ORIGINAL ARTICLE

Sports Activities and Endurance Capacity of Bone Tumor Patients After Rotationplasty

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ABSTRACT. Hillmann A, Weist R, Fromme A, Völker K, Rosenbaum D. Sports activities and endurance capacity of bone tumor patients after rotationplasty. Arch Phys Med Rehabil 2007;88:885-90.

Objectives: To investigate the preferred types of sports activities of patients with rotationplasty and to measure their physiologic performance characteristics through treadmill ergometry.

Design: Cross-sectional, descriptive analysis and repeated measures of different velocities.

Setting: Biomechanics research laboratory.

Participants: Patients (n=61) with rotationplasty after bone tumor surgery, 30 of whom participated in a functional trial (treadmill), and a control group (n=20).

Interventions: Not applicable.

Main Outcome Measures: Patients' participation in sports compared with that of the healthy population, treadmill performance at 2 or 3 different speeds, heart rate, lactate accumulation, oxygen consumption, ventilatory equivalent, efficiency, respiratory minute volume, and respiratory quotient.

Results: High activity in sports participation (85%) in most common sports (8 competitive, 17 sports club members, the remaining subjects were recreational athletes). At the same treadmill speed, lactate accumulation and all cardiorespiratory functions were higher in rotationplasty patients than in the control group.

Conclusions: Patients can re-engage in a high level of physical activity after rotationplasty for bone tumor treatment. This physical activity is necessary if patients want to maintain or improve a desired level of sports activity.

Key Words: Bone neoplasms; Cardiovascular system; Ergometry; Physical endurance; Rehabilitation; Sports; Treadmill test.

THE KNEE REGION is the most common site for bone tumors, especially osteosarcoma.[1] Along with multimodal chemotherapy, surgical options are important in the treatment regimen. In addition to ablative procedures, limb salvage surgery can be considered the treatment of choice.[2] Gait analysis studies[3-6] and evaluations of the quality of life (QOL)[7,8] have demonstrated that rotationplasty is at least comparable, if not superior, to limb salvage. After surgery, many patients are concerned about their physical capabilities and level of sports performance, which are important issues in reintegrating into a normal social life. For patients who were treated with a rotationplasty after wide resection of a tumor in the knee region, sports activities such as cycling, downhill skiing, tennis, and soccer are considered possible and without injury risk as soon as muscular control over the new "knee" joint can be expected.[9-11] Specially designed prostheses also enable patients to swim.[12,13] Other than these general recommendations, however, there is no detailed information about the actual sports and functional activity levels that these patients can achieve.

Spiroergometric analyses after ablative extremity surgery indicate that the resection level has a marked influence on maximal aerobic capacity. Patients in 1 study[14] demonstrated an energetically more efficient gait after rotationplasty than did patients who underwent amputations. Fowler et al[15] found that after rotationplasty, children could run faster with less oxygen consumption than could an age-matched control group that had Syme's amputations. Cammisa et al[16] found that the relative energy cost of walking at self-selected speeds in rotationplasty patients was significantly higher than in a healthy control group, but was significantly lower than the cost for above-knee amputees. There was no difference in patients with endoprosthesis. Van der Windt et al[17] could not detect a difference in energy expenditure in children after rotationplasty, knee amputation, or hip disarticulation. Cummings et al[18] found that the length of the prosthetic shaft apparently had no influence on oxygen consumption; only cardiorespiratory training had a pronounced influence on cardiorespiratory capability. James[19] discussed higher lactate levels as an indication for an increased level of anaerobic metabolism and higher oxygen consumption during locomotion after above-knee amputation. Oxygen consumption remained the same in quiet standing.[19]

The functional capacity of tumor patients is commonly evaluated with the Musculoskeletal Tumor Society rating, according to Enneking et al.[20] Function is described in 6 categories that are related to activities of daily living, pain, need for support, and subjective satisfaction, but the score does not consider the level of sports activities. Participation in sports is important for its cardiopulmonary benefits as well as for its sociologic aspects. This issue has not been evaluated in a large sample of rotationplasty patients, however. Therefore, our purpose in this study was: (1) to evaluate the sports activities in which patients who underwent rotationplasty are actively engaged; and (2) to examine the physiologic performance level of these patients through respiratory and metabolic measurements during treadmill exercise.

METHODS

A total of 61 patients with rotationplasty (35 men, 26 women) were questioned about their activity level in various sports. We asked about their participation in school, leisure, and competitive sports activities, with the last named category being characterized by active participation at a competitive

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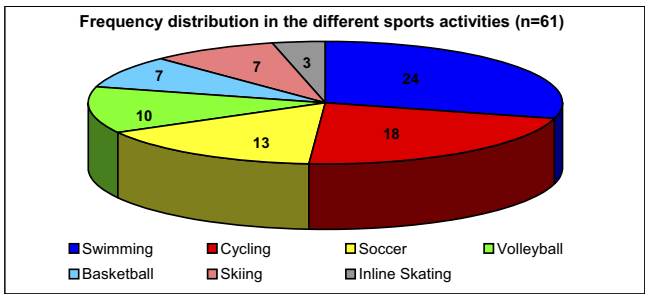

Fig 1. Frequency distribution of the sports participations of the patients (multiple selections were possible).

level. In addition, we sought information about whether they had active membership in a typical sports club or one that was established to help train those with disabilities.

Furthermore, 30 (14 men, 16 women) of the 61 patients volunteered to participate in a clinical and functional follow-up investigation of their sports performance at the Orthopaedics Department and the Institute of Sports Medicine of the University Hospital Münster. For personal reasons (eg, long travel distance), the remaining subjects (n=31) were unable or unwilling to report to the biomechanics lab for physiologic evaluation. The average age of the patients was 23.7±8.8 years (range, 7−54y) at follow-up. The average weight was 63.6±17.3kg and the height was 172.6±14.4cm. The results were compared with a control group of 21 healthy subjects (12 men, 9 women) with a mean age of 25.9±8.7 years (range, 8−42y), mean height of 176.8±14.3cm, and mean weight of 70.3±15.9kg. There were no significant differences between the groups with respect to age, height, or body weight. Statistical tests were performed with commercial software[a]; we used the Mann-Whitney *U* test for nonparametric comparisons between the 2 groups, with an α level at *P* less than .05.

Twenty-two patients underwent A1 rotationplasty, according to the Winkelmann criteria.[21] Only 1 patient had a type A2 rotationplasty. Six patients had received a hip rotationplasty type BI (n=1) or BII (n=5); the youngest patient had a BIIIa rotationplasty. The groups were too small and inhomogeneous to allow statistical comparisons among the different types of rotationplasty.

The patients and control subjects completed walking trials on a motor-driven treadmill[b] at 2 or 3 different speeds, depending on their capabilities. The required walking distance was 400m at each speed. Participants were given a resting period of 8 minutes between the sessions. Because of the marked differences in treadmill velocity reported in previous studies, we adhered to a previously used protocol with the same 3 velocities (slow, .67m/s; comfortable, 1.0m/s; fast, 1.67m/s)[22] and compared the results with those of a control group of similar age and sex.

In the first part of the experimental session, blood lactate concentration at rest was determined from a capillary blood sample taken from the ear lobe.[c] At each treadmill speed, lactate measurements were taken after subjects had walked a distance of 400m. Recovery after exercise was evaluated after the third and sixth minutes of the 8-minute resting period. Furthermore, the heart rate was determined after every 100m of walking. The expired gas was measured to determine the following respiratory parameters[d]: oxygen consumption ($\dot{V}O_2$ [in mL/min], $\dot{V}O_2$/body weight [$mL \cdot min^{-1} \cdot kg^{-1}$]), carbon dioxide expiration ($\dot{V}CO_2$ [in mL/min], $\dot{V}CO_2$/body weight [in $mL \cdot min^{-1} \cdot kg^{-1}$]), ventilatory equivalent (in L/min), efficiency (in $\dot{V}O_2 \cdot kg^{-1} \cdot m^{-1} \cdot s^{-1}$ per 60s), respiratory minute volume (L/min), and the respiratory quotient (in $\dot{V}CO_2/\dot{V}O_2$).

RESULTS

Fifty-two (85%) of the 61 patients (33 males, 19 females) reported that they were regularly involved in sports activities. Their ages ranged from 7 to 54 years (mean, 23.7±8.8y) and their mean follow-up after surgery was 6.7±4.6 years. Two men and 7 women did not participate in sports activities. Eight of the 52 patients participated in competitive sports. Fifteen patients were members of 1 sports club and 2 were in 2 sports clubs. Four patients were involved in swimming club, 3 in a soccer club, and 2 in a table tennis club. The others were involved in canoeing, dancing, basketball, judo, track and field, gymnastics, badminton, and horseback riding (fig 1).

Fifteen patients participated in 1 sport and 37 participated in more than 2 sports. Swimming was the sport that attracted most of the patients (n=24), followed by cycling (n=18), soccer (n=13), volleyball (n=10), and basketball (n=7). Some patients participated in sports that require a higher level of lower extremity coordination, such as in-line skating (n=3) and skiing (n=7). Racket sports, including badminton (n=11), tennis (n=7), and table tennis (n=8), were named often, while squash was not mentioned by any patient. More "exotic" sports like canoeing, ballet dancing, bowling, or cross-country motor biking (n=1) were rarely mentioned. It was encouraging that 1 patient with rotationplasty won the gold medal in the discus throw competition in the 1992 Paralympics, while another won fourth place in seated volleyball in the Athens Paralympics of 2004.

At the initial treadmill speed of .67m/s, the resting heart rate in the patient group was 93bpm, which was slightly higher than that of the control group (85bpm). After the first 100m the heart rate was significantly higher in the patients than in the controls (fig 2). The resting period was sufficient to allow heart rate recovery for both the patients (after 6min) and for the control group (after 3min).

At the intermediate treadmill speed of 1m/s, the initial heart rate after 8 minutes of rest was lower in both groups. Although the control group did not have an increased heart rate, as happened with the first speed level, the patients reacted with a higher heart rate (fig 3) that remained constant over the entire

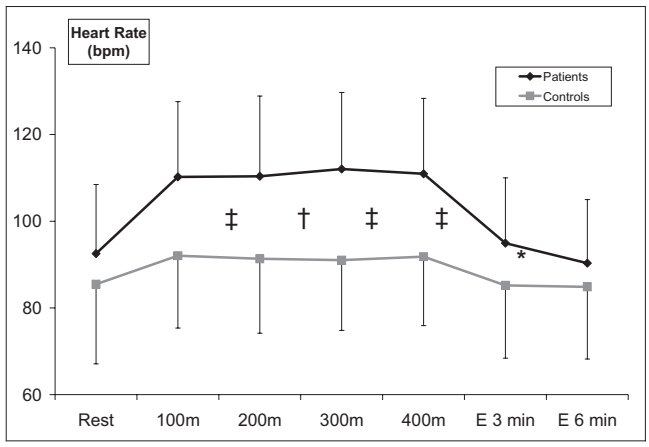

Fig 2. Heart rate development at rest, at the slow treadmill speed of .67m/s (every 100m), and after 3 and 6 minutes of recovery; comparison of the patients and the control group. Abbreviation: E, recovery time. **P*<.05; †*P*<.01; ‡*P*<.001.