maintained between 70–80 rpm. This modest-intensity protocol was intended to assimilate the general warm-up preceding the sport specific warm-up. Breath by breath gas exchange-analysis and heart rate data were collected as during the peak $\dot{V}O_2$ test. Post warm-up measurements were made within two minutes of completion.

Rowing warm-up

The protocol was designed to mimic as closely as possible the routine that is usually adopted in preparation for a rowing race. Five minutes of very light jogging on the treadmill, at a heart rate of 110–130 b/min, were followed by 10 minutes of stretching. Subsequently, 12 minutes rowing of gradually increasing intensity were performed during which the heart rate increased from 148 (± 2) to 178 (± 1.7) b/min. The increase in intensity was achieved primarily by increasing the stroke rate. Then 5 sprints with increasing stroke rate and power output were performed. Between each sprint there was an active rest interval of light paddling which lasted approximately 2 minutes. At the end of the sprints the rower rested for approximately 5–7 minutes before any further measurements were made. This rest interval was designed to simulate the small pause between the end of the warm-up and the start of the race. Details of the structure of the rowing warm-up can be seen in Table 2. Breath by breath gas analysis and heart rate data were again collected.

Table 2 Description of the rowing warm-up on the rowing ergometer

Warm-up (time)	Stroke rate/min @	Percent Power Max (% P_{max})
1 × 12 min (4-4-3-1)	18-20-22-24	50-60-70-75
2 × 30 s	26-28	94.7 (± 3.7) – 103.6 (± 2.6)
2 × 45 s	28	108.9 (± 2.9) – 115 (± 2.6)
1 min	30-32	132.2 (± 5.0)

% P_{max} = percentage of maximum power output achieved during the incremental test

Respiratory warm-up

Two sets of 30 breaths were performed using POWERbreath® inspiratory muscle trainer (IMT Technologies Ltd., Birmingham, UK) at 40% of the MIP measured before the start of the protocol. Between the two sets there was a short rest interval while an intermediate MIP measurement was made. Forty percent of maximum capacity has been suggested to approximate the upper loading limit before fatigue of the diaphragm occurs [26]. POWERbreath® is a pressure-threshold device which requires continuous application of inspiratory pressure throughout inspiration in order for the inspiratory regulating valve to remain open. As with the maximal inspiratory pressures subjects were instructed to initiate every breath from RV. They continued the inspiratory effort up to the lung volume where the inspiratory capacity for the given resistance limited further excursion of the thorax. Powerful execution of the manoeuvres was encouraged to ensure maximal voluntary output for the given loading conditions. Because of the increased tidal volume, a decreased but spontaneous breathing frequency was adopted by the subjects in order to avoid hyperventilation.

Isokinetic strength

Dynamic isokinetic strength was measured before and aft the rowing warm-up. Peak torque (Nm) and angle (degre of peak torque was measured during a concentric knee exte sion of the dominant leg on a Cybex Norm isokinetic dyn mometer (Cubex International, Inc. Ronkonkona, New Yor USA). A relatively slow speed of 60°/s was chosen to approx mate the slow velocity encountered in rowing. All subjec had at least two practice trials on previous occasions for fami iarisation with the nature of the dynamometer and the specifi testing velocity. On the test day three practice trials with light effort preceded the three maximum efforts from whic the best value was taken for further analyses.

Statistical analyses

Student's t-test for paired samples was used to compare differ ences between the MIP values before and after the two whol body warm-up protocols. ANOVA with repeated measures anc Scheffé post-hoc test was used to assess differences in the RespWU. Values of $P < 0.05$ were considered statistically signif icant. Data points were means (± SE) unless otherwise stated.

Results

Rowing warm-up and general warm-up characteristics

Compared with the peak $\dot{V}O_2$ test the rowing warm-up and the general warm-up elicited a ventilatory response with the characteristics shown in Table 3.

Table 3 Data obtained from the general and the rowing warm-up expressed as percent peak values observed during the peak $\dot{V}O_2$ test (Data for the rowing warm-up is from the 12 minutes continuous rowing phase)

Mean (± SE)	General	Rowing
V_E%	40.1 (± 6.9)	70.1 (± 2.6)
$\dot{V}O_2$%	62.3 (± 9.5)	80.5 (± 2.4)
f_c%	71.2 (± 3.2)	90.1 (± 1.0)
VT_I%	88.1 (± 12.6)	88.2 (± 1.7)
f_h%	52.7 (± 5.8)	76.6 (± 3.1)
PIFR %	47.4 (± 9.6)	65.1 (± 1.3)

V_E = minute ventilation, VT_I = tidal volume (inspired), f_h = frequency of breathing, PIFR = peak inspiratory flow rate, f_c = cardiac frequency

Isokinetic strength

The peak torque of the leg extension increased significantly after the rowing warm-up by 3.8 (± 1.4)% ($P < 0.05$). The angle of peak torque increased by 2.8 (± 3.1)% but this increase was not significant.