The importance of body-mass exponent optimization for evaluation of performance capability in cross-country skiing

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av medicine doktorsexamen framläggs till offentligt förvar i Föreläsningssal 6, Högskolan Dalarna, fredagen den 5 juni, kl. 14:00. Avhandlingen kommer att förvaras på svenska.

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Abstract
Performance in cross-country skiing is influenced by the skier’s ability to continuously produce propelling forces and force magnitude in relation to the net external forces. A surrogate indicator of the “power supply” in cross-country skiing would be a physiological variable that reflects an important performance-related capability, whereas the body mass itself is an indicator of the “power demand” experienced by the skier. To adequately evaluate an elite skier’s performance capability, it is essential to establish the optimal ratio between the physiological variable and body mass. The overall aim of this doctoral thesis was to investigate the importance of body-mass exponent optimization for the evaluation of performance capability in cross-country skiing. In total, 83 elite cross-country skiers (56 men and 27 women) volunteered to participate in the four studies. The physiological variables of maximal oxygen uptake ($\dot{V}O_{2\text{max}}$) and oxygen uptake corresponding to a blood-lactate concentration of 4 mmol·l$^{-1}$ ($\dot{V}O_{2\text{obla}}$) were determined while treadmill roller skiing using the diagonal-stride technique; mean oxygen uptake ($\dot{V}O_{2\text{dp}}$) and upper-body power output ($\dot{W}$) were determined during double-poling tests using a ski-ergometer. Competitive performance data for elite male skiers were collected from two 15-km classical-technique skiing competitions and a 1.25-km sprint prologue; additionally, a 2-km double-poling roller-skiing time trial using the double-poling technique was used as an indicator of upper-body performance capability among elite male and female junior skiers. Power-function modelling was used to explain the race and time-trial speeds based on the physiological variables and body mass. The optimal $\dot{V}O_{2\text{max}}$-to-mass ratios to explain 15-km race speed were $\dot{V}O_{2\text{max}}$ divided by body mass raised to the 0.48 and 0.53 power, and these models explained 68% and 69% of the variance in mean skiing speed, respectively; moreover, the 95% confidence intervals (CI) for the body-mass exponents did not include either 0 or 1. For the modelling of race speed in the sprint prologue, body mass failed to contribute to the models based on $\dot{V}O_{2\text{max}}$, $\dot{V}O_{2\text{obla}}$, and $\dot{V}O_{2\text{dp}}$. The upper-body power output-to-body mass ratio that optimally explained time-trial speed was $\dot{W} \cdot m^{0.57}$ and the model explained 63% of the variance in speed. The results in this thesis suggest that $\dot{V}O_{2\text{max}}$ divided by the square root of body mass should be used as an indicator of performance in 15-km classical-technique races among elite male skiers rather than the absolute or simple ratio-standard scaled expression. To optimally explain an elite male skier’s performance capability in sprint prologues, power-function models based on oxygen-uptake variables expressed absolutely are recommended. Moreover, to evaluate elite junior skiers’ performance capabilities in 2-km double-poling roller-skiing time trials, it is recommended that $\dot{W}$ divided by the square root of body mass should be used rather than absolute or simple ratio-standard scaled expression of power output.

Keywords
Allometric scaling, power-function modelling, maximal oxygen uptake, body mass, elite skiers, distance skiing, lactate threshold, double poling, sprint skiing, competition, power output, time trial.