Comparative Study of Osteoarthritis of the Contralateral Knee Joint of Male Amputees Who Do and Do Not Play Volleyball

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ABSTRACT. ***Objective.*** To assess the prevalence of osteoarthritis (OA) of the contralateral knee of men with traumatic amputation who do and do not participate in regular, vigorous physical activity.

Methods. Three groups of patients were assessed. Group 1 consisted of 8 male amputee volleyball players. Group 2 consisted of 24 male amputees who do not play volleyball, and Group 3 was made up of 24 healthy controls matched by age and weight to Group 2. The prevalence of contralateral knee OA in Groups 1 and 2 was assessed by questionnaire, physical examination, and radiographs, and was compared with findings for Group 3.

Results. The rate of OA in all amputees (Groups 1 and 2 together) was 65.6%, which was significantly higher than among the controls ($p < 0.05$). The most common findings among the amputees were patellar and medial osteophytosis of the tibiofemoral joint, with a tendency to medial narrowing of the tibiofemoral joint space.

Conclusion. Traumatic amputees have a higher prevalence of OA in the knee of the nonamputated leg than matched healthy controls. (J Rheumatol 2001;28:169–72)

Key Indexing Terms:
OSTEOARTHRITIS AMPUTEES KNEE VOLLEYBALL

Individuals who have undergone amputation of a lower limb are at greater risk than the general population for many health problems. In a followup study of 4738 Finnish war amputees, Bakalin reported mortality rates from cardiovascular diseases to be 63% higher than controls[1]. Yekutiel, *et al*[2] found higher rates of ischemic heart disease and diabetes mellitus among Israeli trauma casualties with lower limb amputations compared with age matched controls. The critical factor appeared to be decreased physical activity. A number of studies have investigated the secondary effects of amputation on the musculoskeletal system, and the interaction of these potentially detrimental effects with the potentially beneficial effects of sports and other forms of physical activity. Chronic wear and tear are recognized as etiological factors in the increasing prevalence of knee OA with advancing age[3-6]. The added risk of knee OA in obese individuals is attributed to overload on weight-bearing joints[7-11]. However, there is disagreement whether the extreme overload experienced in various sports is detrimental. Panush, *et al*[12] and Lane, *et al*[13] found no increased prevalence of knee OA in long distance runners, and professional football players are not at risk for knee OA unless they suffer meniscus injury or torn ligaments to the knee joint[14-16].

Increased prevalence of OA in the contralateral knee of lower limb amputees has been found in several studies. However, none of these studies contained data on the extent to which the subjects participated in sports or other physical activity. Kramer, *et al*[17] reported an increased prevalence of OA of the knee in 11 above-knee (AK) amputees, as did Burke, *et al*[18] in 19 AK and below-knee (BK) amputees. Hungerford and Cockin[19] also found a statistically increased prevalence of knee OA in 63 AK and BK amputees compared with controls. More recently, Lemaire and Fisher[20] reported an 83% prevalence of OA in the contralateral knee of elderly subjects 35–50 years after BK amputation, compared with a prevalence of 50% in elderly controls. They attributed this finding to increased knee joint reaction forces and net joint moments.

We assessed the prevalence of OA in the knee of the nonamputated leg in men with traumatic amputation who are active or not active in competitive sports, and compared the results with a group of healthy matched controls.

MATERIALS AND METHODS

The study population consisted of 56 men in 3 groups. Group 1 comprised 8 amputee volleyball players (Israel national team). Group 2 included 24 amputees who did not play volleyball. They were recruited from the outpatient clinic at the Beit Levinstein Rehabilitation Center in Ra'anana, Israel. All amputees had undergone traumatic amputation 10–35 years prior to the study and regularly used prostheses. Group 3 consisted of 24 volunteers recruited at random from patients treated in the physical therapy department

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of the Kupat Holim Klalit Sick Fund (health maintenance organization), Dimona, Israel. The participants in Group 3 were matched by age and weight to Group 2. All patients in Group 3 were being treated for various types of minor trauma to the upper limbs. None complained of knee pain and none was diagnosed with OA of the knees. Rheumatic disease and/or a history of knee surgery were exclusion criteria.

The study was approved by the Helsinki Committee of the Soroka Medical Center. All participants signed informed consent.

Subjects completed a questionnaire that included items on medical history, participation in sports, and symptoms related to the knee. All underwent a thorough examination of the lower limb including range of movement of the knee, muscle strength, swelling, crepitation, and length of legs/stump. Gait was observed, and weight distribution between the legs was measured while standing without movement on 2 scales. Anteroposterior and lateral radiographs of the knees were taken and assessed independently by 3 physicians (2 radiologists and one rheumatologist) who were blinded to group affiliation. These 3 physicians examined the radiographs for the evidence of knee OA. The Kellgren-Lawrence classification[21], which has been accepted by the World Health Organization and by the American Rheumatism Association, was used. In this classification OA is graded from 0 (absent) to 4 (severe). OA is considered to be present in patients with a classification of grade 2 (mild) or higher. For purposes of statistical analyses the kicking leg was taken into account for the controls and the normal leg for the amputees. The prevalence of OA of the knee in the study groups was compared by chi-squared test with statistical significance set at $p < 0.05$.

RESULTS

Table 1 presents data comparing the 3 study groups. There were no differences among the groups in mean age, weight, or years since amputation. Volleyball-playing amputees (Group 1) were significantly more active in sports ($p < 0.05$) than other amputees (Group 2) or controls (Group 3). They also participated in other sports such as swimming and gymnastics and used the exercise room regularly. No amputee had played volleyball before the amputation, but some did participate in other activities such as gymnastics and swimming. Group 2 had a significantly higher proportion of individuals with above-knee amputations than those in Group 1 ($p < 0.05$).

Radiological findings. OA was diagnosed in 70.8% of the subjects in Group 2, 50% in Group 1, and 37.5% in Group 3 (Table 2). The rate of OA in all amputees (Groups 1 and 2 together) was 65.6%, which was significantly higher than among the controls ($p < 0.05$).

Table 3 shows the prevalence of radiological findings of knee OA in amputees and controls. A radiological finding was considered positive if 2 of the 3 physicians graded it as such. There was an increased prevalence of medial and patellar osteophytes and medial subchondral cysts in amputees compared with nonamputees. The medial joint space tended to be narrower (over twice that in the controls), while the controls had a higher prevalence of medial and lateral subchondral sclerosis.

Symptoms. Three of 8 amputees in Group 1 and 8 of 24 in Group 2 had minimal knee pain in the normal leg. These findings were similar to the control group. None of the volleyball-playing amputees reported morning stiffness, but 3 in Group 2 amputees and 3 of the controls had morning stiffness that lasted up to 15 min.

Weight distribution. The amputees had a less symmetrical distribution of weight than the controls. The asymmetry was especially marked among nonplaying amputees (42.2% on the amputated limb and 57.8% on the normal limb). This was sig-

Table 2. Prevalence and severity of osteoarthritis by study group and Kellgren-Lawrence grade.

KL Grade	Group 1, n = 8	Group 2, n = 24	Group 3, n = 24
0 — Absent	2	0	2
1 — Subclinical	2	7	13
2 — Mild	3	12	8
3 — Moderate	1	5	—
4 — Severe	0	0	0
2–4 combined (%)	4 (50)	17 (70.8)	9 (37.5)

Table 3. Prevalence (percentage) of radiological signs of knee OA by study group, with Groups 1 and 2 combined.

	Groups 1 and 2, n = 32	Group 3 n = 24	p
Medial osteophytes	53.1	25.0	0.034
Lateral osteophytes	37.5	25.0	NS
Patellar osteophytes	70.8	37.5	0.020
Medial subchondral cysts	16.7	0	0.036
Medial narrowing of joint space	34.4	16.6	0.100
Medial subchondral sclerosis	16.6	45.8	0.030
Lateral subchondral sclerosis	21.9	54.2	0.012

Table 1. Comparison of the 3 study groups.

	Group 1, n = 8	Group 2, n = 24	Group 3, n = 24
Age, mean years ± SD	43.6 ± 7.3	42.0 ± 8.5	42.3 ± 8.2
Weight, kg, mean ± SD	77.5 ± 14.7	73.0 ± 14.6	75.0 ± 13.5
Years since amputation	20.8 ± 6.3	18.4 ± 6.8	—
Ratio below-knee:above-knee amputations	6:2	15:9	—
Weekly hours playing volleyball, mean ± SD	3.7 ± 1.2	0	0
Weekly hours in other sports, mean ± SD	4.5 ± 1.1	0	0

nificantly worse than the controls (49.7% and 50.3% for the 2 limbs) ($p < 0.05$). In contrast, the weight distribution of the volleyball-playing amputees (47.2% and 52.8% for the amputated and normal limb, respectively) was not significantly different from the controls.

DISCUSSION

Our findings are in agreement with those of Kramer, *et al*[17], Lemaire and Fisher[20], Burke, *et al*[18] and Hungerford and Cockin[19], who found a significant increase in tibiofemoral OA in the normal limb of amputees. Our results suggest that OA in the tibiofemoral joint in amputees tends to occur in the medial compartment of the knee joint. This side carries a greater load during normal standing and walking (especially during asymmetrical walking), since the center of gravity passes medially to the knee. These mechanical factors could cause the increased prevalence of OA on the medial side. Frankel and Nordin[22] found that the cartilage in the medial portion of the joint undergoes a compensatory process in which it become 3-fold thicker than the cartilage in the lateral portion.

The analysis of force plate records by Eberhart, *et al*[23] has shown that more time is spent standing on the normal leg, which bears a larger load than the prosthetic leg. Our study also found asymmetrical standing in non-volleyball-playing amputees, with the normal leg bearing the greater load. Solomon and Schnitzer[24] claimed that this overload is the cause of OA in hips and tibiofemoral joints in amputees. In contrast, Burke, *et al*[18] suggest that the occurrence of osteophytic changes without joint space narrowing does not represent true OA, but rather a reaction to stress on adjacent ligaments and tendons.

Our hypothesis was that the normal leg of volleyball-playing amputees is exposed to greater loads than non-playing amputees, so they are at greater risk for developing knee OA. Despite the impression given in Table 2 that there is no dramatic increase in the risk of OA among amputees who play volleyball compared to those who do not, we are aware that due to the small numbers in amputee Group 1 no statistically reliable conclusions can be drawn on this issue. However, if this impression is indeed the case, it is possible that the more symmetrical weight distribution on standing found in the volleyball players and their more massive musculature resulting from active participation in sports may play a protective role for the knee. In a stabilized knee the load of body weight and compressive forces are more evenly distributed over the entire joint surface. Another possible explanation for our findings is that the Group 2 amputees included a higher proportion of AK amputees, who have more asymmetrical standing and walking patterns than BK amputees[25] and appear to be less mobile in their daily lives.

We conclude that volleyball-playing amputees as well as those who do not participate in competitive sports already have high rates of OA in the normal leg at a young age. We cannot determine from our findings whether participation in competitive sports hastens or delays the appearance of OA in the normal leg. To clarify this issue, additional comparative studies based on larger study populations are needed. We believe that until this matter is resolved amputees should not be prohibited from participating in competitive sports, particularly since these activities are beneficial in a broad range of health related areas such as cardiovascular disease and dyslipidemia.

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