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Why Train Together When Racing Is Performed Alone? Drafting in Long-Track Speed Skating

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Purpose: In long-track speed skating, drafting is a commonly used phenomenon in training; however, it is not allowed in time-trial races. In speed skating, limited research is available on the physical and psychological impact of drafting. The aim of this study was to determine the influence of "skating alone," "leading," or "drafting" on physical intensity (heart rate and blood lactate) and perceived intensity (perceived exertion) of speed skaters. ***Methods:*** Twenty-two national-level long-track speed skaters with a mean age of 19.3 (2.6) years skated 5 laps, with similar external intensity in 3 different conditions: skating alone, leading, or drafting. Repeated-measures analysis of variance showed differences between the 3 conditions, heart rate ($F_{2,36} = 10.546$, $P < .001$), lactate ($F_{2,36} = 12.711$, $P < .001$), and rating of perceived exertion ($F_{2,36} = 5.759$, $P < .01$). ***Results:*** Heart rate and lactate concentration were significantly lower ($P < .001$) when drafting compared with leading (heart rate $\Delta = 7$ [8] beats·min^{-1}, 4.0% [4.7%]; lactate $\Delta = 2.3$ [2.3] mmol/L, 28.2% [29.9%]) or skating alone (heart rate $\Delta = 8$ [7.1] beats·min^{-1}, 4.6% [3.9%]; lactate $\Delta = 2.8$ [2.5] mmol/L, 33.6% [23.6%]). Rating of perceived exertion was significantly lower ($P < .01$) when drafting ($\Delta = 0.8$ [1.0], 16.5% [20.9%]) or leading ($\Delta = 0.5$ [0.9], 7.7% [20.5%]) versus skating alone. ***Conclusions:*** With similar external intensity, physical intensity, as well as perceived intensity, is reduced when drafting in comparison with skating alone. A key finding of this study is the psychological effect: Skating alone was shown to be more demanding than leading, whereas leading and drafting were perceived to be similar in terms of perceived exertion. Knowledge about the reduction of internal intensity for a drafting skater compared with leading or skating alone can be used by coaches and trainers to optimize training conditions.

Long-track speed skating is an Olympic discipline where skaters race on a 400-m ice rink. Even though most medals can be won on individual races (distances ranging from 500 to 10,000 m), skaters often train together in groups. To maximize their skating performance, competitive skaters train at a high intensity, often in the crouched skating position (ie, small knee and trunk angle).[1] During training, they skate in a line to benefit from each other's drag. Therefore, the external training intensity of the skaters can be the same, but the internal intensity may be lower for skaters who are drafting behind others. Internal intensity is the disturbance in the homeostasis of the physiological and psychological processes. The external intensity is the work an athlete produces during training.[2] Speed skating is characterized by the crouched position of a speed skater without a saddle bearing their body weight, like in cycling. This results in intermittent blood flow restriction to the legs and deoxygenation of the muscles.[1] As such, skaters do not complete excessive amounts of training hours on the ice.[3] In the development of long-track speed skating, new race elements have been introduced. The team pursuit, Olympic discipline since 2006, and the mass start, Olympic discipline since 2018, are 2 elements in which it is permitted to skate behind other team members or competitors. In these pack-style races, drafting is a common race strategy. Little is known about the physical and psychological effect of drafting in long-track speed skating and how it can efficiently be used during training.

To limit the aerodynamic resistive force in a variety of sports, athletes follow closely behind one or more athletes; this is called drafting. Drafting reduces the energy expenditure of athletes in all kinds of sports. Research in cross-country skiing using the skating technique found a reduction in heart rate (9 bpm; 5.6%) while drafting.[4] Drafting in short-track speed skating resulted in a reduction in heart rate (6 bpm; 3.3%) and lactate (2.19 mmol/L; 28.3%).[5] Inline skating research also found a reduction in heart rate (2 bpm; 0.9%).[6] Research in cycling found a decrease in heart rate (17 bpm)[7] and a decrease in power output (131 W; 33.25%).[8] Running collectively showed lower levels of blood lactate relative to running alone.[9] Another study in cycling at a speed of 39.5 km/h showed a reduction in heart rate (12 bpm; 7%) and lactate (4.4 mmol/L; 52.4%) for the drafting cyclist.[10] Reductions for the drafting athlete when cycling at 41 km/h were also found for heart rate (18 bpm; 10.6%) and lactate (2.8 mmol/L; 44.4%).[11] Aside from the benefits in physical intensity, perceived intensity is expected to be lower under drafting conditions. This is supported by a small number of studies, which found reductions in perceived exertion for the drafting athletes.[6,9,12]

In individual long-track speed skating competition, speed skaters skate in separate lanes, and drafting is not possible. However, in each lap skaters cross lanes, during the crossing, one skater could benefit from drafting behind his opponent. During the team pursuit, drafting is apparent, while 3 skaters have to skate the distance as fast as possible together. In the pack-style races, such as the mass start and in marathon skating, drafting is common and frequent. Drafting reduces energy expenditure in many sports, but little is known about the effect of drafting during long-track speed skating. One study in a wind tunnel has been performed, with speed skaters positioned statically behind each other, which found a drag reduction of 16%

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and 23% when a skater was 2 and 1 m behind the leader, respectively.[13] More recent research in a wind tunnel found a drag reduction of 25.7% for the drafting speed skater while moving.[14] This creates the expectation that drafting will also reduce physical intensity in long-track speed skating. But, when skating on an ice rink, the skaters move by pushing their legs alternately to the side; and the skaters are not perfectly placed behind each other, as in the wind tunnel. Insight into the magnitude of the effects of drafting during skating can help trainers to decide upon the content of their on-ice training. It can also help in deciding the ratio between individual training and training together. In the latter, the results of this study can prove valuable in determining the strategies for team pursuit and pack-style race competitions. Therefore, the aim of this study was to determine the effects of "skating alone," "leading," or "drafting" on physical intensity (heart rate and blood lactate) and perceived intensity (perceived exertion) of ice speed skaters.

Methods

Participants

Twenty-two national-level long-track speed skaters participated in this study (males, n = 12 and females, n = 10). They were recruited from 2 professional regional talent teams. The skaters were active at the national and international levels. The skaters had a mean age of 19.3 (2.6) years, weight of 71.0 (7.8) kg, height of 179.5 (7.0) cm, shoulder width of 43.3 (2.9) cm, and skating experience of 9.3 (2.6) years, and they trained 14.9 (1.2) hours a week. They were divided into pairs matched with similar anthropometry and personal best times in the 1500 m. The participants were informed of the procedures of the study and signed a written informed consent, which was approved by the local ethical committee and was in accordance with the Declaration of Helsinki.

Design

During the test, the skaters skated 3 trials. Each trial consisted of 5 laps. This experimental research started with a warm-up of approximately 20 minutes, consisting of easy running and dynamic stretching off the ice and skating 5 laps in the same pairs at the same velocity as required in the test. The velocity was based on the participants' mean personal best 1500-m times. We took 85% of the velocity on the mean best 1500-m times of all participants per sex. This resulted in lap times of 36 seconds for males and 39 seconds for females. They performed the 3 trials in a random order under 3 different conditions: skating alone, skating in the leading position of the pair, and drafting behind the other skater of the pair (see Figure 1). After each trial, skaters had at least 10 minutes of rest for recovery in which they skated upright on the inner lane of the ice rink at a very low velocity or sat down. Before, during, and after the trials, heart rate was measured. Before and after each trial (within 1 min), lactate levels and RPE were measured (see Figure 2).

Methodology

Testing took place on a regular 400-m indoor lowland long-track ice rink. Skaters skated the inner lane of the race course (384 m per lap). Due to practical reasons, the test was performed on 2 different occasions with 10 and 12 skaters participating. The tests were carried out in the summer during the morning training, with the following circumstances at occasion 1 and 2: air pressure was 1020.6 and 1008.1 hPa, temperature of the concrete ice rink floor

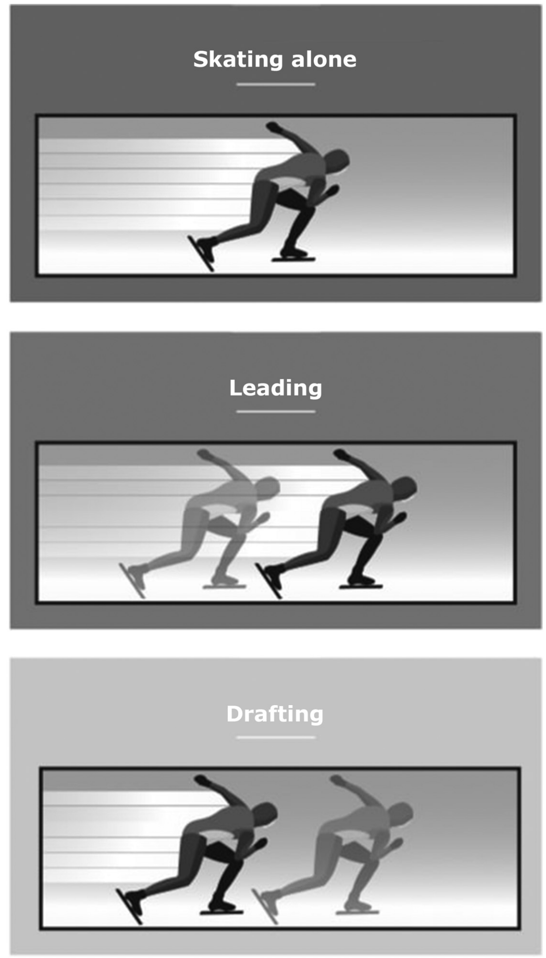

Figure 1 — Overview of the 3 conditions: skating alone, leading, or drafting.

was −11°C and −11.4°C, and ice rink temperature was 13°C and 11.9°C. In total, there were 40 and 32 skaters on the ice. The other skaters did not interfere with the skaters who performed the test. Each pair of participants was familiar with skating with each other and got a coach who monitored each trial. The coach provided lap times for steady velocity and reminded the skaters to execute good drafting skills. This meant skating in the same stroke and as close as possible behind the leader.

To monitor the internal training intensity, measures of heart rate, blood lactate, and rating of perceived exertion (RPE) were included. Heart rate was continuously monitored by Zephyr 3.8 and Zephyr BioHarness 3.0 with a frequency of 24 Hz. The data were stored on a laptop using OmniSense software (Medtronic Zephyr, Boulder, CO). The average heart rate over the last 3 laps was used for analysis. Blood samples were taken from the finger to measure blood lactate approximately within 1 minute prior to and after each trial and were immediately analyzed using Arkray Lactate Pro2 LT-1730 (Arkray Inc, Kyoto, Japan).[15] For monitoring RPE, the Borg CR-10 scale[16] was used. This is an accepted method, which correlates well with heart rate and lactate.[17–19] RPE is a subjective measure that provides additional information on the more objective measurements of heart rate and lactate. RPE was taken before and after each trial by asking skaters to select their rating from the scale provided. The ratings of the Borg CR–10 scale have 11 anchors, which run from 0 (rest) to 10 (maximal).[16]

Between the trials, the skaters had at least 10 minutes rest, so they had enough time to recover to baseline levels. Lactate and RPE were measured within 1 minute before each trial to ensure that all participants were fully recovered before each trial. If both values were considered to be high (lactate above 8 mmol/L and RPE above 4), the participant was excluded from the analysis.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics (version 25.0; IBM Corp, Armonk, NY). Data were checked for normality of distribution, equality of variance, and assumption of sphericity. All data are presented as mean (SD). Within-individual heart rate, lactate, and RPE were compared between the 3 conditions (skating alone, leading, and drafting) using repeated-measures one-way analysis of variance. To compare the 3 conditions with each other, a paired samples *t* test was used as a post hoc test. A *P* value of .05 was chosen to represent statistical significance. Effect sizes were calculated with Cohen *d*. Effect sizes *d* were considered as small (0.21–0.50), moderate (0.51–0.80), and large (>0.80).[20]

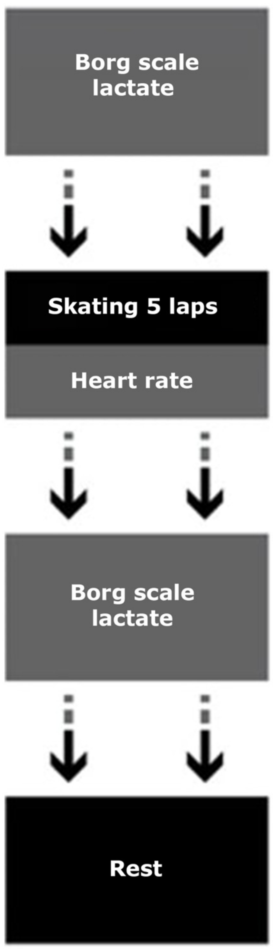

Figure 2 — Overview of 1 trial in the testing procedure.

Results

One participant showed high values on both parameters (lactate = 8.5 mmol/L, RPE = 4) preceding one of the trials and was therefore excluded from the analysis. All other participants were fully recovered before the start of all 3 trials. This was indicated by an average lactate concentration of 2.6 (1.2) mmol/L and an RPE of 1.1 (1.1). As the average velocity (males = 39.1–39.5 km/h and females = 37.2–37.4 km/h) was similar in all 3 trials, according to the lap times in seconds ($P > .05$), equal external intensity in the different conditions was supported.

Heart rate, lactate concentration, and RPE (mean [SD]) during skating alone, leading, and drafting are shown in Table 1. Individual data can be found in Figure 3. Repeated-measures analysis comparing heart rate, lactate, and RPE between the 3 conditions (skating alone, leading, and drafting) showed significant differences ($F_6 = 7$, $P < .01$). Significant differences were found between the 3 conditions for heart rate ($F_{2,36} = 10.546$, $P < .001$), lactate ($F_{2,36} = 12.711$, $P < .001$), and RPE ($F_{2,36} = 5.759$, $P < .007$).

Heart rate was significantly lower when drafting than when leading ($t = 3.888$, $P = .001$, $d = 0.73$) or when skating alone ($t = 4.902$, $P < .001$, $d = 0.83$), but no significant difference was found between skating alone and leading ($t = 0.493$, $P = .628$, $d = 0.10$). Lactate values were significantly lower when drafting compared with when leading ($t = 4.554$, $P < .001$, $d = 0.98$) or skating alone ($t = 5.172$, $P < .001$, $d = 1.14$) but not between skating alone and leading ($t = 0.837$, $P = .412$, $d = 0.17$). No significant difference between drafting and leading ($t = 1.503$, $P = .149$, $d = 0.31$) or between skating alone and leading ($t = 2.351$, $P = .029$, $d = 0.26$) was found for RPE. Between drafting and skating alone ($t = 3.600$, $P = .002$, $d = 0.53$), a significant difference was found.

Discussion

The aim of this study was to determine physical and perceived intensity of "skating alone," "leading," or "drafting" in long-track speed skating. The results from 21 national-level long-track speed skaters showed that, with a similar external intensity, the internal intensity differed between the conditions. Heart rate and blood lactate concentrations were lower during drafting than when leading or skating alone. A key finding of this study was the psychological effect: skating alone was shown to be more demanding than leading, whereas leading and drafting were perceived to be similar in terms of perceived exertion.

Table 1 Heart Rate, Lactate Concentration, and Rating of Perceived Exertion (0–10) for Each Condition and Between Conditions (N = 21), Mean (SD)

	Alone	Leading	Drafting	Δ alone–leading	Δ alone–drafting	Δ leading–drafting
Heart rate, beats·min^{-1}	174 (10)[a]	173 (10)	165 (11)[a]	1 (9)[a]	8 (7)[b,]*	7 (8)[a,]*
Lactate, mmol/L	7.2 (3.1)	6.7 (2.9)	4.4 (1.6)	0.5 (2.7)	2.8 (2.5)*	2.3 (2.3)*
Rating of perceived exertion	4.1 (1.7)	3.7 (1.3)	3.3 (1.3)	0.5 (0.9)*	0.8 (1.0)*	0.3 (1.0)

[a] One missing value. [b] Two missing values.
*$P < .05$.

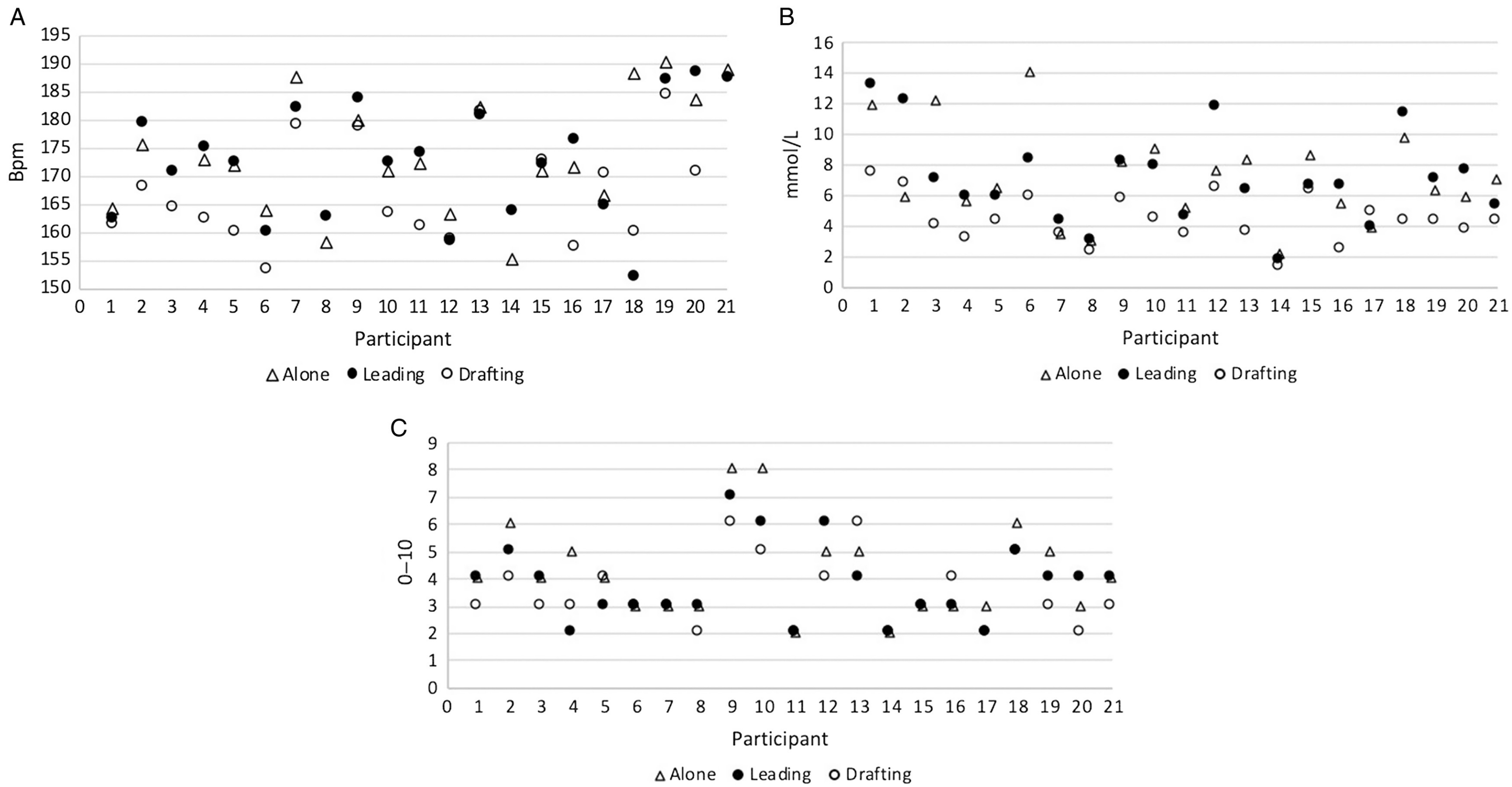

Figure 3 — Individual (A) heart rate (in beats per minute), (B) lactate concentration (in millimoles per liter), and (C) rating of perceived exertion (on a scale of 0 to 10) for each condition of all participants.

In the current study, drafting at a speed of 37.3 to 39.3 km/h resulted in a mean reduction in heart rate of 7 bpm compared with leading, which is a 4.0% reduction. Drafting compared with skating alone resulted in an 8 bpm (4.6%) reduction. Both reductions can be considered large according to the effect sizes. Compared with earlier research in cross-country skiing using the skating technique, a similar 9 bpm (5.6%) difference was found; however, this research was performed at a lower velocity (20 km/h).[4] Drafting in short-track speed skating at a speed of 32 km/h was found to elicit a 6 bpm reduction.[5] A study observing inline skating showed only a 0.9% reduction in heart rate as a result of drafting (25.2 km/h). The participants in this inline-skating study were recreational, and the study was performed at lower speed.[6] Drafting skills, therefore, appear to be essential in reducing heart rates—for example, being able to skate in the same stride pattern and as close as possible to the skater in front.[4–6] The 3 skating sports—speed skating, short track, and inline skating—showed smaller differences in heart rate as a result of drafting compared with cycling. When cycling at 41 km/h, greater differences were found.[11] This could be due to the crouched position of the skater, who has a lower aerodynamic drag than the larger frontal area of a cyclist. Another potential explanation is the complexity of staying close to a leader while skating. Drafting may be less complicated in cycling in which no sideway movements are made in order to move in a forward direction, as is the case in skating. Also, in the corners during speed skating, one cannot draft as closely as in cycling because of the crossover technique, and the skaters must overcome extra centripetal forces.

The current study showed that when an athlete is drafting, a reduction in lactate of 2.3 mmol/L (28.2%) was found, compared with leading, and a reduction of 2.8 mmol/L (33.6%) was found with skating alone. These significant differences were found with large effect sizes. In short track, it was also observed that lactate concentrations were lower while drafting: 2.19 mmol/L (28.3%).[5] Larger differences were found in cycling studies for lactate, with 4.4 mmol/L (52.4%)[10] and 2.8 mmol/L (44.4%) at 41 km/h.[11] Running collectively was also found to result in lower levels of blood lactate than running alone.[9] These results suggest that drafting actually reduces lactate concentration in all these types of sports, including long-track speed skating.

The perceived intensity (RPE) when skating in a pair, either when leading or drafting, was not significantly different. However, the RPE was higher when skating alone, compared with drafting

0.8 (16.5%) AU and leading 0.5 (7.7%) AU. The regulation of the exercise intensity is not purely based on physiological information but also on an external environmental stimulus, like the presence of another athlete.[21] Overall, it seems that perceived exertion is highest when skating alone. A reason for the difference in RPE could be that skaters are used to skating in a group during training, so they may feel more comfortable together. An uphill cycling study found that cyclists experienced more pleasure when following a leading teammate uphill. They suggested that higher ratings of pleasure had a positive impact on performance.[22] A more positive state and a reduced perceived exertion were also found during collectively running compared with running alone.[9] This could also explain the reduced RPE when skating together compared with skating alone. However, it is important to take into account the individual preferences of an athlete. Psychologically, the benefits may differ per athlete. It might be possible that some athletes prefer to train alone. Reasons for this could be, for example, that they do not like their training partner, do not want others to benefit from them, or have difficulties adapting to another skater's technique. Therefore, caution is warranted when generalizing the results concerning perceived intensity.

The significant differences in physiological as well as perceived intensity revealed in this study raise the question: What would be the best condition to train? If the goal is to excel in the individual time-trial distances, it might be smart to train alone more often during ice training. Without the benefits of drafting, skating alone is a good way to simulate competition, making on-ice training more specific. A drawback of training alone, however, can be that the skater is not able to get used to race velocities at a lower intensity. The internal intensity of on-ice speed skating training is so high that in order to reach high velocities multiple times, drafting behind a faster skater is necessary. Besides, even though skaters from a team are each other's opponents in competition, training together can be motivating and fun. As such, it is advised to combine both individual and group training. Based on the results of this study, trainers can decide upon the training conditions. Depending on the goal of the training, a decision can be made to skate trials (a) either alone with high physiological as well as perceived intensity, (b) leading a pair with high physiological and reduced perceived intensity, or (c) drafting with reduced physiological as well as perceived intensity. Future studies can shed more light on the benefits of training in larger groups compared with training in pairs.

Some limitations have to be acknowledged in this study. This research did not consider the differences in types of speed skaters (eg, sprinters vs long distance skaters) and compared only pairs of 2 skaters. During the test, other skaters were also skating on the ice rink, which resulted in wind circulation; however, the influence is considered minimal because of the low number of other skaters. Although the influence is considered minimal because of the low number of other skaters. Directions for future research are to include more than 2 speed skaters. This could help to unravel which position is most beneficial in terms of energy savings. Insight herein is relevant for both team pursuit as well as marathon competitions.

Practical Implications

The optimum training condition, whether drafting, leading, or skating alone, depends on the goal of the training session. Drafting allows for training at higher velocities and for more repetitions while maintaining a reduced internal load. Leading the group is beneficial for training at a higher intensity and is psychologically similar to drafting. Skating alone combines the same physical load as leading with an increased perceived intensity and simulates best the individual competition. See Supplemental Figure S1 (available online). As such, it may be questioned whether training together is always the best option when racing is performed alone.

Conclusion

The results from this study indicate that with a similar external intensity, physical intensity (heart rate and lactate) as well as perceived intensity (RPE) is reduced when drafting in comparison with skating alone. Leading appears to be equally demanding compared with skating alone in terms of physical intensity and, to drafting, in terms of perceived intensity. These results provide valuable practical input for training in speed skating.

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