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SHORT COMMUNICATION

Monitoring of an Alpine Skiing Rehabilitation Program for Pediatric Cancer Patients

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ABSTRACT

INTRODUCTION

Physical activity and sports have various beneficial effects on the human body and its mind and is meanwhile established as a kind of therapy after diseases. Outdoor activities such as skiing also seem to be appropriate to reach a wide range of rehabilitation goals. The aim of this study was to document the physical activity intensity in terms of peak and average heart rate, the effect of skiing on physical and psychological functioning via grip strength and the program satisfaction of the participants via questionnaire.

METHODS

A group of pediatric cancer survivors (PCS) and a group of healthy siblings (HS) were tested. All participants absolved a grip strength test before and after the skiing week. They also wore a heart rate measurement device for one whole day and filled out a questionnaire afterwards.

RESULTS

Heart rate monitoring showed minimal and non-significant differences between PCS (168 bpm for Hf_{max}, 121,6 bpm for Hf_{av}) and HS (176 bpm for Hf_{max}, 125.6 bpm for Hf_{av}). The grip strength was significantly increased for the right hand of the HS group ($p = 0.049$) and not significant for all other values including the comparison between the groups. According to the questionnaire the intensity was rated moderate and most indications were positively connoted.

CONCLUSION

Skiing in a rehabilitation setting exposes participants to reasonable physical activity intensities. The physical and psychological functioning increases slightly or remains the same and the program satisfaction indicates that alpine skiing can represent an extensive sports-oriented rehabilitation program.

KEYWORDS

Physical activity; Pediatric cancer survivors; Heart rate; Skiing

INTRODUCTION

Various investigations showed significant benefits of physical activity in pediatric cancer patients [1]. Traditional training programs in the gym can improve both physiological and psychological parameters such as cardiovascular fitness, muscular capacity and self-reliance or general coping with the disease [2]. Additionally, there are several kinds of adventure outdoor recreational activities that have the potential to particularly motivate, connect with peers and family and support the fun part of sports which potentially improves the compliance and thereby the health aspects of sports.

Besides cycling, rowing, climbing, sailing or hiking, skiing is one of such physical outdoor activities as offered by the Department of Sports Science of the University of Hildesheim in cooperation with the pediatric oncology ward of the children's hospital at Hanover Medical School [3]. Meanwhile this outdoor sport rehabilitation week is established and well evaluated by various participants as a follow-up care project. Within the last ten years some research questions were also followed regarding effects of the skiing week on the immune system [4], on the balance ability [5] or the sports-induced life quality [6]. However, to date there is no evidence-based information about the grade of exhaustion in pediatric cancer patients in skiing. It has been noted before that participants are glad about the motion experience, and they did not seem to be overstrained. Though the aim of this study was to monitor the heart rate-based intensity of the activity. Further effects on the grip force as indication for general physiological and psychological functionality as well as the retrieval of the program satisfaction were also part of this investigation.

METHODS AND MATERIAL

The investigation took place in March 2023 and 2024 during a one-week-skiing-rehabilitation journey in Austria, respectively.

An intervention group of N = 17 pediatric cancer survivors (PCS) (10.4 years ± 4.6) and a control group of N = 8 healthy siblings (HS) (11.6 years ± 5.3) were enrolled in the program. All PCS participants suffered from various entities of cancer (Table 1) and the time since the acute therapy was more than six months as an eligibility criterion. The treatment for all patients was chemotherapy. Further all participants were between three and 18-years old (Figure 1) and the treating oncologists provided a medical clearance prior to the rehabilitation journey. All children and adolescents and their parents were informed about the aims and procedures of the study, and they signed informed consent.

Table 1: Program satisfaction assessed with questionnaire.

	n	Disagree, n (%)	Rather disagree, n (%)	Neutral, n (%)	Rather agree, n (%)	Agree, n (%)	I don´t know, n (%)
The skiing sessions were…							
…fun	13	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	2 (15.38 %)	11 (84.62 %)	0 (0.0 %)
…boring	14	11 (78.57 %)	3 (21.43 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)
…too exhausting	13	6 (46.15 %)	4 (30.77 %)	2 (15.38 %)	1 (7.69 %)	0 (0.0 %)	0 (0.0 %)
…overstraining	13	11 (84.62 %)	0 (0.0 %)	0 (0.0 %)	1 (7.69 %)	0 (0.0 %)	1 (7.69 %)

…a great experience	13	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	13 (100 %)	0 (0.0 %)
Due to the skiing sessions, I…							
…felt more self-confident	14	0 (0.0 %)	1 (7.14 %)	1 (7.14 %)	4 (28.57 %)	7 (50.0 %)	1 (7.14 %)
…dared more	14	0 (0.0 %)	0 (0.0 %)	2 (14.29 %)	4 (28.57 %)	3 (21.43 %)	0 (0.0 %)
…felt stronger	14	0 (0.0 %)	0 (0.0 %)	3 (21.43 %)	3 (21.43 %)	8 (57.14 %)	0 (0.0 %)
…felt more flexible	13	0 (0.0 %)	0 (0.0 %)	5 (38.46 %)	2 (15.38 %)	6 (46.15 %)	0 (0.0 %)
…became more active	13	0 (0.0 %)	0 (0.0 %)	1 (7.69 %)	5 (38.46 %)	7 (53.85 %)	0 (0.0 %)
I…							
…would like to continue skiing in the future	14	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	1 (7.14 %)	13 (92.86 %)	0 (0.0 %)
…would like to improve my skiing skills further	14	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	4 (28.57 %)	10 (71.43 %)	0 (0.0 %)
…felt comfortable in the whole group	14	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	4 (28.57 %)	10 (71.43 %)	0 (0.0 %)
…felt comfortable in my ski group	14	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	14 (100 %)	0 (0.0 %)
…felt being well looked after on the slopes	14	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	14 (100 %)	0 (0.0 %)
…would like to participate again	14	0 (0.0 %)	0 (0.0 %)	1 (7.14 %)	0 (0.0 %)	13 (92.86 %)	0 (0.0 %)
(For parents only) I…							
…felt relieved by the team	11	1 (9.09 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	10 (90.91 %)	0 (0.0 %)

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No.	gender	age	no. of skiing sessions offered	active time per day	Grip Strength pre left	Grip Strength pre right	Grip Strength post left	Grip Strength post right	hf max	hf average	Group	Diagnosis	Time since last Diagnosis	Activity	h/week
1	m	6	12	3,5	20	20	15	20	150	95	PCS	pre-birth stroke	74 months		
2	f	16	12	3,5	60	70	60	65	158	92	PCS	NHL	14 months	Trampoline	6
3	f	4	12	3,5	15	15	15	15	181	139	PCS	ALL	12 months	Gymnastics, biking	8
4	m	5	12	3,5	15	20	15	20	176	132	PCS	ALL	30 months	Gymnastics, Playing Ball	1.5
5	m	19	12	3,5	90	105	95	110	159	99	PCS	ALL	8 months		
6	f	3	12	3,5	10	10	10	10	183	133	PCS	ALL	30 months	Dancing, Gymnastics	3
7	f	11	12	3,5	20	25	20	25	159	91	PCS	ALL	121 months	Dancing	2
8	m	14	12	3,5	75	90	75	90	158	109	PCS	B-ALL	21 months	Handball	6-7
9	f	12	12	3,5	40	35	30	40	190	147	PCS	ALL	11 months	Dancing	4
10	f	11	12	3,5	30	45	35	50	178	136	PCS	ALL	46 months		6-8
11	f	11	12	3,5	45	60	50	55			PCS	ALL	10 months	Handball, Vaulting	6-8
12	m	10	12	3,5	30	30	30	30	153	125	PCS	DLTX / PTLD	22 months	Table Tennis	3
13	m	10	12	3,5	35	30	35	30	177	124	PCS	Kidney tumor	24 months	Soccer	4
14	f	9	12	3,5	30	30	35	40			PCS	ALL	7 months		
15	f	7	12	3,5	30	30	30	35	185	132	PCS	ALL	11 months		
16	m	18	12	3,5	70	75	70	90	140	101	PCS	DBA	140 months	Soccer, Weight training	12
17	m	12	12	3,5	40	35	35	40	183	169	PCS	ALL Relaps	28 months	Tennis	3
18	m	19	12	3,5	105	100	110	105	199	149	Sibling				
19	m	8	12	3,5	35	35	30	35	185	121	Sibling				
20	m	10	12	3,5	30	35	40	35	162	98	Sibling				
21	m	3	12	3,5	15	10	15	10	191	148	Sibling				
22	m	9	12	3,5	25	35	35	40	188	150	Sibling				
23	m	18	12	3,5	140	145	140	155	164	96	Sibling				
24	f	14	12	3,5	45	45	50	50	168	133	Sibling			Handball, Dancing	11-13
25	m	12	12	3,5	60	60	70	60	151	110	Sibling				
PCS means					38.53	42.65	38.53	45	168.7	121.6					
Siblings means					56.88	58.13	61.25	61.25	176	125.63					

NHL = Non Hodgin Lymphom, ALL = Acute Lymphatic Leukemia, DBA = Diamond-Blackfan- Anemia, DLTX = Double lung transplantation, PTLD = Post-Transplant Lymphoproliferative Disorder

Figure 1: Documentation of participant data (PCS n = 17, mean age = 10.47 years; siblings n = 8, mean age = 11.69 years).

Alpine skiing was the main activity during the staying in guided groups of five to eight persons in two sessions per day, each of which took about two hours. The skiing sessions comprised a playful warmup and the skiing on intermediate slopes with some exercises or tasks. The drills and tasks were dependent on the skill level which varied from beginners to intermediate skiers. The physical challenge was therefor also depending on the skill level, whereat beginners usually move less economically even though the tasks are comparably easier.

As assessments methods all participants absolved a grip strength test using the left and the right hand before the first skiing day using a grip strength measurement device (Baseline Hydraulic Hand Dynamometer, Fabrication Enterprises, Irvington, NY, USA). Each participant skied wearing an Apple Watch SE (Model A2722) for one day in order to track the average and peak heart rate. After the week they were all tested for grip strength again and filled out a questionnaire to determine satisfaction with the skiing intervention in general. This questionnaire was adopted from a climbing intervention with pediatric cancer survivors [7]. All participants completed all twelve skiing sessions, apart from one patient and one sibling that took a break for one half day respectively due to headaches.

After calculating the delta values a t-Test for unpaired samples was used for statistical analysis to evaluate the heart rate parameters in order to find out about the exhaustion intensity of alpine skiing in pediatric cancer survivors and for the physical and psychological functionality measured by the grip strength. Statistical analysis was performed using IBM SPSS Statistics (Version 29.0.2.0.20) with a significance level set to $p < 0.05$.

RESULTS

Within the overall sample size, it is obvious that all participants agreed that the skiing intervention was generally associated with rather positive connoted attributes such as fun and great experience and not too exhausting, boring or overstraining (Table 1). The skiing sessions led to the feeling of more self-confidence, being stronger, more flexible and more active by the majority (50%-90 % agree or rather agree). Some participant indicated the neutral option (7% for self-confidence and being more active, 38% for feeling flexible).

All participants stated their interest in alpine skiing beyond the rehabilitation journey and to feel comfortable and being well looked after. Apart from one exception all parents perceived themselves being relieved by the team.

Figure 1 recaps much information of the participants and initially delineates their individual indications regarding the disease such as entity and time elapsed since diagnosis. The current status of treatment was maintenance therapy for all patients. Secondly gender, age and activity level are interesting for the interpretation of the assessment. All participants were right-handers except for one left-hander. Finally, it also shows some captured data such as the total activity time of 21.5 hours skiing within one week, the grip force for both hands at two different measurement times and the maximum and mean heart rate of the participants on one skiing day respectively. The peak heart rate values for PCS (N = 17) within one day of skiing reached in average 168.7 bpm with single values up to 190 bpm. The mean value of the average heart rates was 121.6 bpm for one whole day respectively. The HS group had a maximum heart rate of 176 bpm in average (N = 8) and a mean value of 125.6 bpm over one day. The difference between the PCS and HS groups was not significant ($p = 0.722$ for Hf_{max}, $p = 0.941$ for Hf_{av}).

The grip force did not change from t1 to t2 for the left hand in PCS with steady 38.5 kg and changed slightly from 42.65 kg to 45 kg for the right hand ($p = 0.058$). The HS group reached 4.3 kg ($p = 0.064$) and 3.1 kg ($p = 0.049$) more from t1 to t2 with 56.88 kg *vs.* 61.25 kg for the left hand and 58.13 kg *vs.* 61.25 kg for the right hand. The change of the right hand in the HS group was significant. The difference between PCS and HS was neither significant for the left hand before ($p = 0.177$) and after ($p = 0.102$) nor for the right hand before ($p = 0.282$) and after the intervention ($p = 0.293$).

DISCUSSION

This investigation was the first effort to measure the physical exhaustion in 17 PCS during skiing via heart rate monitoring. In addition, their grip force and program satisfaction were assessed.

The monitored maximum heart rate of the patients was 168.7 bpm and 121.6 bpm in average over two skiing sessions whereas their healthy controls of approximately the same age reached 176 bpm and 125.6 bpm. The PCS group can be rated relatively active with regard to their physical activity level as indicated in Table 2. A study in Norway found an average heart rate in 6-year-old children on the schoolyard of 146 bpm - 147 bpm within 40 minutes with peaks up to 220 bpm [8]. Tsuda et al. [9] found 187 bpm in under 10-years old PCS in physical exercise testing. For precise determination of individual intensity areas in assessing young people's physical activity it is recommended to utilize further assessments and parameters such as VO2 [10]. However, in terms of feasibility and for a first general overview we can estimate the childrens' exhaustion intensity in the current study moderate to low in relation to other findings and determinations [10]. This rating is in line with the perception retrieved by the questionnaire indicating that none rated the skiing sessions too exhausting or overstraining.

The control group with the patients' healthy siblings showed slightly lower values for both peak and average heart rates. According to Tsuda [9] there may be a difference in the composition of metabolically active skeletal muscle mass between PCS and HS. A difference in capillary density and mitochondria concentration within the myocytes can also affect oxygen utilization at a tissue level.

Grip strength is related to total muscle strength [11]. According to Bohannon et al. [12] a clinically important change in grip strength is 5 kg and more. Only slight changes could be detected in the current study for PCS. Greater changes are hardly expectable within one week, however, the maintaining and these slight changes could at least be an indicator for a positive development of muscle strength within such a short period of time. This could also be an explanation for a significant improvement of the patients' balance ability after one week of skiing as investigated previously [5]. This potentially positive development is underlined by the program satisfaction assessment via questionnaire (Table 1) and a previous study about the participants psychological wellbeing on such a rehabilitation journey [6]. The Control Group with the patients' healthy siblings, however, could improve their grip strength slightly more and even reached a significant value for the right hand from t1 to t2. Thus, the HS group was closer to a clinically important change than the PCS group. This partly proves the findings of Tsuda et al. [9] that patients are widely less capable than healthy counterparts due to possible disease-induced cardiovascular abnormalities and/or skeletal muscle alterations and/or vascular dysfunction. However, these values need to be interpreted with care due to the small sample size of this group.

A limitation of this study is a relatively small and heterogenous study sample. The activity level varied between zero and 13 hours of sports per week. Some participants did not indicate any physical activities. Heart rate data was only documented as peak and average values per session. However, reference values are age-dependent, thus further studies of the intensity of skiing is in demand. The participant numbers vary between the parameters due to missing information.

Alpine skiing can be performed in different ways, e.g. in an ambitious manner with steep slopes, few breaks and challenging environments. On the other hand, it can be arranged in a setting with the focus on participant-specific

demands such as wellbeing, conscious motion-experience in gliding and turning with various senses (e.g. sensory motor interaction underneath the feet, centrifugal forces, airstream etc.) as it is the case in such a rehabilitation week. The participants seem to be exposed to moderate intensities and according to the questionnaire and previous findings a variety of influencing factors beyond the physical activity led to an overall evaluation that this week is particularly valuable for the whole family's wellbeing and a way back to normality. Eventually the skiing journey carries the potential to motivate the children and adolescents and their parents to keep being active.

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