The risks and benefits of snow sports for people with disabilities: A review of the literature

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The risks and benefits of snow sports for people with disabilities: a review of the literature

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Snow sports are popular pastimes with therapeutic potential. The aim of this review is to evaluate the risk of injury and evidence of benefits of alpine skiing (including sit-skiing), Nordic skiing, and snowboarding for people with disabilities. Ten studies met the inclusion criteria from 357 citations. Research in this area is still in its infancy, but the risks of engaging in snow sports appear no greater than those of the general population, and there is some evidence that skiing can positively influence self-esteem, physical self-worth, standing balance, and gross motor function among individuals with a disability. ***International Journal of Rehabilitation Research*** **00:000–000**

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Introduction

Skiing has been used as a rehabilitative tool since World War II, particularly for war veterans with amputations (Adams and McCubbin, 1991). Since then, the growing popularity of the sport has been fostered by the continued development of adaptive skiing techniques and modified equipment (McCormick, 1984; Laskowski, 1991). However, research on skiing for those with a disability has not kept pace with the sport's popularity.

Anecdotal information on the rehabilitative and therapeutic benefits of snow sports is more plentiful than empirical evidence. For example, Leung (1988) discusses the positive effects on physical and psychological well-being; Maderna *et al.* (1996) suggest that skiing improves digestive ailments, and promotes better posture and coordination; and others have indicated that skiing positively influences self-esteem (Adams and McCubbin, 1991; Joyce, 2002). This enthusiasm for the potential benefits offered by snow sports is well illustrated by a quote from Laskowski (1991), '…skiing has become the most successful of rehabilitation sports and recreation programs available to people with disabilities.' Despite the excitement that surrounds adaptive snow sports, there is a paucity of empirical evidence to support these claims. The aim of this review is to bring together the evidence on the risks and benefits of snow sports for people with disabilities, looking specifically at alpine skiing (including sit-skiing), Nordic skiing, and snowboarding.

Methods

Data sources

The following databases were searched from their inception through to April 2008: Academic Search Premier, ERIC, Health Source: Nursing/Academic Edition, MEDLINE, PsycARTICLES, SPORTDiscus, Ovid SP, and ProQuest theses and dissertations using the keyword Disability, combined with Skiing, Ski, and Snowboarding. This search produced 355 results; two additional articles were located from the references of retrieved articles.

Inclusion/exclusion criteria and data extraction

To be eligible for inclusion each study needed to (i) be written in English; (ii) be published in a peer-reviewed journal, or be an unpublished thesis/dissertation; (iii) include persons with a disability; (iv) focus on sit-skiing, alpine skiing, Nordic skiing, or snowboarding; (v) be concerned with risks or benefits; and (vi) yield empirical findings. The authors independently assessed each abstract for eligibility and any disagreements were resolved by discussion and consensus. Of the 357 citations, 347 did not meet the inclusion criteria for the following reasons: six were not written in English, 254 did not focus on the snow activities of interest, 33 did not focus on individuals with a disability, 44 did not yield empirical results, six did not focus on benefits or risks, one study combined the results from a skiing intervention with those from a non-snow sport intervention, and three citations were listed twice. A total of 10 studies were deemed to have met the inclusion criteria for this review of literature.

Findings

None of the articles located focused on snowboarding. Consequently, the term 'skiing' is used as the generic descriptor in the remainder of this paper.

Intervention studies

The four intervention studies identified in this review involved small numbers of generally novice skiers and focused on improving balance (Kavanaugh *et al.*, 1996), motor skills (Berg Pasek and Schkade, 1996; Sterba, 2006), and aspects of self-esteem (Berg Pasek and Schkade, 1996; Barbin and Ninot, 2008); see Table 1. Three studies involved less than 6 days of skiing and two of these interventions were week-long camps. The fourth study (Sterba) involved 10 days of skiing across 10 weeks. The skiing interventions were not augmented by additional physical, psychomotor, affective, or cognitive program components. For the studies conducted in the United States, qualified ski instructors delivered the programs and most recently, Sterba used the Adapted Downhill Skiing curriculum [Professional Ski Instructors of America (PSIA), 1997] with certified ski instructors.

All of the studies reported positive findings. Balance (measured by reaching) was reported as having improved after 4–6 days of skiing in people of a wide age range and with different disabilities (Kavanaugh *et al.*, 1996). However, caution should be exercised when interpreting this finding, as there were several threats to the validity of this study. It is difficult to attribute improvement solely to this intervention because control conditions (e.g. using a control group or a time series design) were not instigated. Although there are concerns about the design employed by Kavanaugh *et al.*(1996), Sterba (2006) also found skiing to have a positive effect on standing balance. Sterba used a more robust repeated-measures design to assess motor function at pretest, at weeks 5 and 10 of the intervention, and at 5 and 10 weeks postintervention. Compared with baseline, significant changes in standing; walking, running, and jumping; and total gross motor function were evident at 10 weeks. Changes to standing balance and total gross motor function were still present 10 weeks after the intervention.

Enhanced perceptions of self were also reported. Berg Pasek and Schkade (1996) used a qualitative approach to provide evidence of mastery and the youth's self-satisfaction and self-esteem. These authors found that the adolescents with an amputation '…experienced a sense of mastery over their fears, their limb deficiencies,

Table 1 Skiing intervention studies

Study and country	Outcome investigated	Participants	Design	Instrumentation	Ski intervention	Results	Adverse events
Berg Pasek and Schkade (1996) USA	Mastery and self-esteem	$n=14$ 7M, 7F Age = 13–17 years Mean = 15.1 years Youth with amputation	Participant observation	Video analysis of mastery, notes, questionnaires (validity and reliability not reported)	5 days, NSCD instructors	Evidence of mastery and self-esteem Participants expressed confidence and self-satisfaction with improvement	'Feeling ill', blister on weight bearing stump, and a minor concussion
Kavanaugh *et al.* (1996) USA	Standing balance	$n=15$ 9M, 6F Age = 6–67 years Mean = 20 years Members of Challenged Ski Association[a]	Preexperimental	Functional Reach Test (yardstick method)	4–6 days × 2 h/day Certified instructors	Mean distance reached pre-post increased 0.95 ± 1.55 m, [$t(14)=2.46$, $P=0.01$]	Not reported
Sterba (2006) USA	Gross motor skills	$n=5$ 4M, 1F Age = 4–12 years Mean = 8.4 years Children with CP	Repeated-measures design Measurement taken preintervention, during- at 0, 5, and 10 weeks, and postintervention at 5 and 10 weeks	GMFM (Russell *et al.*, 1989)	One session (2 × 45 min)/ week for 10 weeks using Adapted Downhill Skiing curriculum (PSIA, 1997), certified instructors	No change from pretest to 5 weeks. At 10 weeks improvements in standing (5.4%, $P=0.012$); walking/ running/jumping (4.6%, $P=0.022$); and total GMFM score (3.2%, $P=0.035$) Total GMFM score was significantly higher at 5 and 10 weeks postintervention	Not reported
Barbin and Ninot (2008) France	Self esteem and physical self-worth	$n=10$ 7M, 3F Age = 22–47 years Mean = 32.1 years Wheelchair users with SCI	Time-series design Data collected twice daily during 4-week baseline, 1-week intervention, and 4-week follow-up	Physical Self Inventory, PSI-6 (Ninot *et al.*, 2001)	Mono-ski or bi-ski 5 h/day, 5 days Support provided by physical educators	Significant increases in global self-esteem, $P<0.05$; physical self-worth $P<0.001$; sport competence, $P<0.05$; and attractive body, $P<0.01$; from baseline to program and baseline to follow-up. Perceived physical condition improved from baseline to follow-up, $P<0.01$	Not reported

GMFM, gross motor function measure; NSCD, National Sports Center for the Disabled; SCI, spinal cord injury.
[a]Disabilities were developmental disability, $n=6$; cerebral palsy, $n=3$; head injury, $n=1$; hearing or visual impairment, $n=2$; cerebral vascular accident, $n=2$; Prader Willi Syndrome, $n=1$.

and the challenging physical environment' (p.30). There was also evidence of enhanced self-esteem and many of the youth's responses suggested that they attributed this to improvements in skill. More than a decade later, Barbin and Ninot (2008) also found that skiing positively affected perceptions of global self-esteem, physical self-worth, sport competence, and body attractiveness of adults with spinal cord injury during the ski program and 4 weeks postintervention.

Risk of injury

The benefits of skiing need to be weighed against potential risks to participants. Our review identified six studies of injury patterns among skiers with a disability (Table 2). Five of these studies focused on competitive skiing. The single study that compared injury rates of recreational skiers with and without a disability found no difference in injury rate (3.7 and 3.5 injuries per 1000 skier-days, respectively; $P=0.36$) (Laskowski and Murtaugh, 1992). Among competitive Alpine skiers, rate of injury per 1000 skier-days seemed to range from 2 (McCormick, 1985a) to 9 (Matthews White, 2001) compared with 3.2 among those without a disability (Soma *et al.*, 1996). Of note, however, is the high rate of injury among competitive sit-skiers. McCormick (1985b) reported an injury rate of 16.1 injuries per 1000 skier-days among competitive sit-skiers; particularly for athletes with an injury at T6 or higher. Eighty-three percent of athletes with a T6 or higher injury experienced an acute injury, predominantly to the shoulder and thumb.

Compared with Alpine skiing, Nordic skiing has a lower incidence of injury for individuals with a disability. During the 2002 Paralympic Winter Games, the proportion of Alpine skiers injured was 62% compared to 3% of Nordic skiers (Webborn *et al.*, 2006); similarly, the injury rate during the 1994 Paralympic Winter Games was 9 per 1000 Alpine skier-days and 3 per 1000 Nordic skier-days (Matthews White, 2001). Among Nordic skiers, the incidence of injury for individuals with a disability (3.2 injuries per 1000 skier-days) (Matthews White, 2001) appears higher than for individuals without a disability (<1 injury/1000 skier-days) (Soma *et al.*, 1996).

The most common type of injury to Alpine skiers with a disability was inconsistent. Matthews White (2001) and Webborn *et al.* (2006) reported more lower extremity than upper extremity injuries, whereas Ferrara *et al.* (1992) found that the upper extremities were affected 1.4 times more often. Among Nordic skiers, only upper extremity injuries were reported (Matthews White, 2001; Webborn *et al.*, 2006) and for those using a sit-ski, upper extremity injuries were most common (McCormick, 1985b).

Injury severity was not directly reported in the available studies. Fifteen percent of the injuries in the Ferrara and colleagues (1992) study involved the neck and spine and McCormick (1985a) reported an acute fracture of L5; however, severity was not reported. Webborn *et al.* (2006) noted that only 27% of traumatic injuries during the 2004 winter Paralympics resulted in time lost from training or competition. One intervention study did report adverse events (see Berg Pasek and Schkade, 1996 in Table 1), which included 'feeling ill', a blister, and a minor concussion.

Disability-related problems were notable for skiers. Pressure sores were prevalent (Ferrara *et al.*, 1992; Matthews White, 2001), with 33% of sitting athletes and 25% of standing athletes reporting pressure sores. In addition, Berg Pasek and Schkade (1996) reported that one youth developed a blister on their weight bearing stump. Difficulties with thermal regulation (27%) (Matthews White, 2001) and prostheses (11%) (Ferrara *et al.*, 1992) were also common. Outriggers were associated with risk of injury. Webborn *et al.* (2006) reported that equipment was involved in 18% of injuries, particularly wrist fractures from outriggers, and McCormick (1985a) noted that outriggers caused a face cut, a knee contusion, a sternum contusion, and a shoulder fracture and accounted for 7% of injuries.

Discussion

It is clear that very little empirical evidence of the outcomes of skiing for individuals with a disability exists. The findings of the four intervention studies provide preliminary evidence that skiing may positively affect functional and psychological outcomes. Although the evidence of injury incidence, prevalence, and risk is also sparse, it seems that among recreational skiers the risk of injury is no greater than for the general population. For competitive athletes the highest injury rate was among skiers using a sit-ski, followed by alpine skiers (who do not use a sit-ski), and lastly by Nordic skiers.

Methodological quality of studies

Not only was the available evidence sparse, there were also methodological limitations associated with participant recruitment and selection, study design, and study measures. Generally sample sizes were small and most studies were underpowered. In part this is due to the propensity to collect data at one 'event', such as a ski trip or ski competition.

Intervention fidelity and the associated 'dose' of skiing were of concern. That participants are likely to participate in sufficient skiing to afford change in the intended outcome is a crucial design feature. For example, participants in the study by Kavanaugh and colleagues (1996) engaged in skiing for 2 h on four to six occasions. Although these authors reported a significant change in mean standing balance reach, it is uncertain whether this would be different from a comparison group who did not ski.

Although the measurement tools varied widely, all of the injury studies and two of the intervention studies used

Table 2 **Descriptive studies of injuries among skiers with a disability**

Study	Objective	Participants: *n*, sex, age, source	Participants: Disability/condition	Design	Results	Comments
McCormick (1985a)	Injuries in alpine ski racers	*n*=60 (=RR of 88%) 49M, 11F Age=15–71 years; mean=32 years Registered in Regional Handicapped Skiing Championship	Amputation: *n*=48 Postpolio paralysis: *n*=6 Visual imp: *n*=4 Not reported: *n*=2	Retrospective questionnaire of skiing frequency, equipment, injuries during 1981–1982 season	Rate: 2 injuries/1000 skier-days 70% of respondents had never been injured while skiing Most common site of injury was the knee, followed by legs, spine, shoulder, and thumb	Outrigger injuries (*n*=4) were a face cut, a knee and a sternum contusion, and a shoulder fracture
McCormick (1985b)	Injuries among sit-skiers	*n*=23 (=RR of 44%) 17M, 6F Age=22–54 years; mean=30.3 years Sit-sit racers	Paraplegia: *n*=14 Head injury: *n*=2 Leg amputation: *n*=1 Polio, deafness: *n*=1 Multiple sclerosis: *n*=1 Muscular dystrophy: *n*=1 Arthrogryposis: *n*=1 Vascular disease: *n*=1 Not reported: *n*=1	Retrospective questionnaire of injuries incurred while sit-skiing in the past (no specific time period)	Rate: 16.1 injuries/1000 skier-days Sit-skiers were eight times more likely to sustain an injury Sit-skiers injured at T-6 or above were more likely to sustain a ski injury (*n*=5/6 participants) than those injured at T-7 or below (*n*=2/8 participants) Most common sites of injury were shoulder and thumb	
Laskowski and Murtaugh (1992)	Injuries in non-competitive skiers with and without a disability	*n*, sex, and age not reported All skiers with disability from instructional program in 4 ski resorts Ski resort response rate 30.8%	Data from persons with >45 different disabilities included	X-S survey. Retrospective data from 1985–1989	Ski resort 1: injury rate 1000/skier-days: disability=3.7, without disability=3.5; P=0.36). Knee sprain most common Ski resort 2: no injuries for 5000 sit-ski chair lift rides; some difficulty loading (4%) Ski resort 3: injuries: disability=14 per 1000/ skier-days. Individuals with paraplegia highest injury rate, head and neck trauma common Ski resort 4: injuries: disability=1 (humerus fracture) per 1680 skier-days	The high injury rate at resort 3 reflects reporting of less severe injuries; 89% of injuries were minor
Ferrara, *et al.* (1992)	Training and injuries in competitive skiers with a disability	*n*=68 (RR of 53%) 53M, 15F Mean age=29.6 years Participants of 2 National Games: National Handicapped Sports and US Association for Blind Athletes	Amputation: *n*=38 Spinal cord injury *n*=9 Visual imp: *n*=9 Spina bifida: *n*=4 Multiple sclerosis: *n*=2 Muscular dystrophy: *n*=1 Not reported: *n*=5	Retrospective questionnaire of training and injuries during the 6 months prior to the Games	100 injuries in 6 month among participants Upper extremities affected 1.4x more than lower extremities Chronic injuries more prevalent Disability related problems common (55%): pressure sores (21%) and prosthetic difficulties (11%)	
Matthews White (2001)	Injuries among US and Canadian athletes of the 1994 Paralympic Winter Games	*n*=45 (=RR of 73%) Alpine skiers: *n*=24 Nordic skiers: *n*=12 Sledge hockey players: *n*=9 35M, 10F Age=14–45 years; mean=32.3 years	Amputation: *n*=18 Spinal cord injury *n*=14 Polio: *n*=3 Visual imp: *n*=4 Birth deformity: *n*=3 Upper extremity paralysis: *n*=2 Spina bifida: *n*=1 Not reported	Recall of previous 6-months training and injuries	Rate: 9 injuries/1000 Alpine skier days (lower extremity injury 3x upper extremity) Rate: 3.2 injuries/1000 Nordic skier days (upper extremity injuries only) 93% of athletes with spinal cord injury and 44% of athletes with an amputation reported injuries Disability related problems included difficulty with thermal regulation (27%) and pressure sores (33% of sitting athletes and 25% of standing athletes)	
Webborn *et al.* (2006)	Injuries incurred to athletes during the 2002	*n*=416 (all Paralympic athletes)		Prospective injury surveillance completed by	9.4% of all athletes (*n*=39) competing	Percent of acute traumatic injuries was similar to

Table 2 ***(continued)***

Study	Objective	Participants: n, sex, age, source	Participants: Disability/condition	Design	Results	Comments
				medical personnel during the games	were injured during the games	injury rate for Salt Lake Winter Olympians
	Paralympic Winter Games	Injured athletes Nordic skiers: n=3, 2M; Alpine skiers: n=24, 17M; Sledge hockey players: n=12; 12M Age=17–58 years; mean=33 years			77% of injuries were acute. Of 30 traumatic injuries, 8 resulted in time lost in training or competition. % of all injuries: Alpine, 62% (33% to upper limbs, 38% to lower limbs); Nordic, 3% (only upper-limb injuries) Equipment involved in 18% of injures	

F, female; M, male; RR, response rate.

questionnaires as a method of data collection. On the whole, authors did not report the psychometric properties of these instruments. Validity of the questionnaire was only reported in one study (Barbin and Ninot, 2008) and reliability was reported in two (Kavanaugh *et al.*, 1996; Sterba, 2006).

Implications/recommendations

The available evidence does not suggest that the risks of skiing as a recreational pursuit, sport, or therapy outweigh the benefits; but neither is the research particularly definitive in this regard. To more adequately assess the relative risk to benefit ratio much additional work needs to be done. In particular, we call upon investigators to address gaps in the literature, recruit adequate samples, and ensure the clinical efficacy or biological plausibility of interventions.

Gaps in the literature

To date, very few of the potential benefits of snow sport participation have been investigated. This study has documented limited, but positive, outcomes in terms of perceptions of self and motor proficiency. However, broader examination of physiological, psychological, functional, and quality of life outcomes is needed. In addition, none of the studies compared participation in snow sports with participation in other types of programs, for example, kayaking. As a result it is not possible to say whether there are unique benefits of snow sports.

Additional research with unrepresented and under-represented samples is needed. Data on snowboarders and individuals with intellectual disability were absent and studies involving recreational skiers and women were limited. Further work on injury prevention and control is also warranted. In particular, greater attention to the nature, severity, and mechanisms of injury; inquiry into preventing injuries among sit skiers; and examination of factors that may mitigate chronic injuries and disability-related injuries such as pressure sores.

Recruit adequate samples

Larger scale studies are needed. Although we appreciate the logistical and financial challenges of research on snow sports, it is still important to ensure samples are adequate. Only 44 participants were involved in the four intervention studies. Recruiting participants across multiple events/trips may be needed; or striving for high participant recruitment and response rates at one event.

Clinical efficacy or biological plausibility

Finally, the ‘dose’ of skiing in the intervention studies was small, especially for three of the four studies of short duration. It is necessary to design studies to afford levels of skiing (i.e. duration, frequency, and intensity) that are biologically or clinically likely to produce change in the intended outcome. Augmenting therapy with virtual activities is showing promise (see for example, Deutsch *et al.*, 2008) and virtual ski-related activities like Wii Fit ski slalom could complement or supplement therapeutic or recreational programs.

Conclusion

Research on snow sports is scarce, but the risks of engaging in skiing appear no greater than those of the general population and there is some evidence that skiing can positively influence self-perceptions and motor performance. Methodological concerns and the dearth of evidence moderate our confidence in the research findings. Further research is sorely needed, particularly in relation to injury prevention and mitigation as well as broader examination of the benefits of snow sports. Without definitive findings it is difficult for therapists and professionals to recommend participation in snow sports as a best practice.

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