Measuring straight time in elite short track speed skating relays

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Measuring straight time in elite short track speed skating relays

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Abstract

In short track speed skating, the relay exchange provides an additional strategic component to races by allowing a team to change the skater involved in the pack race. It is thought that during this period of the race, time can be gained or lost due to the execution of the relay exchange. However, the only temporal measurement reported in short track speed skating is lap time, of which the relay exchange accounts for less than 30 %. As such, a more appropriate measurement of relay exchange performance might be the time taken to complete the straight where the relay exchange was executed. The aim of this study, therefore, was to validate a method for measuring straight time during elite short track speed skating relays. The proposed method used a single HD camcorder to create virtual timing gates at the start and end of both straights. To validate the method, straight times measured using the single HD camcorder were compared to synchronised cameras located perpendicular to the virtual timing gates. The root mean square error for both near and far straight times was less than the temporal resolution of the camera. In addition, Bland-Altman plots showed that the single HD camcorder method was invariant to race speed. Collectively, these findings suggest that a single HD camcorder does provide a valid method for measuring straight times during elite short track speed skating relays.

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Keywords: Short track speed skating; relay exchange; race analysis.

1. Introduction

The short track speed skating relay involves three to six teams, racing head to head, around a 111.12 m oval. With each team consisting of four skaters, the relay event provides an additional strategic component to short track speed skating races; the relay exchange. Excluding the final two laps of the race, the relay exchange allows a team to change the skater involved in the pack race at any time [1]. With change in race responsibility initiated by touch, the relay exchange is typically executed by the skater involved in the pack race (skater 1) pushing the new skater (skater 2) at the start of the straight (Figure 1).

Teams will typically change the skater involved in the pack race every 1 ½ laps, resulting in 17 relay exchanges over 3000 m (27 laps) and 29 relay exchanges over 5000 m (45 laps). It is thought that during this period of the race time can be gained or lost, relative to other teams, depending on how effectively these relay exchanges are executed [3,4]. At present, however, the only temporal measurement reported during short track relays is lap time; of which the relay exchange, executed in the space of a single straight (28.84 m), accounts for less than 30 %. Therefore the time taken to complete the straight, where the relay exchange was executed, may provide a more appropriate temporal measurement for determining whether time is gained or lost during this period of the race.

When considering approaches to measure straight time, a camera located perpendicular to the finish line currently provides the highest temporal resolution during elite short track competitions; allowing race time to be reported to a thousandth of a second. Synchronised cameras located perpendicular to the start and end of both straights, therefore, could provide a similar resolution for measuring straight time. This method, however, is not viable in a competition environment due to: (1) the complexity of the

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setup; and (2) the required access to areas of the rink. For this reason, the aim of this study was to validate the use of a single HD camcorder to measure straight times during elite short track speed skating relays. In order to do this, straight times measured using a single HD camcorder were compared to synchronised cameras during a simulated 5000 m relay race.

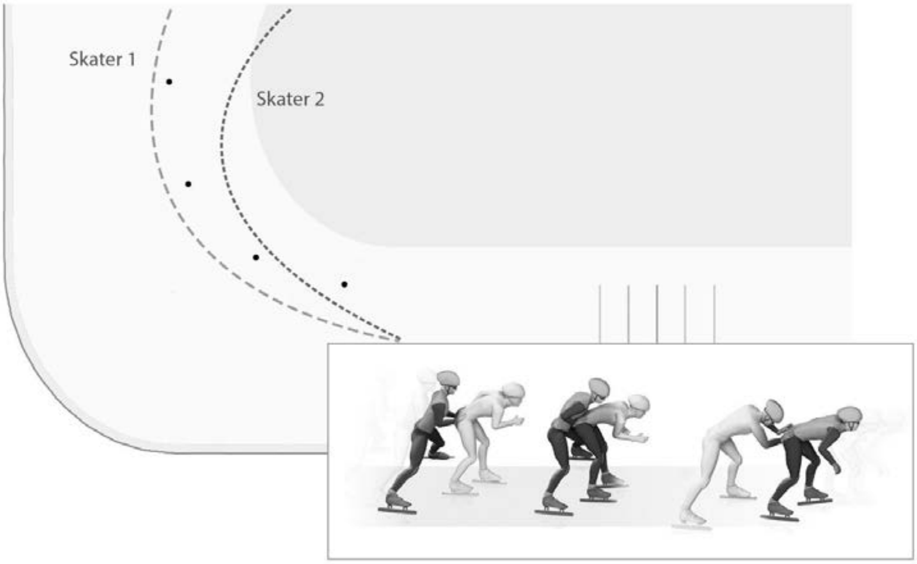

Fig. 1. The short track relay exchange. Adapted, in part, from *Short track speed skating* [2] (adapted with permission).

2. Method

2.1. Participants

Four short track speed skaters (3 males and 1 female, age 23.5 ± 0.5 years) participated in this study. All skaters were members of the Great Britain short track speed skating World Class performance programme. The study was approved by the Faculty of Health and Wellbeing Ethics Committee, Sheffield Hallam University, UK, with informed consent obtained from each skater prior to the study commencing.

2.2. Experimental procedure

The four skaters, as a team, completed a single 5000 m relay at the National Centre for Short Track Speed Skating, Nottingham, UK. The relay was performed at the end of a training session along with another team of Great Britain short track speed skaters. The second team were not analysed as part of this study.

2.3. Experimental setup

Two Prosilica Manta G033C machine vision cameras, operating at 100 Hz (200x650, progressive scan), were positioned perpendicular to the start (camera 3) and end (camera 4) of the straight in the spectator gallery opposite the relay start line (Figure 2). To ensure that the cameras were perpendicular to the start and end of the straight, the 1st and 7th track marking blocks of the corner were used to align a vertical line overlaid onto the cameras live view (Figure 3). The cameras were linked to a computer through a network switch and synchronised using each cameras timestamps. The synchronised cameras provided a comparative and more precise measure of straight time, akin to the current timing system used during elite short track speed skating competitions

Two Sony HDR PJ260VE camcorders, operating at 50 Hz (1920x1080, progressive scan), were mounted on tripods in the spectator galleries alongside both straights. The cameras were fixed approximately 45° to the rinks longitudinal axis with the cameras field of views adjusted to capture the full rink surface (Figure 2). Due to only one straight being measured by the synchronised cameras, the two camcorders allowed the near (camcorder 1) and far (camcorder 2) straights in a single HD camcorder view to be assessed.

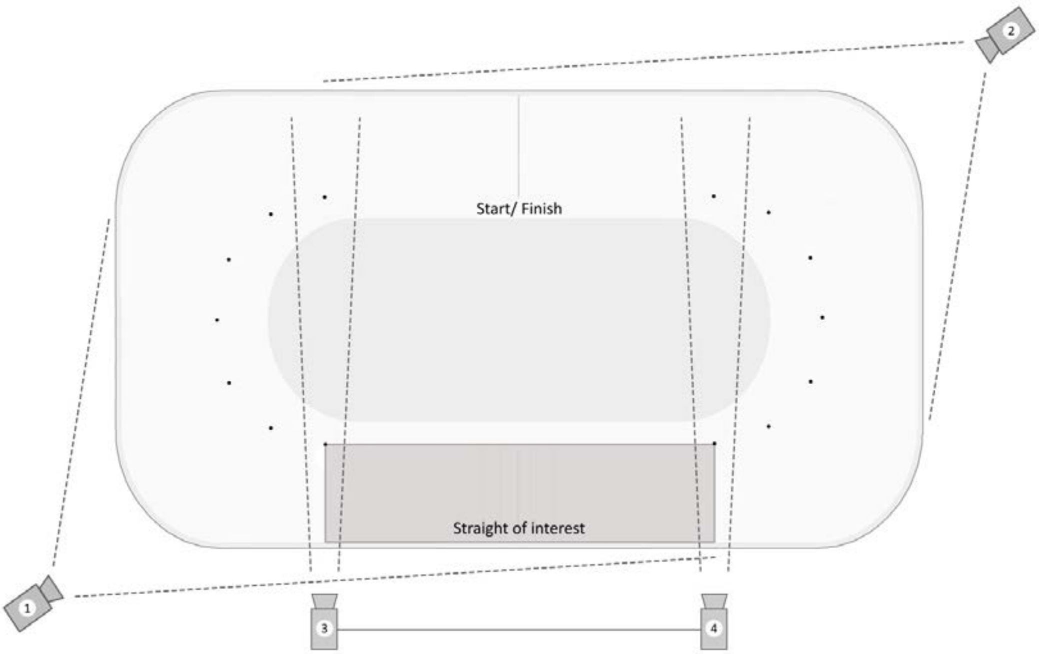

Fig. 2. The experimental setup used to validate the single HD camcorder method. Two single HD camcorders were used to provide the near (camcorder 1) and far (camcorder 2) view of the straight of interest, for a single camcorder. Cameras 3 and 4 represent the syncrohnised cameras at the start and end of the straight, respectively.

2.4. Race analysis

To measure straight time, virtual timing gates were overlaid onto the captured race footage. For the synchronised cameras, the vertical lines that ensured the cameras were perpendicular to the straight were also used as virtual timing gates (Figure 3). For the single HD camcorders, lines were extended through the 1st and 7th track marking blocks of both corners (Figure 3). A frame approximately two seconds into the captured footage was used to manually digitise the 1st and 7th track marking blocks to ensure that: (1) the camera had settled in its fixed position after record was pressed; and (2) the track marking blocks had not yet been displaced from their correct location.

For the entirety of the 5000 m relay, for all cameras, the frame number was digitised at the point where the lead blade of the skater active in the race first passed through a virtual timing gate (Figure 3). For both synchronised and single camcorder methods, straight time was calculated as the difference between frames from the start and end of the straight at a resolution of 0.01 seconds and 0.02 seconds, respectively. All manual digitisation was performed by a single operator using bespoke software.

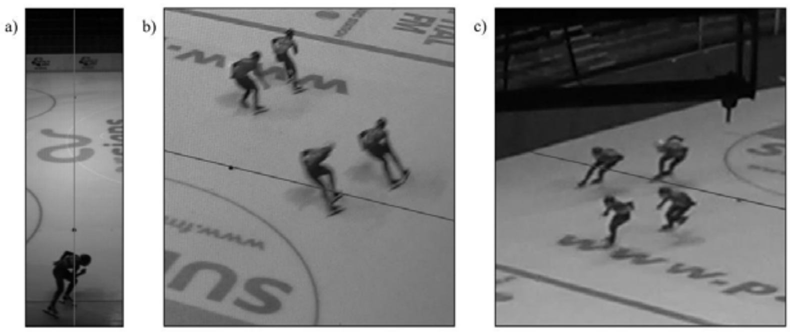

Fig. 3. The virtual timing gates at the start of the straight for the (a) synchronised; (b) near; and (c) far cameras. For all conditions, the figure highlights when the lead blade of the skater first passed through the timing gate.

2.5. Statistical analyses

All data were entered into Microsoft Excel (2010) for analysis. The root mean square error was used to measure the differences in straight time between the synchronised cameras and single HD camcorders. In addition, agreement was measured between the two methods using Bland and Altman's 95 % limits of agreement [5]. As described by Ludbrook [6], fixed and proportional biases were assessed using 95 % confidence limits for: (1) the mean difference; and (2) the intercept value of an ordinary least squares regression. For both assessments of bias, if the confidence intervals included zero no bias was present. For all statistics, the near and far straight camcorder views were treated as separate conditions.

3. Results

The mean straight times (n = 44, per method) for the synchronised, near, and far straights were 2.50 seconds (SD = 0.13), 2.49 seconds (SD = 0.13) and 2.50 seconds (SD = 0.12), respectively. When compared to the synchronised cameras, the root mean square error for both near and far straights was 0.011 seconds.

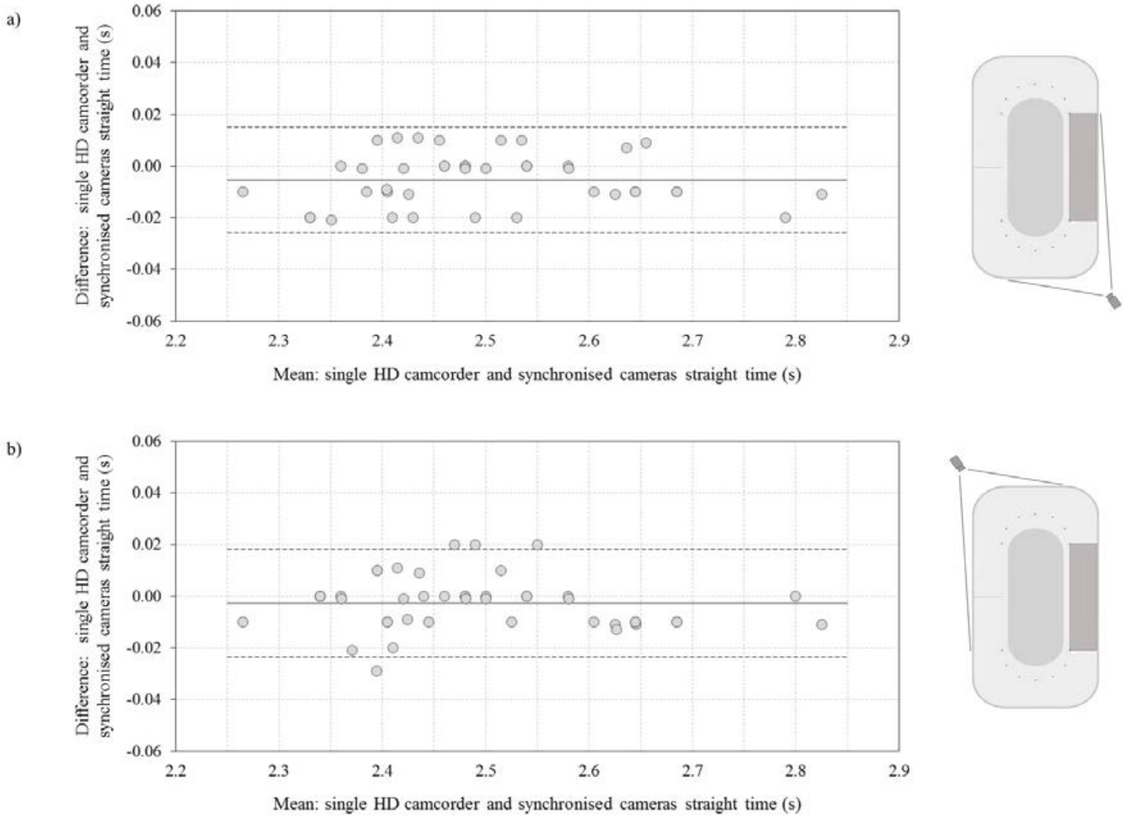

Fig. 4. Bland-Altman's 95 % limits of agreement for (a) near; and (b) far, straights.

The results of Bland-Altman's 95 % limits of agreement are presented graphically in Figure 4. The mean difference between the synchronised and single HD camcorder methods, for the near and far straights, were -0.0054 seconds, 95 % CI [-0.0085, -0.0024] and -0.0027 seconds, 95 % CI [-0.0059, 0.0004]. Likewise, the calculated intercepts from the ordinary least squares regression were -0.021 seconds, 95 % CI [-0.0851, 0.0430] and -0.018 seconds, 95 % CI [-0.0473, 0.0842].

4. Discussion

This study examined the validity of using a single HD camcorder to measure straight time during elite short track speed skating relays. When compared to measurements from synchronised cameras located perpendicular to the start and exit of the straight, the root mean square error for both near and far straights was less than the 0.02 second temporal resolution of the HD camcorder. Moreover, the single HD camcorder method was invariant to race speed with both near and far straights exhibiting no proportional bias. As such, the findings of this study suggest that that a single HD camcorder does provide a valid method for measuring straight time during the entirety of a short track relay at a resolution of 0.02 seconds. The resolution, determined by the camcorders frame rate, equates to approximately 1 % of the mean straight time.

When assessing agreement, however, the near straight did exhibit a mean fixed bias of -0.0054 seconds; highlighting a systematic under estimation in the measured straight time. Still, at approximately 25 % of the 0.02 second temporal resolution and 0.2 % of the overall mean straight time, the magnitude of the fixed bias is negligible. The fixed bias was most likely the result of occlusion at the end of the near straight leading to the misidentification of when the lead blade of the skater first passed through the virtual timing gate. For the single HD camcorder method, the end of the near straight is most prone to occlusion due to skaters skating away from the camera. Subsequently, no fixed bias was found for the far straight where the skaters were always skating towards the camera.

Due to the nature of the race format i.e., head to head pack style racing, occlusion is a problem faced by all image based measurement systems in short track speed skating; most recently discussed by Wang et al. [7]. We acknowledge, therefore, that with only two teams participating in this study the experimental procedure did not fully recreate the occlusion that a typical relay race may be subject too. More teams may have affected the validity of the method by having a negative impact on the identification of when the lead blade of a skater first passed through a virtual timing gate. In addition, the findings of this study are based on the camera view point at the National Centre for Short Track Speed Skating, Nottingham, UK. Although not investigated here, the validity of the method may be sensitive to changes in camera position (constrained by the stadia). We expect that a steeper view point of the short track would perform better in comparison to a shallow view point, due to minimising the potential for occlusion.

5. Practical implications

The findings of this study suggest that a single HD camcorder can be used to measure straight times during elite short track speed skating relays. As such, a more specific temporal measurement can now be used to assess whether the execution of the relay exchange allows time to be gained or lost during elite short track speed skating relays. Furthermore, although the rationale for this study was to measure straight time during short track relays, the method could be utilised during all short track speed skating race formats. To provide a more detailed assessment of where time was gained or lost over a whole lap, the method could be developed to measure corner entry and exit time as defined by Bullock et al. [8]. Although further work would be needed to validate these metrics, we believe that the validity of using a single HD camcorder would yield similar results to this study due to the end of the near straight always representing the virtual timing gate that is most susceptible to occlusion.

6. Conclusion

The findings of this study suggest that a single HD camcorder can be used to measure straight time during elite short track speed skating relays at a resolution of 0.02 seconds.

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Data availability

Due to ethical concerns, not all supporting data can be made openly available. Further information about the data and conditions for access are available at the Sheffield Hallam University research data archive: http://doi.org/10.17032/shu-160003

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