Introduction

Cross-country skiing is a commonly practiced and popular outdoor activity where the prevailing environmental conditions during the winter frequently expose cross-country skiers to cold stress. The lowest permitted ambient temperature (T<sub>a</sub>) for international ski-race events is -20°C. At moderate and high exercise intensities with T<sub>r</sub> down to -15°C, which typically occur during cross-country races, the core temperature would be expected to rise while skin and muscle temperatures would fall. However, the effect of cold exposure has not yet been examined in upper and whole body exercise modes such as cross-country skiing that are frequently used in cold environments.

Methods

Thirteen highly-trained male cross-country skiers volunteered to participate in the study. All participants performed the following two test protocols consisting of a 10-min warm-up: followed by a 5-min submaximal DP economy (DPE) test (test 1), a 20-minute self-paced maximal DP test, following 8-min of recovery a second DPE test (test 2), and finally an incremental DP test to exhaustion. Power output, respiratory variables, and skin and rectal temperatures were measured during all tests. To avoid any order effects, the main tests randomly performed under a low (-14.5 ± 0.7°C) and a moderate (5.6 ± 0.3°C) T<sub>a</sub> (later referred to as -15°C and 6°C, respectively) with a wind velocity of 4 m·s<sup>−1</sup>.

Results

- There was a 5% (P<0.05, Cohen's d=0.31) lower mean power output for the 20-minute test at low compared to moderate T<sub>a</sub>. This difference mainly occurred in the first phase of the test.
- DPE did not differ between T<sub>a</sub> at test 1, was reduced from test 1 to test 2 at both T<sub>a</sub> and revealed a 3.7% (P<0.01, d=0.83) larger decrease for the low T<sub>a</sub>.

Discussion

This study demonstrated reduced DP endurance performance at -15°C compared to 6°C in male cross-country skiers wearing a standard cross-country racing suit. This was mainly caused by a more conservative pacing strategy and coincided with reduced DP economy at the cold conditions. Although cross-country skiers have a high aerobic capacity that enables them to produce large amounts of heat to efficiently maintain thermal balance, their low percent of body fat and the large surface-to-volume ratio of the upper body in skiing techniques makes them vulnerable to heat loss and thereby cooling in cold environments. Thus, skiers may optimize their performance by adapting clothing and insulation. Future studies are required to elucidate mechanisms related to the more conservative pacing strategy more in detail, and the physiological reasons for reduced economy in cold environments.