Quality of life, functional ability and physical activity in children and adolescents after lower extremity bone tumour surgery

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Chapter 5

FUNCTIONAL ABILITY AND PHYSICAL ACTIVITY IN CHILDREN AND YOUNG ADULTS AFTER LIMB SALVAGE OR ABLATIVE SURGERY FOR LOWER EXTREMITY BONE TUMORS

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ABSTRACT

Background: Aim of our study was to compare functional ability and physical activity in children and young adults who underwent surgery for a malignant bone tumor that was located around the knee.

Methods: This cross-sectional study included 82 patients aged 8-25 years with a follow-up of 1 to 5 years. Functional ability and the amount of physical activity were evaluated by means of questionnaires and objective instruments.

Results: Thirty-nine patients underwent limb-salvage surgery (24 allograft and 15 endoprosthesis) and forty-three underwent ablative surgery (27 amputations and 16 rotationplasty). Patients in the limb-salvage group were significantly older at the time of surgery than patients in the ablative group (mean age 15.2 versus 13.2 years, p = .03). Apart from significantly better scores for the Timed Up and Down Stairs and Various Walking Activities in the limb-salvage group as compared to the ablative surgery group, no significant differences were seen for any of the outcome measures.

Conclusions: One to five years after limb-salvage and ablative surgery due to a malignant bone tumor children and young adults do, apart from a few activities involving walking and climbing stairs, not differ with respect to overall functional ability and physical activity.

INTRODUCTION

To date, various surgical procedures are available for patients with lower extremity bone tumors. Limb-salvage procedures include the application of allograft or endoprosthetic devices. Ablative surgery includes amputation and rotationplasty. The rotationplasty procedure can be used for tumors of the distal femur or proximal tibia and consists of en-block resection of the tumor and the knee joint. For the reconstruction, the lower leg is 180 degrees rotated and attached to the remaining femur resulting in an ankle joint functioning as knee joint (Figure 1).

Functional ability and the level of physical activity are important outcome measures in children and young adults after surgery for a malignant tumor of the lower extremity. Over the past decade, seven studies have been published comparing functional ability between limb-salvage and ablative surgery [1-7]. In these studies, functional ability was evaluated according to the patient reported Toronto Extremity Salvage Score (TESS), the physician reported Musculoskeletal Oncology Society (MSTS) score [2,4,5,7] or the objective Functional Mobility Assessment (FMA) measure [5]. In one study [6], significantly better TESS scores were reported after ablative surgery than after limb-salvage surgery, whereas

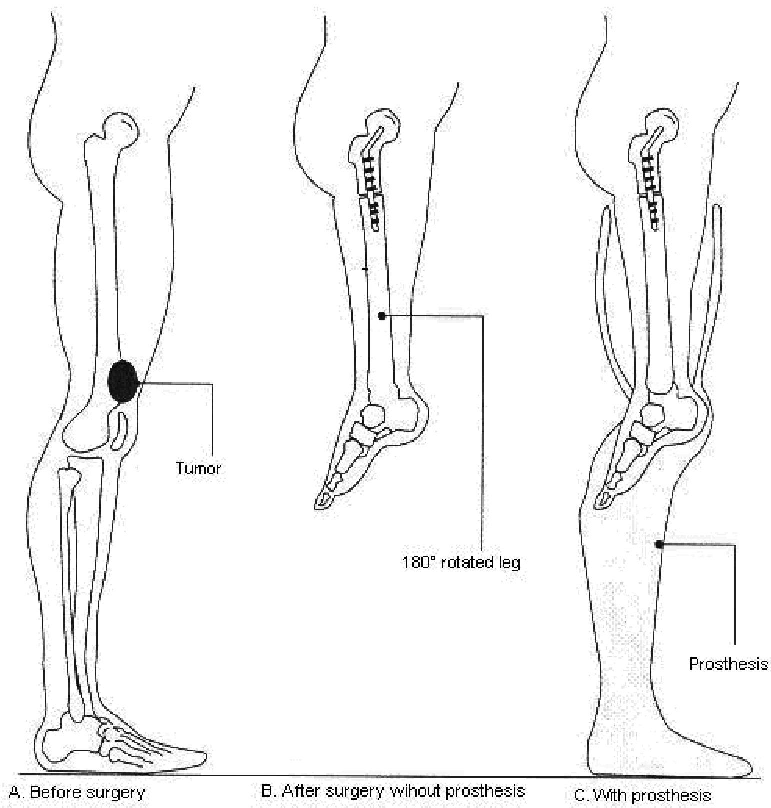

Figure 1. Rotationplasty.

in three other studies significantly better functional ability according to the MSTS [4,7] or FMA [5] was seen in patients after limb-salvage surgery. Moreover, in three other studies [1-3], the differences between limb-salvage and ablative surgery did not reach statistical significance.

How the level of physical activity between patients after ablative and limb-salvage surgery compare is unclear, as the literature is scarce [2,4,8]. In all published studies, physical activity was evaluated with a questionnaire [2] and/or an activity monitor [2,4,8]. No statistically significant difference in physical activity levels between the various surgical intervention groups was found in these studies.

The implication of the data published so far for children and young adults is hampered by the selection of predominantly elderly patients with mean ages varying between 20 and 49 years. Moreover, only few objective measures to evaluate functional ability or the amount of physical activity [9] were used.

This study aimed to answer the question whether functional ability and the level of physical activity differs in a nationwide cohort of children and young adults who underwent a limb-salvage or an ablative surgical procedure for a malignant tumor around the knee. This study differs from most previous studies by the young age of our patients, the relatively short follow up and the combination of questionnaires as well as objective measures to evaluate functional ability and physical activity.

MATERIALS AND METHODS

Study design and patient recruitment

This cross-sectional, multi-centre study was performed in five university medical centers in the Netherlands (Leiden University Medical Center, Academic Medical Center University of Amsterdam, Radboud University Nijmegen Medical Centre, Erasmus Medical Center - Sophia Children's Hospital Rotterdam, and University Medical Center Groningen).

The study was performed between 2004 and 2008. Participants in this study were patients who underwent a surgical procedure as part of their treatment for a malignant bone tumor in one of these five centers between 2000 and 2007. Inclusion criteria were: a malignant bone tumor (osteosarcoma or Ewing's sarcoma) that was located around the knee; the surgery was either ablative surgery (amputation or rotationplasty) or a limb salvage procedure (allograft or endoprosthesis); surgery took place at least 1 year or at most 5 years prior to the evaluation; completed chemotherapy and/or radiation therapy; age between 8 and 25 years at the time of evaluation and no other medical conditions that could affect functional ability or the amount of physical activity.

The Medical Ethics Committees of all medical centers approved the study and all patients and their parents gave informed consent. Eligible patients were selected from hospital registries by their treating surgeon or (pediatric) oncologist. Selected patients were sent an information leaflet and after informed consent has been obtained, patients were included into the study.

Assessment Methods

Sociodemographic and disease characteristics (age, sex, follow-up, morphology and surgical intervention) were derived from the medical record. Depending on the type of surgical procedure, patients were classified into the ablative (amputation or rotationplasty) surgery or limb-salvage surgery (allograft reconstruction or endoprosthesis) group.

All assessments were done by means of questionnaires which were administered by regular mail and performance tests executed in the hospital in combination with a routine follow-up appointment with the treating surgeon. All functional performance tests were executed by the principal investigator, who is a trained child physical therapist (WPB).

Functional ability

The Toronto Extremity Salvage Score (TESS). The TESS is a self-report measure, designed to assess physical disability in patients aged 12-85 years after limb-salvage surgery for a sarcoma of the lower extremity [10]. This questionnaire allows participants to indicate the level of difficulty experienced in dressing, grooming, mobility, work, sports, and leisure. The lower extremity version of the TESS questionnaire consists of 30 items. Each item is rated on a scale from 1 to 5 points, with the value 5 representing "not at all difficult" and 0 representing "impossible to do". The raw score is converted to a total score ranging from 0 to 100 points, with higher scores indicating better functioning.

Performance tests. The performance tests consisted of three tests which have been validated in persons with an amputation and/or children; timed up and down stairs (TUDS) , timed up and go (TUG) and 6-minutes walk test (6-MWT) and two test which were especially developed for this study; lay down and stand up (LDSU) and various walking activities (VWA). A stopwatch was used to record the time (in seconds) needed to perform each test.

1. TUDS test; defined as the time it takes for a patient to walk up and down 10 stair steps [11-12].
2. TUG test; defined as the time needed to stand up from a sitting position, walk three meters, turn around, return to the chair and sit down [13].
3. LDSU test; defined as the time it takes to lay down on the floor and stand up again.
4. VWA test; A combination of three different walking activities including of 10 meter straight walking [14], 10 meter slalom walking with five pylons and 10 meter walking with five obstacles of 20 centimeter high.
5. The 6-MWT is a test of functional capacity that is useful to assess degree of dysfunction, prognosis, and response to therapy in patients who are moderately to severely impaired, with a range of cardiopulmonary and other conditions [15-16]. Patients were informed to walk and not run, with the objective to cover as much distance as possible. All participants walked squares of 25 meter length for the 6-minute period. In addition, the patient's heart rate before and after the test was recorded. With the available data, the physiological cost index (PCI) was computed by dividing the difference in heart rate (heart rate after walking – heart rate at rest) by the average walking speed. It thereby yields an outcome that is expressed in beats per meter [17-18].

Physical Activity

Baecke questionnaire. The Baecke Questionnaire [19] is a 13-item questionnaire resulting in three indices of physical activity: sport (sport index), leisure time (leisure time index) or work (work index). In the explanation of the Baecke questionnaire it was mentioned that students should read questions about "at work" as "at school". Each item was scored on a 5-point Likert scale, with the average of the item scores representing the index scores (index scores ranging from 1-5) and a total activity score (range 3-15), with higher scores indicating more physical activity. The reliability and validity has been described in different adult and adolescent populations [20] and with a test-retest correlation of 0.77 to 0.93 the Baecke questionnaire proved to be sufficient for research purposes [21].

ActiLog©. The amount of physical activity was measured by an activity monitor [22], the Actilog® V3.0 (Radboud University Nijmegen Medical Centre, Nijmegen, the Netherlands). This activity monitor has the size of a matchbox and was placed around the ankle of the non-affected limb. This device consists of a piezoelectric sensor that is sensitive in 3 directions. Accelerations of the sensor are stored into an internal memory. The microcontroller reads and resets the counter of the activity monitor every second. The integration counter is set at 5 minutes, providing an activity score every 5 minutes that is stored into the internal memory of the activity monitor. At the end of the registration period, data are fed into an external computer [23]. Accelerometers based on piezoelectric sensors were found to be reliable and valid measures of physical activity in healthy persons as well as in patients with chronic fatigue syndrome [22]. Furthermore, monitoring for 5 consecutive days has been described to be sufficient to achieve a reliability coefficient of 0.80 [24]. In this study, the activity monitor was worn day and night around the ankle for 24 hours on 7 consecutive days. Specialized software (Actilog Analyzer V4.3) was used to calculate a General Physical Activity score (GPA) over the 7-day period, expressed as the average number of accelerations per 5-minute period throughout the day Furthermore the program calculated the 10 largest activity peaks. Both the average peak amplitude and average peak duration of these 10 largest peaks were calculated. In addition, the average number of 5-minute high (peak) activity periods throughout the day above the threshold value has been calculated.

Statistical Analysis

Initial descriptive analyses were performed on all variables to ascertain the data distribution and assess normality. Descriptive statistics of sociodemographic and disease characteristics included frequencies and percentages or means and standard deviations, where appropriate. Sociodemographic characteristics were compared between the surgical intervention groups by analysis of variance (ANOVA), independent samples *t*-tests, or Chi-square tests.

Comparisons of measures of functional ability and physical activity levels between the limb-salvage and ablative surgery and between the surgery groups were done by ANOVA and analysis of covariance (ANCOVA) with adjustment for those sociodemographic or disease characteristics that were significantly different between the surgery groups. Homogeneity of the regression coefficients was evaluated with analysis of variance and by drawing regression lines at the scatter plots. When there was no homogeneity of the regression lines, the adjusted scores were rejected. In case of a significant difference among the four surgery groups as identified by ANOVA, additional comparisons of measures of functional ability and physical activity levels between the four surgery groups were done by independent samples *t*-tests. As the time since surgery may have an impact on the functional outcomes, the comparisons of measures of functional ability and physical activity between the ablative and the limb sparing surgery groups were repeated separately for patients with a time since surgery of at least two years. The proportions of patients using crutches were compared between the limb-salvage and ablative surgery groups by Chi-square tests.

For all analyses a *p*-value of less than .05 was considered to be statistically significant. All analyses were performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

Patient characteristics

One hundred and ten patients who underwent surgery as part for their treatment for a malignant bone tumor located around the knee in one of the 5 participating centers between 2000 and 2007 were identified. Of those 110 selected patients, 22 patients had died, 1 patient was in a bad medical condition, and 2 lived abroad. Of the 85 invited patients, 3 refused for personal reasons. Finally, 82 patients fulfilled the inclusion criteria and accepted to participate.

The sociodemographic and disease characteristics of the participants are presented in Table I and II. Forty-one were girls and 41 were boys. Their mean age was 16.9 years (SD 4.2), their mean age at surgery was 14.2 (SD 4.1) and the mean time since surgery 2.8 years (SD 1.6).

Limb-salvage surgery was done in 39 patients and ablative surgery in 43 patients. In the limb-salvage group 24 patients underwent an intercalary allograft reconstruction and

Table I: Sociodemographic and disease characteristics of 82 patients who underwent surgery for a malignant tumor of the lower extremity

Gender; number (%)	Female	41 (50%)
	Male	41 (50%)
Age; years (SD)	At surgery	14.2 (4.1)
	At evaluation	16.9 (4.2)
Follow-up; years (SD)	Since surgery	2.8 (1.6)
Morphology; number (%)	Osteosarcoma	67 (82%)
	Ewing's sarcoma	15 (18%)
Type of surgery; number (%)	Limb salvage	39 (48 %)
	Allograft	24 (29 %)
	Endoprosthesis	15 (18 %)
	Ablative	43 (52 %)
	Amputation	27 (33 %)
	Rotationplasty	16 (20 %)

Table II: Characteristics of 82 patients with a malignant tumor of the lower extremity classified according to type of surgery or surgical technique.

	Type of surgery			Surgical technique				
	Limb-salvage	**Ablative**	***p*-value#**	**Allograft**	**Prosthesis**	**Amputation**	**Rotationplasty**	***p*-value#**
Number of patients	39	43		24	15	27	16	
Female gender; No (%)	20 (51%)	21 (49 %)	0.83 ns	13 (54%)	7 (47%)	14 (52%)	7 (44%)	0.91 ns
Age; Years (SD)								
At surgery (SD)	15.2 (4.1)	13.2 (4.0)	0.03 *	14.5 (4.2) $	16.2 (3.7) $	14.0 (4.0)	12.0 (3.4)	0.03 *
At evaluation (SD)	17.7 (3.9)	16.1 (4.4)	0.10 ns	17.3 (4.1) $	18.5 (3.7) $	17.3 (4.2) $	14.4 (4.3)	0.04 *
Follow-up; Years (SD)	2.6 (1.5)	3.0 (1.8)	0.30 ns	2.8 (1.5)	2.3 (1.5)	3.2 (1.7)	2.5 (1.7)	0.23 ns
Morphology; No (%)								
Osteosarcoma	27 (69 %)	40 (93 %)	0.01 **	15 (63%)	12 (80%)	24 (89%)	16 (100%)	0.02 *
Ewing's sarcoma	12 (31 %)	3 (7 %)		9 (37%)	3 (20%)	3 (11%)	0 (0%)	

#P-values of analysis of variance (ANOVA) or Pearson Chi-square test, where appropriate.
* Significance is at the $p<0.05$ level, ** Significance is at the $p<0.01$ level
$ Significant difference ($p<0.05$) in comparison with rotationplasty patients

15 received an endoprosthesis. In the ablative surgery group 27 patients underwent an amputation of the lower extremity (4 below and 12 above the knee amputations, and 11 knee disarticulations) and 16 a rotationplasty. All patients in the ablative surgery group used a prosthesis at the time of assessment.

Patients who underwent limb-salvage surgery were significantly older at the time of surgery (mean 15.2 years) than patients who had ablative surgery (mean 13.2 years, $p < .05$). As patients in the limb-sparing surgery group had a slightly shorter duration of follow-up than patients in the ablative surgery group, the difference in age at evaluation between the two groups did not reach statistical significance. Comparisons between the four surgery groups showed that patients who underwent rotationplasty were significantly younger at surgery than patients in the allograft and endoprosthesis groups (p-values $< .05$ in both groups). Moreover, patients in the rotationplasty group were significantly younger than patients in the other three groups (all $p < .05$).

Concerning the tumor morphology, the majority of patients (n=67) were diagnosed with an osteosarcoma, whereas 15 patients had a Ewing's sarcoma. The localization of the tumor was most frequently the distal femur (54 patients), the proximal tibia was reported in 28 patients.

There were significantly more patients with a Ewing's sarcoma in the limb-sparing surgery group than in the ablative surgery group ($p < .01$). Comparisons between the four surgery groups showed that significantly more patients in the allograft group than in the other groups had a Ewing's sarcoma ($p < .01$).

Comparisons of functional ability and amount of physical activity between different types of surgery

Comparisons between limb-salvage and ablative surgery

Table III shows the average functional ability and physical activity scores in the total group and the limb-salvage and ablative surgery groups.

Functional ability

The mean TESS score for all 82 patients was 85.3, suggesting moderate disability. There were no significant differences in TESS scores between patients following ablative and limb-salvage surgery., Patients who had limb-salvage surgery were significantly faster according to the TUDS and VWA tests ($p < .01$; after correction for covariates $p < .05$) In comparison with patients who underwent ablative surgery. There were no significant differences in walking distance, speed and the Physical Cost Index as evaluated with the 6-MWT. Regarding the usage of walking aids, at the time of the assessment 19 patients (44%) in the ablative surgery group (11 in the amputation group and 8 in the rotationplasty group) and 14 patients (36 %) in the limb-salvage surgery group (11 in the allograft group and 3 in the endoprosthesis group) reported that they used crutches, these differences were not statistically significant.

Table III: Functional ability and physical activity levels in 82 patients with a tumor of the lower extremity after limb-salvage or ablative surgery

	All patients		Limb-salvage		Ablative				
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	MD (95%CI)	ANOVA	ANCOVA
FUNCTIONAL ABILITY									
TESS (1-100)	81	85.3 (11.9)	38	84.4 (13.0)	43	86.1 (11.1)	-1.7 (-7.0:3.6)	.52 ns	.50 ns
Function tests	80		37		43				
Timed Up / Down Stairs (sec)		15.4 (7.4)		12.8 (5.5)		17.7 (8.2)	-4.8 (-8.0:-1.6)	.003 **	.02 *
Timed Up and Go		7.1 (1.7)		6.9 (1.8)		7.4 (1.6)	-0.48 (-1.2:0.3)	.21 ns	.65 ns
Lay Down / Stand Up		7.1 (2.9)		7.5 (3.9)		6.7 (1.6)	0.80 (-0.5:2.1)	.22 ns	.66 ns
Various Walking Activities (sec)		28.7 (7.0)		26.4 (5.7)		30.8 (7.4)	-4.4 (-7.4:-1.4)	.004 **	.01 **
6-minutes walk test	80		37		43				
Distance (meter)		452.6 (95)		468.0 (95)		438.8 (94)	29 (-13:71)	.17 ns	.16 ns
Physical Cost Index		0.82 (0.22)		0.81 (0.2)		0.84 (0.23)	-0.03 (-0.1:0.07)	.55 ns	.38 ns
PHYSICAL ACTIVITY									
Baecke	82		39		43				
Work index (1-5)		2.40 (0.59)		2.47 (0.63)		2.33 (0.54)	0.14 (-0.1:0.4)	.29 ns	≈
Sport index (1-5)		2.28 (0.68)		2.26 (0.71)		2.30 (0.67)	-0.03 (-0.3:0.3)	.83 ns	≈
Leisure time index (1-5)		2.66 (0.78)		2.76 (0.81)		2.57 (0.75)	0.19 (-0.2:0.5)	.29 ns	≈
Total activity index (3-15)		7.4 (1.32)		7.67 (1.33)		7.20 (1.30)	0.47 (-.01:1.1)	.12 ns	≈
Actilog V3.0	66		30		36				
GPA score		94.4 (27.6)		93.9 (25.4)		94.8 (29.7)	-0.87 (-15:13)	.90 ns	.15 ns
Peak amplitude		192.2 (32.3)		192.2 (27.2)		192.3 (36.5)	-0.08 (-16:16)	.99 ns	.18 ns
Peak duration		27.1 (12.8)		29.1 (12.4)		25.4 (13.1)	3.73 (-2.6:10.1)	.24 ns	.65 ns
Average peaks		143.1 (18.8)		142.3 (14.7)		143.8 (21.9)	-1.53 (-11:7.5)	.74 ns	.84 ns

MD: Mean difference; **95%CI:** 95% Confidence interval of the difference; * Significance is at the 0.05 level; ** Significance is at the 0.01 level; **ANCOVA**: adjustment for covariates, with age at evaluation and morphology as covariates; ≈ Adjustment for covariates rejected by absence of homogeneity in the regression lines; **TESS:** The Toronto Extremity Salvage Score; **GPA score:** General Physical Activity score, expressed as the number of accelerations per 5-minute period.

Table IV: Functional ability and physical activity levels in 82 patients after different surgical techniques (allograft-, endoprosthetic reconstruction, amputation or rotationplasty).

	Allograft		Endoprosthesis		Amputation		Rotationplasty			
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	ANOVA	ANCOVA
FUNCTIONAL ABILITY										
TESS (0-100)	23	85 (15)	15	84 (10)	27	87 (10)	16	85 (13)	.85	.72 ns
Function tests	22		15		27		16			
Timed Up / Down Stairs (sec)		12.6 (5.6) #		13.2 (5.6) $		17.6(.3)		17.7 (6.4)	.04*	.12 ns
Timed Up and Go (sec)		6.7 (2.0)		7.2 (1.6)		7.2 (1.5)		7.6 (1.6)	.43	.51 ns
Lay Down / Stand Up (sec)		7.1 (4.1)		8.1 (3.6)		6.8 (1.6)		6.5 (1.6)	.44	.80 ns
Various Walking (sec)		26.0 (6.2) #		27.0 (5.0) $		29.8 (6.0)		32.5 (9.2)	.02*	.09 ns
6-minutes walk test	22		15		27		16			
Distance (meters)		466 (107)		471 (75)		440 (104)		437 (79)	.59	.72 ns
Physical Cost Index		0.82 (0.82)		0.78 (0.78)		0.83 (0.83)		0.85 (0.85)	.84	.81 ns
PHYSICAL ACTIVITY										
Baecke	24		15		27		16			
Work index (1-5)		2.5 (0.6)		2.4 (0.7)		2.5 (0.4)		2.1 (0.6)	.08	≈
Sport index (1-5)		2.3 (0.7)		2.2 (0.7)		2.3 (0.6)		2.4 (0.8)	.92	≈
Leisure time index (1-5)		2.6 (0.9)		2.9 (0.6)		2.7 (0.7)		2.4 (0.8)	.31	≈
Total activity index (3-15)		7.6 (1.5)		7.8 (1.1)		7.4 (1.1)		6.8 (1.6)	.22	≈
Actilog V3.0	17		12		22		14			
GPA score		95 (29)		93 (21)		87 (28)		107 (29)	.18	.12 ns
Peak amplitude		190 (29)		196 (25)		183 (41)		206 (23)	.20	.07 ns
Peak duration		29 (14)		29 (11)		22 (12)		30 (13)	.20	.47 ns
Average peaks		139 (14)		147 (15)		140 (21)		149 (23)	.63	.67 ns

* Significance is at the 0.05 level; ** Significance is at the 0.01 level; # Significant difference after T-test in comparison with amputation and rotationplasty patients; **$** Significant difference T-test in comparison with rotationplasty patients; **ANCOVA**: adjustment for covariates, with age at evaluation and morphology as covariates; ≈ Adjustment for covariates rejected by absence of homogeneity in the regression lines; **TESS:** The Toronto Extremity Salvage Score; **GPA score:** General Physical Activity score, expressed as the number of accelerations per 5-minute period.

Physical activity

The mean Baecke score of all 82 patients was 7.4, with mean domain scores from 2.28 (sport index), 2.40 (work index) and 2.66 (leisure time index). These findings indicate that physical activity was moderately limited in this group as compared to healthy peers [20]. None of the differences of parameters of physical activity between the two surgical groups reached statistical significance.

Subgroup analysis among patients with a follow-up of two years or more.

Repetition of these analyses within the subgroup of patients with a time since surgery of two years of more (n=42) yielded in general similar results as within the total group (results not shown), with only one statistically significant difference between the limb sparing and the ablative groups remaining (various walking activities 25.7 versus 29.6 sec; mean difference -3.9; ANOVA p-value 0.04).

In the limb-salvage group 23 (59%) of the patients had a paid job, 14 (36%) were at school and 2(5%) were neither working or at school. These numbers were 36 (84%), 7 (16%) and 0 (0%) in the ablative surgery group, respectively.

Comparisons among the four surgery groups

Table IV shows the average functional ability and physical activity scores in the four different surgery groups.

Functional ability

Patients who had an allograft reconstruction were significantly faster according to the TUDS and VWA tests ($p < .05$) than patients who underwent either amputation or rotationplasty, whereas patients with an endoprosthetic reconstruction were significantly faster according to the TUDS and VWA tests than patients undergoing rotationplasty ($p < .05$). These differences were not statistically significant after adjustment for covariates.

Physical activity

There were no statistically significant differences for any of the measures of physical activity between the four surgery groups.

DISCUSSION

This study aimed to investigate functional ability and physical ability in a nationwide cohort of children as well as young adults after different surgical interventions for bone tumors of the lower extremity. With the help of questionnaires as well as objective measures for childhood and adolescence, their results were compared between ablative and limb-salvage surgery and between allograft reconstruction, endoprosthetic replacement, amputation and rotationplasty. The results of this study indicate small differences in functional ability and physical activity between children and adolescents who underwent limb-salvage or ablative surgery, these differences were mainly not significant. Exceptions were significantly better timed up and down stairs and various walking scores in the limb-salvage group. These results were confirmed by the results of the analyses on the four surgical intervention groups, wherein patients after allograft reconstruction or endoprosthetic replacement reached significantly better timed up and down stairs and various walking activities scores.

In agreement with the majority of previous studies, we were not able to identify clear differences in functional ability between patients after limb-salvage or ablative procedures [1-5,7]. With respect to self reported or physician reported functional ability, one study demonstrated better TESS-scores in patients after ablative surgery than after limb-salvage surgery [6], whereas in all other studies no significant differences in the TESS scores were seen [1-5,7]. In two of these latter studies [4,7] significant better functional ability scores in patients with limb-salvage surgery were observed than in patients who underwent ablative surgery as was reported with the physician reported MSTS score.

Concerning performance tests, we found a significant difference in favor of limb-salvage surgery at the performance tests; timed up and down stairs and various walking activities. The comparison among the four surgery groups showed that both allograft and endoprosthesis contributed to this finding and TUDS and VWA scores differed significantly with the scores in patients after amputation or rotationplasty.

These results are in line with the results of the comparative study from Ginsberg [4], where patients scored significantly better at the FMA function test after limb-salvage surgery than after ablative surgery. Overall, it remains to be established to what extent objective measures like performance tests are more sensitive to detect small differences in functional ability than questionnaires, which are more susceptible to emotional influences.

Concerning physical activity, in our study no significant differences between the groups were seen for physical activity levels as evaluated with the Baecke questionnaire and by the results of the activity monitor. Previously, differences in physical activity levels between patients after limb-salvage and ablative surgery have been evaluated with either a questionnaire [2] and/or an activity monitor [4, 8]. Differences appeared to be small and in none of the studies significant. This might indicate that there are indeed no differences in physical activity between patients after limb-salvage and ablative surgery or on the other hand that the evaluation instruments are not susceptible enough to detect any existing differences. So far, little is known on which instruments are most suitable and valid for use in this patient group.

With respect to the Baecke questionnaire, it should be noted that this instrument was developed for healthy children or adolescents. It remains to be established whether other questionnaires, like the Physical Activity Scale for Individuals with Physical Disability (PASIPD) [25] or the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) [26] would have greater discriminative potentials. In our study, the activity monitor was not capable to detect any differences between both surgical groups. It is not clear to what extent the positioning of the activity monitor, at the non-affected side, and the asymmetrical walking pattern of most patients may have influenced the results.

A limitation of this study was that patients were studied only at 1-5 years following surgery. This may be an insufficient time for some of the procedures, particularly the reconstructive ones. Allograft and metallic devices are known to have significant problems in advancing years including allograft infection, fracture, non-union or metallic device failures or problems with nerves or blood vessels, which may require additional surgery. Amputees may have had their prosthesis changed after surgery, and may not have reached their optimal level of functioning at the time of follow-up either. On the other hand, the results of a subgroup analysis of functional outcomes in patients with a time since surgery of 2 years of more yielded similar results as in the total group, suggesting that time since surgery did not have a significant impact on the results of our study.

In addition, our study did not take into account the potential impact of psychological functioning on functional ability and physical activity. It is generally known that here is a complex interplay between the physical ability of the patient and various psychological factors, including acceptance of the procedure, self-esteem, and motivation [9,27]. Moreover, despite the fact that all patients had completed chemotherapy and/or radiation therapy at the time the study was conducted, their previous usage could have influenced the patients' level of functional ability and physical activity at the time of the assessment.

Another limitation inherent to the design of the study is the possibility of confounding by indication. Due to the preoperative chemotherapy, which is standard in contemporary protocols, limb-salvage is considered to be the surgical procedure of choice for malignant bone tumors [28]. Amputation is only done when oncological results will be compromised by a limb salvage procedure, for example a large tumor encompassing nerve bundles and major vessels or progression of disease. Although our results were statistically adjusted for significant differences in disease characteristics, it remains unclear to what extent the unequal distribution of factors that were not measured like oncological or orthopedic complications could have resulted in confounding bias [29].

In conclusion, one to five years after limb-salvage and ablative surgery due to a malignant bone tumor children and young adults do, apart from a few activities involving walking and standing up, not differ with respect to overall functional ability and physical activity. The results of our study indicate that, if ablative surgery has to be performed in children or adolescents with a malignant bone tumor around the knee, the functional outcome appears to be similar to that of limb-salvage surgery. In addition, the average time since surgery was relatively short. For an appropriate insight into the change over time of functional ability and physical activity after both types of surgery, a prospective study with a longer follow-up (at least two years) is needed.

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