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SENSATION SEEKING AND INJURY RISK IN DOWNHILL SKIING

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Summary—A validated Dutch version of Zuckerman's sensation seeking (SS) scale was sent to a population of downhill skiers. It was expected that injured skiers ($N = 219$) would have higher thrill and adventure seeking (TAS) scores compared to a control group of uninjured skiers ($N = 288$). Information on other risk factors for ski injury, as measured in an earlier study among the same skiers, was included in a logistic model in order to adjust for confounding. Response (73%) was slightly higher among females, younger skiers and higher educated persons. Skiers have a high TAS score compared to a Dutch reference population. The observed correlations between SS subscales, as well as the trends associated with age and gender are in full agreement with the literature. Surprisingly, TAS scores were lower among the cases (35.0) compared to the control group (37.3) [$P < 0.01$]. Adjustment for other risk factors for ski injury in the logistic regression does not change the effect of the TAS score substantially. It is postulated that skiers with a high TAS score could be more experienced in balancing on the border of their individual capacities. More research into this problem, preferably with a prospective design, is recommended.

INTRODUCTION

The popularity of downhill skiing has increased substantially during the last decades. Even in a small and completely flat country like The Netherlands some 750,000 people are travelling abroad every year to enjoy their winter sports (C.B.S., 1986). Like most other sports, downhill skiing is not without risk. The incidence of injuries can nowadays be estimated at about 5 per 1000 skier days (Bouter and Knipschild, 1985a; Jaffin, 1981). This figure, however, depends heavily on the definition of a ski injury and the way the cases are collected (Bouter and Knipschild, 1987a; Knipschild and Bouter, 1987). Most authors agree that during the last 10–15 yr the incidence rate has decreased substantially due to the introduction of modern ski bindings and possibly also because of a better management of the ski runs (Johnson, Ettlinger, Campbell and Pope, 1980; Tapper, 1978; Shealy, 1985). Probably a further substantial decrease cannot be established along these lines. It is widely advocated that nowadays prevention strategies should be aimed at other risk factors, such as physical condition, abstinence from alcohol and preparation by way of ski gymnastics. However, a sound empirical basis for these assumptions is lacking. Therefore a case-control study was conducted among Dutch skiers during the winter season '84/'85 (Bouter and Knipschild, 1985b). In this study the importance of certain risk factors, such as being a beginner, lack of experience and not taking ski lessons, could be confirmed and quantified (Bouter, Knipschild and Volovics, 1987b). Some other results, however, were surprising and it was our general impression that this study lacked essential information within the behavioral domain. From these considerations the hypothesis was generated that individual differences in risk taking tendency between downhill skiers was an important risk factor for injury (Bouter, 1986).

Theoretical support for an influence of risk taking tendency was found in the concepts of risk homeostasis and sensation seeking. In risk homeostasis (Wilde, 1982) the central idea is that everyone has a target level of risk that is considered acceptable. A feedback mechanism is postulated in which the individual makes sure that this target level of risk is realized, taking into account all internal (e.g. ability, physical condition) and external (e.g. quality of snow, difficulty of slope) circumstances. In this line of argument, the increased risk because of fatigue, bad snow

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quality and impaired coordination due to alcohol use, can for instance be compensated for by a decrease in velocity and/or amount of skiing done. Assuming that the skier has an adequate perception of risk and enough skill to adapt his behavior with the right amount in the right direction, the individual target level would be an important determinant of the injury risk (Wilde 1982, 1985). This target level of risk is supposed to be a function of the expected advantages and disadvantages of risky and cautious behavior alternatives (Wilde, 1982). Optimal arousal of the central nervous system seems to be an important motive in risk taking (Wilde, 1986a). Individual differences in optimal arousal, and thus in risk taking tendency (target level), can probably at least partly be operationalized with the personality trait sensation seeking (SS) (Wilde, Claxon-Oldfield and Platenius, 1985). This trait has been defined as "the need for varied, novel and complex sensations and experiences and the willingness to take physical and social risks for the sake of such experience" (Zuckerman, 1979, p. 10). The SS scale consists of four subscales (Zuckerman, Buchsbaum and Murphy, 1980):

1. *Thrill and Adventure Seeking*: TAS-items indicate a desire to engage in risky and adventurous activities and sports providing unusual sensations.
2. *Experience Seeking*: ES-items represent the seeking of stimulation through the mind and the senses, e.g. through music, art, travelling and drugs.
3. *Disinhibition*: DIS-items describe the seeking of sensation through drinking, partying, gambling and sexual variety.
4. *Boredom Susceptibility*: BS-items represent an aversion to repetitive experience, whether in work or with other persons. Restlessness and boredom arise when such constancy is unavoidable.

The TAS subscale seems especially relevant with respect to downhill skiing. Zuckerman (1983) places skiing in the group of high risk sports, for which it is postulated that participation will be associated with a high score on the SS scale. For some other sports in this category (e.g. mountaineering, parachuting and deep sea diving) this was reported indeed and a number of studies indicate that the injured sportsmen and sportswomen (e.g. in hang-gliding and in auto-racing) had the highest SS scores among the participants. One small cross-sectional study (Conolly, 1981) reports a higher TOTAL and TAS score for skiers ($N = 47$) compared to a group of non-skiers ($N = 36$). Among the skiers, respondents who reported an injury in the past, tended to have a higher TAS, DIS and TOTAL score compared to skiers who had never been injured.

To investigate whether the SS (especially TAS) score is an important risk factor in downhill skiing, a validated Dutch translation of the SS scale (Feij and van Zuilen, 1984) was sent to the majority of the respondents of our earlier case-control study. The central hypothesis was that SS (especially TAS) score would be higher in cases compared to controls.

METHOD

The subjects were selected from the respondents of the case-control study which we performed during the winter season '84/'85 among Dutch skiers (Bouter and Knipschild, 1985b). In the earlier study, cases ($N = 572$) were those who claimed medical costs because of a ski injury (that made skiing or other activities impossible for 1 day or longer) from a certain insurance company. This company covers roughly one-third of the Dutch downhill skiers. For every case the next claim received from a skier for non-medical reasons (e.g. loss or theft) was selected. Controls ($N = 576$) were slightly older and more often of the male gender. This probably reflects the fact that males are often considered head of the family and mentioned as the owner of lost or stolen objects. As a consequence the relation of age and gender with injury risk could not be assessed. All presented measures of association are adjusted for differences in these factors.

For the present study all controls and all cases with a fracture, a dislocation or a ruptured ligament were selected. From this group only those persons who declared earlier that they had no objection against a second study, received the Dutch version of the sensation seeking scale (Feij and van Zuilen, 1984) 12–18 months after the first questionnaire (Bouter and Knipschild, 1985b). Relatively few respondents of the earlier study (13% of the cases and 19% of the controls) had objections against participation in a second study. For 52 persons the names and addresses were no longer correct. In total 290 SS forms were sent to the cases (131 had a fracture and 159 a

dislocation or a ruptured ligament) and 407 to the controls. The first reminder was sent 2 wk later and the second reminder 4 wk later.

Data analysis was performed with BMDP and GLIM statistical software (Dixon, 1983; Baker and Nelder, 1978). Mean SS scores were calculated for males and females separately and group means were adjusted for differences in gender and age by means of an analysis of covariance. A number of other risk factors for the same respondents, as measured in our earlier study, were added to the analysis in order to adjust for confounding. For this purpose multivariate analysis by means of logistic regression was chosen (Kleinbaum, Kupper and Morgenstern, 1982). A model was fitted both with and without SS subscales. This attempts to answer the question, whether SS explains a portion of the variance above the established risk factors. From the logistic models odds ratios (cross product ratios) with their 95%-confidence intervals (CI) (Kleinbaum *et al.*, 1982) are calculated as the appropriate measures of association.

RESULTS

Response

Information on 507 downhill skiers (290 males and 217 females) was included in the analysis. Non-response was 27% (24% in cases and 29% in controls). Response was higher among females, younger respondents and higher educated persons (higher professional training or university). The data are given in Table 1. Among the respondents about 50% responded following the original request and 25% after the first, and another 25% after the second reminder. No difference was found between cases and controls in this respect.

Sensation seeking

Table 2 presents the means of sensation seeking subscores and TOTAL scores both for cases and controls. Males tended to have higher TAS and DIS scores, and consequently higher TOTAL scores, compared to females. A trend for decreasing scores with increasing age was found for TAS (Table 3), ES, BS, DIS and TOTAL scores (data not given).

Table 1. Response in separate categories of gender, age and education for cases and controls (N = 507)

	Cases	Controls
Males	72% (91)	70% (199)
Females	78% (128)	72% (89)
15-29 yr	77% (96)	73% (133)
30-44 yr	76% (87)	70% (117)
45-59 yr	71% (36)	66% (38)
Higher education	80% (88)	74% (149)
Lower education	70% (131)	68% (139)
Total	76% (219)	71% (288)

Table 2. Mean SS subscores for cases and controls

			Cases (N = 219)	Controls (N = 288)	P-value ^a
TAS	Males	(N = 290)	37.9	39.4	<0.01
	Females	(N = 217)	31.2	35.1	
	M + F ^b	(N = 507)	35.0	37.3	
ES	Males		34.2	34.7	0.90
	Females		34.0	33.7	
	M + F		34.2	34.3	
BS	Males		40.5	40.2	0.89
	Females		39.3	40.1	
	M + F		40.0	40.1	
DIS	Males		33.9	33.3	0.98
	Females		28.0	29.2	
	M + F		31.3	31.3	
Total	Males		11.5	11.6	0.23
	Females		10.4	10.8	
	M + F		11.1	11.2	

^aSignificance of t-test for adjusted group means.
^bGroup means adjusted for gender and age by way of analysis of covariance.

Table 3. TAS-subscale scores for different categories of age and gender

		N	Cases	Controls
Males	15–29 yr	123	42.4	44.1
	30–44 yr	124	33.8	36.8
	45–59 yr	43	34.4	34.4
Females	15–29 yr	106	35.4	38.5
	30–44 yr	80	29.6	30.8
	45–59 yr	31	25.2	28.7

Table 4. Correlations between SS scores among cases (upper-half) and controls (lower-half)

	TAS	ES	BS	DIS	Total
TAS	—	0.39	0.41	0.47	0.81
ES	0.38	—	0.33	0.43	0.70
BS	0.28	0.28	—	0.36	0.69
DIS	0.32	0.24	0.34	—	0.76
Total	0.77	0.64	0.66	0.68	—

When group means adjusted for gender and age were calculated, only the TAS score differed between cases and controls. Surprisingly, TAS scores were lower in the cases group (35.0) compared to the control group (37.3). Additional adjustment for self-reported ability, the most prominent risk factor in our earlier study, could not change the calculated adjusted means substantially (cases 35.3, controls 37.1, $P = 0.03$).

In Table 4 a comparison is made between the sensation seeking scores. Correlations are given for cases and controls separately. The correlation between TOTAL score and the scores on the various subscales ranged from 0.6 to 0.8. Between subscales of the SS scale the correlation varies from 0.3 to 0.5.

Logistic model

To estimate the contribution of the TAS score relative to other risk factors, a logistic model was fitted both with and without the TAS score. In such a model mutual confounding of the incorporated risk factors is adjusted for. Data on the 14 most prominent risk factors for the respondents of the present study were retrieved from the data of our earlier study and included in a logistic model. Examples of these risk factors are: ability, number of hours skiing, physical condition, and alcohol consumption. A second model was fitted after adding the TAS scores to this list of 14 risk factors. There appears to be very little difference between the odds ratios calculated from these two models. In Table 5 odds ratios for some dichotomous variables from both models are given as illustration.

The similarity of the two models suggests that the TAS score should be considered as a risk factor which is to a large extent independent of the other risk factors included in the model. In Fig. 1 the contribution of the TAS score to injury risk is further quantified. In this figure the odds ratios and 95%-confidence intervals are given for different TAS scores relative to the mean TAS score of the study population (36.3).

DISCUSSION

Before discussing the results, the validity of our study deserves some attention. Validity can be impaired by selection bias, information bias and uncontrolled confounding. Selection bias deals with the question of whether the cases and controls are (self)selected in a comparable way. Elsewhere (Bouter, Knipschild and Volovics, 1987b) it is argued that, besides the differences in age and gender, for which we adjusted, there is probably no selection bias in the earlier case-control study. However, not all these earlier responders were actually included in the present study. Controls volunteered for further participation less often, and those who did volunteer more often became non-responders in the present study compared to cases. Furthermore, response was slightly higher among females, younger skiers and higher educated persons. This should lead to some caution in generalization, but does not mean that within our study population the comparison

Table 5. Odds ratios and 95%-confidence intervals for some dichotomous risk factors from the logistic regression

Risk factor	Odds ratio	
	Model without TAS	Model with TAS
Beginners compared to intermediate or advanced skiers	1.38 (0.84–2.24)	1.25 (0.76–2.06)
Bad or intermediate compared to good self-reported physical condition	0.78 (0.49–1.22)	0.77 (0.48–1.22)
Inadequate compared to adequate knowledge about ski equipment	2.09 (1.26–3.47)	2.18 (1.30–3.63)
Afraid of an accident before ski holiday compared to not afraid	0.60 (0.32–1.11)	0.56 (0.30–1.06)

Fig. 1. Odds ratio and 95%-confidence bounds for different TAS scores based on the logistic model.

between cases and controls is necessarily biased. The selection of more severe injuries was introduced on purpose and served to increase the contrast between cases and controls.

The main threat to validity seems to be the 'double' retrospective design of our study. The earlier study was performed shortly after the winter sport episode. The present study is situated 12–18 months later. In this procedure it is assumed that SS is a trait which is reasonably constant over time within the individual and is not influenced a great deal by the experience of getting injured (or not). Although there is some support (Feij and van Zuilen, 1984; Wilde, 1986b) for these assumptions, a prospective design would have been more conclusive. Another possible source of information bias is the circumstance that all gathered information is based on self-assessment and thus may be subject to incomplete recall. The choice of the control group (loss or theft) made information bias due to selective recall less probable. Controls thus also had a reason to remember the details of their ski holiday.

As stated above, confounding by age and gender has been controlled for. Furthermore, in the logistic model, every important confounder we collected information on is included and subsequently adjusted for. This does of course not exclude bias due to unmeasured confounders, nor confounding due to imprecise measurement.

Compared to a Dutch reference population ($N = 300$) consisting of 18–30 yr old individuals registered in general practices (Feij, van Kampen and van den Berg, 1987), skiers in the same age group have a much higher TAS score. In this reference population the mean TAS score of males was 36.4 and of females 30.8 (Feij *et al.*, 1987). No differences in ES and DIS scores with the same age group within our ski population could be found, while BS and TOTAL scores among the skiers seemed to be slightly higher. The latter was mainly due to the higher TAS score among skiers. The trends in SS scores that we found with respect to different categories of age and gender are in full agreement with other Dutch populations investigated (Feij and van Zuilen, 1984). The same holds for the correlations found between the TOTAL score and the several subscales. Correlations between subscales seem slightly higher in our study compared to other studies with the Dutch version of the SS scale (Feij and van Zuilen, 1984).

The difference in mean TAS score between cases and controls was surprisingly not in the expected direction. Controls appeared to have the highest TAS scores. The protective effect of a high TAS score materialized also in the logistic model. This means that skiers who were more inclined to show a risky behavior by definition (Zuckerman, 1979) actually got injured less often. Our results contradict those of Conolly (1981), who reported a higher TAS score among skiers who reported an injury in the past compared to skiers who had never been injured. However, the validity of this study (Conolly, 1981) should be looked upon with some caution. Skiers who did not ski again after their injury were not represented in the sample, and no adjustment is made for differences in other risk factors between cases and controls.

The observed difference in TAS score in our study also contradicts the idea that the individual target level of risk, as measured by the SS scale, would be higher among the cases. An alternative

explanation of our findings would be that skiers with a high TAS score are better at handling the risk of several forms of physical exercise and therefore less prone to accidents and injury, compared to those with a relatively low TAS score who may be less skilled in estimating and handling the risks of downhill skiing. In this line of argument persons with high TAS scores would be experienced in balancing on the border of their individual capacities, while people with low TAS scores would unknowingly take risks, which are inadequately matched to their skill in handling them. Of course this is an *ad hoc* hypothesis, which should be tested in new research preferably with a prospective design.

The confidence intervals calculated in the logistic model are rather wide. This is probably mainly due to the fact that our earlier study ($N = 1148$) consisted of more skiers compared to the present one ($N = 507$). There are some differences between the odds ratios calculated from the logistic model without TAS score from the present study and the same model in our earlier study. This again indicates that the present study population is not a random sample of the earlier study population. However, the direction of the effect of a risk factor is almost always, and the order of magnitude mostly the same within these two populations (Bouter and Knipschild, 1987a, 1987b). From the comparison of the two logistic models based on the present study, it appears that including the TAS score does not change the odds ratios of the other risk factors substantially. The TAS score seems to be a risk factor with an effect largely independent of that of the other risk factors.

CONCLUSION

Skiers have a relatively high TAS score when compared to non-skiers. Sensation seeking subscales among skiers give roughly the same inter-correlations, the same trends with age and the same differences between males and females, compared to other populations. Cases and controls differed only with respect to TAS score. The protective effect of a high TAS score that was found was not expected.

From the comparison of logistic models, it appeared that TAS is a risk factor which operates largely independent of other risk factors. More research into this problem, preferably with a prospective design, is recommended.

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