

# The physiology of world-class sprint skiers

Ø. Sandbakk<sup>1</sup>, H.-C. Holmberg<sup>2</sup>, S. Leirdal<sup>1</sup>, G. Ettema<sup>1</sup>

1: Center for Elite Sports Research, NTNU, Trondheim, Norway; 2: Mid-Sweden University, Östersund, Sweden.

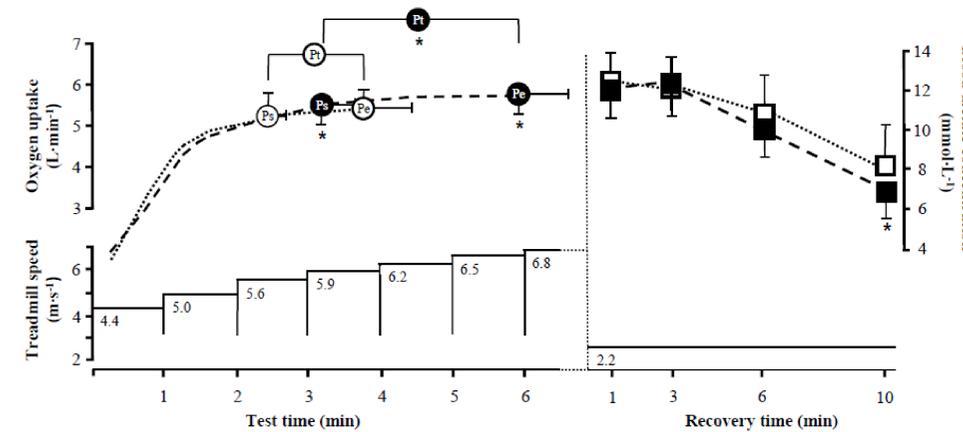


## Introduction

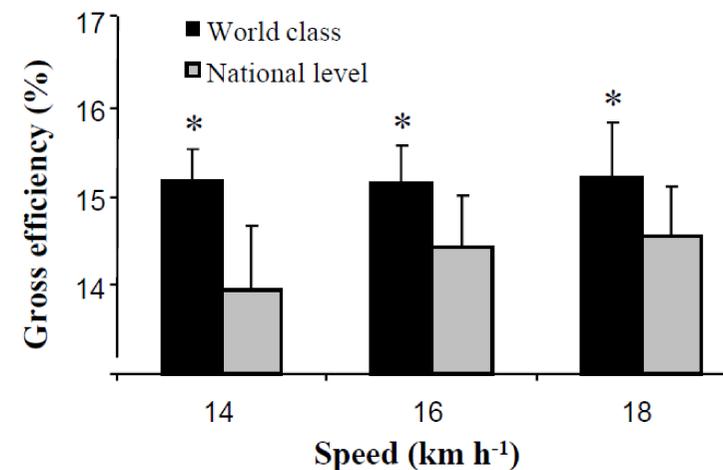
Physiological investigations throughout the last decades have shown that world class skiers are among the endurance athletes with the highest maximal oxygen uptake ( $VO_{2max}$ ). Clearly, aerobic work capacity is one of the most important factors in traditional cross-country skiing performance. However, the introduction of the shorter sprint competitions in modern cross-country skiing requires a new appraisal of the performance limiting factors among world class sprint cross-country skiers. The present study investigated the physiological characteristics of eight world class (WC) and eight national class (NC) Norwegian sprint cross-country skiers.

## Methods

To measure physiological response and performance, three treadmill roller ski tests were performed: 1) a submaximal test, 2) a peak aerobic capacity ( $VO_{2peak}$ ) test and 3) a peak treadmill speed ( $V_{peak}$ ) test. Moreover, the skiers were tested for G3 acceleration and lower and upper body maximal strength. The standard of sprint skating performance was determined by FIS points ( $FIS_{sk}$ ), and the training distribution was quantified. All roller ski tests were performed in the G3 technique



**Fig. 1.** Oxygen uptake (circles) measured continuously during an incremental protocol to exhaustion ( $VO_{2peak}$  test), and blood lactate concentration (squares) measured directly after finishing the test in eight world class (filled symbols) and eight national class (open symbols) sprint cross-country skiers (vertical bars indicate SD).



**Fig. 2** Gross efficiency in world class and national level sprint cross-country skiers during 5-min stages at 14 (V14), 16 (V16) and 18 (V18) km h<sup>-1</sup> at a 5% inclination using the skating G3 technique in treadmill roller skiing (mean and SD).

## Results

- WC skiers showed 8% higher  $VO_{2peak}$  and twice as long  $VO_2$  plateau time at the  $VO_{2peak}$  test
- Higher gross efficiency (GE) at the submaximal test were found in WC skiers (all  $P < 0.05$ ).
- WC skiers showed 8% higher  $V_{peak}$  ( $P < 0.05$ ), but did not differ from NC skiers in acceleration and maximal strength.
- WC skiers performed more low and moderate-intensity endurance training and speed training (both  $P < 0.05$ ).

## Discussion

The current results show that maximal aerobic capacity, efficiency and high speed capacity differentiate WC from NC sprint skiers, and it is suggested that these variables determine sprint skiing performance. However, more studies are needed to further investigate the specific needs of aerobic and anaerobic capacities, and efficient techniques at high speeds in sprint skiers. The current study also indicates that low and moderate-intensity endurance training and maximal speed training is of important in attaining international level in sprint skiing. However, the optimal design of training to improve sprint performance over time needs further examination.