TABLE 3. Coefficients of variation for selected parameters related with the 6-min all-out test.

	CV %
MIP decrease (%)	10.1 ± 2.7
Power (W)	0.36 ± 0.12
Dyspnea	1.7 ± 0.7
$\dot{V}O_2$ (L)	1.4 ± 0.7
$\dot{V}E$ (L)	3.2 ± 0.3

mediate MIP measurement was made. Forty percent of maximum capacity has been suggested to approximate the upper loading limit before fatigue of the diaphragm occurs (20). POWERbreath® is a pressure-threshold device that 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 maneuvers 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. This breathing pattern resulted in a very low duty cycle (inspiratory time/total breath duration) and further ensured that fatigue was avoided. The respiratory warm up was performed before the RWU. This protocol has been shown to enhance the strength of the inspiratory muscles (26).

Perception of dyspnea. A category scale, the modified Borg (3) scale, was chosen to evaluate the respiratory effort during exercise. The scale consists of a series of integers from 0 to 10. The rower was asked to estimate the effort required to breath but not the effort of the exercise. During rowing, the Borg scale remained in front of the rower, and an assessment immediately followed the all-out effort. The rowers were asked to assess their dyspnea retrospectively, i.e., during the 6-min effort.

Statistical analyses. One-way ANOVA with repeated measures and Bonferroni *post hoc* test were used to assess differences between the three different warm-up protocols and between the MIP values before and after the different warm-up protocols. Pearson's correlation coefficient was used to assess the association between variables. Values of $P < 0.05$ were considered statistically significant. Data points were means (± SE) unless otherwise stated.

RESULTS

Test-retest reliability of the 6-min all-out effort. Reliability was expressed as a coefficient of variation, (SD/mean) × 100; for mean power, this was 1.4% and the retest correlation was 0.99 (see Table 3).

MIP response to the respiratory warm-up. The respiratory warm-up was effective in enhancing the strength of the inspiratory muscles. MIP increased by 7.0 (± 1.0) % from baseline values.

Inspiratory muscle fatigue. After the 6-min all-out rowing effort, MIP was lower for all three protocols. After the SWU and the RWU, the deficits in inspiratory muscle strength were 10.2 (± 1.4) and 11.1 (± 1.3)%, respectively. In the RWUplus protocol fatigue was significantly reduced to 4.2 (± 0.3)% ($P < 0.01$) compared with the other two warm-up protocols (see Fig. 1).

Rowing performance. As can be seen from Table 4, power output in the 6-min all-out test was 3.2% higher after the RWU compared with power output after the SWU ($P < 0.01$). After the RWUplus, power output increased significantly a further 1.2% compared with the power output after the RWU ($P < 0.05$). The distances covered in meters were increased by 11 (± 15) m ($P < 0.05$) and 18 (± 13) m ($P < 0.01$) after the RWU and RWUplus protocols, respectively, compared with the SWU protocol. There were no significant differences between any gas exchange parameters.

Perception of dyspnea. The perception of dyspnea during the 6-min all-out effort was not statistically different between the SWU and RWU protocols. However, it was significantly decreased after the RWUplus protocol by 0.8 (± 0.3) and 0.6 (± 0.3) units of the Borg scale compared with the SWU and RWU protocols, respectively ($P < 0.05$; see Table 4). Even though none of the parameters related to the 6-min all-out effort were significantly correlated, the association between changes in dyspnea and improvements in power output gave an $r = 0.474$, which accounts for 22.5% of the variance.

DISCUSSION

The main finding of this study was that a specific respiratory warm-up has a significant impact upon rowing performance. Indeed, the RWUplus was more effective as a preparatory and warm-up routine for the 6-min all-out effort than both the RWU alone and the SWU protocols.

Reproducibility data for the 6-min all-out effort are in agreement with previous reports, suggesting that this test is very reliable and suitable for monitoring rowing performance (9,21). Indeed, high reproducibility was observed in

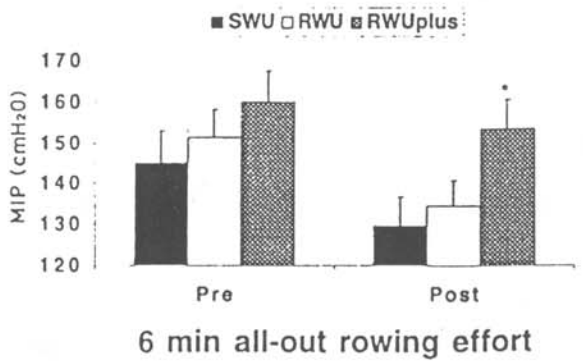

FIGURE 1—Maximum inspiratory pressures (MIP) in cm H_2O before and after the 6-min all-out rowing test, for the three different warm-up protocols. Values are means (± SE); * ($P < 0.05$) significantly different reduction of baseline MIP from the two other conditions.