

Abstract

Monitoring health problems and training to support performance in competitive cross-country ski athletes

Competitive cross-country (XC) ski athletes (defined hereafter as XC skiers and biathletes combined) are vulnerable to developing various health-related symptoms and conditions due to several factors, such as high physiological and psychological demands, extreme competition and training environments, high training loads, demanding competition schedules, and frequent travel. On initiating this work, we (the author and supervisory team) were approached by the Swedish Ski Association (SSF) and the Swedish Biathlon Federation (SSSF) to investigate the relationships between training, racing, and health problems, with a specific focus on illnesses (rather than injuries), and an ultimate goal of improving future support practices and athletic performance. The project coincided with the teams' Olympic-cycle preparations for the 2022 Beijing Olympic Winter Games, which were held at an altitude of ~ 1700 m. Therefore, optimizing preparation to competitions at altitude was also a key concern for the two sports organizations.

The project comprised four studies (*Study I–IV*). In *Study I* we examined the endurance training, performance, and illnesses characteristic in a group of highly-trained XC skiers throughout their transition from junior to senior level. In *Study II* we investigated the prevalence of injuries and illnesses in national team XC skiers over a competitive XC ski season. In *Study III* we monitored the daily variations and time course of changes in selected subjective and objective variables during an altitude training camp at ~ 1800 m in national team XC skiers and biathletes. Finally, in *Study IV* we explored whether the resting metabolic profile or changes in the metabolic profile in response to an exercise test can discriminate between athlete groups with different physiological, performance, and illness characteristics.

The skiers in *Study I* progressively increased their endurance training volume in a linear fashion from age 16 to 22 years old by ~ 50 h per year from ~ 470 h at age 16 to ~ 730 h at age 22 years old. The increase in endurance training volume was primarily achieved through an increase in low-intensity training and sport-specific training, rather than high-intensity and non-specific training. Furthermore, the skiers in Study I reported an average of three illness episodes per year, each typically lasting four days, which is comparable to senior elite-level athletes and the general population. During the competitive season health problems, especially illnesses, were relatively common, with approximately one in five skiers (19%) reporting at least one problem in any given week (*Study II*). Moreover, 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 skiers. Health problems, especially illnesses, were also more prevalent among female than male XC skiers.

In *Study III*, we observed that measures typically recommended to monitor acclimatization and responses to altitude in athletes, such as resting peripheral oxygen saturation (SpO_{2rest}) and resting heart rate (HR_{rest}), did not follow the patterns suggested in the literature (e.g., an increase in SpO_{2rest} and a decrease in HR_{rest} over time at altitude). We also observed that 11 out of 15 illness episodes were reported within four days of the outbound or homebound flight. In addition, the biathletes who remained free of illness improved submaximal endurance performance from before to after the camp by ~ 4%.

Study IV showed that acute changes in the metabolic profile in response to a standardized exercise testing session could distinguish athletes based on performance level in sprint skiing competitions, and illness susceptibility in the subsequent 33 weeks. This information is particularly valuable for susceptible athletes and their coaches, as preventive measures, such as vaccination, hygiene education, and social distancing, can be implemented to reduce the risk of illness.

Overall, this thesis expands upon previous knowledge about the health and training of competitive XC ski athletes and provides insights that can improve the support practices and athletic performance within the sports of XC skiing and biathlon.

Keywords: altitude training, athlete monitoring, athlete testing, biathlon, endurance exercise, epidemiology, illness, injury, metabolic profiling, metabolomics, Nordic skiing, performance development, winter sports