Starting Position Analysis of Winners in Short Track Speed Skating Competitions during 2007-2019

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Abstract: Short track speed skating is a racing sport on ice, in which contestants compete against each other instead of the clock. Thus compared to the speed and technical skating ability, equally, if not more important is race tactics. This study analysed in-depth the starting positions of winners in 121 competitions during 2007-2019, where 173 female and 247 male champions were announced correspondingly from 4313 female and 5212 male individual races (preliminaries, heats, quarter-finals, semi-finals, and final in 500m, 1000m, 1500m, and 3000m classifications), to explore a pattern of effective tactical positioning strategy. The Kendall's tau-b (rt) correlation between starting and finishing position decreases with race distance, which was highest and positive for all 500m races (0.347, $P<0.05$), which verified previous studies. Furthermore, starting position distributions of winners in each round and starting positions variations of champions along the rounds were analysed. Results show that skaters in the first track were inclined to win the rounds in 500m, 1000m and 1500m (28%, 28% and 22%, respectively) and the differences between starting and finishing positions for champions were minimized in semi-finals, indicating skaters should spare no effort in semi-final to achieve success.

1 INTRODUCTION

Short track speed skating is a form of competitive ice speed skating. In races, competitors are pitched against each other in groups ranging from four to six and skate on an oval ice track with a length of 111.12 meters. The races are fast and furious with fastest speed reaching 91 kilo-meters per hour and skaters who scramble for advantage regularly come to grief, often taking their rivals to ground with them. Furthermore, short track speed skating is a racing game that tests the speed, technical skating ability, and aggressiveness of its competitors. Unlike traditional long-track speed skating, contestants race against each other instead of the clock, which means it is how faster you are than you competitors rather than how fast you really are that will determine your final positions. To win the competition, strength quality (specifically defined as strength of leg muscles contraction) (Felser, 2016), propulsion (Bullock, 2008), pacing behavior (Noorbergen, 2016; Menting, 2019; Konings, 2016) and race tactics (Bullock, 2008, Konings, 2018) are important factors that coaches and athletes care about. And for race tactics, the starting position analysis of elite performance is the first step to acquire an effective tactical positioning strategy.

According to the special regulations of short track speed skating from ISU (International Skating Union), the lane positions of the first qualifying round of a distance are drawn by the Competitors Steward, which is a software that can assign the athletes with random lane numbers and for the subsequent rounds, the lane positions will be decided by the results from the preceding qualifying round. More specifically, athletes who advance to the next round will be regrouped according to their ranks in the preceding round and assigned the lane positions from the inside to the outside of the track by the order of their times commencing with the fastest time.

A study focused on the influence of starting position on finishing position in 500m races has found that there is a significant positive correlation between them especially in semi-finals and finals regardless of sexes. This study is based on the data from 500m races in ISU Short Track World Cups held over the five seasons from 1999-2000 to 2003-2004 (Maw, 2006). Muehlbauer et al. (Muehlbauer, 2011) extended that work by studying the relationship between the starting and finishing positions in all classifications based on the data from six

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Table 1: Pairwise correlation of rounds in different events. P-values are presented in brackets while asterisks indicate that correlations have significant difference.

	500	1000	1500	3000
Preliminaries	0.127** (0.000)	0.080** (0.000)	0.063** (0.004)	-
Heats	0.474** (0.000)	0.214** (0.000)	0.090** (0.000)	0.099** (0.000)
Quarter-finals	0.500** (0.000)	0.265** (0.000)	0.154** (0.000)	0.272** (0.000)
Semi-finals	0.465** (0.000)	0.219** (0.000)	0.162** (0.000)	0.397** (0.000)
Final	0.429** (0.000)	0.247** (0.000)	0.168** (0.000)	0.351** (0.000)
All	0.347** (0.000)	0.194** (0.000)	0.133** (0.000)	0.286** (0.000)

competitions during three seasons from 2006-2007 to 2008-2009 and what they have found is that the strength of correlation between the two positions decreases with race distance, which is highest and positive in the 500m races, lowest in the 1500m races and negative in the 3000m races and shows no sex difference. A more recent study in 2015 by William B. Haug et al. (Haug, 2015) also focused on World Cup 500m races, but was more interested in the relationship between start performance, which is measured by rank position entering first corner (RPEFC) and race outcome in elite athletes. As they had to use videos get the RPEFC, their data acquisition was limited by this labor-intensive work.

Although starting position analysis has shown its prominent role in short track speed skating races, yet current studies on it seem a little out-of-date with limited data. This study will first verify the previous conclusions with new larger data sets, and then focus on the winners in each round to find out their starting positions distribution, finally the champion's starting positions variations along the rounds are analysed to examine positioning strategies of this final winners.

2 METHODS

2.1 Data Acquisition

This paper investigated the relationship between the starting and finishing positions from 121 competitions (World Cup Series / Championships / Olympic Games) ranging from 2007/08 to 2019/20 season. All data were obtained from the official website of International Skating Union (ISU). The original dataset contains 183,158 match information with 714 female and 904 male athletes. After data cleaning, which attempted to discard data when penalty or disqualification occurred, 67,258 data points altogether including the positional information about 500m, 1000m and 1500m competitions in the preliminary, heat, quarterfinal, semi-final and final rounds were thus filtered.

2.2 Statistical Analysis

Starting positions were marked as 1 to 4 (500m and 1000m), and 1 to 6 (1500m) that represent inner to outer lanes. The Kendall's tau-b (rt) correlation was analysed to evaluate the correlation between starting and ending positions during race. The interpretations of correlation coefficients vary depending on magnitudes, with values lower than 0.2 or between 0.2 and 0.5 or larger than 0.5, indicating low, moderate and strong correlations, respectively. All data were analysed via the SPSS (version 16.0), and the level of significance was set as $P < 0.05$.

3 RESULTS

Three statistical experiments were conducted accordingly. (1) We calculated the correlations between starting and finishing position on the basis of rounds in all competitions to investigate the overall impacts of starting lanes on final ranking. (2) Based on the first part, the starting position distribution of the winners in each round were analysed. (3) Dynamical evolution of starting and finishing position for champions. These sequential characteristics revealed the strategic patterns of elite short track speed skating athletes.

3.1 Correlations between Starting and Finishing Position

Table 1 showed the correlations between starting and finishing position by different race distances and rounds. All of these correlations were significant, with the largest value appearing in the event of 500m

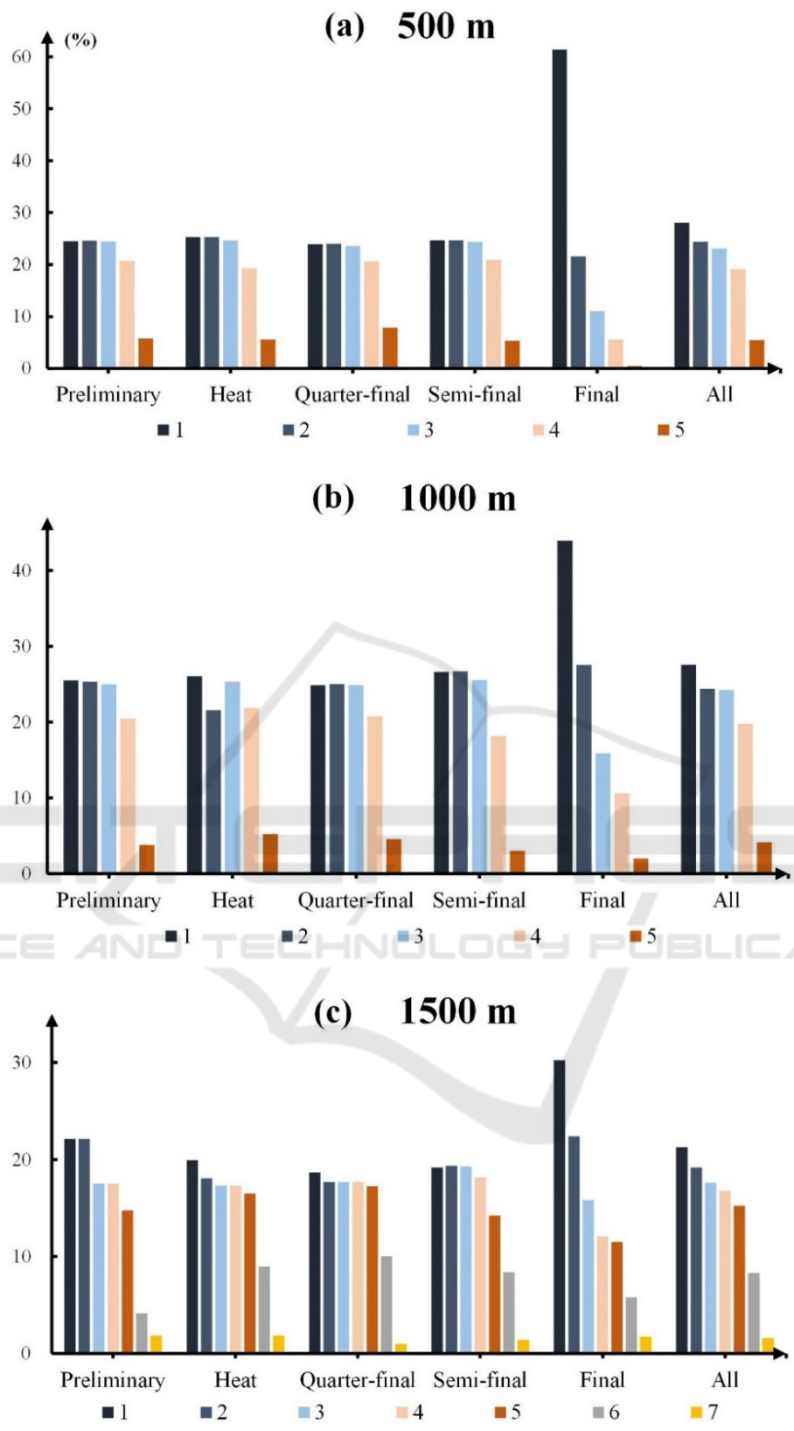

Figure 1: Starting position distribution for round winners.

(0.347, $P < 0.05$) and decreasing with progression in race distance 1000m (0.194, $P < 0.05$) and 1500m (0.133, $P < 0.05$). 3000m was an exception since the correlation coefficient is evidently higher that 1000m and 1500m (0.286, P<0.05). To figure out the abnormal phenomenon of 3000m, the correlations of 3000m Superfinal and 3000m Relay were calculated, respectively, the results were shown in Table 2. 3000m Superfinal race displayed the lowest correlation coefficient in all the race distances (-0.006, $P < 0.05$), and the high value was contributed by 3000m Relay (0.281, $P < 0.05$).

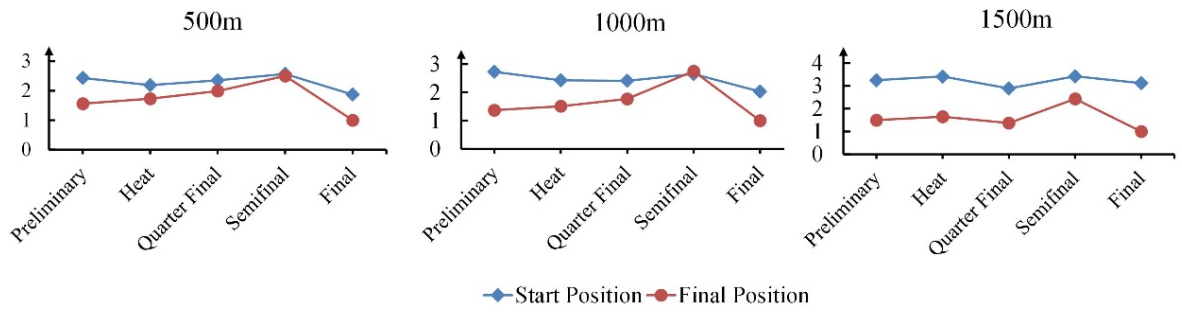

Figure 2: Dynamical evolution of starting and finishing position for champions by rounds.

Furthermore, the correlation coefficients by different rounds showed different tendencies. Such as 500m column in Table 1, although all the rounds were positively correlated, the correlation coefficients of preliminaries were obviously lower than others (0.127, $P < 0.05$), and the similar tendency was found in 1000m race. But in 1500m and 3000m race, correlation coefficients of Heats were also far lower than the final-rounds. By contrast, there was no specific linear relation about the correlation between starting and finishing position among quarter-final, semi-final and final rounds.

This research mainly concentrates on the individual races, so that we only conduct further investigation on 500m, 1000m and 1500m races. And sex was not considered in this research since the previous related researches drawn no conclusion about sexual significant difference.

3.2 Starting Position Distribution for round Winners

Figure 1 showed the starting position distribution of the winners in each round of the 500m, 1000m and 1500m race. In all three race distances, starting position 1 had the highest probabilities to be round winners (28%, 28%, 22%), the narrow margins suggested that advantages of starting lanes mattered in some extent. Observing the sub-images of each race distance, athletes with position 1 possessed an apparent advantage to win the final rounds (61%, 44%, 30%). On the contrary, in preliminary, heat, quarterfinal and semi-final rounds, the winners were mainly distributed in top 3 starting lanes. Skaters in last few lanes always contributed less winners in all kinds of race and rounds.

3.3 Dynamical Evolution of Starting and Finishing Position for Champions

In order to investigate the performances from hundreds of champions in every qualifying round, the dynamical evolvements of mean starting and finishing positions were calculated in Figure 2. The blue broken line with square mark represented starting positions, and the red one with circle represented finishing positions. The graphs of 500m and 1000m showed the similar pattern, where mean starting position and finishing position overlapped on semi-final. Besides, mean starting positions in all race distances and qualifying rounds were lower than 3 (out of 4), with mean finishing positions of 500m and 1000m lower than 3 (out of 4) and 1500m lower than 4 (out of 6).

4 DISCUSSION

The purpose of the present study was to determine the relationship between starting and finishing positions in championship-level short track speed skating races. The positive correlations occur in 500m to 3000m events, which are consistent with findings in [8, 9]. Interesting to note that the magnitude of correlation decreases by the accumulation of race distances, which suggests that a change in pacing strategy occurs depending on race distances. One possible explanation accounts for such phenomenon as longer distance is accompanied with more energy expenditure. For instance, the maintenance of leading position in 500m requires less energy than during 1000m or 1500m races (Prampero, 1976). In addition, negative correlation was obtained on superfinals of 3000m. From the energy point of view, it is more effective and less exhausting to draft than to lead in prolonged races (Kyle, 1979).

Additionally, the starting and finishing positions are closest in semi-finals for champions, because competitions in short track speed skating are elimination races, which means the performance differences between skaters shrink from preliminary to final. Elite skaters might adopt a strategy to conserve energy during qualifying rounds before semi-finals, however, they must keep excellent performance to advance to the final round. Besides, skaters in the first track are inclined to win the rounds in 500m, 1000m and 1500m (28%, 28% and 22%, respectively) after computing the mean positions for winners from preliminary to final qualifying round. Although starting positions are randomly drawn in preliminary, faster skaters acquire inner starting positions compared to slower ones in the subsequent rounds, which makes it more difficult for opponents to overtake.

Using artificial intelligence technologies to visualize and analyse data gains popularity in modern sports science, due to its outstanding abilities for generalization and efficiency in investigation of the nonlinear latent relations between variables. We acknowledge that some limitations exist in the present study, such as the involvement of starting and finishing positions alone instead of incorporating more detailed information extracted from racing profiles (i. e. split time). And any disqualifications or penalties are ruled out during data cleaning process, which, however, deserves a thorough analysis in the future work since these accidental events impacts on the adjustment of racing strategy for skaters.

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