


Health problems in national team cross-country skiers over a competitive season: a 17-week prospective cohort study

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ABSTRACT

Objective Few long-term prospective studies have investigated health problems in elite competitive cross-country (XC) skiers. Hence, our objective was to compare the prevalence of health problems in national team XC skiers over a competitive season.

Methods Forty national team XC skiers participated in this prospective, observational study. Two groups were characterised according to performance level: senior (n=18, ~26 years old, 9 women) and development (n=22, ~21 years old, 9 women). The skiers reported all and substantial injuries and illnesses weekly for 17 consecutive weeks throughout the 2019/2020 competitive season using the Oslo Sports Trauma Research Center Questionnaire on Health Problems.

Results The average weekly prevalence of all and substantial health problems was 19% (95% CI: 16% to 22%) and 12% (95% CI: 9% to 15%), respectively, and was similar between senior and development level skiers (p>0.05). The injury prevalence was higher in senior versus development level skiers (12%, 95% CI: 9% to 15% vs 5%, 95% CI: 3% to 7%; p<0.001), while illnesses were less common (8%, 95% CI: 3% to 13% vs 13%, 95% CI: 9% to 17%, respectively; p=0.031). Illnesses accounted for 72% of all problems. The prevalence of all health problems was higher in female than in male skiers (23%, 95% CI: 19% to 27% vs 15%, 95% CI: 11% to 19%; p<0.003).

Conclusions Health problems, especially illnesses, were relatively common, with approximately one in five skiers (19%) reporting at least one problem in any given week. Both performance level and sex influenced the prevalence of different types of health problems.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ While research on health problems in competitive cross-country (XC) skiing is quite extensive, most existing studies have been retrospective, have focused on specific types of health problems or have only included adolescent or subelite-level skiers.

WHAT THIS STUDY ADDS

- ⇒ Health problems were found to be relatively common among senior and development level national team XC skiers, with 19% of athletes affected by at least one problem in any given week.
- ⇒ While the prevalence of all health problems was similar between performance levels, illnesses were less prevalent, and overuse injuries were more prevalent in senior compared with development level XC skiers.
- ⇒ Health problems, especially illnesses, were found to be more prevalent among female compared with male XC skiers.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The Oslo Sports Trauma Research Center Questionnaire on Health Problems could be used as a standardised methodological framework to identify differences in health problems between cohorts of athletes, and future strategies could focus on preventing athlete illnesses, especially respiratory tract infections.



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INTRODUCTION

Health problems, such as injuries and illnesses, have potentially devastating implications for the performance of elite athletes and even minor problems can result in athletes missing important competitions and training.^{1,2} Moreover, health problems may have career-ending consequences.^{3–5} Compared with other sports, the risk of injury in cross-country (XC) skiing is relatively low.^{6–8} During short-term major championships (lasting ~14 days), such as the Olympic Winter Games (OWG) and the Winter Youth Olympic Games (WYOG), ~5% of participating XC skiers sustained an injury

compared with ~12% when all participating athletes were considered.^{9–14} The proportions of XC skiing injuries appear similar between the OWG and WYOG (~5.4% vs ~5.1%, respectively) and between women and men (~5.9% vs ~5.0%, respectively).^{9–14} Previous long-term studies (lasting ~1 year) have reported injury incidence rates in well-trained competitive and World Cup XC skiers of between 2.1 and 3.8 injuries per 1000 exposure hours,^{5 15 16} and 11.4 injuries per 100 athletes per season,¹⁷ respectively. Injuries to the lower extremities and lower back appear most common.^{5 9–11 15 16} However, while the injury research in XC skiing is quite extensive, most of the studies have been

retrospective, have focused on specific types of injuries or have only included adolescent or subelite-level skiers. Hence, a prospective study investigating injury characteristics in elite adult XC skiers over extended time periods is warranted.

During the OWG and WYOG, ~11% of participating XC skiers have been reported to present with an illness, compared with ~8% of all participating athletes, and respiratory tract infections (RTIs) accounted for 74%–87% of all of these illness cases.^{9–14} During the OWG, a somewhat higher proportion of illnesses have been recorded among male compared with female XC skiers (~10% vs ~7%, respectively).^{9–11} Furthermore, a greater proportion of male XC skiers became ill during or in the 10 days immediately after an intense competition period.¹⁸ In contrast, during the WYOG, a greater proportion of female compared with male XC skiers have been reported to be affected by illness (~19% vs ~7%, respectively).^{12–14} In the only multiseason study of illness characteristics in high-performing XC skiers, Svendsen *et al*¹⁹ reported that elite Norwegian XC skiers typically experience 3–4 RTIs and gastrointestinal infections per year, with the highest incidence recorded in the winter months (ie, December–February). The authors also reported that better-performing skiers experienced a lower total number of symptomatic days per year, and that neither sex nor age were significant risk factors for the incidence or duration of symptoms.¹⁹ The contrasting results concerning illness patterns in skiers of different sexes and ages, and the lack of long-term prospective studies on illness characteristics in XC skiers, warrants further investigation.

The competitive XC ski season (November–March) represents the most critical period for elite athletes' health as the potential for missing races is greatest. During this period, skiers are exposed to several factors

known to increase the risk of health problems, such as frequent air travel, altitude, cold and dry air, increased psychological stress, crowding and participation in competitions in itself.^{18–21} Thus, accurate knowledge of the characteristics of health problems during this period will support the effective protection of athletes' health.²² Our primary aim was to describe the prevalence of injuries and illnesses in national team XC skiers over a competitive XC ski season. Our secondary aim was to compare the prevalence and severity of these health problems between performance levels and to explore any potential sex differences.

METHODS

Participants

We invited all skiers selected to represent the Swedish national senior or development XC ski teams for the 2019/2020 competitive season to participate in this prospective cohort study. The two teams are selected by the Swedish Ski Association according to performance level, with the senior team superior to the development team. According to the 2019/2020 World Cup Nations Cup, the Swedish national team was among the top three national teams in the world.²³ Fifty skiers were initially eligible (22 women and 28 men) and 40 (18 women and 22 men) completed the study (table 1). Of these, 18 (out of a possible 26) were senior (9 women and 9 men) and 22 (out of a possible 24) were development (9 women and 13 men) level athletes. Of the remaining ten initially eligible skiers, five were excluded due to long-term injuries or illnesses incurred before the start of the competitive season, which excluded them from partaking in competition. Four further skiers were excluded after failing to report in the athlete monitoring system and one skier withdrew from the study.

Table 1 Participant characteristics and comparisons by performance level and sex

	Senior		Development	
	Female (n=9)	Male (n=9)	Female (n=9)	Male (n=13)
Age (years)	25.6±2.9	26.3±2.6	20.4±1.5*	20.6±1.3*
Body mass (kg)	61.4±4.3	81.4±6.3†	65.0±3.4	75.6±4.4*†
Height (cm)	167.0±4.7	182.9±6.9†	171.4±3.1	180.8±5.0†
VO _{2peak} (L/min)	4.02±0.16	5.80±0.35†	3.99±0.24	5.27±0.22*†
VO _{2peak} (mL/kg/min)	65.6±4.8	71.5±4.7†	61.3±1.4*	71.0±3.3†
FIS distance points	39.9±17.2	51.8±15.1	73.1±11.2*	63.5±15.7
FIS sprint points	59.9±34.6	78.4±46.0†	107.3±62.9*	155.2±51.4†
FIS distance rank	71 (4–127)	220 (93–547)	200 (111–328)	323 (152–683)*†
FIS sprint rank	91 (3–141)	63 (29–590)	190 (27–567)	639 (76–1153)*†

Data are shown as mean±SD except for FIS distance rank and FIS sprint rank that are shown as median (range).

*Significantly different from same sex in the senior team (p<0.05).

†Significantly different from female skiers of the same performance level (p<0.05).

FIS, International Ski Federation; VO_{2peak}, peak oxygen consumption.

Data collection

The data collection was carried out from 24 November 2019 to 15 March 2020, which corresponded to the complete 2019/20 International Ski Federation (FIS) World Cup season (17 weeks). The skiers reported health problems each week using the Oslo Sports Trauma Research Center Questionnaire on Health Problems (OSTRC-H2).²⁴ Every Sunday evening throughout the data collection period, a hyperlink to the OSTRC-H2 was distributed automatically by email to the skiers using an online survey tool (AthleteMonitoring, FITSTATS Technologies, New Brunswick, Canada). Non-responders received daily reminders by email to complete the questionnaire. Body mass, stature and peak oxygen consumption ($\dot{V}O_{2peak}$) were recorded during preseason testing carried out between August and October 2019 in our laboratories at the Swedish Winter Sports Research Centre (see Jones *et al*²⁵ for a detailed description of the test protocols). In addition, we retrieved FIS points and rankings for distance and sprint competitions from the official FIS website (<https://www.fis-ski.com/DB/cross-country/fis-points-lists.html>) for each skier on 28 March 2019 to determine their performance level at the start season (see FIS²⁶ for a detailed description of how FIS points and rankings are determined).

The Oslo Sports Trauma Research Center Questionnaire on Health Problems

Since its introduction in 2014, the OSTRC-H2 has become an increasingly popular tool for collecting data on health problems in athletes.²² The main advantages of the questionnaire are its practicality and affordability, combined with the possibility to capture a broad range of health problems and their consequences.^{22 24 27} In addition, the OSTRC-H2 can identify health problems prior to athletes requiring medical attention or losing training time, which makes it especially useful in settings where overuse injuries and illnesses represent a considerable burden on performance and health.^{22 28} The OSTRC-H2 consists of four key questions assessing the consequences of health problems on sports participation, training volume, sports performance and the degree of experienced symptoms in the past 7 days.^{24 28} A health problem was defined as any health issue reported by the athlete, irrespective of severity, impairment in sports participation or performance or whether the problem received medical attention.^{22 24 28} If a health problem was reported, the skier was asked whether it was a recurring problem and to provide additional information on the type of the problem (acute injury, overuse injury or illness). Injury was defined as a physical complaint affecting the musculoskeletal system.^{22 24} An acute injury was defined as an injury caused by a single, clearly identifiable event (eg, a fall or collision), whereas an overuse injury was defined as an injury that could not be linked to a single, clearly identifiable event.^{22 24} Illness was defined as a complaint or disorder not related to an injury, affecting organ systems such as (but not limited to) the respiratory,

gastrointestinal, cardiac or dermatological systems and unspecified or general symptoms such as fever, dizziness or fatigue.^{22 24} Illness also included psychological conditions (eg, anxiety, depression and sadness).^{22 24} Furthermore, the skiers provided information on injury location, illness symptoms (eg, symptoms indicative of RTIs such as a blocked or runny nose, sore throat, sneezing, coughing, sputum, chest congestion or wheezing¹⁹), date of first symptoms, time loss (reported as number of days with a total inability to train or compete^{22 24}) and whether or not the problem had received medical attention. The identities of all respondents were known to the coaches, medical team and researchers to facilitate the appropriate care of all reported problem.

Prevalence and severity of health problems

After the data collection was completed, we computed the prevalence of all health problems, injuries (acute and overuse) and illnesses for each week of the competitive season for all skiers combined, senior and development levels separately and female and male skiers separately. We also computed the prevalence of substantial health problems, defined as health problems leading to moderate or severe reductions in training volume, moderate or severe reductions in sports performance or a complete inability to participate in sport, for each category of problems and participants.²⁴ Prevalence was computed by dividing the number of skiers reporting a specific health problem by the number of questionnaire responses in a specific week.²⁴ Using the method outlined by Clarsen *et al*,²⁴ we also calculated weekly severity scores based on responses to the four key questions for each reported health problem, which were allocated a numerical value from 0 (no problem) to 25 (maximal level). The numerical values were then summed to generate a severity score ranging from 0 to 100. Subsequently, we computed cumulative severity scores for each health problem by adding up the severity scores for each week the health problem was reported. Average weekly severity scores for all health problems were calculated by dividing the cumulative severity score of a health problem by the total number of weeks the health problem was reported. Finally, we computed the

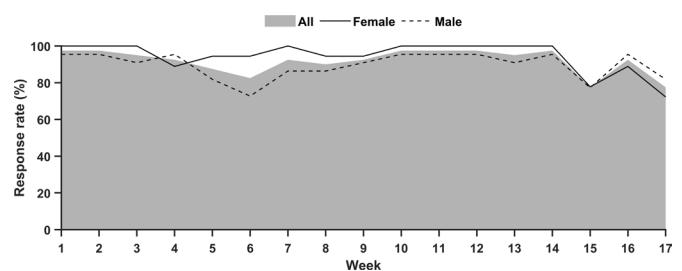


Figure 1 Weekly response rate (%) to the Oslo Sports Trauma Research Center Questionnaire on Health Problems for all (filled grey), female (solid line) and male (dashed line) skiers over the 17-week competitive season.

total time loss for each health problem by adding up the weekly reported time loss for each week a problem was reported.

Statistical analysis

Participant characteristics are presented as mean (SD), except for FIS rankings, which are presented as median (range). All prevalence measures are shown as means with 95% CI. We assessed differences in age, body mass, height, $\dot{V}O_{2peak}$, FIS points and FIS rankings between skiers of the same sex in the senior and development levels and between female and male skiers of the same performance level using either independent samples t-tests (for normally distributed data) or Mann-Whitney U tests (for non-normally distributed or ranked data). Normality of the data was assessed using Shapiro-Wilk tests ($p > 0.05$). We used Mann-Whitney U tests to assess differences in response rates and prevalence of health problems both between senior and development level skiers and between female and male skiers. The statistical significance level (α) was set at 0.05 for all tests and all statistical analyses were performed in MATLAB (R2019b, MathWorks, Natick, Massachusetts, USA).

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Participant characteristics and compliance

Participant characteristics and comparisons according to performance level and sex are presented in [table 1](#). The average weekly response rate for all skiers was 92% (SD 7%). There was no significant difference in average weekly response rate between senior and development level skiers (94% (SD 10%) vs 90% (SD 9%), respectively; $U=344$, $z=1.625$, $p=0.104$). By contrast, the average weekly response rate was higher in female compared with male skiers (94 (SD 8%) vs 90 (SD 7%), respectively; $U=356$, $z=2.032$, $p=0.042$). Weekly response rates to the OSTRC-H2 for all, female and male skiers are shown in [figure 1](#).

Prevalence of health problems

During the 17-week competitive season, 51 health problems were reported by 31 skiers (78%), including 37 illness episodes (72%), 10 acute injuries (20%) and 4 overuse injuries (8%). Overall, 16 skiers (40%) reported 1 problem, 10 skiers (25%) reported 2 problems and 5 skiers (13%) reported 3 problems. Of all reported problems, 36 (71%) were categorised as substantial.

Weekly prevalence of all and substantial health problems, including acute injuries, overuse injuries and illnesses in all, senior level, development level, female and male skiers are shown in [figure 2](#). There was a distinct spike in the prevalence of all health problems in week 15, which was clearly due to the spike in the prevalence of all

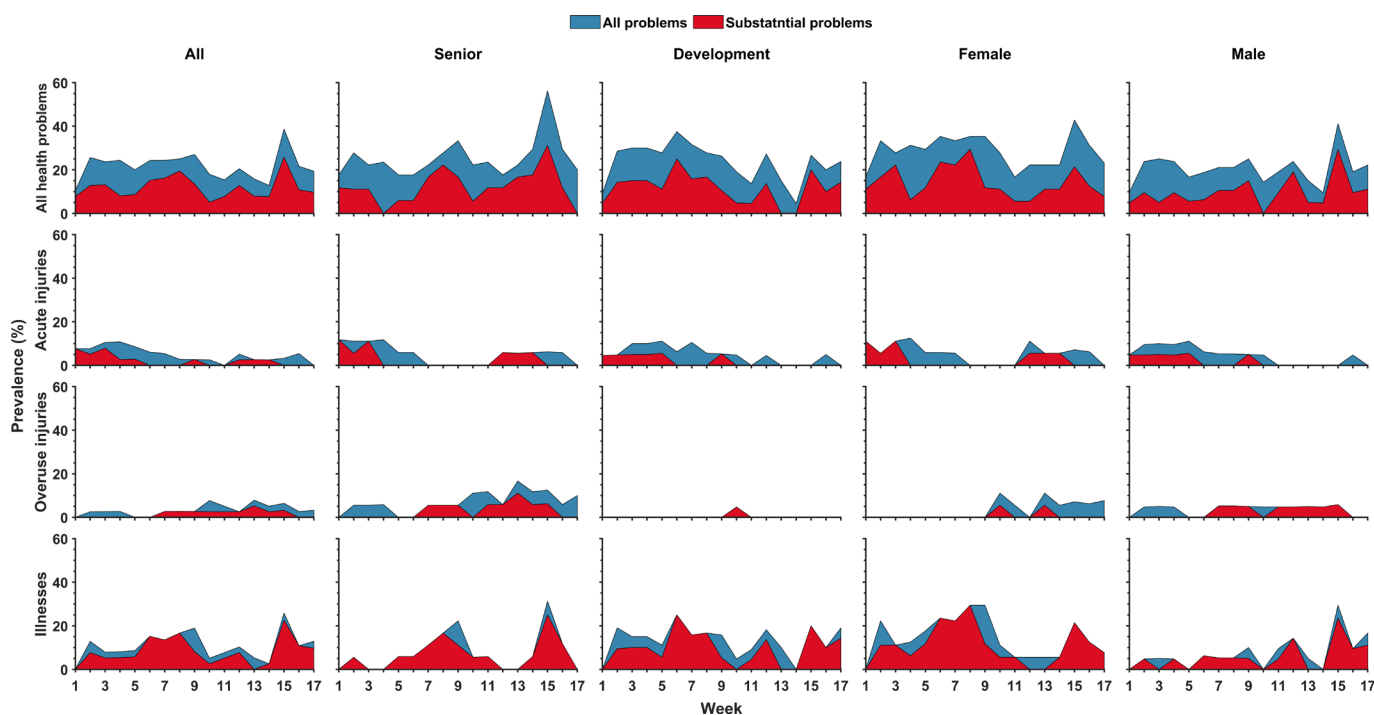


Figure 2 Weekly prevalence (%) of all and substantial (ie, leading to moderate or severe reductions in training volume, moderate or severe reductions in sports performance or a complete inability to participate in sport) health problems in respective subcategories (ie, all health problems, acute injuries, overuse injuries and illnesses) in all, senior team, development team, female and male skiers over the 17-week competitive season.

Table 2 Average weekly prevalence (%) of all and substantial (ie, leading to moderate or severe reductions in training volume, moderate or severe reductions in sports performance or a complete inability to participate in sport) health problems in respective subcategories (ie, all problems, all injuries, acute injuries, overuse injuries and illnesses) in all, senior level, development level, female and male skiers

	All skiers (n=40)	Senior (n=18)	Development (n=22)	Female (n=18)	Male (n=22)
All health problems	19 (16–22)	20 (15–25)	18 (14–22)	23 (19–27)	15 (11–19)*
Injuries	8 (7–9)	12 (9–15)	5 (3–7)†	9 (7–11)	8 (6–10)
Acute	5 (3–7)	5 (3–7)	5 (3–7)	5 (3–7)	4 (2–6)
Overuse	3 (2–4)	7 (5–9)	0 (0–1)†	3 (1–5)	4 (3–5)
Illnesses	11 (8–14)	8 (3–13)	13 (9–17)†	14 (9–19)	7 (3–11)*
Substantial health problems	12 (9–15)	12 (8–16)	11 (7–15)	14 (10–18)	10 (7–13)*
Injuries	4 (3–5)	6 (3–9)	2 (1–3)†	3 (1–5)	4 (3–5)
Acute	2 (1–3)	3 (1–5)	2 (1–3)	3 (1–5)	2 (1–3)
Overuse	2 (1–3)	3 (1–5)	0 (0–1)†	1 (0–2)	2 (1–3)
Illnesses	8 (5–11)	6 (2–10)	9 (5–13)	11 (7–15)	6 (3–9)*

Data are shown as mean (95% CI).

*Significantly different from female skiers ($p < 0.05$).

†Significantly different from senior level skiers ($p < 0.05$).

health problems, and illnesses specifically, in the senior level skiers that week.

As highlighted in [table 2](#), all and substantial injuries were more prevalent in senior than in development level skiers ($U=407$, $z=3.769$, $p < 0.001$ and $U=368$, $z=2.553$, $p=0.011$, respectively). Related to this, both all and substantial overuse injuries were more prevalent in senior than in development level skiers ($U=415$, $z=4.445$, $p=0.026$ and $U=361$, $z=2.798$, $p < 0.001$, respectively). By contrast, all illnesses were less prevalent in senior than in development level skiers ($U=235$, $z=-2.152$, $p=0.031$). Regarding sex differences, all and substantial health problems were more prevalent in female than in male skiers ($U=384$, $z=2.968$, $p=0.003$ and $U=369$, $z=2.453$, $p=0.014$, respectively). Related to this, all and substantial illnesses were more prevalent in female than in male skiers ($U=375$, $z=2.661$, $p=0.008$ and $U=363$, $z=2.263$, $p=0.024$, respectively).

Total time loss, severity of health problems, injury locations, and illness symptoms

Total time loss, weekly severity score and cumulative severity score for all health problems, acute injuries,

overuse injuries and illnesses are displayed in [table 3](#). Injuries were primarily reported in the lower body (eg, pelvis, hip/groin or knee; [table 4](#)). The most common illness symptoms were sore throat, blocked nose/running nose/sneezing and headache, which were reported in 59%, 46% and 22% of all reported illness episodes, respectively, ([table 4](#)). In total, 84% of the reported illness episodes included symptoms indicative of RTIs.

DISCUSSION

To our knowledge, this is the first study to prospectively investigate and compare the prevalence of health problems between senior and development level female and male national team XC skiers. Our main findings were that: (1) in any given week, 19% of the skiers reported some kind of health problem (ie, injury and/or illness) and of these, 12% were substantial; (2) illnesses, and specifically those indicative of RTIs, were the most common health problem; (3) while the prevalence of all health problems was similar between performance level, illnesses were less prevalent and injuries were more prevalent in the senior compared with the development level

Table 3 Total time loss, weekly severity score and cumulative severity score for all health problems, acute injuries, overuse injuries and illnesses over the 17-week competitive season

	All health problems	Acute injuries	Overuse injuries	Illnesses
Total time loss (days)	4 (3–5)	2 (0–4)	2 (–1–5)	5 (4–6)
Average weekly severity score	62 (55–69)	39 (27–51)	42 (23–61)	71 (63–79)
Cumulative severity score	131 (97–165)	146 (22–270)	153 (–16–322)	124 (88–160)

Data are shown as mean (95% CI).

Table 4 Overview of reported injury locations and illness symptoms

	All skiers	Senior	Development	Female	Male
Acute injuries					
Total problems	10	5	5	3	7
Hand	2 (20%)	–	2 (40%)	1 (33%)	1 (14%)
Hip/groin	2 (20%)	1 (20%)	1 (20%)	1 (33%)	1 (14%)
Lower back	2 (20%)	1 (20%)	1 (20%)	–	2 (29%)
Pelvis	2 (20%)	2 (40%)	–	–	2 (29%)
Chest/ribs/upper back	1 (10%)	–	1 (20%)	–	1 (14%)
Knee	1 (10%)	1 (10%)	–	1 (33%)	–
Overuse injuries					
Total problems	4	3	1	3	3
Hip/groin	2 (50%)	2 (67%)	–	–	2 (67%)
Foot	1 (25%)	1 (33%)	–	–	1 (33%)
Pelvis	1 (25%)	–	1 (100%)	1 (100%)	–
Illnesses					
Total problems	37	14	23	17	20
Sore throat*	22 (59%)	9 (64%)	13 (57%)	8 (47%)	14 (70%)
Blocked nose/running nose/sneezing*	17 (46%)	7 (50%)	10 (43%)	6 (35%)	11 (55%)
Headache	8 (22%)	3 (21%)	5 (22%)	3 (18%)	5 (20%)
Cough*	7 (19%)	4 (29%)	3 (13%)	3 (18%)	4 (15%)
Swollen glands	6 (16%)	2 (14%)	4 (17%)	3 (18%)	3 (15%)
Fever*	5 (14%)	1 (7%)	4 (17%)	2 (12%)	3 (15%)
Fatigue/malaise	3 (8%)	1 (7%)	2 (9%)	2 (12%)	1 (5%)
Abdominal pain	1 (3%)	–	1 (4%)	1 (6%)	–
Anxiety	1 (3%)	1 (7%)	–	1 (6%)	–
Breathing difficulty/tightness	1 (3%)	1 (7%)	–	1 (6%)	–
Chest pain/angina	1 (3%)	1 (7%)	–	1 (6%)	–
Depression/sadness	1 (3%)	1 (7%)	–	1 (6%)	–
Diarrhoea	1 (3%)	–	1 (4%)	1 (6%)	–
Ear symptoms	1 (3%)	1 (7%)	–	–	1 (5%)
Irregular pulse/arrhythmia	1 (3%)	–	1 (4%)	1 (6%)	–
Nausea	1 (3%)	–	1 (4%)	1 (6%)	–
Other pain	1 (3%)	1 (7%)	–	1 (6%)	–
Vomiting	1 (3%)	–	1 (4%)	1 (6%)	–

Data are shown as absolute numbers (%).

*Symptoms indicative of respiratory tract infections.¹⁹

skiers; and (4) health problems, especially illnesses, were more prevalent in women than in men.

Health problems in XC skiers

We believe that this is the first study to report the average weekly prevalence of all types of health problems (ie, the combined prevalence of injuries and illnesses) in national team XC skiers. Clarsen *et al*²⁴ and Moseid *et al*²⁹ have reported the average weekly prevalence in mixed groups of endurance athletes to be 30% and 38%, respectively. These proportions are somewhat higher

than the 19% observed in the present study and could potentially reflect the relatively low risk of injury in XC skiing compared with other sports.^{6–8} Indeed, injury prevalence reported by Clarsen *et al*²⁴ and Moseid *et al*²⁹ was approximately two times that reported for our skiers (17% and 15% vs 8%, respectively). Alternatively, the disparate injury prevalence may be explained by differences in the performance levels of the athletes (ie, Norwegian athletes with the potential to qualify for the 2012 Olympic or Paralympic Games in Clarsen *et al*²⁴ vs

all national team skiers in our study) or the age of the participants (ie, average age of ~16 years in Moseid *et al*²⁹ vs ~23 years in our study).

Illnesses were the most common health problem identified in the present study, accounting for 72% of all reported problems. Our observation that illness episodes with symptoms indicative of RTIs accounted for the majority (84%) of these illness episodes in XC skiers is consistent with previous studies,^{16 18 30} as well as with studies on athletes in general. For example, RTIs accounted for 62%–87% of all illnesses reported during the OWG^{9–11} and WYOG^{12–14} and ~96% of illnesses reported by elite swimmers over a 4-year period.³¹ Basic preventive measures such as vaccination, hygiene education and social distancing (for a full description of suggested measures, see Schwellnus *et al*²⁰) appear to be effective in reducing the risk of illnesses in elite endurance athletes.³² Such measures should therefore be considered by athletes and coaches, especially during the competitive season when XC skiers are more frequently exposed to factors that increase the risk of illnesses, such as frequent air travel, increased psychological stress, crowding and participation in competitions in itself.^{18–21}

In a previous study, the average weekly prevalence of illnesses was 14.6% in a mixed-sex group of highly trained XC skiers attending sports academy high schools in Sweden.¹⁶ This is slightly higher than the average weekly illness prevalence observed in our study (11%), but considerably lower than the 23% prevalence reported in a mixed-sex group of elite adolescent endurance athletes attending similar schools in Norway.²⁹ In our study, the average weekly prevalence of illnesses is also lower than that reported for Norwegian female and male endurance athletes preparing for the 2012 Olympic and Paralympic Games (16%).²⁴ While all four studies used the same methodological approach (ie, the OSTRC Questionnaire²⁸), differences in the age of the participants (eg, 16–19 years in von Rosen *et al*¹⁶ vs 18–31 years in the present study), performance level (eg, elite senior²⁴ vs elite junior^{16 29}) and a mixture of endurance sports^{24 29} may explain the inconsistent results. However, based on our results, it seems reasonable to expect that at least one out of ten skiers will be affected by an illness in any given week.

While the prevalence of all health problems generally fluctuated between ~15% and 25% throughout the season, there was a distinct spike in the prevalence in week 15, which approached 40% for all athletes (figure 2). This outlying data point corresponded to a spike in illness prevalence among the senior level skiers. Interestingly, this increase in illness prevalence occurred the week after the FIS Ski Tour 2020, a 9-day event comprised of six competition stages. A further although less pronounced spike in illness prevalence among the senior skiers could be observed in weeks 8 and 9, which followed the 2020 Tour de Ski, a 9-day event comprised of seven competition stages. These observations are consistent with a previous study, which reported an increase in

illness incidence among elite XC skiers during or in the 10 days after an intensified competition period.¹⁸

Health problems in senior versus development team skiers

While the prevalence of all health problems combined was similar in senior and development level skiers, the prevalence of all and substantial injuries were higher in the senior compared with the development level skiers (7% vs 0% and 3% vs 0%, respectively). As well as differing by performance level, these two groups also differed in average age (26.0 vs 20.5 years, respectively). However, data from the OWG and WYOG suggest that the proportion of injured athletes are the same in both events (3.1%–7.7% vs 3.1%–7.3%, respectively), despite a considerable age difference between participating athletes (average age: ~26 years vs ~16 years, respectively).^{9–14} Differences in training volumes rather than age may explain the group differences observed in our study, with former investigations reporting that elite senior level XC skiers complete greater training volumes than development level XC skiers.^{30 33} Senior athletes may therefore be more susceptible to injuries than junior athletes.²¹ However, a potential causal link between high training volumes and increased injury risk has not been established.²¹

Data from OWG and WYOG indicate that the occurrence of illnesses is broadly similar during these two events (7.0%–13.8% vs 10.3%–14.0%, respectively).^{9–14} Other investigators have reported that age was not a significant predictor of symptom incidence for RTIs or gastrointestinal infections in Norwegian national senior and development XC level skiers.¹⁹ In contrast, we found illnesses to be less prevalent in senior compared with development level skiers (8% vs 13%, respectively). Our results may be explained by the fact that the senior level skiers were full-time professional athletes, while most of the development level skiers were semiprofessionals and were likely to be exposed to more non-training stressors such as studies and paid work.^{33 34} The opportunity for recovery may also have been diminished in this group.³³ Moreover, the senior team skiers' access to superior support (eg, sports nutritionists, physiotherapists, physicians) may be of importance.

Finally, but also noteworthy, are the differences in competition schedules between the two performance groups. While the senior team skiers primarily competed in the World Cup, the development team skiers primarily competed in national competitions and in some instances, the Scandinavian cup. Participating in the World Cup involves frequent air travel, which has been reported to be the single greatest risk factor for reporting illness symptoms in elite XC skiers.¹⁹ However, a higher prevalence of illnesses in the senior skiers, who travel more frequently by plane, was not identified in our study.

Health problems in female versus male skiers

In our study, health problems were more prevalent in female (23%) than in male (15%) skiers, mainly due

to more illnesses (table 2). This observation is consistent with reports from the WYOG.¹²⁻¹⁴ Other studies, however, have reported no differences between sexes^{16 19} or fewer illnesses in female skiers.^{9-11 18} We observed no differences in injury prevalence between female and male skiers (table 2). This agrees with data from OWG, WYOG and FIS World Cup events.^{9-14 17} Other investigators reporting average weekly injury prevalence over complete training seasons in XC skiers attending sports academy high schools in Sweden found that the average weekly prevalence of all and substantial injuries was significantly higher in female compared with male XC skiers (26.6%–35.6% vs 14.1%–25.4% and 11.1%–17.5% vs 5.9%–13.0%, respectively).^{2 16} The inconsistent results concerning both injuries and illnesses can probably be explained by differences in the duration of registration periods, time of year, training phase, age of participants, study design (ie, retrospective vs prospective) and/or definitions of injuries and illnesses (ie, time loss, medical attention, types of complaint). Hence, while our results indicate that female skiers are at a greater risk of experiencing health problems than male skiers, more studies using a common methodological framework, such as the OSTRC-H2,^{24 28} are needed to fully understand the potential effects of sex on the occurrence of health problems in elite XC skiers.

Strengths and limitations

The strengths of our study include the prospective study design, the high (92%) response rate, the inclusion of 80% of all Swedish national senior and development XC ski team members and the use of a valid and sensitive tool to collect information on health problems (OSTRC-H2).²⁴ However, we acknowledge that several limitations should be considered when interpreting our results. First, the latter part of the data collection coincided with the COVID-19 pandemic outbreak. As a result, the competitive season was terminated prematurely (eg, 1 week early for the FIS World Cup). Related to this, the first national infection control measures were introduced in Sweden on 11 March 2020 (ie, the last week of the study). Increased awareness of infection control among the skiers and in the general population prior to this date might have reduced the incidence of illnesses in the group. This should be taken into consideration when comparing the results of the present study with studies conducted in the absence of a pandemic. Second, our results are based on self-reported data only. Health problems were not verified and/or diagnosed by a physician. This was not feasible as skiers were spread across Sweden and had varying access to medical support. Third, the relatively short and specific registration period (ie, the 17-week competitive season during winter months) limits the generalisability of our results to other parts of the training season and to other weather seasons.

CONCLUSIONS

Health problems, especially illnesses, were common among the XC skiers, with approximately one-fifth of athletes affected by at least one problem in any given week. While the prevalence of all health problems was similar between performance levels, illnesses were less prevalent and overuse injuries were more prevalent in the senior compared with the development level skiers. Health problems, especially illnesses, were more prevalent in women than in men, with three out of ten women (compared with two out of ten men) affected by at least one problem in any given week. Future research adopting a standardised methodological framework, such as the increasingly popular OSTRC-H2 approach used in this paper,²⁸ could help us to better understand the modulating factors that affect the prevalence of health problems in elite XC skiers.

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