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Comprehensive Descriptive Video Analysis of All Short Track Speed Skating Falls in 16 International Competitions From 2021 to 2023 With Injury Reporting for the Canadian Team

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ABSTRACT

Short track speed skating (STSS) is an Olympic Winter Sport well known for its high-speed races—often exceeding 50 km/h—on short oval tracks. These extreme speeds and close athlete proximity make falls frequent, which can result in serious injuries. However, no study has comprehensively analyzed falls or fall-related injuries in this sport. The objectives of this study were to describe all fall incidents during international STSS competitions from October 2021 to October 2023 and to identify fall-related injuries sustained by Canadian athletes during these events. Video recordings from 16 International Skating Union and Olympic Games competitions were analyzed by two engineering interns to describe the characteristics of falls—including race type, location and cause of the fall, and body impact zone—among all participating athletes. In addition, the medical records of Canadian STSS athletes were reviewed by the team's physical therapists to document all fall-related injuries sustained by the athletes. Forty-three countries and 18 631 race entries were involved across the competitions. A total of 1505 falls were recorded, averaging 94.1 ± 39.6 falls per competition. Men had a higher fall proportion than women (8.6% vs. 7.1%, $p < 0.05$). Of the falls, 34.6% were individual and 60.9% were group falls. The Canadian team's injury-per-crash proportion was 7.1%. Fall-related injuries mainly involved strains in the spinal region and contusions on the lower legs. This first comprehensive analysis of falls in STSS revealed a high frequency of falls, with athlete interactions as the primary cause. It also highlighted a higher fall proportion among men and a higher incidence of injury to the spinal region, emphasizing the need for a deeper understanding of injury mechanisms to improve safety and protective measures.

1 | Introduction

Tracing its origins to the early 1900s, short track speed skating (STSS) made its official Olympic debut in 1992. In contrast to its elder counterpart, long track speed skating, STSS athletes skate in groups on short (111.12 m) oval tracks equipped with fixed blades, helmets, and cut-resistant skinsuits [1, 2]. Each race involves four to eight high-speed athletes who must skillfully employ techniques to execute strategic blocks and precise overtaking maneuvers, all while avoiding collisions and slips, with the ultimate goal of crossing the finish line first. Moreover, speed skating stands out as the fastest human-powered mode of propulsion on flat terrain, eclipsed only by cycling, as skaters achieve remarkable speeds surpassing

50 km/h [3]. These distinctive features, along with the opportunity to compete for a total of nine Olympic medals across individual events (500, 1000, and 1500 m for both men and women) and relays (mixed relay of 2000 m, women's relay of 3000 m, and men's relay of 5000 m), have significantly contributed to the global rise of STSS. This sport has gained significant popularity, especially in the Netherlands, Italy, South Korea, the USA, China, and Canada. Notably, it is Canada's most decorated winter sport, with an impressive total of 37 Olympic medals since 1992.

Despite its international popularity and long history, scientific literature on STSS remains scarce. A comprehensive review conducted by van der Kruk [3] found that only 15% of the 193 listed articles on speed skating focused on STSS. Currently, the literature on STSS comprises fewer than 50 articles, primarily focusing on athletes' physiology and tactics [3]. Intriguingly, the biomechanics of STSS and strategies to improve athletes' techniques, or mitigate injury risks, remain largely unexplored [4–9]. However, the risks of falls are particularly noteworthy in STSS owing to the proximity of competitors, elevated speeds, and sharp turns on ice [10–15]. These high-speed falls can lead to acute injuries, sometimes serious ones, such as fractures or concussions. While some epidemiological studies of injuries at the Olympic Games reported a low injury rate of just 0.9% among all STSS athletes at the 2006 Turin Olympics [16], others found significantly higher rates—up to 5.0% for women and as high as 27.8% for men during the 2010 Vancouver Olympics [17]—making it one of the winter sports with the highest rate of competition-related injuries during this event. Fall-related concussions are one of the most common injuries in STSS and can account for up to 33.3% of all injuries [18–20]. Notably, STSS has the highest estimated incidence of concussion (0.47/1000 h) among athletes training at the Institut National du Sport du Québec, nearly twice that of Olympic boxing (0.24/1000 h) [21]. These concussions, which occur slightly more often during training than in competition [21], can cause symptoms such as headaches, neck pain, dizziness, concentration difficulties, and sleep disturbances, ultimately affecting athletes' quality of life and careers [22].

Despite advancements in protective gear such as helmets and crash pads, the incidence of concussions appears to be on the rise [20], not only in competitions but also during training [21]. However, to our knowledge, studies on falls or fall-related injuries in STSS are limited to a handful of epidemiological investigations focused on recorded injuries in the sport [10, 11, 14, 15, 17–19] and a few studies on the shock absorption capabilities of STSS helmets [20, 23–25]. These latter studies tested the safety of STSS helmets using drop tests on an anvil in compliance with established standards [26, 27], with impact velocities not exceeding 6.2 m/s (22.3 km/h)—less than half of competition speeds. However, the slippery surface and the location of some falls—especially at the apex of a turn—often leave athletes with no time to slow down before hitting the protective crash pads at nearly full speed. Furthermore, the conclusions of these studies suggest that STSS helmets may not offer adequate protection against concussions, suggesting that these helmets are not sufficient to protect athletes in real high-speed competition conditions [23–25].

To date, no published study has specifically examined falls or fall-related injuries in STSS. However, a detailed analysis of these incidents could yield valuable insights into the causes of falls, the impact characteristics, and the specific anatomical regions affected—enabling the evaluation of protective gear under more realistic conditions in the future. The main objective of this study is then to thoroughly analyze all fall incidents during international STSS competitions using video analysis. The subobjective of this study aims to identify fall-related injuries sustained by Canadian athletes during these events. Going beyond, such analyses may provide insights into body segment velocities and orientations at the moment of impact, thereby helping to clarify injury mechanisms. This data will serve as a foundation for long-term studies aimed at improving and optimizing protective equipment, with the present descriptive study as a critical first step.

2 | Methods

This study was performed according to the guidelines of the Declaration of Helsinki and approved by the Research Ethics Committee of École de technologie supérieure (ÉTS) (protocol codes H20230106 and H2025102), and was carried out in collaboration with the International Skating Union (ISU). Established in 1893, the ISU is the sole organization officially recognized by the International Olympic Committee (IOC) to oversee international competitions in STSS. No identifiable personal data was disclosed.

2.1 | Study Design

This study adopted a comprehensive descriptive observational design combining retrospective and prospective video analyses of STSS competitions and a retrospective review of medical records from the Canadian STSS team. The study population included all athletes who participated in 16 international senior STSS competitions sanctioned by the ISU or the IOC between October 2021 and October 2023. All athletes had provided image rights release consent to the event organizing committees. Eligibility required that skaters had started at least one race during these events, with no exclusion based on nationality, sex, or performance ranking. The Canadian national team subpopulation (20 athletes: 9 men, 11 women) was specifically included for injury reporting based on the review of their medical records, accessible through the medical clinic of the Institut national du sport du Québec, following specific ethics approval. No additional exclusion criteria were applied.

The study was conducted in two phases. The retrospective phase (October 2021–March 2023) involved collecting and reviewing all available public YouTube recordings (1080p, 30 frames per second (fps)) from ISU and IOC senior international competitions. Since several falls were not visible in the ISU YouTube footage (4.5% of falls), the prospective phase (October 2023) consisted of live video capture during the Montreal ISU World Cups 1 and 2, where two additional fixed cameras (Canon VIXIA HF G20, 4K, 60 fps, Canon, New York, USA), installed with ISU approval, were positioned from the stands, perpendicular to the straight lines, to record the apex and exit of turns, complementing the existing YouTube broadcast. For both phases, when penalties were issued during races, additional video clips from all six cameras (1080p, 30 fps, one at ice level, two in the stands at the corner, two above the straight sections, and one fixed on the roof) stored on the ISU servers for arbitration training purposes were accessed, in addition to the edited footage available on YouTube, thereby expanding the range of perspectives and enhancing the accuracy of fall descriptions. Video sources, therefore, included official ISU YouTube race footage (both phases), ISU arbitration videos from six cameras (both phases), and two fixed cameras (prospective phase). All videos were downloaded and securely stored on a server at ÉTS.

2.2 | Data Analysis

In accordance with current recommendations for sports injury video analysis and guided by the principles of the QA-SIVAS scale [28], the events of interest (falls) were clearly defined, and the video sources as well as the number and placement of cameras were reported above. All races from the 16 competitions were reviewed by two interns in biomedical and biomechanical engineering with no prior experience in sports video analysis—each analyzing eight competitions, representing approximately 16–20 h of YouTube footage per competition—to systematically identify every fall, regardless of its intensity. Before the review, both observers received 2 days of training from an STSS performance analyst and followed a structured observation grid to ensure reproducibility in fall description. Any uncertainties regarding fall identification were resolved through mutual consensus. This approach aligned with recent best practices in video-based injury research across sport disciplines, emphasizing systematic data extraction, rater training, and documentation of video quality to enhance methodological rigor and reporting transparency.

The analysis covered all race phases, from preliminary rounds to finals, including repechages, individual, and relay events. For every identified fall in these competitions, data were systematically collected on the race (event, distance, type, etc.), the athletes involved (sex, country, etc.), and falls characteristics (location, type, cause, impact zones, etc.). A detailed description of the data reported for each fall was provided in the Appendix A. Figure 1 illustrates the various causes of falls, as well as crash pad and head impacts. Finally, following the video analyses, the medical records of Canadian STSS athletes were reviewed by the team's physical therapists. All injuries resulting from falls during the analyzed competitions were documented, along with their consequences in terms of competition withdrawals.

2.3 | Statistics

As this study provides a comprehensive descriptive analysis of STSS falls, the results were presented using descriptive statistics via mean and standard deviation. Chi-square tests were used to assess differences in the proportion of falls between men and women, the distribution of main reasons for individual and group falls, and the anatomical regions of initial impact on the ice in men and women, ensuring an adequate sample size beforehand [29]. All statistics were made using Excel (Microsoft 365 Subscription).

3 | Results

The 16 international senior STSS competitions included athletes from 43 countries, with an average of 100 ± 26 male (95% CI [88–113]) and 75 ± 22 female (95% CI [64–86]) athletes per competition, for a total of 18 631 race entries—each race entry representing one athlete at the starting line of a race. Of these race entries, 10 539 (56.6%) were from men and 8092 (43.4%) from women. A total of 1505 falls were identified, resulting in a global fall proportion of 8.1% and an average of 94.1 ± 39.6 falls (95% CI [74.7–113.5]) per competition. Among these falls, 910 involved men and 572 involved women, with 23 not identifiable in the videos of mixed relay events, corresponding to significantly different fall rates of 8.6% and 7.1%, respectively ($\chi^2(1) = 76.28$, $p < 0.001$).

Ten athletes participated in each competition for the Canadian STSS team, with 20 different athletes across all events (9 men and 11 women). Canadian athletes had a total of 1544 race entries, during which 127 falls were recorded, resulting in an overall fall proportion of 8.2%. The details of the top 10 countries with the highest race entries during the 16 competitions are presented in Table 1 for informational purposes.

Of these 1505 falls, 34.6% were individual falls, and 60.9% were group falls (4.5% were not visible on videos). Refer to Table 1 for the details of the top 10 countries. The distribution of falls based on the type of race, the race distance, and the location of the fall was depicted in Figure 2, while the distribution of individual and group falls across different race distances was given in Table 2. The shorter, and therefore faster, the races were, the higher the number of falls. However, the total number of races was higher for the shorter distances—typically 20 to 36 races per competition for the 500 m and 1000 m events—compared to 15 to 22 races for the 1500 m and 7 to 8 races for the relay events (2000, 3000, and 5000 m).

The primary reasons for individual falls were slipping (56.4%), stumbles (25.1%), cone incidents (9.8%), skates stuck in the ice (7.3%), skates contacts (0.2%), and relay exchanges (0.2%) (no data for the remaining 1.0%). The chi-square test revealed a statistically significant difference in these proportions ($\chi^2(5) = 735.67$, $p < 0.001$). Slipping incidents were highly overrepresented, whereas skates contacts and relay exchanges were strongly underrepresented according to the analysis of standardized residuals. Similarly, the main reasons for group falls were opponent contacts (40.5%), opponent falls (25.7%), skates contacts (25.2%), pushes/blocks (5.3%), relay exchanges (2.3%), and cone incidents (0.4%) (no data for the remaining 0.6%). The chi-square test revealed a statistically significant difference in these proportions ($\chi^2(5) = 729.82$, $p < 0.001$). Opponent contacts were highly overrepresented, whereas relay exchanges and cone incidents were strongly underrepresented according to the analysis of standardized residuals.

Out of the 1505 recorded falls, 83.5% involved an impact with the protective crash pads (11.2% did not, and 5.3% lacked visible

FIGURE 1 | Images showing various causes of falls, falls with and without crash pad impact, and falls with direct and indirect head impacts.

TABLE 1 | Number of race entries and fall rates of the top 10 major nations in STSS.

Country	No. of race entries (rank no.)	No. of falls (rank no.)	Falls rate (%)	Individual falls (%)	Group falls (%)
Canada	1544 (1)	127 (4)	8.2	35.4	63.0
Korea	1475 (2)	97 (9)	6.6	16.5	79.4
The Netherlands	1373 (3)	112 (6)	8.2	33.0	64.3
China	1277 (4)	77 (10)	6.0	35.1	64.9
Italy	1207 (5)	108 (3)	8.9	34.3	63.9
Japan	1051 (6)	80 (8)	7.6	33.8	62.5
USA	1028 (7)	79 (7)	7.7	30.4	68.4
Poland	953 (8)	118 (1)	12.4	41.5	55.1
Kazakhstan	912 (9)	84 (2)	9.2	26.2	66.7
Hungary	881 (10)	72 (5)	8.2	33.3	62.5

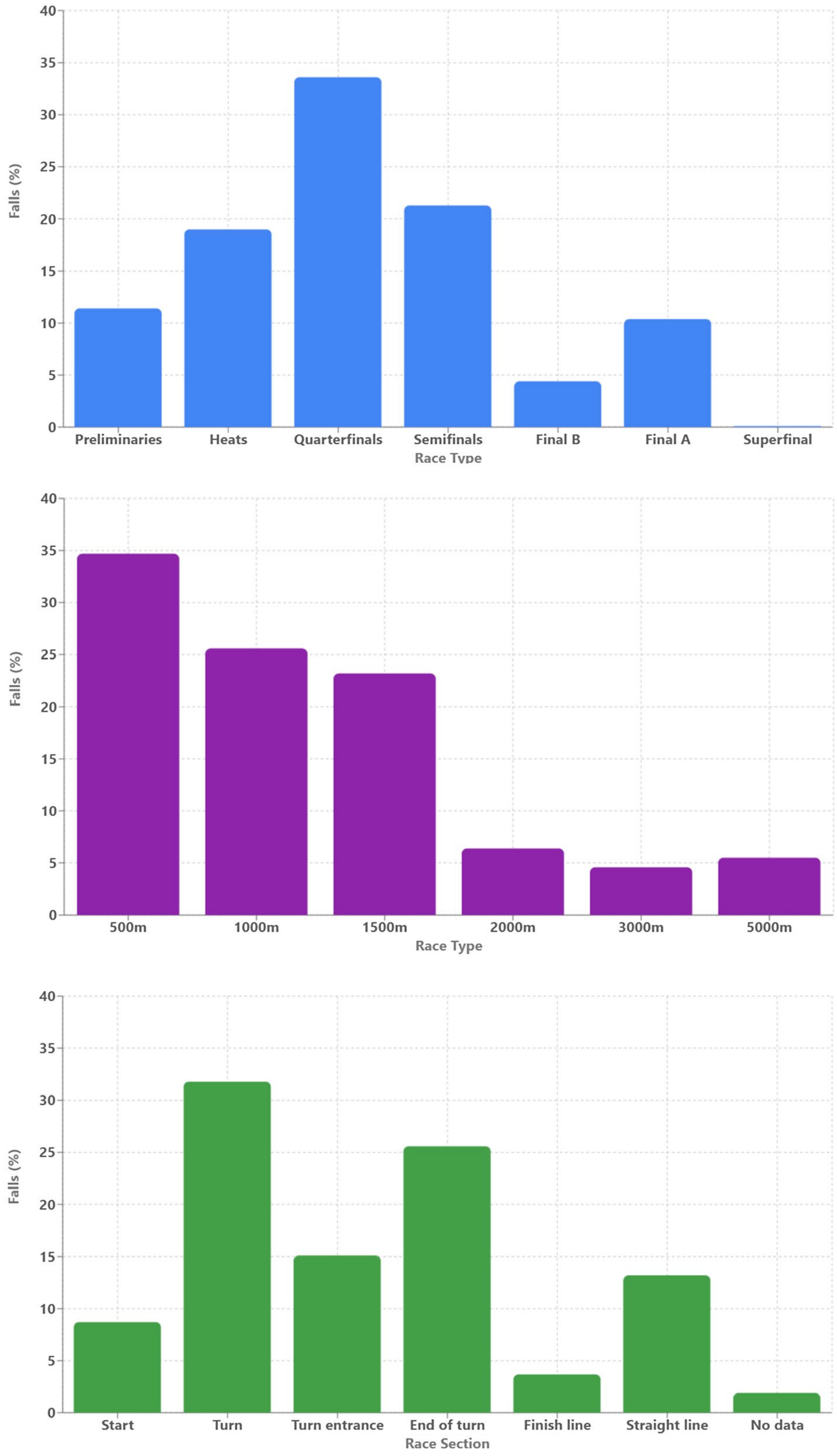

FIGURE 2 | Distribution of falls based on the race (Top), the distance (Middle), and the location (Bottom).

footage). Among these crash pad impacts, 43.2% resulted in head impacts, with 24.7% being direct and 18.6% indirect. As for the observed differences between men and women, Figure 3 illustrated the distribution of falls based on race type for both sexes. There was a significant difference between sex regarding falls depending on race type ($\chi^2(1) = 51.29$, $p < 0.001$). Men fell much more than women during the preliminary phases, according to the analysis of standardized residuals. The five anatomical regions that most frequently hit the ice first during falls were the buttocks (19.2% for men vs. 24.7% for women), hips (17.7%

vs. 18.9%), hip and elbow (11.1% vs. 10.1%), knees (10.3% vs. 10.5%), and hand and knee (9.3% vs. 7.7%). The distribution of the anatomical regions of initial impact on the ice, illustrated in Figure 4, was independent of sex ($\chi^2(151) = 24.43$, $p = 0.058$).

Regarding the Canadian team, the number of race entries and the fall proportion varied greatly from one athlete to another. For the men, the number of race entries ranged from 4 to 178 (mean 89 ± 59, 95% CI [50–127]), the number of falls from 0 to 18 (mean 7 ± 6, 95% CI [3–11]), and the fall rates from 0.0% to 25.0% (mean 11.8 ± 7.5, 95% CI [5.9–15.7]). For the women, the number of race entries ranged from 2 to 163 (mean 69 ± 50, 95% CI [39–99]), the number of falls from 0 to 16 (mean 5 ± 5, 95% CI [2–8]), and the fall rates from 0.0% to 20.0% (mean 7.8 ± 7.4, 95% CI [3.3–12.1]). Among the 127 falls sustained by Canadian athletes, nine resulted in injuries that required at least one intervention by physiotherapists, representing a global injury-per-crash proportion of 7.1%. In total, four women and three men sustained injuries, with injury rates per race entries ranging from 0.6% to 5.9% depending on the athlete. Table 3 gave the details of the nine falls resulting in injury. Four of the falls that caused an injury were individual, and the others occurred in groups. Two of the solo falls were caused by slipping, and the other two by stumbling, while all the group falls were caused by contacts with an opponent. Except for one solo fall that resulted in an impact on the hip then the flank, all other falls led to a first impact on the buttocks before hitting the protective crash pads, which caused a direct head impact in five cases. The reported fall-related injuries were six muscle strains in the spinal region (two cervical, two lumbosacral, two thoracic) and three contusions affecting the hip, knee, and ankle. Fortunately, these falls did not cause any withdrawals from competitions. However, the medical records did not contain systematic information regarding the severity of the injury, the number of treatments required, or the duration of symptoms.

TABLE 2 | Proportion of individual and group falls based on distance.

	Solo (%)	Group (%)	No data (%)	Total fall no.
500 m	39.0	52.6	8.4	523
1000 m	32.5	66.0	1.6	385
1500 m	21.8	76.4	1.7	348
2000 m	53.6	42.3	4.1	97
3000 m	39.1	56.5	4.3	69
5000 m	44.6	50.6	4.8	83

4 | Discussion

This study offers a comprehensive analysis of falls occurring in senior international STSS competitions, representing a step toward understanding situational factors associated with injury risk within the sport and ultimately reducing their incidence. This descriptive study revealed that falls in STSS were frequent, averaging nearly 100 falls per competition. With a fall rate of eight per 100 race entries and an average of five athletes per race, this suggests that a fall occurred in every two races. Nearly two-thirds of these falls occurred in groups, and over 60% occur during the shorter 500 and 1000 m distances. This is likely due to the athletes' close proximity and the need to maintain full speed during these races, as well as the greater number of races for the shorter distances. These races and falls pose a high risk of injury due to the high speeds involved, often exceeding 50 km/h, combined with the potential for violent collisions between athletes, who wear 45 cm long blades on their feet. Nearly two-thirds of falls occurred in the turns (entry, apex, and exit), and the majority of falls (83.5%) ended against the protective crash pads, with head impact occurring in 43.2% of cases. This occurs because athletes reach higher speeds as they exit turns, counterbalancing the outward forces exerted by centrifugal acceleration. Furthermore, the direction of their falls in the turns leaves little distance before they collide with the protective crash pads, limiting their ability to slow down effectively, further exacerbated by the presence of water on an already slippery surface. In terms of proportions, men exhibit a higher tendency to fall compared to women, with a proportion of 8.6% and 7.1%, respectively. More precisely, men experienced more falls than women during the preliminary rounds. This

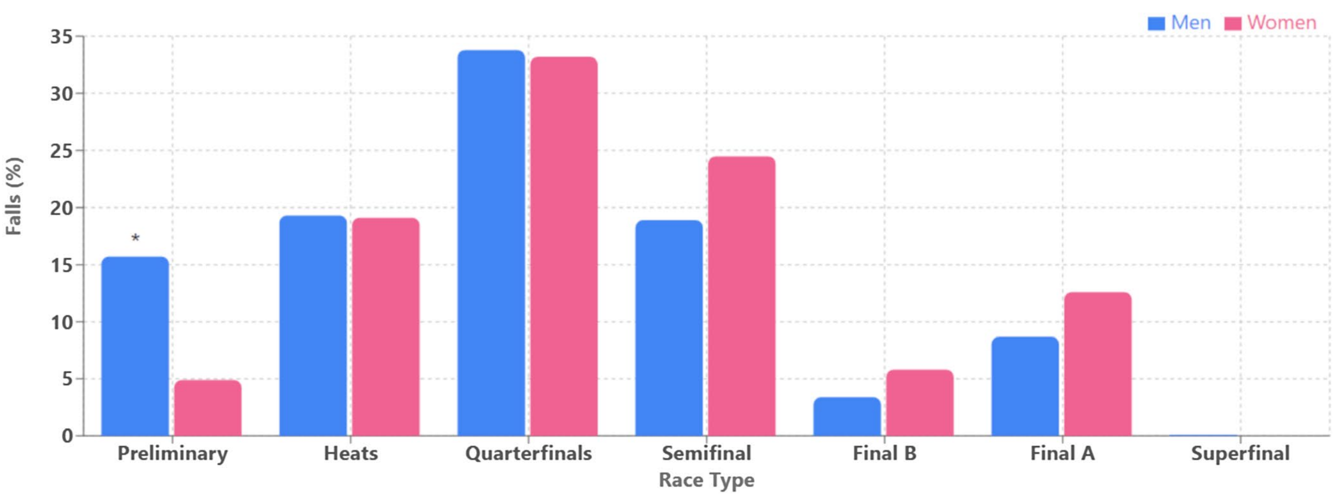

FIGURE 3 | Distribution of falls based on race types and sex. * indicates statistical differences ($p < 0.05$).

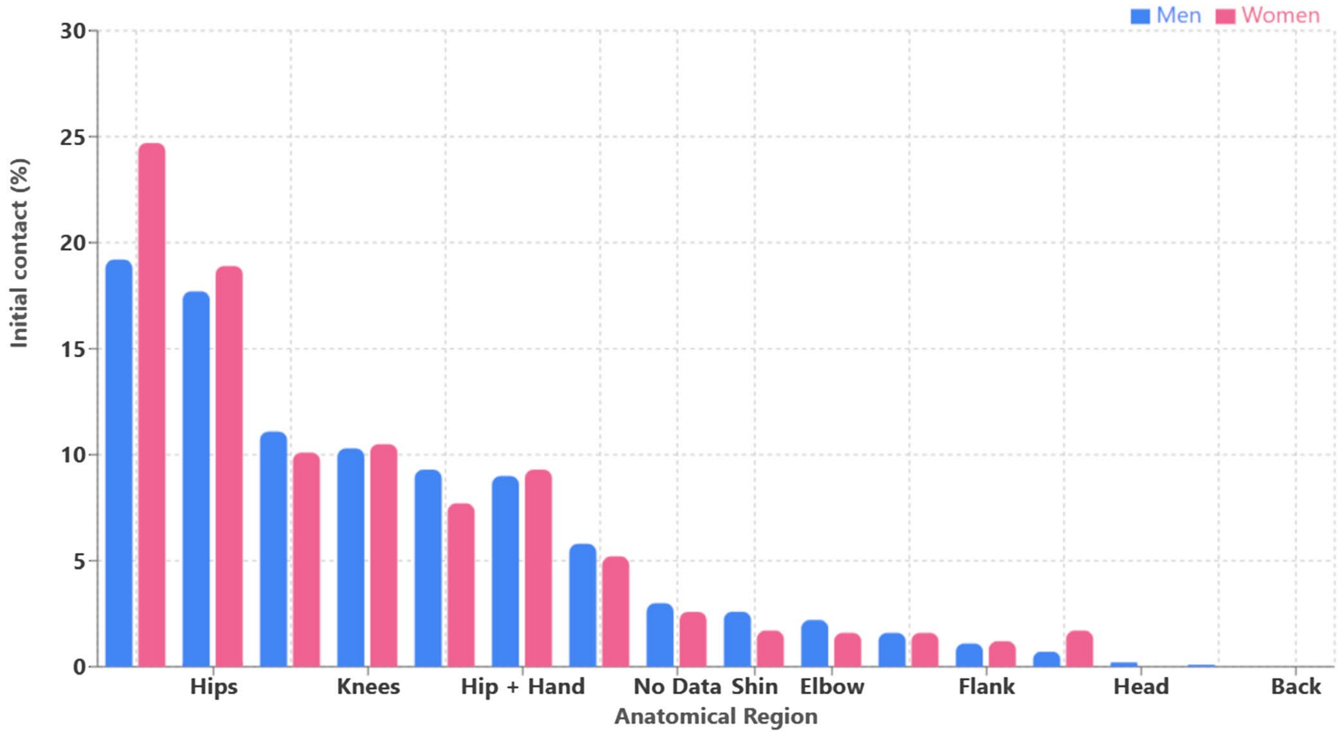

FIGURE 4 | Anatomical regions of initial contact with the ice after a fall based on sex.

difference may be partly explained by the larger number of male competitors (10 539 race entries vs. 8092), particularly in these early phases, combined with their generally higher racing speeds and the presence of less experienced athletes, which together may increase the risk of falls. Nevertheless, no difference was found between men and women in the anatomical regions that first impacted the ice. Ultimately, the number of race entries and fall rates varied considerably among athletes on the Canadian team. Fortunately, the nine injuries sustained from the 127 recorded falls did not have a major impact on the athletes. Most falls resulted in head impacts and injuries in the spinal region. Although this was not the case for the Canadian team, impacts to these vulnerable zones can, on very rare occasions, lead to disastrous consequences—such as the cervical fracture (C5) suffered by a French athlete during the Dutch Open in October 2022.

To our knowledge, this is the first study of its kind in STSS, which limits the ability to make direct comparisons with previous research in this sport. This lack of research in STSS is remarkable given the extensive body of research on falls and impacts in professional sports like football, soccer, rugby, and hockey [30–37]. Similar studies to ours have nevertheless been conducted on sports with less coverage in the literature, such as skiing and snowboarding [38], taekwondo [39], lacrosse [40], and wheelchair sports [41]. These recent studies underscore the critical importance of fall analysis and injury prevention in sports, particularly concerning concussions, which have been a major topic of research over the past decade. These studies collectively detail the various types of falls and impacts across sports, highlighting their prevalence among athletes of all levels, from amateur to professional, and across age and sex groups. Importantly, the consensus is clear: implementing changes to game rules and/or adopting innovative equipment and testing methods is crucial to reducing injuries, especially concussions, which can have severe long-term effects on athletes' health.

The present findings suggest that preventive strategies in STSS should target several modifiable situational and technical factors. Since most falls occurred in turns and involved contact between skaters, emphasis should be placed on enhancing athletes' spatial awareness, overtaking safety, and stability during cornering through targeted technical training. Optimizing ice quality and the configuration of protective pads in the turns could help reduce rebound impacts and mitigate head injuries. Adjusting competition formats to decrease crowding during preliminary heats, together with ongoing equipment innovations—such as advanced helmet designs and cut-resistant suits—also represents promising avenues to reduce the frequency and severity of falls in elite competition.

This study has several limitations. First, it is a descriptive analysis of falls in STSS based solely on video footage. No measurements of speed or acceleration were conducted from the video, and no onboard sensors were used. This will be addressed in future work aiming at precisely quantifying the head impacts experienced by athletes during falls. Second, athletes were not consulted in this study, as the results were solely derived from video footage. While conducting direct interviews with athletes could yield a more detailed analysis, it would pose significant challenges due to language barriers and logistical distances, especially given the diverse origins of athletes spanning 43 different countries. Third, a direct comparison of fall proportions between men and women at each competition phase would require normalization by the number of race entries per sex and round; however, such detailed race entry data was not collected, which limits the precision of this comparison. Lastly, the injuries sustained by the Canadian athletes lack documentation

TABLE 3 | Details of falls resulting in injury to Canadian athletes.

Competition name	Year	Distance	Gender	Solo/relay	Race type	No. of skaters	Penalty	Place of fall	Solo/group	Reason of fall	First impact	Second impact	Crash pads impact	Head impact
World Cup	2022	500 m	Men	Solo	Heats	5	No	Finish line	Group	Skates contact	Buttocks	Hand	Yes	No data
World Cup	2022	1000 m	Men	Solo	Final A	5	No	End of turn	Solo	Stumbles	Buttocks	Hand	Yes	Direct impact
World Cup	2023	500 m	Men	Solo	Heats	5	No	Turn	Solo	Stumbles	Hip	Flank	No	No data
World Cup	2023	500 m	Men	Solo	Semifinals	5	Yes	End of turn	Solo	Slipping	Buttocks	None	Yes	Direct impact
World Cup	2021	1500 m	Women	Solo	Heats	7	Yes	End of turn	Group	Opponent contact	Hip	None	Yes	No data
World Cup	2022	1500 m	Women	Solo	Final B	7	Yes	Turn entrance	Group	Opponent fall	Buttocks	None	Yes	No
World Cup	2023	1500 m	Women	Solo	Semifinals	8	No	Finish line	Group	Opponent contact	Buttocks	None	Yes	Direct impact
World Cup	2023	500 m	Women	Solo	Semifinals	5	No	End of turn	Solo	Stumbles	Buttocks	Elbow	Yes	Direct impact
World Championships	2023	500 m	Women	Solo	Semifinals	5	Yes	End of turn	Group	Opponent contact	Buttocks	None	Yes	Direct impact

regarding their severity, the number of treatments, or the duration of symptoms. We only know that the athletes did not withdraw from the competition, but they may have reduced their training duration or followed recommendations to continue training as long as the pain was manageable.

5 | Perspective

This study, conducted in collaboration with the ISU, represents the first comprehensive analysis of falls in STSS, encompassing both men and women, as well as all types of individual and team races. The findings revealed a high frequency of falls, averaging nearly a hundred per competition. A predominance of falls was caused by interactions between athletes, but it is noteworthy that individual skating errors account for nearly one third of falls in this sport. Finally, there appears to be a higher proportion of falls among men compared to women, and a higher incidence of fall-related injury in the spinal region for the Canadian athletes. It is now imperative to further quantify these falls to better understand injury mechanisms, test the protective equipment and, if necessary, improve them and/or adapt rules.

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Ethics Statement

This study was performed according to the guidelines of the Declaration of Helsinki and approved by the Research Ethics Committee of École de technologie supérieure (protocol code H20230106, approved on 20/03/2023).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available in Skating ISU at https://www.youtube.com/c/SkatingISU. These data were derived from the following resources available in the public domain: ISU World Cup Short Track 2021/2022|Beijing, https://www.youtube.com/watch?v=1DSMR4o9ObA.

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Appendix A

The following data were systematically recorded in a dynamic Excel:

- For the race:
  - Competition, city, year
  - Day of the competition: 1 to 3
  - Race # (from ISU)
  - Distance: 500 m, 1000 m, 1500 m, 2000 m relay, 3000 m relay, 5000 m relay
  - Race type: repechages, heats, preliminaries, quarterfinals, semifinals, finals A or B
  - Heat #
  - Number of skaters at the start
  - Penalty given during the race: yes or no
- For the athletes who fell:
  - Sex: male or female
  - First name and Last name of the fallen athlete(s)
  - Country of the fallen athlete(s)
- For the falls:
  - Lap number during the fall
  - Location of fall (before eventually impacting the protective crash pad): start, straight line, entrance of the turn, apex, end of turn, finish line
  - Individual fall or group fall. A group fall involves at least 2 athletes falling simultaneously and is counted as one fall per athlete involved. Falls occurring during starts were also recorded, as well as impact with the crash pad while the athlete stays on their feet.

- Reason of individual falls:
  - Slipping: typically occurs when the skater is in a turn, and their skate loses traction on the track. The skater slips and falls on their side.
  - Stumble: when the skater tangles their feet, causing their own skates to come into contact.
  - Skate Stuck in Ice: when the skate's blade gets stuck in the ice.
  - Cone Incident: during a turn, if the skater slips over one of the 7 rubber cones. It's also possible for another skater, due to their speed, to dislodge a cone that lands in the path of the skater behind, leading to a fall.
- Reason of group falls:
  - Opponent Contact: When one skater unintentionally touches another, often with arms, shoulders, or hips, resulting in the fall of both skaters.
  - Pushed/Blocked: When a skater intentionally blocks another, usually by extending their arm in a turn. Alternatively, when a skater deliberately pushes an opponent, typically only the pushed or blocked skater falls.
  - Opponent Fall: When one skater falls and causes another skater to fall because they cannot maneuver around the fallen person.
  - Relay Exchange: This type of contact is specific to relay races. It occurs when a skater pushes a teammate from behind to exchange the relay baton, and the pushed skater is destabilized or pushed into an opponent, resulting in a fall.
  - Contact Between Skates: When the skates of two skaters touch, causing imbalance or detachment.
- Anatomical zone of the first impact, that is, the first region making contact with the ice or the crash pads: back, buttocks, elbow, knee, flank, hand, head, etc.
- Anatomical zone of the second impact, that is, the second region making contact with the ice or the crash pads: back, buttocks, elbow, knee, flank, hand, head, etc.
- Impact with the crash pad: yes or no
- Head impact:
  - None
  - Direct impact occurring when a part of the head or the helmet enters in contact with the ice or the crash pads
  - Indirect impact occurring when the athlete's head doesn't directly hit an object but experiences a neck and/or head rotational movement