as a rule, slight. This group also includes feet broadened in their distal portion owing to

TABLE 28

PES PLANUS, PES PLANOVALGUS

Group	Pes planus or planovalgus %
AK	83
BK	94
C	53

weakness of the intrinsic muscles; this condition is often called pes transversoplanus. The flat-feet were in most cases subjectively symptom-free. The radiographic findings are given in table 29.

TABLE 29

RADIOGRAPHIC FINDINGS IN THE FOOT

Group	Calcaneal spur %	Arthrosis of the 1st metatarso-phalangeal joint %	Arthrosis of the joints of the foot %	Changes indicating postfractural condition %
AK	3	8	8	3
BK	—	5	6	2
C	—	17	1	—

There was slightly more arthrosis of the joints of the foot in the group of lower limb amputees than in the control group. The arthrotic changes were commonest in the talonavicular joint.

Arthrosis of the 1st metatarsophalangeal joint was slightly commoner in the control group.

Circulatory Disturbances

Varicose veins occurred in the intact limb in 2 per cent of the leg amputees, 5 per cent of the thigh amputees and 9 per cent of the control group. Arteriosclerosis obliterans of the lower limbs was observed in 1 per cent of the lower leg amputees and 4 per cent of the forearm amputees.

Circulatory disturbances of the upper limbs were not demonstrable in the clinical investigation.

Miscellaneous

Such sequelae of amputation as atrophy of the stump and of the muscles directly concerned in its motility, and changes in the skin of the stump and in the subcutaneous tissue will not be considered here, except insofar as they have influenced the classification of the stump as good, satisfactory or poor. The occurrence of such changes after amputation is regular and unavoidable. This also applies to radiographically demonstrable but, as a rule, clinically insignificant osteophytosis of the stump which occurred in all groups of amputees, varying from 19 per cent (lower leg amputees) to 46 per cent (thigh and forearm amputees).

Phantom Limb Pain

The phantom limb problem has not been dealt with in detail in the present work since the same series has recently been used to investigate this phenomenon (Solonen 1962). Table 30 gives the information obtained in the present investigation:

TABLE 30

SIGNIFICANCE OF PHANTOM LIMB PAIN

Group	Great inconvenience %	Slight inconvenience %	No inconvenience or phantom %
AE	42	33	25
BE	4	63	33
AK	60	20	20
BK	26	31	43
D	35	18	47

Great inconvenience means persistent pain which disturbs work and sleep, slight inconvenience means rare occurrence of phantom pain which does not significantly reduce working capacity.

PHYSIOLOGICAL EXAMINATION

Exercise is of the utmost importance from the point of view of physical condition. Since amputation of a lower limb in particular renders movement more difficult, it is to be expected that the exercise obtained by a lower limb amputee will differ from that of a normal person not only in quantity but also in the degree of effort required. The result may be a change in the physical condition of the amputee. We therefore deemed it advisable to examine the physical condition of the amputee by physiological methods.

Determination of condition was based on ergometric tests.

The circulation in the intact limb and the stump was moreover investigated by registration of the pulse of the limb arteries.

Method

The ergometric test was carried out with a frictional bicycle ergometer (Karpovich 1950). The test was carried out either by pedalling or by winding with the hand. The load was either 10 or 15 kgm/s and the test was carried out for five minutes. An electrocardiogram was recorded (Leads V4, V6 and V4R), before work, during work and 1, 2, and 5 minutes after work while the person examined was still sitting in the saddle of the bicycle. The maximal oxygen uptake was estimated according to Åstrand (1962) on the basis of the ECG pulse rates obtained.

Physical fitness classification was modified from Åstrand's classification by adding a fitness group 6 to accommodate those subjects who could not perform the test. Thus, the fitness classification was as follows:

Class 1 good
Class 2 rather good
Class 3 medium
Class 4 rather poor
Class 5 poor
Class 6 could not perform for the time required

Oscillograms were made both of the intact and the amputated leg with a Cameron heartometer. On the basis of the oscillation amplitude the oscillograms were divided into normal and weak.

Results

The results of ergometry are given in table 31.

The estimated average maximum oxygen uptake is not much lower than in the control series. The estimated average fitness classification for both amputees and controls, including all those who interrupted their test, lies as a rule within the medium range (class 3). A lower average fitness class was only observed in the test which thigh amputees carried out using lower limbs only when the small size of the remaining muscle groups reduce the result and the result cannot here be considered illustrative of the physical fitness of the thigh amputees. When estimated from the result of upper limb performance, the condition of thigh amputees was quite comparable to that of control subjects. That the figures obtained when measuring the condition with upper limbs are lower than those obtained with the lower limbs depends on the fact that the grading is severer for efforts achieved with upper limbs than it is for lower limbs. The average fitness class of persons with two stumps was lower than the figure for the control group. This is perhaps due to poorer adaptation in these cases to cardiovascular stress than in normal persons, as demonstrated by Ruosteenoja and Karvonen (1956) in paraplegics and in double thigh amputees.

The number of interrupted performances was greater in the group of amputees than in the control group. The factors causing interruption in each individual case might merit closer examination.

The oscillographic findings are given in table 32.

It can be seen that the oscillograms of the intact legs are on the whole as normal as those of the control group. The oscillograms obtained from the amputated limbs, however, are throughout weaker.

DISCUSSION AND CONCLUSIONS

A surprisingly large number of the war amputees of the present series, 62 per cent, were engaged in heavy or medium heavy work and over three-quarters were obliged to move about a great deal in their work.

Internal disorders in the history of the amputees were no more frequent than in the control group, neither did they show any trend deviating from the usual.

The use of the prosthesis was most regular in the lower limb amputees and least so in the upper arm amputees. 8 percent of the latter and 4 per cent of the forearm amputees had never used a prosthesis.

Fatigue pain in the intact lower limb was commoner than in upper limb amputees or in the control group. The difference was statistically significant and pain was commonest in the area of the knee and ankle.

Fatigue pain in the area of the ankle was significantly commoner in thigh than in lower leg amputees. Only a few lower limb amputees complained of fatigue pain in the stump.

In upper limb amputees fatigue pain in the intact arm was common. In the control group, however, there was no history of any such disturbance. Fatigue pain in the upper limb stump, particularly in persons who made great use of their stump, was also common in forearm amputees.

Pain in the cervical spine was commoner in upper limb amputees than in the other groups. Symptoms from the lumbar spine, however, were com-

TABLE 31

RESULTS OF ERGOMETRIC TESTS

Group	Maximum oxygen uptake 1/min	Test carried out with lower limbs: Ml oxygen per kg x min. average [1]	Test carried out with lower limbs: Mean fitness classification [2]	Subjects who interrupted the test %	Tests carried out with upper limbs: Maximum oxygen uptake 1/min	Tests carried out with upper limbs: Ml oxygen per kg x min. average [1]	Mean fitness classification [2]	Subjects who interrupted the test %
AE		38.7	3.4	9				
BE		39.2	3.4	13				
AK	2.7	34.3	4.2	13	2.9	35.7	3.9	14
BK		35.8	3.9	10		33.1	4.1	14
D		35.6	4.4	20				
C	3.0	40.1	3.2	3	2.8	38.6	3.9	22

[1] The estimated weight of the missing limb was added to the body weight.

[2] Condition classes according to Åstrand except that those who interrupted the test were referred to a group of their own. The best class is 1, the "medium" is 3.

TABLE 32

OSCILLOGRAPHIC FINDINGS

Group	Intact limb: Normal %	Intact limb: Subnormal %	Weak %	Not measured %	Amputated limb: Normal %	Amputated limb: Subnormal %	Weak %	Not measured %
AE	76	10	5	10	0	4	61	35
BE	89	0	11	0	0	15	85	0
AK	89	0	11	0	2	0	67	31
BK	96	0	4	0	55 [1]—13	11 [1]—13	33 [1]—52	2 [1]—23
D								
C	91	0	6	3				

[1] Thigh; the second figure = lower leg.

moner in lower limb amputees and highly significantly commoner than in non-amputated persons.

Phantom limb pain caused great inconvenience in the groups of thigh and upper arm amputees and was of less consequence to forearm and lower leg amputees.

The investigation revealed that the general condition of the amputees was very good and of the same level as that of the non-amputated persons of the control group.

The results of examinations carried out by an internist were more or less the same in the control group and the different groups of amputees. A tendency to overweight was commonest in lower limb amputees. (We intend to pursue this result more thoroughly in a subsequent investigation in which attention will also be paid to constitutional differences).

In the different groups the stumps were satisfactory or good in ⅔ to ¾ of cases.

Scoliosis of the thoracic spine was very common in upper limb amputees and was observed at clinical examination in as many as 90 per cent of the upper arm amputees. Scoliosis of the throacic spine in upper limb amputees must be considered a characteristic deformity of this group of amputees.

Scoliosis of the lumbar spine was a common clinical and radiological finding in lower limb amputees and was much commoner in upper limb amputees than in the control group.

Other changes in the shape and posture of the spine were also frequent in all groups of amputees, *i.e.* changes in the curvature of the thoracic and lumbar spine. These changes naturally affected the shape of the whole chest, as did also the asymmetric level of the shoulders in upper limb amputees, the commonly occurring hunching of the shoulder on the amputated side and the atrophy of the muscles of the shoulder on the same side. The significance of these changes for the function of the organs of the chest could not be determined.

Besides the many afore-mentioned changes, radiographic examination also showed that the frequency of spondylosis was commoner in all groups of amputees as compared with the control group. No clear difference in the frequency of this degenerative change was observed between upper and lower limb amputees. Neither was such a difference demonstrable with regard to other degenerative changes in the lumbar spine of amputees and non-amputated persons. Radiographically demonstrable arthrosis of the sacroiliacal joint, although rare, seemed to be commonest in thigh amputees.

The frequency of osteochondrosis of the cervical spine as a radiographic finding was commoner in upper limb amputees than in the control group.

The muscles of the back that maintain the changed posture of the amputee exhibit, as a result, an asymmetric tension which is, as a rule, quite evident and clinically demonstrable in most upper and lower limb amputees.

By contrast, disturbed function of the spine is mostly insignificant and not demonstrable by clinical methods.

Objective signs of anamnestic stress symptoms in the amputees were not observable but this fact does not justify the belief that such symptoms do not exist. It would be difficult to assume that a disturbance of function, such as a changed centre of gravity, abnormal weight-bearing on and abnormal use of the intact limb would not in the amputee as in others result in deformities and degeneration, such as unphysiological compression of the affected joints, stretching of the joint capsules, ligaments and muscular in-

sertions with ensuing distress. No doubt the symptoms observed in amputees, as in many other patients suffering from back disorders, originate in such elements of the multifold and multifunctional structure of the back which cannot be demonstrated radiographically and whose clinical symptoms are unspecific. The amputee does not, of course, complain of scoliosis, osteochondrosis, etc., but of symptoms of various organic disturbances such as pain, tenderness, tendency to fatigue, etc. There is reason to believe that with increasing structural and functional disturbances, their symptoms or subjectively demonstrable distress also increase.

In upper limb amputees, limited motility of the shoulder joint, together with other symptoms of so-called periarthrosis, was common in the shoulder joint of both the amputated and the intact limb. Periarthrosis was highly significantly commoner in upper limb amputees than in lower limb amputees and the control group; among the latter there was only one case referable to periarthrosis. Radiographically demonstrable degenerative changes of the shoulder joint, however, were not significantly commoner in the amputees than in persons of the control group.

In upper limb amputees limited motility was observed in the elbow joint of the intact limb and also in the amputated limb of forearm amputees. Arthrosis of the elbow joint was radiographically commonest in the intact arm of forearm amputees. Arthrosis of the wrist was radiologically demonstrable in about 4 per cent of cases in the wrist of the intact arm of upper limb amputees. This joint lesion did not occur in the control group.

As would be expected, the motility of the hip joint of the amputated limb was often reduced in thigh amputees. A radiologically demonstrable arthrosis of the hip joint was in these amputees commoner and more serious in the intact than in the amputated limb. The arthrosis was on both sides statistically significantly commoner than in the control group. In lower limb amputees these findings were not so clear. In both groups of lower limb amputees there occurred some cases of protrusio acetabuli, which was not observed in the control group.

In the motility of the knee joint no significant difference could be observed between the different groups of amputees or the control group. By means of clinical examination, however, the conclusion was drawn that chondromalacia patellae was commoner and more distinct in lower limb amputees than in non-amputated persons. In lower leg amputees chondromalacia patellae was somewhat commoner in the intact than in the amputated lower limb. The difference was not statistically significant. Significant differences in the frequency of arthrosis of the knee joint between different groups were not radiologically demonstrable.

No difference was observed in the motility of the ankle joint in the different groups. On the other hand, radiological examination revealed that arthrosis of the talocrural joint was significantly commoner in lower limb amputees than in the control group (the person being the unit).

As a clinical finding, flat-foot was highly significantly commoner in lower limb amputees than in non-amputated persons in whom, however, this insignificant deformity was observed in over 50 per cent of cases.

Radiologically demonstrable arthrosis of the joints of the foot was commoner in lower limb amputees than in non-amputated persons.

The amputees passed the physiological tests for physical condition practically as well as the persons of the control group, the only exception being the amputees with two stumps, one-fifth of whom interrupted the test.

No significant differences in the frequency of circulatory disturbances or vascular diesases between amputated and non-amputated persons could be

observed. The oscillographic findings indicate that in the intact arm of the upper limb amputees and the intact leg of the lower limb amputees the arterial circulation is normal, being considerably weaker in the stump than in the intact limb. It should be observed, on the other hand, that the circulation required is less in an amputation stump than in a normal limb.

SUMMARY

The series consisted of 311 disabled war veterans from whose limb amputation an average of eighteen and a half years had elapsed and whose average age was 45 years. The series comprised 48 upper arm, 24 forearm, 65 thigh and 157 lower leg amputees and 17 disabled men with two stumps. The control group consisted of 95 non-amputated men of the same age.

Over three-fifths of the amputees were engaged in heavy or medium heavy work.

The same orthopaedist, internist, radiologist and physiologist carried out the examinations of all amputees and control subjects.

The commonest symptoms of the amputees were back pain and fatigue symptoms, which in the lower back of lower limb amputees were highly significantly commoner than in the control group. In upper limb amputees symptoms from the area of the cervical spine were commoner than in persons belonging to the control group. Fatigue symptoms in the intact leg were also significantly commoner in lower limb amputees than in upper limb amputees or non-amputated persons. Similar symptoms were also common in the intact arm of upper limb amputees and they also commonly complained of symptoms caused by stress on the stump, a complaint that was hardly ever mentioned by the group of lower limb amputees. Phantom limb pain was commonest in thigh and upper arm amputees.

The investigation showed the general physical condition of the amputees to be as good as that of the control group. Disorders of the internal organs and peripheral disturbances in the circulatory organs were no commoner in the amputees than in the control group. The maximum oxygen uptake capacity of the amputees, with the exception of those with two stumps, was fairly similar to that of the controls.

In two-thirds to three-quarters of the different groups the stumps were at least satisfactory.

Scoliosis of the thoracic spine was observed to be a characteristic deformity of the upper limb amputees. Scoliosis of the lumbar spine again was common in lower limb amputees and also commoner in upper limb amputees than in non-amputated persons.

The frequency of spondylosis deformans of the lumbar spine was higher in all groups of amputees than in the control series.

The frequency of degenerative changes in the cervical spine was higher in upper limb amputees than in the control series.

Periarthrosis of the shoulder joint was highly significantly commoner in the upper limb amputees than in the control group. Likewise, limited motility in the elbow joint was most frequent in upper limb amputees and arthrosis of the elbow joint was commonest in the intact arm of forearm amputees. Arthrosis of the wrist was radiologically demonstrated only in a few upper limb amputees.

Radiographic examination revealed that arthrosis of the hip joint was commoner in the intact lower limb of thigh amputees than in the amputated limb and in both significantly commoner than in the control group.

Chondromalacia patellae was slightly commoner and severer in lower limb amputees than in non-amputated persons.

Flat-foot was highly significantly more frequent in lower limb amputees than in the control group, while subjectively it did not seem to be of any great consequence.

As a radiological finding arthrosis of the ankle joint in the intact leg of the lower leg amputees was statistically significantly commoner than in the subjects of the control group and arthrosis of the joints of the foot was also commoner in the former.

In the incidence of other pathological findings and their severity no significant differences were observed between amputees and non-amputated persons.

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