

Low Back Pain Among Endurance Athletes With and Without Specific Back Loading—A Cross-Sectional Survey of Cross-Country Skiers, Rowers, Orienteers, and Nonathletic Controls

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Study Design. Cross-sectional survey among athletes competing at the national elite level in cross-country skiing, rowing, and orienteering, as well as a matched nonathletic control group.

Objective. To compare the prevalence of symptoms of low back pain between endurance sports with different loading characteristics on the lumbar region: cross-country skiing, rowing, and orienteering, as well as a nonathletic control group.

Summary of Background Data. Although it is claimed that back pain is a frequent problem in endurance sports loading the lower spine such as rowing or cross-country skiing, the prevalence of low back problems in such sports has not been compared with relevant control groups.

Methods. Self-reported questionnaire on low back pain adapted for sports based on standardized Nordic questionnaires for musculoskeletal symptoms. Responders were 257 cross-country skiers (response rate: 100%), 199 rowers (99.5%), and 278 orienteers (99.3%), and 197 control subjects (66%).

Results. Low back pain was reported to be somewhat more common among cross-country skiers and rowers than orienteers and nonathletic controls. The prevalence among cross-country skiers of reported low back pain ever (65.4%) and low back pain during the previous 12 months (63.0%) was higher than nonathletic controls (OR [95% CI]: 1.94 [1.29–2.92]). Rowers (25.6%) reported missing training because of low back pain more frequently than orienteers did (13.7%, OR: 2.16 [1.25–3.74]). The athletes reported more low back pain during periods when training and competition load was higher, and cross-country skiers more frequently reported having low back problems using classic than freestyle skiing techniques.

Conclusions. Low back pain appears to be somewhat more common in endurance sports that specifically load the low back during training and competition. The relationship between seasonal training patterns and specific skiing techniques indicate that there is a relationship be-

tween low back pain and the specific loading patterns of skiing and rowing. [Key words: low back pain, endurance sports, cross-country skiing, rowing, orienteering] **Spine** 2004;29:449–454

During recent years, as many as five Norwegian Olympic gold medal winners in cross-country skiing have undergone surgery because of lumbar disc degeneration/herniation. Despite surgery, some have had to retire because of persistent low back pain (LBP). Based on these high-profile cases, it has been speculated that low back injury is an occupational hazard of cross-country skiing on the elite level.

However, our understanding of the effects of intensive endurance training on the low back is limited. Reports about an increased incidence of LBP in adults with a history of elite sports participation compared with adults who did not participate in elite sports are a matter of controversy.^{1,2} Moreover, previous studies have mainly focused on sports with a high risk of acute hyperextension or hyperflexion trauma or requiring excessive flexibility in extension, such as wrestling, weight lifting, and gymnastics. A series of cross-sectional radiographic investigations have also shown that there is an increased risk of spondylolysis^{3–6} and injury to the endplate or ring apophysis^{7–12} in the thoracolumbar spine among athletes in these sports.

Less attention has been given to LBP resulting from endurance sports. Two previous studies have shown that LBP is a common complaint among young cross-country skiers,^{13,14} but because LBP is a common problem in the general population as well, it is not possible to attribute the problems to skiing. Similarly, although back pain is a frequent problem in rowing,^{15,16} it is not clear whether the risk of low back problems is higher in rowing than in other sports or in age-matched nonathletic control groups. In fact, Keene *et al* found that only 3% of college rowers had been examined for back injuries in their retrospective review of patient records, compared with an overall rate of 7% for college athletes in general, and 17% and 11% for football players and gymnasts, respectively.¹⁷

Thus, the aim of the present study was to compare the prevalence of symptoms of LBP between endurance sports with different loading characteristics on the lumbar region: cross-country skiing, rowing, and orienteering, as well as a nonathletic control group. In cross-

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country skiing, the athletes mainly load the low back during forward flexion of the hip, in contrast to rowing where the low back is mainly stressed in backwards extension of the hip.^{18,19} Orienteering—long distance off-track running—was included as an athletic control group without specific back loading.

■ Materials and Methods

The study was designed as a cross-sectional survey among athletes competing at the national elite level in cross-country skiing, rowing, and orienteering, as well as a nonathletic control group. The study was approved by the Regional Committee for Research Ethics and the Data Inspectorate, as well as by the Norwegian Skiing, Orienteering, and Rowing Federations.

The survey was conducted during the 2000 Norwegian Championships in cross-country skiing (March), orienteering (September), and rowing (June). Each of the competitions lasted for 2 to 5 days. All athletes who were qualified for the national championships in the three sports were asked to complete a two-page questionnaire on LBP. This included athletes who qualified during the season or were part of the teams at the start of the season. Athletes who did not take part in the competition (for any reason, including those who withdrew due to injury or illness) were identified through personal interviews of the team coaches.

Coaches and athletes were informed about the study during the preliminary inquiry and questionnaires, and a letter and consent form describing the purposes and procedures of the study were distributed to the athletes on arrival at the competition site. Study personnel were present during the competition to answer questions and encourage the athletes to complete and hand in the forms by the end of the championships. Athletes who did not participate in the championships received the questionnaire by mail. Questionnaires were also sent by mail to an age- and gender-matched control group that was randomly selected from the total population by the National Registrar. Anyone who did not complete the questionnaire within a few weeks was contacted by telephone to encourage participation. A total of 737 athletes were identified as participants in the championships or as team members preparing to take part: 257 cross-country skiers, 200 rowers, and 280 orienteers. Of these, all the cross-country skiers, 199 rowers, and 278 orienteers completed the questionnaire (99.6%). Of the 278 orienteers who responded, 51 reported that they participated in ski orienteering during the previous winter season and these were excluded from the study, giving a final sample of 227 orienteers. Out of a control group of 300 subjects, 197 subjects completed the questionnaire (66%). Thirty-nine of these reported being competitive athletes and were excluded from the study. Thus, the final sample consisted of 158 control subjects.

The questionnaire was developed based on standardized Nordic questionnaires that have been developed and validated to study the prevalence of occupational musculoskeletal symptoms.^{20,21} This questionnaire includes questions on LBP (defined as “pain, ache, or discomfort in the low back with or without radiation to one or both legs (sciatica)”). The form also includes a full-figure outline of the posterior body where the low back was shown as a hatched area covering the lumbar region. The definition of LBP and the figure were shown prominently on the first questionnaire page. The standard questions from the Nordic questionnaire include the following:

- Have you ever experienced LBP?
- Have you been examined or treated for LBP by a physician, physical therapist, chiropractor, or other health personnel as an outpatient during the previous 12 months?
- Have you ever been admitted to hospital because of LBP?
- Have you ever had surgery because of LBP?
- Have you ever had to change your occupation or working assignments because of LBP?
- Have you experienced LBP during the previous 7 days?
- Have you ever had radiating LBP?
- How many days during the past 12 months have you had LBP?

In addition to the standard questions, questions on symptoms related to sports activity were developed and thoroughly pilot tested. These include the following (not for the nonathletic control group):

- Have you experienced LBP during the following parts of the season: the resting period, basic training period, transitional period, or competitive season? (no, sometimes, weekly, daily for each part of season)
- Using which of these techniques have you experienced LBP? (for cross-country skiers only: classic diagonal skiing, double poling, double poling and kicking, freestyle paddling, freestyle single dancing, freestyle double dancing)
- How many days of training have you missed because of LBP during the past 12 months?
- How many days of competition have you missed because of LBP during the past month?

The form also included questions about age, gender, height, weight, career duration (number of years of competition in the relevant sport), and yearly training volume (<400 hours, 401–549 hours, 550–700 hours, >700 hours).

The forms were manually entered twice and analyzed using SPSS (Statistical Program for Social Science, v. 10.0 for Windows, SPSS, Evanston, IL). The subject characteristics are reported as means \pm standard deviations and group means were compared using unpaired *t* tests. Low back pain prevalence between groups was compared using χ^2 statistics (Pearson χ^2 or Fishers exact test, as appropriate). A χ^2 test for trend was used to test for changes in LBP prevalence across the season.

Logistic regression analyses were used to test for differences in LBP prevalences between groups adjusted for variables such as age, gender, and height. Odds ratios are reported with 95% confidence limits and *P* values. Three dummy variables were created for volume of training, and the lowest category was used as reference group. The nonathletic control group served as reference group *versus* the three sports groups, and these were also categorized using dummy variables. In analyses comparing the three sports only, orienteering was applied as the dummy reference group. Women were chosen as reference group for the gender variable.

To test for interaction between training volume and the three sports with regard to prevalence of LBP a logistic regression model including as independent variables the two for sports, training volume, and the two product terms between the dummy variables and training volume was created. A χ^2 likelihood ratio test was done to test if the two multiplicative interaction terms collectively were significant. A *P* value between 10% and 20% for this test was regarded as a trend towards interaction. Otherwise, a two-sided *P* value of less than 0.05 was regarded as statistically significant.

Table 1. Subject Characteristics (n = 842) by Sport and Gender

	Skiing		Rowing		Orienteering		Nonathletes	
	Men (n = 165)	Women (n = 92)	Men (n = 131)	Women (n = 68)	Men (n = 129)	Women (n = 98)	Men (n = 95)	Women (n = 63)
Age (yrs)	23 ± 5	21 ± 4	21 ± 6	22 ± 5	24 ± 7	23 ± 6	24 ± 5	22 ± 4
Height (cm)	182 ± 6	168 ± 5	184 ± 6	172 ± 5	182 ± 5	169 ± 5	180 ± 8	169 ± 6
Weight (kg)	74 ± 6	59 ± 6	80 ± 11	63 ± 10	72 ± 6	59 ± 6	81 ± 16	63 ± 12
Competition (yrs)	11 ± 5	10 ± 3	6 ± 5	4 ± 3	12 ± 6	11 ± 6	—	—

Results shown as mean ± SD (range). Competition: years of competitive participation in their sport.
— = data not applicable.

Stepwise backward logistic regression analyses were employed and in some of them the dummy variables for sports were forced into the regression model, and the stepwise procedure was done among the remaining independent variables.

■ Results

The subject characteristics of the different groups are shown in Table 1. The rowers were younger and had fewer years of competitive experience than the two other sports groups. In paired group comparisons of the yearly training volume between each of the groups, the skiers trained more than the rowers and orienteers ($P < 0.0001$, χ^2), and the rowers trained more than the orienteers did ($P < 0.0001$).

Table 2 gives an overview of the response to the LBP questionnaire. More than half of all the groups had previously experienced LBP, almost the same proportion had experienced LBP during the previous 12 months, and one-fourth to one-fifth reported having had LBP during the previous 7 days. Significant overall group differences were observed for LBP ever, LBP previous 12 months, having received outpatient medical assistance, occupational change, and missed training. Very few of the participants had been hospitalized or operated on because of LBP. There was a slight difference in the number of participants who had made occupational changes with the highest proportion in the control group. Few athletes had missed competitions, and there were no differences among the groups.

In a paired group comparison, there was no difference in the response to any of the LBP questions between cross-country skiers and rowers (Table 2). When comparing skiers and orienteers, the skiers had a significantly higher prevalence of reported LBP the previous 12 months and receiving outpatient medical assistance. The rowers reported a higher prevalence of receiving outpatient medical assistance and missed training than the orienteers. Finally, when compared with the nonathletic control group, LBP was reported more frequently for some of the questions by skiers and rowers (Table 2).

A pretest of interaction by logistic regression did not demonstrate any trend towards differences in the relationship between LBP during the previous 12 months and yearly training volume between the 3 sports groups. In a logistic stepwise regression analysis of LBP during the previous 12 months (Table 3), age and gender were the only parameters that influenced the results, and when adjusting for these, there were significant differences between the skiers and the controls. Additional adjustments for height, weight, and yearly training load did not change the results. Similar and at least as marked results were found if the dependent variable “have you ever experienced LBP” was used.

A similar logistic stepwise regression analysis with missed training during the last 12 months as a dependent variable showed that height, weight and age influenced the results, and when adjusting for these, there were significant differences between the rowers and the orienteer-

Table 2. Responses (%) to the Various LBP Questions by Group (n = 842)

	Skiing (n = 257)	Rowing (n = 199)	Orienteering (n = 227)	Control (n = 157)	P Value
LBP ever	65.4†	63.3†	57.3	51.0	0.018
LBP previous 12 mos	63.0*†	55.3	49.8	47.5	0.005
LBP previous 7 days	24.1	25.3	19.4	19.6	0.35
Outpatient medical assistance	31.9*†	24.1*†	14.1	15.2	< 0.001
Hospitalization	1.6	2.5*	0	1.9	0.16
Operation	1.6	0.5	0	0.6	0.23
Occupational change	9.7	8.6	5.7†	13.3	0.08
Missed training	19.1	25.6*	13.7	—	0.007
Missed competition	5.8	4.0	5.7	—	0.64

The P values shown refer to the overall χ^2 analysis between all groups
Paired comparisons between groups: *denotes different from orienteering group; †denotes different from nonathletic control group.
LBP = low back pain; — = data not applicable.

Table 3. Logistic Backward Stepwise Regression Analysis of LBP in the Previous 12 Months With Sport Groups as Forced Variables Into the Regression Equation and Controls as Reference Group

Variables	Regression Coefficient	SE	P Value	95% Confidence Limits of Odds Ratio*		
				LB	OR	UB
Forced variables						
Cross-country skiing	0.662	0.209	0.012	1.29	1.94	2.92
Rowing	0.377	0.218	0.084	0.95	1.46	2.24
Orienteering	0.035	0.211	0.869	0.68	1.04	1.57
Backwards selected variables						
Age (yrs)	0.035	0.013	0.009	1.05	1.19	1.35
Gender	-0.308	0.148	0.037	0.55	0.74	0.98

* Calculated for 1 SD (= 5 years) change in age.

Candidate variables not included in regression: height, weight, yearly training volume.

LBP = low back pain; SE = standard error; LB = lower bound; OR = odds ratio; UB = upper bound.

ers (Table 4). Additional adjustments for gender and yearly training load did not change the results.

Figure 1 illustrates the variation in the reported prevalence of LBP during the different periods of the season. In all three groups, there was an increase in the prevalence of LBP from the recovery period to the more intense training and competition periods ($P < 0.01$ for skiers and orienteers, $P < 0.05$ for rowers, χ^2 test for trend). Among cross-country skiers, more than twice as many skiers reported experiencing LBP when using the three classic skiing techniques compared with the three freestyle techniques, and this pattern was the same for both genders (Figure 2).

Discussion

The main findings of this study were that LBP appears to be somewhat more common among cross-country skiers and rowers than orienteers and nonathletic controls. Also, the athletes report more LBP during periods when training and competition load is higher. Finally, cross-country skiers report having more frequent low back problems using classic than freestyle techniques.

Although a cross-sectional study is an acceptable approach to compare the prevalence of LBP between sports, this study design has some limitations that must

be borne in mind when interpreting the results. First, a cross-sectional study is a “survey of the survivors”—athletes suffering from serious injuries causing them to withdraw from competition would not be available for interview. We attempted to eliminate this potential source of error by including athletes who were qualified for the national championship or were part of the teams at the start of the season 12 months before the study, but did not participate in the championship. Although we did not identify any athletes who had quit sport due to LBP during this period, we know of individual cases from previous seasons. We plan to follow this cohort prospectively for 5 to 10 years to examine the effects these sports may have on later low back function.

Second, the response rate is critical for the evaluation of the results. The strength of the present study lies in the exceptionally high compliance in all of the athletic groups (nearly 100%); its weakness lies in the low response rate among nonathletic controls (66%). Although the letter inviting the nonathletic controls to participate in the study clearly stated that we wanted them to respond whether they had LBP or not, being asymptomatic could still be a main reason for not responding. We cannot verify whether this was the case, but if so, it means that the prevalence of symptoms in this group

Table 4. Logistic Backward Stepwise Regression Analysis of Missed Training Because of LBP in the Previous 12 Months With Sport Groups as Forced Variables Into the Regression Equation and Orienteering as Reference Group

Variables	Regression Coefficient	SE	P Value	95% Confidence Limits of Odds Ratio*		
				LB	OR	UB
Forced variables						
Cross-country skiing	0.389	0.262	0.138	0.88	1.48	2.47
Rowing	0.770	0.280	0.006	1.25	2.16	3.74
Backwards selected variables						
Height	-0.045	0.020	0.027	0.60	0.76	0.97
Weight	0.029	0.016	0.072	0.98	1.26	1.62
Age (yrs)	0.033	0.018	0.068	0.99	1.18	1.41

* Calculated for 1 SD (= 5 years) change in continuous variables.

Candidate variables not included in regression: yearly training volume, gender.

LBP = low back pain; SE = standard error; LB = lower bound; OR = odds ratio; UB = upper bound.

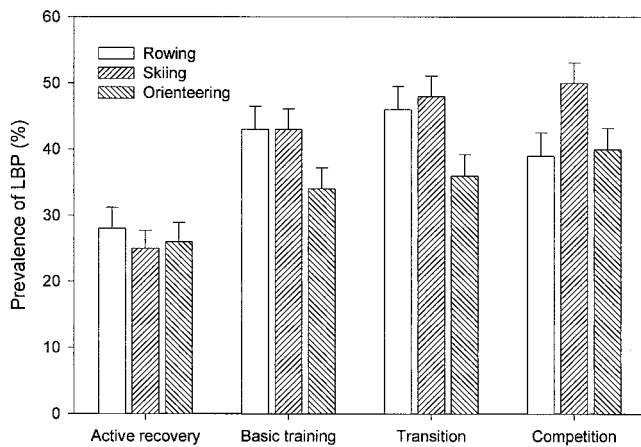


Figure 1. Prevalence of reported LBP ($\% \pm$ SE) during four periods of the season: the active resting period, the basic training period, the transitional period, and the competition season for cross-country skiers ($n = 257$), orienteers ($n = 227$), and rowers ($n = 198$).

may have been overestimated by up to one-third. For this reason, care must be taken when interpreting the results from the nonathletic control group.

Third, the study is based on self-reported questionnaire data, not a clinical interview, an objective physical examination or radiographic evidence of low back injury. However, the validity and reliability of the standardized Nordic questionnaires for musculoskeletal health, which were used as the basis for the present form, have been shown to be good.^{20,21} Test-retest reliability was acceptable, and the correlation with history taking and examination by physical therapist was good. Nevertheless, it should be noted that the form has been developed to study the prevalence of low back pain in an occupational setting, not sports.

The responses to most of the LBP questions showed that although the group differences were modest, cross-country skiers and rowers consistently more often reported symptoms than did orienteers and nonathletic

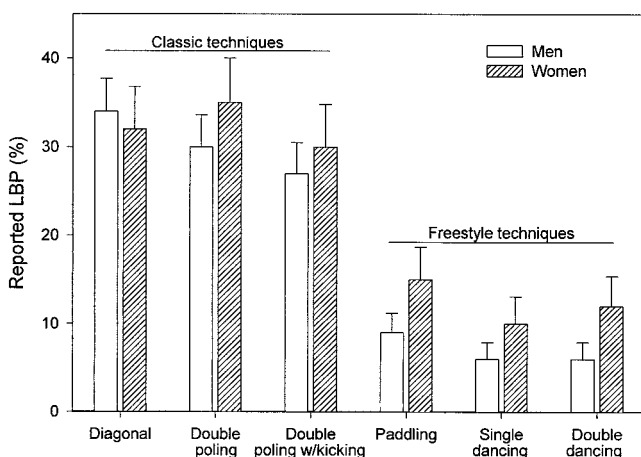


Figure 2. Prevalence of reported LBP ($\% \pm$ SE) among cross-country skiers when using different classic and freestyle (skating) techniques ($n = 257$).

controls. This showed up also in the multivariate analyses, adjusting for confounders such as height, weight, gender, and age at survey. Orienteers and nonathletic controls were chosen to contrast skiing and rowing, assuming that they did not specifically load the low back to the extent required by elite skiers and rowers. Orienteering was included to control for any effects, positive or negative, training in itself may have on low back symptoms. Orienteering is an endurance sport characterized by off-track running, navigating between targets using a map and compass, and except for the sport-specific techniques of skiing and rowing, their training programs are similar to those used by skiers and rowers.^{22,23} It could be argued that orienteering may have its own risks for LBP such as unexpected sudden movements and falls due to uneven terrain, and that this may have attenuated some of the differences observed, but the same could be said for cross-country skiing. However, keeping the differences in response rates mentioned above in mind, there does not appear to be any effect, positive or negative, of endurance training itself on the self-reported rate of low back symptoms.

However, it should be noted that although the rates of reported LBP among rowers and cross-country skiers was higher, this does not necessarily mean that the symptoms are caused by sports participation. Low back pain caused by inherent dysfunction or injury outside sport may be aggravated by sports training or competition. Nevertheless, that acute injuries could explain the observed differences is highly unlikely, because the rate of acute trauma in general, and trauma to the spine in particular, is very low in all three sports.²²⁻²⁵ Nevertheless, athletes may have a lower threshold for reporting symptoms, because LBP may interfere more with athletic performance than other daily activities. Twice as many cross-country skiers and rowers reported having received medical assistance by a physician or a physical therapist than the other groups. This could mirror the severity of the injury, result from a more disabling effect of LBP in rowing and cross-country skiing compared to the other groups, or be a reflection of easier access to professional care, especially among the well-organized cross-country ski teams. Very few of the athletes had been hospitalized or gone through surgery because of LBP. This shows that LBP in these groups, although interfering with their athletic performance, was benign in nature at least in the short-term.

The rowers reported the highest frequency of missed training because of LBP. This could indicate that symptoms were more severe among the rowers, but it is also possible that LBP impairs the rowing movement more than it does for skiing and running. In the individual sport of cross-country skiing, the athlete can reduce the intensity of the training session. He also has the option of using skating, a technique that is less related to LBP, as shown in this study. In contrast, the rower is usually a member of a crew, and cannot go easy while in the boat with others. Although the rowers missed more training, they did not miss more competitions than the others did,

possibly because they do not have as many competitions as skiers and orienteers.

However, even with these caveats in mind, the athletes reported a clear seasonal pattern of LBP. This indicates that there is a relationship with the specific loads induced by sport-specific training, especially among cross-country skiers and rowers. The skiers also reported an unambiguous relationship between skiing techniques and LBP, which also indicates a link between loading pattern and symptoms. This is not surprising, because the classic techniques involve loading of the spine from extension to deep flexion of the spine and hips, while during skating the trunk and lower back is held in a more stable, upright position.^{14,26,27}

The results of this study, showing a gradient between spinal loading and LBP across different sports and different seasons, suggest that there may be a monotone dose-response relationship between spinal loading and LBP. Thus, this study may be relevant not only to athletes, but also to other occupational groups exposed to spinal loading. Recent reviews conclude that there is strong evidence that lifting or carrying loads, whole-body vibration, and frequent bending and twisting are risk factors for LBP.^{28,29} In contrast to the results of the present study, they also concluded that there was no evidence^{28,29} that sports or exercise has any effect on the occurrence of back disorders.

■ Conclusion

The main findings of this study were that LBP appears to be somewhat more common among cross-country skiers and rowers than orienteers and nonathletic controls. Also, the athletes report more LBP during periods when training and competition load is higher. Finally, cross-country skiers more frequently report having more low back problems using classic than freestyle techniques. The results indicate that there is a relationship between LBP and the specific loading patterns of skiing and rowing.

■ Key Points

- Low back pain appears to be somewhat more common among cross-country skiers and rowers than orienteers and nonathletic controls.
- Athletes report more low back pain during periods when training and competition load is higher, which indicates that there is a relationship with the specific loading patterns of skiing and rowing.
- Cross-country skiers more frequently report having more low back problems using classic than freestyle techniques. The classic skiing techniques involve loading of the spine from extension to deep flexion of the spine.

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