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Research Article

The Incidence of Injuries in Development Short Track Speed Skaters Part 1: On Ice

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Abstract

Short track speed skating is a sport that has enjoyed recent notoriety as one of the more exciting events currently taking place at the Olympics. Children entering the sport continue to engage in this physically demanding, organized sports despite the lack of physical readiness both on and off the ice during training and competition, predisposing themselves to injury. This study identifies injuries associated with development speed skaters during competition in Alberta. The analysis considers Characteristics of Competition: Date (time during season), location of competition, Competition Level, Rink Size, and Protocol (sprints/distance first). Data also included characteristics of fall: Distance of Race, Situation of Injury, Type of Injury, Location of Fall on the Track, and Location of Impact with Pads of racing on a 100m track. Using a principal component analysis, 3 Factors were identified that make up 57.87% of the variance. Factor 1 was related to Date of Competition (-0.762) and made up 21.79% variance; Factor 2 was related to Rink Size (0.804) and Protocol of Racing (0.763) and made up 21.55% of the variance, Factor 3 was related to Zone of Impact (0.851) and made of 14.58% of the variance of the data. A model to predict Injury Type was created using the results of the PC analysis ($F = 3.77$; $p = 0.006$). The Tukey HSD Post Hoc test indicated that hitting mats safely no injury ($p = 0.02$), hitting mats improperly no injury ($p < 0.001$), serious bone ($p = 0.001$) and concussions ($p = 0.001$) could be predicted by parameters identified in the model.

Keywords: Concussion; Factors Affecting Injuries; Learn to Train; Rink Size; Short Track Speed Skating; Technical Ability; Train to Train; Youth Injuries

Introduction

Short track speed skating is a sport that has enjoyed recent notoriety as one of the more exciting events currently taking place at the Olympics [1]. Short track is pack-style speed skating that takes place within hockey arenas on a 111.12-meter track. Participants in short track speed skating are at risk of sustaining injuries during both training and competition [1]. The pack-style format of short track speed skating creates an environment of close passing at high speeds that often results in injurious collisions between skaters [1]. Only a few studies to date has been conducted on injuries in speed skating; one study consisting of elite athletes, using a survey questionnaire to identify injury locations [2], the other identified the two most common injuries occurring on the ice are lacerations from the knee down and ankle fractures [3]. There is also a high incidence of lower back pain among young speed skaters [3]. Further understanding of the nature of injuries in short track speed skating will assist sports medicine physicians, physiotherapists, sports scientists, and sports governing bodies in the prevention and treatment of injury.

Studies conducted on youth sports injuries have suggested a link between injury risk and the use of protective equipment, but it is possible that a child's high exposure to the sport and inexperience may play a role as well [4]. Studies indicate that an improper environment or poorly fitted, improper equipment can lead to higher potential risk of injury [5]. Risk factors are traditionally divided into two main categories: internal (or intrinsic) athlete-related risk factors and external (or extrinsic) environmental risk factors [6,7]. Although risk factors such as gender and age may be of interest, as a minimum it is important to study factors which are potentially modifiable through physical training or behavioural approaches, such as strength, balance, or flexibility [8]. However, merely to establish the internal and external risk factors for sports injuries is not enough. To establish a complete understanding of the causes, the mechanisms by which they occur must also be

identified [9]. Lack of information for development skaters is even scarcer as significant knowledge deficits exist regarding sports injuries in the young child. As a result, children continue to engage in physically demanding, organized sports despite the lack of physical readiness, predisposing themselves to injury.

A prospective study would also be useful in assessing the intrinsic and extrinsic risk factors at play in short track speed skating. Intrinsic risk factors are those inherent factors, such as sex, age, biomechanical alignment, joint laxity, muscle strength, flexibility, conditioning, and maximum velocity capability. Whereas some extrinsic risk factors for injury in short track skating are ice quality, safety equipment worn, time exposed to racing/training, number of skaters in a race, number of people falling in a single collision, and type and quality of protective matting covering the rink boards.

A comprehensive longitudinal study has been underway to determine both the intrinsic and extrinsic factors involved in determining speed skating injuries in development athletes in both dryland and on ice training and competition respectively. To better understand the dynamics involved with development skaters when they fall and therefore the potential for injury; location of falls on the track, conditions of falls, injury extent due to falls, data was collected over the 2012-2013 speed skating season from competitions throughout Alberta Canada. The information in this study will document extrinsic factors involved in the potential for injuries in developmental speed skaters in short track speed skating occurring while racing.

Methods

Data was collected during the 2012-1013 short track speed skating season from 14 competitions held for skaters; Fundamentals to Train to Train. Skaters in these age categories skate on the 100m track. The 100m track is recommended for skaters who have not reached the Learning to Compete stage of development. The 100m track may be laid out on any size ice surface in so long they will accommodate the provisions of ISU Rule 280 Paragraphs 1b, c, d [10].

Competitions took place on several rink sizes so there was opportunity to look at the relationship between incidents of falling and rink size. Data was collected from the center of the track to optimize observations over the entire racing surface. Data was recorded immediately after the skater was deemed ok or after the skater was removed from the ice following a serious injury. Follow up with medical staff occurred during breaks in racing to determine the extent of the injury and collaboration occurred with the medical staff to determine injury classification. Injury classification included: No injury (skater fell and got up immediately, skater able to continue racing), minor injury (bump or bruise or small cut that required minimum attention, skater able to continue), serious cut (abrasion received through a fall or contact with another skater during a fall, may or may not require stiches but requires attention, skater may miss a section of racing but continued to race after observation or skater withdraws from racing) serious back (skater falls and slides on back through the crash zone or impacts the mats incorrectly, scratches, bruising the results, or impact jars back, loss of breath may occur, skater withdraws from competition), serious bone, (bruise or break to a bone, usually tibia, or ankle, or femur, skater withdraws from competition); concussion (traumatic brain injury that is caused by a blow to the head or body, a fall, or another injury or impact with the mats that jars or shakes the brain inside the skull, skater withdrawn from competition). No differentiation was made between mild to serious concussions in this study.

Data collected included; Characteristics of Competition: Date (time during season), location of competition, Competition Level, Rink Size, and Protocol (sprints/distance first). Data also included characteristics of fall: Distance of Race, Situation of Injury, Type of Injury, Location of Fall on the Track, and Location of Impact with Pads. A figure identifying the location of mats and the zones of protection for Short Track Speed Skating [11] and a description of the extent of the zones is in Appendix 1. All competitions also have a crash zone (represented by the blue dashed lines), an area where the ice is not smooth Appendix 1. This area is present to reduce the speed of skaters as they approach mats in the corners. This area is approximately 2 meters away from the mats at the apex and approximately 3 meters from the pads at the corners. No crash zone is required in the straightaways to encourage passing [10]. Descriptive statistics were conducted to identify general trends for information. A principle component analysis was used identify what factors contribute to falls during the season [12]. A multiple linear regression was used to determine the injury potential [12].

Results

During the 2012-2013 season, n = 128 falls occurred over 14 competitions ranging from Fundamentals to Train to Train levels. Of those falls 81% (n = 103) of the falls took place during sprints, 100 - 500m, 13.3% (n = 17) of the falls occurred during middle distances, 1000 - 1500m, whereas 6.3% (n = 8) of the falls took place during the longer distance, the 3000m. Table 1 indicates the locations on the track where skaters fell during competitions.

Location on The Track	N	Percentage of Fails	Mat Coverage	Percentage
Off the Start	5	3.9	Yellow/Red	3.9
Entrance to Corner	9	7		
Apex	63	49.2	Red	75
Apex Finishing Corner	17	13.3		
Corner Exit	19	14.8		
Straight Away	6	4.7	Green	4.7
Finishing	5	3.9	Yellow	10.2
Failed to Reach Mats				5.5

Table 1: Mat Location of falls by Skaters on the Track.

Table 1 indicates that most of the falls 49.2% occurred at the apex, while 14.8% of the falls took place at the corner exit. Of interest is the 3rd highest number of falls took place at the apex of the finishing corner 13.3% (approximately 3m from the finish line). Both the start and the finish had the lowest number of falls; 3.9%. An important consideration in determining injury type is the location of impact. Different zones of impact indicate where the greatest depth of protection of mats occurs (Appendix 1).

As indicated in Table 1 the highest number of falls occurred at the apex therefore the highest number of impacts by skaters occurred in the Red Zone (75%). Of interest is the second highest percentage of impacts with the pads occurs in the Yellow Zone (10.2%). This corresponds with the number of falls taking place on corner exits (14.8%), particularly the finishing corner (13.3%). Five-point five percent (5.5%) of the falls failed to reach the mats while both Yellow/Red and Green Zones showed 3.9% and 4.7% of impact respectively (Table 1).

To prevent injuries from crashes and/or reduce their severity, understanding where skaters fall into mats is only part of the answer. Understanding why skaters fall and what happened during a fall can provide important information into what other information can be provided to skaters to reduce injuries. Table 2 provides a breakdown of the type of injuries identified overall during racing over each distance. Sprint distances include 100m, 200m pursuit, 400m and 500m (T2T skaters racing in Single Distance Series at Calgary Oval); Middle Distances include 1000m and 1500m and Long Distance is a 3000m points/time trial race.

A general trend was identified where a reduction of injury types is seen as the distances become longer (7 injury types identified in sprint distances, 4 injury types identified in middle distances and 2 injury types identified in long distance). Overall skaters showed the highest percentage of falls happened with no injury in all distances; sprint: 66.9%, middle: 50% and long distance: 83.3% respectively. However; concussions were the second highest injury result regardless of distance, short: 10.7%, middle: 27.8% and long distance: 16.7% respectively. Of interest is the percentage of skaters that hit the mats improperly without injury during sprints (8.7%) and the serious bone injuries that occurred in Sprint distances (4.9%). Table 2 provides a further breakdown of the main reasons for injuries and percentages of injuries by Heat, Semifinals and Finals.

Distance	Description of Main Causes for Injuries	Result	Heat	Semi Percentage	Final Percentage
Sprint	two skaters collide and fall together,	no injury	65.5	58.3	82.5
	toe in his face first	minor (bruised)	17.2	8.3	1.5
	lost balance (tried to pivot, can't handle speed)	serious bone	6.9		7.9
		Concussion	6.9	33.3	7.9
Middle Distance	lost balance	no injury	83.3		45.4
	contact with another skater	minor (bruised)			1.8
	two skaters collide and fall together	serious back	1.6		9
		concussion			27.2

Long Distance	part of skater (arm/skate/body) will hit another skater lose balance fall on their own (fatigue)	no injury			83.3
		concussion			1.6

Table 2: Description of Main Causes of Injuries and results during heats, Semifinals and Finals.

Overall the main reasons for falling in all distances appears to be when two skaters collide or contact of some part of the body occurs between skaters. The second reason appears to be loss of balance or control that may occur because of increased speed; as during the sprints, or fatigue; as during the middle and longer distances (Table 2). The overall trend in the percentage of injures appears to increase over the course of racing in sprints with a higher percentage of injuries occurring during finals (Table 2). However, the number of injury types remains the same. The exception to this is the occurrence of concussions which increases during semifinals (33.3%) and is reduced in finals (7.9%). A possible explanation may be seen in the attempts of skaters to place in a higher final. In the middle distance the overall trend is a reduction of percentage of injuries however there is an increase in the type of injuries that can occur (Table 3). In the longer distance (3000m) injuries occur only in the finals since during most competitions this distance is a super-final (only raced once during competition).

In Alberta the opportunity to race occurs on the local rink in town. In Alberta only, Calgary and Lethbridge have Olympic sized rinks (60.96/30), the rest of the locations have rinks with similar lengths though smaller widths (60.96/27.43; 60.96/25.91). Figure 1 shows the percentage of injuries in relation to rink size.

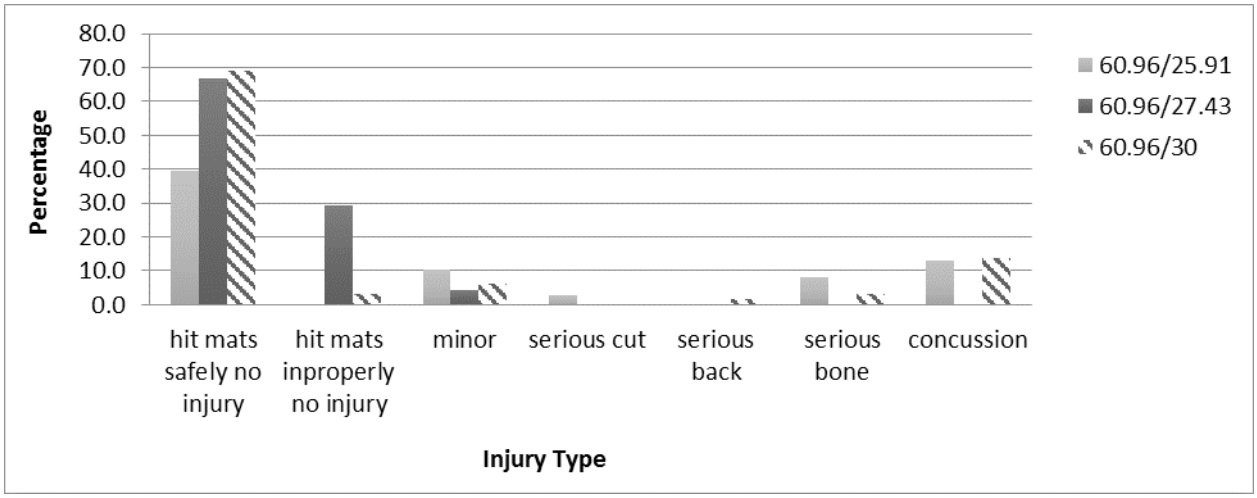

Table 3: Percentage of Injuries in Relation to Rink Size.

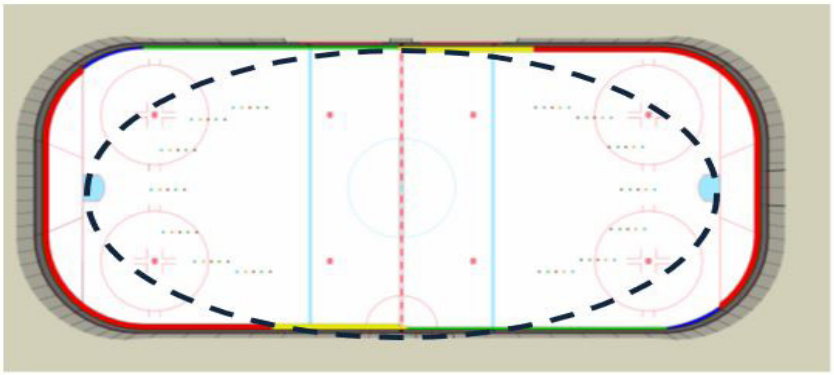

Figure 1: Locations of mats and Short Track Crash Protection Zones (SIMEC 2012).

To determine which components of racing may determine injury potential a Principal Component Analysis and multiple linear regression were run on the data to identify what factors may lead to injury. Using a principal component analysis (extraction method PCA; Varimax rotation with Kaiser Normalization - rotation converged in 5 iterations); 3 Factors were identified that make up 57.87% of the variance. Factor 1 was related to Date of Competition (-0.762) and made up 21.79% variance; Factor 2 was related to Rink Size (0.804) and Protocol of Racing (0.763) and made up 21.55% of the variance, Factor 3 was related to Zone of Impact (0.851) and made of 14.58% of the variance of the data.

To determine if the information collected in this study could predict Injury Type date collected on Date of Competition, Rink Size, Distance, Protocol (whether sprints were first, or middle/long distance was raced first), location of fall and zone of impact were assessed using a multivariate analysis. A Tukey HSD Post Hoc test was run on parameters to determine which types of injuries were most likely to be explained by the analysis. The results of the Multiple linear regression indicate that Injury Type could be significantly predicted by Date of the Competition, Rink Size, Protocol of racing and Zone of Impact ($F = 3.77$; $p = 0.006$). The Tukey HSD Post Hoc test indicated that hitting mats safely no injury ($p = 0.02$), hitting mats improperly no injury ($p < 0.001$), serious bone ($p = 0.001$) and concussions ($p = 0.001$) could be predicted by parameters identified in the model.

Discussion

Overall speed skating competitions in Alberta within the Fundamentals through Train to Train development stages provide an "adequately safe" environment in which to develop racing skills. The results of this work will help identify situations and injuries related to falls in development speed skaters during competition.

The results of this study indicate that most falls in these developmental stages mainly occurs during the sprint distances (100m - 500m) with falls typically occurring at the apex of a corner, a corner exit and between the apex and exit of the finishing corner. Because the corners in speed skating are used to build speed during the straightaway it is possible that the results are related to three essential components; 1) the inability to properly build speed in the corners; instead of building speed at the start of the corners skaters are cutting the entry too short and trying to increase speed at the apex. Because speed is inconsistent skaters then swing too wide or try to cut sharply on the exits resulting in collision with other skaters or loss of balance (this is a common observation in Fundamental and Learn to Train skaters). The second component is that speed is built during the straightaway and skaters are travelling (what they feel is) too fast to properly navigate the corners, try pivot by reaching out, loosing balance and falling or colliding with another skater (this is a common observation in Fundamental, Learn to Train skaters and Train to Train skaters). Finally, skaters are properly entering corners and carrying good speed through the corners however pick the wrong strategy (trying to pass on the inside, not waiting to pass on the exit and collide with another skater (this is commonly seen in Train to Train skaters). This strategy is further complicated by the size of the rink and corresponding track.

Falls do occur in the middle and longer distances however the location of the falls are similar, occurring at the apex, corner exit and finishing corner. At these age/stages of development 1000m, 1500 and 3000m races are presented in super finals. Skaters are often inexperienced in racing these distances, therefore most of crashes identified are interactions with other skaters during bell lap (finishing), loss of technique due to becoming tired; lost balance, attempt to pivot lean too far and fall. Most of crashes therefore result in low impact and therefore minimal to no injury. One concussion was documented and occurred early in the race; the injury was the result of exiting the corner too wide to collide with the mats, to catch up to the pack, the skater fell again hitting her face.

In this study a general trend was identified where a reduction of injury types is seen as the distances become longer (7 injury types identified in sprint distances, 4 injury types identified in middle distances and 2 injury types identified in long distance). Overall skaters showed the highest percentage of falls happened with no injury in all distances; 66.9%, 50% and 83.3% respectively. However; concussions were the second highest injury result regardless of distance, 10.7%, 27.8% and 16.7% respectively. Of interest is the percentage of skaters that hit the mats improperly without injury during sprints (8.7%) and the serious bone injuries that occurred in Sprint distances (4.9%). Most skaters who fell improperly commonly went into the mats feet first or hands first. This indicates a lack of learning the proper way to fall. Of the two serious bone injuries one was the result of direct impact with the mats improperly on a boarded rink. The Learn to Train skater fell at the apex carrying too much speed and went into the mats with both feet up. Because he went in feet first, his ankles were locked, and the resulting impact fractured his tibia. It is important to note that the presence of the skid zone did little to slow his speed. The second serious bone injury during sprints was the result of increased torque on the ankle; the skater was exiting the corner with a lot of speed but tried to stay tight on the track. The result was a change in weight too quickly which resulted in increased torque on the ankle/tibia. The result was a fractured tibia. The skater fell and impacted the mats in the Yellow Zone. Because this skater was a Train to Train and had shown an increase in growth during the summer; therefore, an increase in strength, it is likely his injury was a result of his inability to handle the increase in speed.

All the main reasons for falling in all distances appears to be when two skaters collide, or contact occurs with some part of the body between skaters. The second reason appears to be loss

of balance or control that may occur because of increased speed; as during the sprints, or fatigue; as during the middle and longer distances (Table 2). Skaters in the Fundamental and Learn to Train developmental stages currently in Canada quite often do not train for the longer distance events. The overall trend in the percentage of injures appears to increase over the course of racing in sprints with a higher percentage of injuries occurring during finals (Table 2). However, the number of injury types remains the same. The exception to this is the occurrence of concussions which increases during semifinals (33.3%) and is reduced in finals (7.9%). Two possible explanations may occur; the attempts of skaters to place in a higher final, or reduction of technique in a speed situation. In the middle distance the overall trend is a reduction of percentage of injuries however there is an increase in the type of injuries that can occur (Table 2). In the longer distance (3000m) injuries occur only in the finals since during most competitions this distance is a super-final (only raced once during competition).

When analyzed several factors be contributing to a situation that instigates a fall and the corresponding injury; Date of Competition, Rink Size, Protocol of Racing, and Zone of Impact. These factors make up 58% of the reason for injury to occur. Other components not analyzed include how the fall was initiated, skater size and skater ability, thought these remain to be tested. The results indicate that a greater percentage of injuries occurred during the second half of the season, than the earlier half of the season. During the second half of the season skaters are attempting to qualify for higher level competitions (such as Canada West/East, Provincial championships) and are skating at higher levels of competitions where they are potentially taking more risks than earlier in the season. The majority of injuries also occurred on smaller rink sizes, although the highest number of injuries occurred on rink sizes 60.96/27.43. Skaters who do not practice on this size of rink were more likely to fall and receive an injury than skaters who trained and raced on this size of rink. Observations indicate that these skaters also did not know how to properly hit the mats, nor respond to a hit on a rink where mats cover boards. The protocol of the competition also had an impact on percentages of fall and injury types. A higher percentage of fall and serious injuries occurred when sprint distances were run first. This result may indicate that skaters have had very little time to adapt to a different ice surface than they are used to skating on, are trying to go fast in a rink that may have different dimensions. As a result, skaters may impact different zones with different levels of padding than they are familiar with. By identifying these components, a model can be used to predict the potential for injury type thereby determining which ability of competitions skaters should be attending potentially reducing injury. The fact that changes in the percentage of hitting mats safely no injury and hitting mats improperly no injury occurs indicates that those skaters who are familiar with smaller, boarded rinks can prevent injury to themselves whereby skaters who are not familiar with these conditions are more likely to fall and injure themselves and potentially receive a serious injury including concussion. This should lead to increased education for skaters who are not familiar with smaller boarded ice surfaces; skaters attending these competitions should have knowledge and experience of the ice they are skating on either through previous racing or coached to skate on this type of rink.

It is important to note that the risk of injuries in the Fundamental through Train to Train skaters is potentially increased greatly since they do not have basic knowledge and lack sound skating technique. For example, a typical fall in skaters of these developmental stages is often due to a spontaneous loss of balance. Beginners also underestimate the attainable velocity and generally have trouble stopping. Falling in advanced skaters has been associated with travelling at high speed, performing specific manoeuvres in the curves or interaction with other skaters. Conversely, beginners are more likely to fall from an inability to avoid an obstacle (in racing another skater, puck or presence of water on the track) or inadequate stopping capability.

Stronger emphasis needs to be placed on teaching falling technique for all levels as well as proper coaching of strategy in racing in the higher Train to Train skaters. While there is only anecdotal evidence that learning basic skating skills would reduce injuries, the acquisition of skills such as balance, turning, braking, speed control and stopping, as well as falling technique should be highly recommended as injury prevention tactics.

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Conflict of Interest

There is no conflict of interest.

Appendix 1 Description of Crash Zone Protection for Short Track Speed Skating

- Red Zone: The red zone shall extend from the icing line (or 1m from the end of the rink if there is no icing line) through to the track marker closest to the rink's centre line.
- Yellow Zone: The yellow zone shall extend from the track marker closest to the rink's centre line (end of the red zone) to the rink's centre line.

- Blue Zone: The blue zone shall extend from the end of the green zone to the beginning of the red zone.
- Green Zone: The green zone shall extend from the rink's centre line to the beginning of the curvature of the corner boards.

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