

Designing a Warm-Up Protocol for Elite Bob-Skeleton Athletes

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Purpose: To investigate how different warm-ups influenced subsequent sled-pull sprint performance in Olympic-level bob-skeleton athletes as part of their preparation for the 2010 Winter Olympics. **Methods:** Three female and 3 male athletes performed 5 different randomized warm-ups of differing intensities, durations, and timing relative to subsequent testing, each 2 days apart, all repeated twice. After warm-ups, testing on a sled-pull sprint over 20 m, 3 repeats 3 min apart, took place. **Results:** Performance testing showed improvement ($P < .001$, $ES > 1.2$) with both increasing intensity of warm-up and closeness of completion to testing, with 20-m sled sprinting being 0.1–0.25 s faster in higher-intensity protocols performed near testing. In addition, supplementing the warm-ups by wearing of a light survival coat resulted in further performance improvement ($P = .000$, $ES 1.8$). **Conclusions:** Changing timing and intensity of warm-up and using an ancillary passive heat-retention device improved sprint performance in Olympic-level bob-skeleton athletes. Subsequent adoption of these on the competitive circuit was associated with a seasonal improvement in push times and was ultimately implemented in the 2010 Winter Olympics.

Keywords: sprint performance, body temperature, passive heat maintenance, winter sports

A warm-up is important for subsequent performance,^{1,2} and a recent meta-analysis suggests that 79% of research demonstrated improvement in performance with warm-up.³ Bob-skeleton (skeleton) is a winter Olympic sport in which participants push a sled for 20–30 m before launching their upper torso onto the sled and then “driving” down an ice course. The initial push demands great speed and power,⁴ which can be influenced by warm-up.^{1,2} The event is in cold environments, ranging anywhere from approximately +5°C to –40°C, and athletes spend considerable time prior to the race outside. Observing British international competing athletes, a typical pattern emerged: They perform warm-ups outside 30 to 40 min before race start. They come outside several minutes in advance of their race, stripping down to a light Lycra race suit. Similar observations have been recently reported by Sporer et al.⁵ Our purpose was to adjust warm-ups and examine subsequent performance outcomes. Athletes used their current warm-up protocol as the control basis against which we changed intensity, duration, and timing relative to performance testing.

Methods

Three female and 3 male British skeleton athletes competing for selection to the Olympic team participated. Male

athletes at time of study were (mean \pm SD) height 1.74 \pm 0.08 m, weight 78.7 \pm 10.2 kg, and age 28.3 \pm 3.1 years, while female athletes were height 1.72 \pm 0.02 m, weight 62.0 \pm 1.6 kg, and age 27.3 \pm 0.5 years. Warm-ups were performed at 9 AM on alternate days in a randomized counterbalanced manner. Protocol 1 (P1) consisted of a standardized version of the athletes’ own existing competition warm-ups. This warm-up took 20 minutes and was completed 35 minutes before testing. It consisted of 3 \times 20-m jogging and skipping with walking back; 3 \times 20-m of submaximal sprinting; 3 \times 20-m sprint form drills; 2 \times 20-m leg swings, fast feet and high knees; 3 \times 10-m maximal sprints; 30 seconds of mixed calisthenics (press-ups, dead bugs, planks); and 2 minutes of dynamic stretching. Protocol 2 (P2) consisted of the same timing and durations but with increased intensity due to including more sprint drills and sprints and reducing rest intervals. The load increase per time (meters covered) was approximately 30%.

Protocol 3 (P3) consisted of the same high intensity but was completed 15 minutes before testing. Protocol 4 (P4) was the same high-intensity warm-up but split into 2 \times 10-minute warm-ups, one completed 40 minutes before testing and the second completed 15 minutes before testing. In all protocols, athletes undertook 3 further short bursts (20- to 30-s duration) of activities such as press-ups or knee-ups at 12, 8, and 4 minutes before testing.

After completion of the warm-up trials, a further protocol 5 (P5) was undertaken in which a survival garment (Blizzard Survival Garments, UK) was worn, for passive heat retention, between warm-up activities and until testing while undertaking P4.

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Protocols, each 2 days apart, were repeated twice, at room temperature ($\sim 20^{\circ}\text{C}$, 70–75% humidity), giving a total of 6 trials per protocol per athlete. Room temperature was used, as it allowed compliance to this study within the time frame (off-season) available.

Heart rate (Polar, USA) and tympanic temperature (Braun, Germany) were recorded for each protocol. Tympanic was chosen to enable compliance, as athletes were reluctant to undertake core, skin, or muscle measurements.

Performance testing consisted of 3 repeats (each 3 min apart) of 20-m sprints pulling a weighted sled (7.5 kg for women and 15 kg for men) with timing gates at 20 m. This test has shown high validity according to British Bobskeleton for push performance. Initial analyses of data showed no effect of repeat sprints or protocol repeats or presentation order.

Descriptive statistics are presented as mean \pm SD. Sprint performance and physiological measures were analyzed in a post-only crossover design.⁶ Precision of estimation was indicated with 90% confidence limits. Magnitude of the difference between conditions was interpreted using a Cohen effect statistic, with <0.2 trivial, 0.2–0.6 small, 0.6–1.2 moderate, 1.2–2.0 large, and >2.0 very large.

Results

Within the same protocol testing and across a repeat of that protocol, individual athletes showed less than 1.5%

variation in performance on testing. In protocol 1, as an example, the mean and SD% difference in individual performance across the 6 trials was for women $0.6\% \pm 0.4\%$ and for men $0.8\% \pm 0.5\%$.

Performance varied significantly across the different warm-ups (Figure 1). Combining the data for each athlete in 6 trials per protocol into 1 pool of both men and women showed for average sled-pull times that all modified protocols were associated with faster sled pulls than the athletes' standardized warm-up (P1): P1 versus P2 ($P = .01$, ES = 0.6), versus P3 ($P = .000$, ES = 1.5), versus P4 ($P = .001$, ES = 1.0), and versus P5 ($P = .000$, ES = 1.8). P3 ($P = .000$, ES = 1.0), P4 ($P = .003$, ES = 0.4), and P5 ($P = .000$, ES = 1.2) showed significantly faster mean sled-pull times than P2, while P3 ($P = .005$, ES = 0.6) and P5 ($P = .001$, ES = 0.9) were faster than P4, and P5 (the addition of a heat-retention garment) was significantly faster (but at a small effect size) than P3 ($P = .004$, ES = 0.3).

Maximum heart rate and tympanic temperature increased significantly across warm-up protocols (Table 1).

On subjective report, athletes preferred P5 and P4 to P3 and P2. Compliance-wise, the general decision by athletes was to use P4 (despite data suggesting a lower performance outcome than P3) or, when heat-retention garments were available, P5.

Subsequently, in-season, a 3.53% ($\pm 0.61\%$) improvement in push track performance was seen with adoption of the routines (P4 and P5).

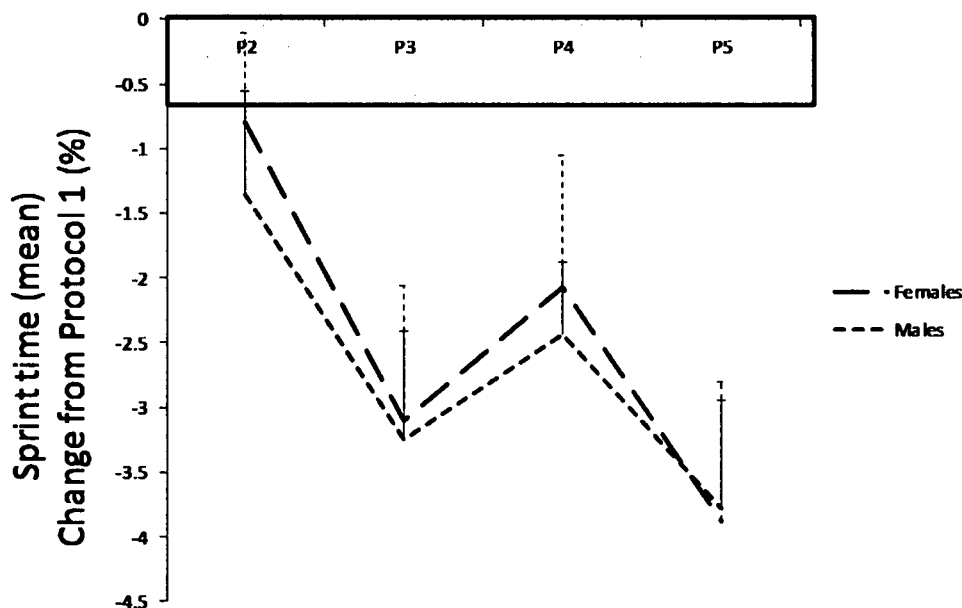


Figure 1 — Sled-pull sprint times (mean of 6 trials per protocol) \pm 90% confidence intervals (CI) presented as a change from the standard warm-up (P1) trial (% delta) for the different warm-up interventions. Top shaded bar indicates lower 90% CI for P1.

Table 1 Warm-Up Protocol-Related Changes (Post – Pre)

	P1	P2	P3	P4	P5
Maximum heart rate (beats/min)	138.0 ± 8.9	145.8 ± 7.1°	159.3 ± 9.8°*	157.2 ± 13.8°*	160.1 ± 14.2°*†
Rating of perceived exertion	2.5 ± 0.4	3.7 ± 0.5	4.5 ± 0.4	3.4 ± 0.6	3.3 ± 0.4
Tympanic change (°C) at room temperature	0.1 ± 0.2	0.5 ± 0.2°	0.9 ± 0.2°*†	0.6 ± 0.1°*	1.0 ± 0.3°*†‡

Note. Group mean ± SD is presented pooled across all protocol repeats combined for both women and men.

°Significant difference ($P < .001$) compared with P1. *Significant difference ($P < .001$) compared with P2. †Significant difference ($P < .001$) compared with P4. ‡Significant difference ($P < .01$) compared with P5.

Discussion

The results demonstrated that intensity, duration, and body temperature are characteristics of successful warm-up, the latter also being achievable by passive means. The 2 most successful protocols in term of performance were P3 and P5. P3 was associated with the highest intensity and duration of activity closest to performance testing, while P5 used this in a 2 × 10-minute split manner but incorporated the heat-retention garment. Tympanic temperature and heart rate were chosen due to athlete compliance and did show significance in difference.

In this group of elite skeleton athletes, high-intensity warm-up with some activity close to time of performance improved sprint performance, and this performance carried over to subsequent Olympic-cycle best push track times. Shorter durations were favored, and athletes subjectively feel better with these and with warm-ups with some overlap to previous traditions. Indeed, athletes chose to comply to a modified warm-up that did not produce the best performance data (albeit significantly better than their traditional one, and equal to the best when combined with a heat-retention garment). Athlete belief and acceptance were thus crucial to adoption of the warm-up going forward to the Olympic Games. The addition of a heat-retention garment between warm-ups and

up to performance testing had a beneficial performance outcome and was easily adoptable. Actual elite athletes' adoption and practicality in the competitive environment are essential factors to consider in studies of warm-ups if they are to be ultimately implemented.

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