The Impact of Different Competitive Environments on Pacing and Performance

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ORIGINAL INVESTIGATION

The impact of different competitive environments on pacing and performance

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ABSTRACT

Purpose. In real-life competitive situations, athletes are required to continuously make decisions about how and when to invest their available energy resources. This study attempted to identify how different competitive environments invite elite short-track speed skaters to modify their pacing behaviour during head-to-head competition. **Methods.** Lap times of elite 500, 1000 and 1500 m short-track speed skating competitions between 2011–2016 (n=34095 races) were collected. Log-transformed lap and finishing times were analysed with mixed linear models. The fixed effects in the model were sex, season, stage of competition, start position, competition importance, event number per tournament, number of competitors per race, altitude, and time qualification. The random effects of the model were Athlete identity and the residual (within-athlete race-to-race variation). Separate analyses were performed for each event. **Results.** Several competitive environments, such as the number of competitors in a race (a higher number of competitors evoked most likely a faster initial pace; CV=1.9-9.3%), the stage of competition (likely to most likely, a slower initial pace was demonstrated in finals; CV=-1.4-2.0%), the possibility of time qualification (most likely a faster initial pace; CV=2.6-5.0%) and competition importance (most likely faster races at the Olympics; CV=1.3-3.5%), altered the pacing decisions of elite skaters in 1000 and 1500 m events. Stage of competition and start position affected 500 m pacing behaviour. **Conclusion.** As demonstrated in this study, different competitive environments evoked modifications in pacing behavior, in particular in the initial phase of the race, emphasizing the importance of athlete-environment interactions, especially during head-to-head competitions.

KEYWORDS: Pacing strategy, Affordance, Ecological psychology, Decision-making, Sport

INTRODUCTION

The regulation of the exercise intensity over an exercise bout, a process known as pacing, is widely recognized as an essential determinant of performance.[1] In this regulatory mechanism, the sensation of fatigue and a willingness to tolerate discomfort in anticipation of future rewards appears to play a crucial role.[2] Yet the decision-making process involved in the regulation of exercise intensity has been shown to be rather complex. Several physiological, psychological and biomechanical variables have been revealed to influence on the outcome of pacing decisions[2] and performance.[3] The importance of the interaction between the exerciser and environmental cues has been emphasized, in particular in the context of decision-making and pacing in head-to-head competition.[2,4] Perceptual affordances provided by the environment can invite athletes to respond, thereby evoking in-race adaptations of pacing behavior.[2,4] As shown before in observational and experimental studies, an opponent could be such an affordance, inviting exercisers to adjust their pacing behavior.[4–6] For example, the presence of a virtual opponent has been revealed to improve performance.[5,7–9] Moreover, different behavior of the opponent has been shown to invite different pacing responses.[5]

However, apart from the opponents as most obvious affordances in competition, many other external cues will be presented simultaneously to an exerciser in real-life competitive situations. Therefore, it seems likely that the response of an exerciser to an opponent is not only based on the opponent itself, but also on the context in which the opponent is presented to the exerciser. Indeed, we have already shown that a change in an exerciser's internal state, such as fatigue, alters the response to an opponent.[9] In the present study we will explore the effect of different competitive environments on pacing and performance in short-track speed skating competitions, a sport in which it has been shown that the pacing behavior of a competitor is significantly affected by the pacing behavior of the other competitors.[6,10,11] We hypothesize that different competitive environments, such as the number of competitors within a race, the stage of competition, and the additional possibility of time fastest qualification, could affect the chosen pacing behavior and performance when competing against others. This would demonstrate the importance of the context in which the opponent is presented to the exerciser in the decision-making process involved in pacing.

METHODS

Participants and data acquisition

Finishing and intermediate lap times were gathered for men and women from 500 m (4.5 laps), 1000 m (9 laps) and 1500 m (13.5 laps) Short Track Speed Skating World Cups, the European Championships and World Championships during the seasons 2010/11 until 2015/16. In total, 47 indoor competitions (thirty-four World Cups, six European Championships, six World Championships, and the Olympic Games) were analysed. Each short-track competition consisted of qualification stages in which a skater had to qualify for the next stage by finishing in first or second position, and the final race in which the goal was to win the event. Lap times were recorded for each competitor automatically at the finish line, using electronic time-measuring systems based on optical detectors that started automatically by the firing of a starting-gun. The International Skating Union (ISU) demands that lap times are recorded with the accuracy of at least a hundredth of a second. Therefore, for every automatic timekeeping system that was used, a certificate stating the reliability and accuracy of the system had to be presented to the referee before the competition, ensuring that all systems recorded with the accuracy of at least a hundredth of a second. No written consent was given by participants as all data used are publicly available at the ISU website (http://www.sportresult.com/federations/ISU/ShortTrack/) and no interventions occurred during the data collection. The study was approved by the local ethical committee and in accordance with the Declaration of Helsinki.

In total, 3414 500 m races (14036 skating performances), 3210 1000 m races (13646 skating performances) and 1851 1500 m races (10894 skating performances) were analysed. Whereas falls and/or disqualifications could affect the lap times and positioning of the athlete him/herself as well as those of the other competitors (especially for the lower placed finishers) possibly leading to a misinterpretation of the results, skating performances from races with a disqualification, a fall and/or races with one or more missing values were excluded. In addition, outliers, defined as performances with a standardized residual >5.0, were excluded from the dataset.[12] A standardized residual >5.0 means that the performance was far slower than normal for the given skater. This resulted for the 500 m in 12550 of the 14036 skating performances (89.4%), for the 1000 m in 12143 of the 13646 skating performances (89.0%), and for the 1500 m in 9402 of the 10894 skating performances (86.3%) that were examined.

Statistical analysis

The mixed linear modelling procedure in SPSS was used for the analyses of each event. Finishing and lap times were log transformed before modelling, because this approach yields variability as a percent of the mean (CV), which is the natural metric for most measures of athletic performance.[13] Subsequently, within- and between-athlete CV were derived by back transformation into percentages of the residual and subject random effects in the mixed model. Separate analyses were performed for data from each event. The fixed effects in the model were Sex (men/women), Season (2010/11 up until 2015/16), Stage of competition (final, semi-final, quarter-final, rep. semi-final, rep. quarterfinal, rep. heats, heats, preliminaries), Start position (inner lane to outer lane), Competition importance (World Cup, European Championships, World Championships, and Olympic Games), Event number per tournament (sometimes an event is performed twice in one Tournament weekend, e.g. 2x 500 m event), Number of competitors per race (varies from two to nine competitors), Altitude (sea-level/high altitude; i.e. >1000m above sea-level), and the opportunity to qualify for the next stage as one of the time fastest if not qualified via finishing position (Time qualification; no/yes). The random effects of the model were Athlete identity (between-athletes differences) and the residual (within-athlete race-to-race variation). The dependent variables were the natural log of the lap times and finishing times in an event; analysis of these transformed variables yields coefficients of variation (CV), which are variations in performance expressed as a percent of average performance.[14] Precision of the estimates of CV are shown as 95% confidence limits which represent the limits within which the true value is 95% likely to occur. A spreadsheet was used to combine and compare fixed effects and CVs.[15] For the interpretation of the probability that an effect was substantial or trivial, we used the following scale: < 0.5%, most unlikely; 0.5-5%, very unlikely; 5-25%, unlikely; 25-75%, possibly; 75-95%, likely; 95-99.5%, very likely; >99.5, most likely.[12]

RESULTS

Mean ± SD of the lap times and finish times in seconds of the 500, 1000 and 1500 m event can be found in Table 1.

500 m event

Fixed and random effects per lap and for the finish time can be found in Table 2 for 500 m races. Men were most likely faster compared to women in all laps. The fixed effect of Season indicated a faster completion of the final three laps (likely to very likely substantial), while differences in the first lap time over the seasons are most likely trivial. Lap times and finishing times were most likely completed faster in finals, semi-finals, and quarterfinals compared to the preliminary stages of the competition. The fixed effects of number of competitors within a race, the competition importance, the possibility of time qualification, and the event number per tournament appeared to be most likely trivial for each lap and for the finishing time. Start position had a most likely substantial effect in the first lap, indicating a more inner start position led to faster lap times. Interestingly, races performed at high altitude only led to a likely positive effect compared to sea-level in the final lap. A more inner or outer start position did not led to any likely effect on lap times or finish time.

1000 m event

Fixed and random effects per lap and for the finish time can be found in Table 3 for 1000 m races. Lap times and finishing times were most likely faster for men compared to women. The fixed effect of Season indicated a change in chosen pacing behavior over the seasons to a more conservative starting pace and faster final lap times. Except for the first lap, a likely to most likely positive effect on lap times and finish time was found at high altitude compared to sea level. The very likely to most likely substantial fixed effect for the number of competitors within a race in the first four laps, indicates a higher number of competitors leads to a faster initial pace and faster finish time compared to a lower number of competitors within a race. The possibility of time fastest qualification led to a most likely positive effect on lap time in the first three laps and a very likely positive effect on the finish time. The very likely to most likely substantial effect of competition importance in the first four laps, appears to be mainly due to differences in initial pace between the Olympic Games on one hand, and the World cups, European and World championships on the other. Initial pace during the Olympic Games was found to be most likely faster (1.3-6.9%). A more inner or outer start position or whether it was the first or second time the event was organized in a tournament weekend did not led to any likely effect on lap times or finish time. Finals, semi-finals, quarterfinals, and heats were most likely leading to faster lap times in all laps compared to repechage races (1.4-5.9%) and the preliminaries (0.3-5.1%).

1500 m event

Fixed and random effects per lap and for the finish time can be found in Table 4 for 1500m races. Lap times and finishing times were most likely faster for men compared to women. The fixed effect of Season indicated a change in chosen pacing behavior over the seasons to a more conservative starting pace and faster final lap times. High altitude had a most likely positive effect on the first ten lap times and the finish time compared to sea level performances. The most likely substantial fixed effect for the number of competitors within a race in the first seven laps indicates a higher number of competitors leads to a faster initial pace and faster finish time compared to a lower number of competitors within a race. The possibility of time fastest qualification led to a most likely positive effect on lap time in the first five laps and a most likely positive effect on the finish time. The most likely substantial effect of competition importance in the first six laps, appears to be mainly due to a differences initial pace during the Olympic Games. Initial pace during the Olympic Games was found the be most likely faster (3.2-8.3%) compared to the World cups, European and World championships. Whether it was the first or second time the event was organized in a tournament weekend had a possibly to most likely substantial effect on the first six lap times, indicating a faster initial pace if it was the second time the event was organized in a weekend. The fixed effect of Stage of competition indicated a slower initial pace is adopted the further in the tournament. Finals are slower in the first laps compared to all other stages of competition, while semi-finals and quarterfinals are starting slower compared to all other stages of competition except the finals.

DISCUSSION

The present study aimed to examine the effect of different competitive environments on pacing and performance in a head-to-head structured competition, such as short-track speed skating. Several competitive environments, such as the number of competitors in a race, the stage of competition, the tournament, and the start position appeared to alter the pacing decisions of elite short-track speed skaters. Our findings demonstrate the importance of the external setting in which an opponent is presented, and highlights several novel external cues that need to be incorporated in understanding the complex decision-making process involved in pacing.

Different competitive environments appeared to affect mainly the initial phase of a race. As some laps are more influenced than others, it indicates that the decision-making process involved in pacing is influenced by the included variables in the present study. In this respect, we have shown in a previous study that in this initial stage elite short-track speed skaters are highly variables between races, however, within a race short-track speed skaters appear to adjust their pace to the behavior of the other contenders.[6] This effect of the competitive environment on initial pace could be seen as well when presenting an opponent to athletes in a controlled laboratory setting. Cyclists seemed to adapt their initial pace in order to keep up with the pace of their virtual opponent.[5] However, a change in pace of the opponent halfway the time-trial did not have a major effect on the pacing behavior of the same cyclists.[5] A likely explanation for why external cues mainly seem to affect the decision-making of exercisers in the beginning of a race could be the perceived level of fatigue of the exerciser. Variables such as perceived exertion have been shown to be key components in exercise regulation,[2,16,17] and will likely accumulate throughout the race. In this perspective, a higher level of fatigue has indeed been shown to alter the attentional focus from external to internal related variables.[18]

For many years, the central governor model has been the predominant theory underpinning exercise regulation, arguing a subconscious governor that would set the pace and protect homeostasis.[19,20] However, the governor model has been criticized for several reasons. For example, the fact that catastrophic failures of homeostasis can and do occur in athletes.[21,22] questions the existence of a governor protecting homeostasis at all costs as explained in a recent review on the regulation of exercise.[2] The present study provides another complication for the model: if pacing would be based on matching a predetermined template with the current bodily state, in respect to the remaining distance ahead, this would require the exerciser/governor to have thought of a template or schema for each possible combination of external cues presented around the exerciser before starting to exercise. All of these templates will have to be stored somewhere in the exerciser's memory, leading to a storage problem, a phenomenon that is well-discussed in motor control literature.[23]

Exercisers are required to decide continuously about how and when to invest their available energy resources during their competition.[2] In this decision-making process, an important role has been proposed for the interaction between the exerciser and the environment surrounding the exerciser.[2,4] At any point the external world around the exerciser presents multiple invitations for actions to the exerciser, so-called affordances.[24,25] These invitations for action can arise and dissipate over time, and evoke an exerciser's decision to remain on current pace, to slow down or to accelerate.[2] With the multitude of affordances that are presented to an exerciser continuously and simultaneously, it is up to the athlete to act upon certain affordances, and not on others.[26]

Arguably the clearest example of how competitive environments could impact on pacing behavior is illustrated by the possibility of time qualification. In some stages of some competitions it was possible to qualify for the next stage not only via finishing position, but also via qualification on the basis of time achieved for the time fastest skaters in that stage of competition whom did not qualify via finishing position in their race. When the possibility to qualify as one of the time fastest in that stage of competition was present, races in that particular stage of competition started most likely faster in the 1000 m and 1500 m event compared to that same stage in other competitions when the possibility of time fastest qualification was not present. This faster initial pace led to very likely (1000 m event) and most likely (1500 m event) faster finishing times when time fastest qualification was possible.

Another environmental factor that appeared to be a crucial factor for the initial pace was the number of competitors competing within a race. That is, the lower the number of competitors within a race the slower the adopted initial pace by the competitors compared to a higher number of competitors. An effect that was especially apparent during the 1000m and 1500m competitions. A confounding effect of group size on performance has been reported before.[27,28] Performance of individual members of a group tend to become increasingly less in a cooperative setting as the size of their group increases, and effect well known as the Ringelmann effect.[27,28] To our knowledge, this is the first time a contrary confounding effect is found for group size on decision-making and performance in a competitive situation.

Interestingly, possibly faster finishing times were revealed over the seasons in the 500 m event. The faster finishing times were established mainly by a likely to very likely faster completion of the final three laps rather than by a faster initial lap (most likely trivial effect over the seasons). At the same time, this study once again highlights the importance of the start position for 500m short-track speed skating competitions.[11,29,30] In contrast to the 500 m event, a change in chosen pacing behavior to a more conservative starting pace and faster final lap times was found over the seasons for the 1000 and 1500 m event. This could be an indication of an increased depth of competition over the years. That is, a similar change to a more conservative initial pace was found in the final stages of the tournament in comparison to the preliminary stages of the tournament during the 1500 m event. For the 500 and 1000 m event, lap times and finishing times were most likely faster in finals, semi-finals, and quarterfinals compared to the preliminary stages of the competition. Remarkably, during the Olympic Games the skaters adopted a faster initial pace compared to World cups, European and World championships, leading to faster finishing times in the 1000 m and 1500 m event. Differences in pacing and performance for competition importance in the 500 m event were found to be most likely trivial.

Noteworthy, yet not surprisingly, Sex and Altitude affected performance. Men completed their races most likely faster compared to women, while races at high altitude led to most likely faster finishing times compared to races at sea-level for the 1000 and 1500 m event. Interestingly, the difference in finishing time between sea-level and high altitude races was most likely trivial for the 500 m event. In terms of pacing, races at sea-level were most likely slower in the first ten laps of the 1500 m event. For the 1000 m event all laps were likely to most likely faster at high altitude, except for the first lap, while for the 500 m event only the final lap was very likely faster at high altitude.

The possibility to benefit from the effect of drafting behind their opponent is crucial in in short-track speed skating competitions, and could reduce air frictional losses up to 23%.[31,32] Therefore, adjusting your own pacing behavior based on your competitors could provide a clear advantage in short-track speed skating. Whether this has an effect on the influence of the competitive environment on pacing decisions is yet unclear. However, one could expect at least comparable results in sports where aerodynamics play a similar prominent role, such as cycling. In addition, it seems likely that a variable such as time fastest qualification could invite to adjust the chosen pacing behavior in other sports such as for example running, although more experimental evidence is required to support this hypothesis.

Practical applications

Previously, we demonstrated that the behavior of the other contenders in the race is an important affordance in elite short-track speed skating competitions.[6] That is, elite short-track speed skaters adjust their pacing response during competition heavily based on the actions and pacing behavior of the other competitors in their race.[6] However, the adopted pace by the competitors during a race appeared to vary widely between races. The present study revealed that part of this variability per race could be related to the context in which a race is presented. Several competitive environments, such as the number of competitors in a race (a higher number of competitors evoked most likely a faster initial pace), the stage of competition (likely to most likely, a slower initial pace was demonstrated in finals), the possibility of time qualification (most likely a faster initial pace) and competition importance (most likely faster races at the Olympics), altered the pacing decisions of elite skaters in 1000 and 1500 m events. In addition, the stage of competition and start position affected pacing behaviour in the 500 m event.

Conclusions

A multitude of external cues, inviting for action, are presented continuously and simultaneously to an exerciser during a competition. As demonstrated in this study, different competitive environments impacted on pacing behavior, in particular in the initial phase of the race. This emphasizes the importance of athlete-environment interactions, especially during head-to-head competition. To understand the decision-making involved in pacing both the internal state of the exerciser as well as the external world around the exerciser need to be considered.

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Tables

Table 1. Mean ± SD of the lap times and finish times in seconds of the 500, 1000 and 1500 m event

	500m	1000m	1500m
Lap 1	7.33 ± 0.35	13.72 ± 0.99	9.73 ± 1.06
Lap 2	9.33 ± 0.38	10.42 ± 0.80	13.16 ± 1.68
Lap 3	8.88 ± 0.39	10.07 ± 0.66	12.14 ± 1.48
Lap 4	9.02 ± 0.41	9.83 ± 0.53	11.60 ± 1.26
Lap 5	9.27 ± 0.44	9.66 ± 0.46	11.10 ± 1.06
Lap 6		9.54 ± 0.46	10.66 ± 0.84
Lap 7		9.49 ± 0.49	10.30 ± 0.65
Lap 8		9.57 ± 0.57	10.06 ± 0.55
Lap 9		9.80 ± 0.66	9.89 ± 0.49
Lap 10			9.75 ± 0.48
Lap 11			9.66 ± 0.51
Lap 12			9.66 ± 0.60
Lap 13			9.80 ± 0.71
Lap 14			10.08 ± 0.84
Finish time	43.82 ± 1.81	92.09 ± 4.18	147.59 ± 7.93

Table 2. Random (x/÷ 95% CI) and fixed effects (± 95% CI) per lap and for the finish time for 500m short-track speed skating races.

	Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Finish time
Random effects						
Between-athlete	2.1 x/÷1.08	2.0 x/÷1.08	2.6 x/÷1.08	2.7 x/÷1.08	2.7 x/÷1.08	2.5 x/÷1.07
Within-athlete	2.3 x/÷1.01	2.0 x/÷1.01	2.1 x/÷1.01	2.3 x/÷1.01	2.8 x/÷1.01	1.8 x/÷1.01
Fixed effects						
Sex	7.5 ±0.2 [MS]	6.2 ±0.1 [MS]	6.3 ±0.2 [MS]	6.3 ±0.2 [MS]	6.1 ±0.2 [MS]	6.4 ±0.1 [MS]
Season	0.0 ±0.3 [MT]	1.0 ±0.2 [PS/PT]	1.3 ±0.3 [VS]	1.2 ±0.3 [LS]	1.2 ±0.3 [LS]	1.0 ±0.2 [PS/PT]
Stage of Competition	-0.8 ±0.5 [LT]	-1.1 ±0.4 [PS/PT]	-1.4 ±0.4 [VL]	-1.3 ±0.5 [LS]	-1.2 ±0.6 [PS/PT]	-1.1 ±0.4 [LS]
Start position	-2.2 ±0.2 [MS]	0.0 ±0.2 [MT]	-0.1 ±0.2 [MT]	-0.1 ±0.3 [MT]	-0.2 ±0.3 [MT]	-0.4 ±0.2 [MT]
No of ST	-0.1 ±0.3 [MT]	-0.3 ±0.2 [MT]	-0.1 ±0.2 [MT]	-0.1 ±0.3 [MT]	-0.1 ±0.3 [MT]	-0.1 ±0.2 [MT]
Altitude	0.1 ±0.2 [MT]	0.6 ±0.1 [MT]	0.8 ±0.2 [VT]	0.9 ±0.2 [PS/PT]	1.2 ±0.2 [VS]	0.8 ±0.1 [MT]
Competition importance	0.1 ±0.3 [MT]	0.5 ±0.4 [MT]	0.2 ±0.4 [MT]	0.1 ±0.4 [MT]	0.0 ±0.5 [MT]	-0.2 ±0.5 [MT]
Event No. per tournament	-0.1 ±0.1 [MT]	-0.1 ±0.1 [MT]	-0.1 ±0.1 [MT]	0.1 ±0.1 [MT]	0.1 ±0.1 [MT]	0.0 ±0.1 [MT]
Time qualification	-0.0 ±0.3 [MT]	-0.1 ±0.2 [MT]	-0.2 ±0.3 [MT]	-0.2 ±0.3 [MT]	-0.1 ±0.4 [MT]	-0.1 ±0.2 [MT]

[MS] most likely substantial; [VS] very likely substantial; [LS] likely substantial; [PS] possibly substantial; [PT] possibly trivial; [LT] likely trivial; [VT] very likely trivial; [MT] most likely trivial.

Table 3. Random (x/÷ 95% CI) and fixed effects (± 95% CI) per lap and for the finish time for 1000m short-track speed skating races.

	Lap 1	**Lap 2**	**Lap 3**	**Lap 4**	**Lap 5**	**Lap 6**	**Lap 7**	**Lap 8**	**Lap 9**	**Finish time**
Random effects										
Between-athlete	1.5 x/÷1.12	1.2 x/÷1.16	1.0 x/÷1.17	0.8 x/÷1.16	0.8 x/÷1.15	1.4 x/÷1.11	2.5 x/÷1.09	3.2 x/÷1.08	3.4 x/÷1.09	1.6 x/÷1.09
Within-athlete	5.4 x/÷1.01	6.2 x/÷1.01	5.0 x/÷1.01	3.8 x/÷1.01	3.1 x/÷1.01	2.8 x/÷1.01	3.1 x/÷1.01	3.8 x/÷1.01	4.8 x/÷1.01	2.6 x/÷1.01
Fixed effects										
Sex	5.0 ±0.3^{MS}	5.5 ±0.3^{MS}	5.9 ±0.3^{MS}	6.4 ±0.2^{MS}	6.9 ±0.2^{MS}	6.9 ±0.2^{MS}	6.9 ±0.2^{MS}	6.9 ±0.3^{MS}	6.7 ±0.3^{MS}	6.4 ±0.2^{MS}
Season	-2.1 ±0.6^{MS}	-1.2±0.7$^{PS/PT}$	-0.1 ±0.5^{MT}	0.5 ±0.4^{VT}	0.7 ±0.3^{LT}	1.1±0.3$^{PS/PT}$	1.2 ±0.4^{LS}	1.4 ±0.5^{LS}	1.4 ±0.6^{LS}	0.2 ±0.3^{MT}
Stage of Competition	-2.0 ±1.2^{VS}	-1.6 ±1.4^{LS}	-1.8 ±1.1^{LS}	-1.7 ±0.9^{VS}	-1.7 ±0.7^{VS}	-1.4 ±0.6^{LS}	-1.4 ±0.7^{LS}	-1.4 ±0.9^{LS}	-1.3±1.1$^{PS/PT}$	-1.6 ±0.6^{VS}
Start position	-0.5±1.3$^{PS/PT}$	0.2 ±1.5^{LT}	0.2 ±1.2^{LT}	0.2 ±1.0^{LT}	0.0 ±0.8^{VT}	0.0 ±0.7^{VT}	-0.2 ±0.8^{VT}	-0.3 ±1.0^{VT}	-0.8±1.2$^{PS/PT}$	-0.1 ±0.7^{MT}
Number of shorttrackers	3.8 ±1.1^{MS}	3.9 ±1.2^{MS}	3.4 ±1.0^{MS}	1.9 ±0.7^{VS}	0.8 ±0.6$^{PS/PT}$	0.1 ±0.5^{MT}	-0.4 ±0.6^{VT}	-0.9±0.7$^{PS/PT}$	-0.9±0.9$^{PS/PT}$	1.5 ±0.5^{VS}
Altitude	0.2 ±0.3^{MT}	1.1 ±0.4^{LS}	1.5 ±0.3^{MS}	1.7 ±0.2^{MS}	2.0 ±0.2^{MS}	1.9 ±0.2^{MS}	1.7 ±0.2^{MS}	1.5 ±0.2^{MS}	1.4 ±0.3^{VS}	1.4 ±0.2^{MS}
Competition importance	1.6 ±1.1^{VS}	2.2 ±1.2^{MS}	1.9 ±1.0^{MS}	1.3 ±0.8^{VS}	0.5 ±0.6^{MT}	0.3 ±0.6^{MT}	0.0 ±0.6^{MT}	-0.4 ±0.7^{MT}	-0.7 ±0.9^{MT}	0.8 ±0.5^{LT}
Event No. per tournament	0.5 ±0.3^{MT}	0.7 ±0.3^{LT}	0.9 ±0.3^{LT}	0.8 ±0.2^{VT}	0.6 ±0.2^{MT}	0.2 ±0.2^{MT}	0.0 ±0.2^{MT}	-0.1 ±0.2^{MT}	-0.1 ±0.3^{MT}	0.4 ±0.1^{MT}
Time qualification	-2.6 ±1.0^{MS}	-2.6 ±1.2^{MS}	-2.3 ±1.0^{MS}	-1.1±0.8$^{PS/PT}$	-0.7 ±0.6^{LT}	-0.3 ±0.6^{MT}	-0.4 ±0.6^{MT}	-0.2 ±0.8^{MT}	-0.6 ±1.0^{VT}	-1.3 ±0.5^{VS}

^{MS} most likely substantial; ^{VS} very likely substantial; ^{LS} likely substantial; ^{PS} possibly substantial; ^{PT} possibly trivial; ^{LT} likely trivial; ^{VT} very likely trivial; ^{MT} most likely trivial.

Table 4. Random (x/÷ 95% CI) and fixed effects (± 95% CI) per lap and for the finish time for 1500m short-track speed skating races.

	Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Lap 7	Lap 8	Lap 9	Lap 10	Lap 11	Lap 12	Lap 13	Lap 14	Finish time
Random effects															
Between-athlete	2.5 x/÷1.12	2.0 x/÷1.18	1.8 x/÷1.20	1.4 x/÷1.22	1.1 x/÷1.25	0.8 x/÷1.30	0.5 x/÷1.37	0.6 x/÷1.27	0.7 x/÷1.21	1.4 x/÷1.12	2.7 x/÷1.09	4.0 x/÷1.08	5.0 x/÷1.08	5.2 x/÷1.08	1.4 x/÷1.11
Within-athlete	8.4 x/÷1.02	10.7 x/÷1.02	10.3 x/÷1.02	9.0 x/÷1.02	7.7 x/÷1.02	6.2 x/÷1.02	4.8 x/÷1.02	4.1 x/÷1.02	3.6 x/÷1.02	3.2 x/÷1.02	3.4 x/÷1.02	4.0 x/÷1.02	4.8 x/÷1.02	6.0 x/÷1.02	3.5 x/÷1.02
Fixed effects															
Sex	4.5 ^{MS} ±0.5	6.6 ^{MS} ±0.6	7.1 ^{MS} ±0.5	7.1 ^{MS} ±0.5	7.4 ^{MS} ±0.4	6.8 ^{MS} ±0.3	6.5 ^{MS} ±0.2	6.1 ^{MS} ±0.2	6.1 ^{MS} ±0.2	6.3 ^{MS} ±0.2	6.0 ^{MS} ±0.3	5.7 ^{MS} ±0.3	5.5 ^{MS} ±0.4	4.9 ^{MS} ±0.5	6.4 ^{MS} ±0.2
Season	-6.5 ^{MS} ±1.0	-5.1 ^{MS} ±1.2	-3.9 ^{MS} ±1.2	-2.6 ^{MS} ±1.0	-1.2 $^{PS/PT}$ ±0.9	-0.2 ^{VT} ±0.7	0.6 ^{LT} ±0.6	1.1 $^{PS/PT}$ ±0.5	1.4 ^{VS} ±0.4	1.4 ^{VS} ±0.4	1.6 ^{VS} ±0.5	1.6 ^{VS} ±0.6	1.8 ^{VS} ±0.7	2.0 ^{VS} ±0.8	-0.9 $^{PS/PT}$ ±0.5
Stage of Competition	0.6 $^{PS/PT}$ ±1.5	2.3 ^{LS} ±1.8	1.3 $^{PS/PT}$ ±1.7	-0.1 ^{LT} ±1.5	-1.4 $^{PS/PT}$ ±1.4	-1.7 ^{LS} ±1.0	-1.6 ^{LS} ±0.8	-1.4 ^{LS} ±0.7	-1.4 ^{LS} ±0.6	-1.3 ^{LS} ±0.6	-1.3 ^{LS} ±0.6	-1.5 ^{LS} ±0.7	-1.6 ^{LS} ±0.8	-1.7 ^{LS} ±1.0	-0.7 ^{LT} ±0.6
Start position	-1.3 $^{PS/PT}$ ±1.2	0.6 $^{PS/PT}$ ±1.5	0.2 ^{LT} ±1.7	0.1 ^{LT} ±1.3	0.0 ^{LT} ±1.1	0.0 ^{VT} ±0.9	-0.1 ^{VT} ±0.7	-0.1 ^{MT} ±0.6	-0.1 ^{MT} ±0.5	-0.2 ^{MT} ±0.5	-0.2 ^{MT} ±0.5	-0.3 ^{VT} ±0.6	-0.4 ^{LT} ±0.7	-0.7 ^{LT} ±0.9	-0.1 ^{MT} ±0.5
Number of shorttrackers	5.0 ^{MS} ±1.6	7.9 ^{MS} ±2.1	9.3 ^{MS} ±2.1	8.3 ^{MS} ±1.8	7.0 ^{MS} ±1.5	5.9 ^{MS} ±1.2	3.9 ^{MS} ±0.9	1.7 ^{VS} ±0.8	0.5 ^{LT} ±0.7	-0.1 ^{MT} ±0.6	-0.5 ^{LT} ±0.6	-0.8 $^{PS/PT}$ ±0.8	-0.8 $^{PS/PT}$ ±0.9	-0.6 ^{LT} ±1.1	3.7 ^{MS} ±0.7
Altitude	3.3 ^{MS} ±0.6	4.5 ^{MS} ±0.8	4.8 ^{MS} ±0.8	4.8 ^{MS} ±0.7	4.7 ^{MS} ±0.6	3.7 ^{MS} ±0.5	2.6 ^{MS} ±0.4	2.0 ^{MS} ±0.3	2.0 ^{MS} ±0.3	1.6 ^{MS} ±0.2	0.8 ^{VT} ±0.3	0.2 ^{MT} ±0.3	-0.1 ^{MT} ±0.4	-0.1 ^{MT} ±0.5	2.6 ^{MS} ±0.3
Competition importance	3.5 ^{MS} ±1.8	3.5 ^{MS} ±2.2	3.1 ^{MS} ±2.1	2.2 ^{MS} ±1.9	2.0 ^{MS} ±1.6	2.1 ^{MS} ±1.3	0.7 ^{LT} ±1.0	0.8 ^{LT} ±0.8	0.8 ^{LT} ±0.7	0.9 ^{LT} ±0.7	0.7 ^{VT} ±0.7	0.4 ^{MT} ±0.8	0.4 ^{VT} ±1.0	0.1 ^{MT} ±1.2	1.6 ^{MS} ±0.7
Event No.per tournament	0.8 ^{LS} ±0.4	1.0 $^{PS/PT}$ ±0.6	1.4 ^{LS} ±0.5	1.8 ^{MS} ±0.5	1.4 ^{VS} ±0.4	1.1 $^{PS/PT}$ ±0.3	0.8 ^{VT} ±0.3	0.6 ^{MT} ±0.2	0.2 ^{MT} ±0.2	-0.3 ^{MT} ±0.2	-0.3 ^{MT} ±0.2	-0.5 ^{MT} ±0.2	-0.5 ^{MT} ±0.3	-0.4 ^{MT} ±0.3	0.5 ^{MT} ±0.2
Time qualification	-3.9 ^{MS} ±1.3	-5.0 ^{MS} ±1.6	-4.4 ^{MS} ±1.6	-3.5 ^{MS} ±1.4	-2.6 ^{MS} ±1.3	-1.4 ^{LS} ±1.0	-0.5 ^{VT} ±0.8	-0.5 ^{MT} ±0.7	-0.2 ^{MT} ±0.6	-0.3 ^{MT} ±0.6	0.0 ^{MT} ±0.6	0.1 ^{MT} ±0.7	0.0 ^{MT} ±0.8	-0.2 ^{MT} ±1.0	-1.8 ^{MS} ±0.6

^{MS} most likely substantial; ^{VS} very likely substantial; ^{LS} likely substantial; ^{PS} possibly substantial; ^{PT} possibly trivial; ^{LT} likely trivial; ^{VT} very likely trivial; ^{MT} most likely trivial.

468