

Original Research

# Sport Specialization, Physical Performance and Injury History in Canadian Junior High School Students

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### Background

Youth sports participation is encouraged for proposed physical and psychological benefits. However early sport specialization and the potentially negative consequences may be a cause for concern.

### Purpose

To describe sport specialization in Canadian youth and investigate associations with previous injury and physical performance.

### Study design

Cross-sectional study.

### Methods

Junior high school students (grades 7-9, ages 11-16) were invited to participate. All participants completed a questionnaire capturing specialization level (low, moderate, high; based on year-round training, exclusion of other sports, and single-sport training) and injury history in the previous 12-months. Additionally, all participants completed physical performance measures including vertical jump (cm), predicted VO<sub>2</sub>max (mL/kg/min), single-leg balance (secs) and Y-Balance composite score (%). Logistic regression examined the association between school grade, school size, sex and sport specialization (Objective 1) and the association between sport specialization and injury history (Objective 2). Multivariable linear regression analyses (4) assessed associations between sport specialization category and physical performance measures (Objective 3).

### Results

Two hundred and thirty-eight students participated in the study. Eighteen percent of participants reported high specialization, with no significant associations between sex, grade or school size and specialization category. There was no significant difference in the odds of sustaining previous injury between participants reporting moderate (odds ratio [OR]=1.94, 95% CI 0.86-4.35) or high (OR=2.21, 95% CI 0.43-11.37) compared to low specialization. There were no significant differences in vertical jump height (mean diff [MD] = -0.4 to 2.1cm), predicted VO<sub>2</sub>max (MD = 2.2 to 3.1mL/kg/min), single leg balance (MD = 0.5 to 1.9sec) or Y-balance (MD = 0.6 to 7.0%) between sport specialization

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categories.

## Conclusions

Sport specialization exists in Canadian junior high schools but may be less common than previously reported and it was not associated with sex, grade, or school size. Level of specialization was not associated with history of injury nor a range of physical performance measures.

## Level of Evidence

Level 3

## INTRODUCTION

Participation in youth sport, centered on recreational and fun activities, offers many physical and psychological benefits.<sup>1,2</sup> However, recent trends in youth sport have seen less emphasis on recreation and increased focus on specialization in a single sport with more importance on competition and success.<sup>1</sup> While there is no universally accepted definition, sport specialization generally relates to intense, year-round competition in a single sport at the exclusion of other sports.<sup>3</sup> The push for greater specialization is linked to the belief of some coaches and parents that it is more likely to lead to high school and adult sport successes.<sup>4</sup> However much debate remains as to whether early specialization is needed in most youth sports. Early sampling of many sports, with gradual specialization in later adolescence, is thought more likely to lead to later success.<sup>5,6</sup> Additionally, several expert groups have advised against early specialization due to concerns regarding increased injury risk and burnout.<sup>7,8</sup>

The increased injury risk with specialization is potentially related to repetitive homogenous loads experienced when performing repetitive movement patterns in a single sport. In a study including American high school athletes, students rated as medium to high specialization were two to four times more likely to sustain a gradual onset or recurrent injury than athletes rated as low specialization.<sup>9</sup> Similarly, in a large retrospective study including children and adolescents attending a sports medicine clinic for a sport-related injury, high specialization was an independent risk factor for serious overuse injury but not acute injury.<sup>10</sup> In contrast, McGowen et al. studied early specialization and found no independent association between high specialization and injury history.<sup>11</sup> Two recent systematic reviews concluded there is evidence that a link exists between specialization and sports related injury, however this evidence is limited to a small number of studies.<sup>12,13</sup>

Early specialization may also lead to increased injury risk due to a reduction in the range of motor skills developed. The development of diverse motor skills is fostered when parents and educators facilitate opportunities for free unstructured play and involvement in a variety of sports.<sup>14</sup> By engaging in a wide variety of sports youth are exposed to a greater range of strength, flexibility and balance challenges which may improve neuromuscular development and thus reduce injury risk. Single sport male high school athletes have been reported to perform worse than multisport athletes on the Y-Balance test.<sup>15</sup> Poor performance on balance testing has been linked to increased risk of lower extremity injury.<sup>16</sup>

There is little evidence as to the levels of sport specialization in Canadian junior high school children and the association with physical performance outcomes and/or injury in this group. Thus the purpose of this study was to describe sport specialization in Canadian youth and investigate associations with previous injury and physical performance. The specific study objectives were to investigate (1) levels of sport specialization and its association with school grade, school size and sex; (2) if sport specialization is associated with injury history; and (3) if sport specialization is associated with physical performance outcomes (vertical jump height, predicted maximal aerobic capacity (VO<sub>2</sub>max), single-leg balance time, and Y-Balance performance).

## METHODS

### PARTICIPANTS

Participants included junior high school students (ages 11-16) from four schools in a Canadian city. Data for this cross-sectional study were collected as a component of a large randomized controlled trial (RCT) that evaluated the effectiveness of a physical education (PE) class neuromuscular training warm-up in reducing injuries.<sup>17</sup> Schools that met the inclusion criteria (those that included a minimum of two PE classes within each of grades 7, 8, and 9 that were taught or co-taught by a PE specialist) were recruited in a randomized sequence to participate in the RCT, separated by East and West halves of the city. This was done to ensure there was a representative sample of schools across the city.

### PROCEDURES

Prior to the beginning of the RCT, participants were asked to complete a baseline questionnaire at home with the help of their parents. Questions included information on demographics, injury history and physical activity participation, including hours of organized sport and recreational activity in the previous year. Previous injury was defined as any injuries sustained during a sport or recreational activity within the previous 12-months that required medical attention or resulted in time loss. Sport and recreational activity participation over the previous 12-months included the number of weeks and hours per week of participation. The questionnaire has been used in multiple community sports previously as part of a youth-based injury surveillance system and was found to be valid in a junior high school PE context.<sup>17</sup>

The research coordinator spoke to each participant in person during the study period to ask them three questions regarding sport specialization. These three questions were

taken from Jayanthi<sup>10</sup> and addressed year-round training, exclusion of other sports, and single-sport training, respectively: “Do you train for a sport more than eight months of the year?”, “Have you quit other sports to focus on a main sport”, and “Do you have a primary sport that you consider to be more important than other sports?”. A “Yes” answer was scored as 1, and a “No” answer was scored as 0. Based on their answers, participants’ specialization levels were categorized on a three-point scale, where a score of 0-1 indicated low specialization, a score of 2 indicated moderate specialization, and a score 3 indicated high specialization. If applicable, the Research Coordinator also recorded the sport that the participants considered to be their primary sport, as well as any other sport(s) that they played.

Physical performance measures included vertical jump height, aerobic capacity (predicted  $VO_2\max$ ), single-leg eyes-closed dynamic balance time on an Airex foam pad (Airex Balance Pad®, L-group, St. Louis, MO) and Y-Balance test reach distance using the Y Balance Test™ kit ([FunctionalMovement.com](http://FunctionalMovement.com), Danville, VA). Vertical jump height was calculated as the distance (in centimeters) between standing reach height and reach height at the peak of the jump, measured using a marked fingerprint on paper adhered to the gymnasium wall alongside a vertical measuring tape.  $VO_2\max$  was predicted from the Fitnessgram PACER 20-m shuttle run using the following equation  $VO_2\max = 45.619 + (0.353 * \text{PACER laps}) - (1.121 * \text{age})$ .<sup>18</sup> Foam pad balance was timed (in seconds) from the time the participant closed their eyes and were balancing on one foot (centered on the pad) with hands on their hips until they lost their balance, for a minimum of two seconds. Loss of balance included removing hands from hips, free leg touching balancing leg or floor, and/or balancing leg losing contact with the foam pad, or opening the eyes. If the participant did not balance for at least two seconds, the trial was repeated. The Y-Balance normalized composite reach distance, expressed as a percentage of limb length, was calculated for each foot as the sum of all reach distances (in centimeters) divided by a factor of 3\*limb length, multiplied by 100. The best of three trials was used for vertical jump height and foam pad balance measures. Foam pad balance and Y-Balance were assessed on each foot, but only the maximum score from both feet was included in the analysis for each test.

#### STATISTICAL ANALYSIS

All statistical analyses were completed using Stata/SE 14.1 for Mac (StataCorp, College Station, TX). Frequencies and proportion of each sport specialization category (low, moderate, high) is reported for sex (boys vs girls), school size (small; 1-2 classes per grade vs large; 3-5 classes per grade) and grade (7, 8 or 9). Frequencies and proportions were also reported for previous injury characteristics (body part and injury type) and for primary sport reported.

Ordinal multivariable logistic regression analysis was used to assess if sex, grade or school size was associated with specialization category, adjusting for clustering by school. Multivariable logistic regression analysis, adjusted for sex, total sport hours over one year and clustering by school, was used to assess if specialization category was as-

sociated with history of injury.

Separate multivariable linear regressions were performed for each of the four performance outcomes, adjusting for interaction by sex and clustering by school, to assess if specialization category was associated with physical performance.

Outcomes for objectives 1 and 2 are presented as odds ratios [95% confidence intervals (CI)], whereas beta coefficients ( $\beta$ ) for objective 3 were used to compare mean differences in balance performance (i.e., dynamic balance, Y-Balance), vertical jump performance, and aerobic capacity for high compared to low and moderate compared to low specialized groups. Statistical significance was based on an alpha level of 0.05 for objectives 1 and 2 and an alpha level of 0.0125 for objective 3, which was calculated from a Bonferroni correction to account for the four tests ( $\alpha/\text{number of tests} = 0.05/4$ ).

#### RESULTS

Two hundred and thirty-eight students participated in the study (mean age 12.6 years, range 11-16 years, boys=49%). Students were rated in each specialization category including low (48%), moderate (34%) or high specialization (18%) ([Table 1](#)). Two of the four participating schools were larger schools, with three to five PE classes in each of the junior high grades ( $n=312$  and  $n=325$ ), while two were smaller schools with only two classes per grade ( $n=188$  and  $n=163$ ).

Forty-six (19%) students reported a history of previous musculoskeletal injury, with 50 injuries reported in total ([Table 2](#)). Most injuries were to the lower extremity (76%), particularly to the ankle (34%) and knee (18%). The most common injury types were sprains (52%), fractures (9%) and strains (10%). The most commonly reported primary sport was soccer (25%), followed by basketball (14%), hockey (11%) and dance (10%).

There was no significant association found between sex, grade or school size and specialization category ([Table 3](#)).

Ordinal multivariable logistic regression revealed that there was no independent association between history of injury and specialization category ([Table 4](#)). The odds of girls reporting an injury were higher than the odds of boys (OR=2.70, 95% CI 1.69 to 4.35;  $p < 0.01$ ), the other variables held constant, and the odds of injury increased (OR=1.001, 95% CI 1.0005 to 1.002;  $p = 0.001$ ) for every one-hour increase in yearly sport participation, the other variables held constant. This is equivalent to approximately 10% increase in the odds of injury for a consistent 2 extra hours per week during a year (i.e., increase by 104 hours per year).

Multivariable linear regression analyses (adjusting for total sport hours over previous year, interaction of sports specialization with sex and clustering by school) demonstrated no significant mean differences for vertical jump height, predicted  $VO_2\max$ , eyes closed dynamic or Y-Balance performance outcomes between high or moderate specialization categories compared to low specialization in girls or boys ([Table 5](#)).

**Table 1. Proportions in each specialization category**

	Low Specialization (n=113, 48%)	Moderate Specialization (n=82, 34%)	High Specialization (n=43, 18%)
Sex			
Girls	58 (48%)	41 (34%)	23 (19%)
Boys	55 (47%)	41 (35 %)	20 (17%)
School size			
Small	48 (43%)	37 (33%)	27 (24%)
Large	65 (52%)	45 (36%)	16 (13%)
School grade			
7	52 (50%)	35 (34%)	17 (16%)
8	40 (50%)	24 (30%)	16 (20%)
9	21 (39%)	23 (43%)	10 (19%)

Values are reported as n(%).

**Table 2. Injury and Primary Sport Characteristics**

Body part	n (%)	Injury type	n (%)	Primary sport	n (%)
Ankle	17 (34%)	Sprain	25 (50%)	Soccer	35 (25%)
Knee	9 (18%)	Fracture	9 (18%)	Basketball	19 (14%)
Foot	7 (14%)	Strain	5 (10%)	Hockey	16 (11%)
Finger	3 (6%)	Dislocation	3 (6%)	Dance	14 (10%)
Leg	3 (6%)	Tendonitis	3 (6%)	Swimming	9 (6%)
Back	2 (4%)	Contusion	2 (4%)	Baseball	6 (4%)
Wrist	2 (4%)	Missing	2 (4%)	Badminton	5 (4%)
Arm	1 (2%)	Other	1 (2%)	Figure Skating	4 (3%)
Elbow	1 (2%)			Football	4 (3%)
Groin	1 (2%)			Gymnastics	3 (2%)
Shoulder	1 (2%)			Horseback riding	3 (2%)
Trunk	1 (2%)			Lacrosse	3 (2%)
Toe	1 (2%)			Mixed Martial Arts	3 (2%)
Missing	1 (2%)			Taekwondo	3 (2%)
				Cheerleading	2 (1%)
				Ringette	2 (1%)
				Skateboarding	2 (1%)
				Karate	2 (1%)
				Martial Arts	2 (1%)
				Parkour	2 (1%)
				Rock climbing	2 (1%)
				Sprinting	2 (1%)
				Tennis	2 (1%)
				Volleyball	2 (1%)
				Missing	7
				No primary sport	91

## DISCUSSION

The main aims of this study were to describe sport special-

ization in Canadian junior high school students and investigate levels of sport specialization and links to injury and physical performance in this population. This is one of the

**Table 3. Ordinal multivariable logistic regression demonstrating odds of being in a more highly specialized sport category by sex, school size, and grade**

	Cumulative ORs (95% CI)
Sex	
Girls	Reference
Boys	0.9 (0.6 to 1.4)
School size	
Small	Reference
Large	0.6 (0.4 to 1.1)
School grade	
7	Reference
8	1.1 (0.4 to 2.6)
9	1.4 (0.6 to 3.4)

OR=odds ratio comparing high to moderate and low specialization, and moderate to low specialization, given the other variables held constant; CI=confidence interval

**Table 4. Multivariable logistic regression showing odds ratios of reporting a history of injury**

	Adjusted Odds Ratio (95% CI)
Specialization category	
Low	Reference
Moderate	1.94 (0.86 to 4.35)
High	2.21 (0.43 to 11.37)
Sex	
Boys	Reference
Girls	2.70 (1.69 to 4.35)*
Total sport Hours	
Per hour increase (per year)	1.0010 (1.0005 to 1.0020)*

Multivariable logistic regression with variables sports specialization, sex, total sport hours over one year, and clustering by school; \*p<0.05, CI=confidence interval

few studies in this field to focus on the younger adolescent age group (ages 11-16), adjust for sport participation hours, and include measures of physical performance. The proportion of highly specialized students was approximately 10% lower than reported in several previous studies,<sup>1,10,19,20</sup> perhaps reflecting the younger average age in this group. The proportion of highly specialized children has recently been reported to be lower in a group of 10-13 year old children.<sup>11</sup> Junior high school students may not face the same pressure from their school, parents or coaches to specialize. Authors of two previous studies have reported lower levels of highly specialized high school students similar to that seen in the current study.<sup>9,21</sup> Comparable to previous studies, level of specialization was not associated with sex or school grade.<sup>19</sup> This does however contrast a recent study by Biese et al.<sup>22</sup> that reported more highly specialized female athletes compared to male athletes in a group of 12-18 year old adolescents and this is an area that requires further investigation. A higher proportion of highly specialized high school students have been reported in larger schools<sup>19</sup> but this was not the case in the current junior high school group. This may be due to differences in the definition of

small versus large school used. These findings suggest sport specialization is not as common in junior high school students but the pattern across sex and grade is similar to high school.

Being highly or moderately specialized did not increase the odds of reporting a history of injury. This confirms the findings of recent studies which have failed to show an independent link between sport specialization and injury.<sup>11,23</sup> This is however in contrast to several studies that have reported increased injuries in highly specialized groups.<sup>10,19,20</sup> While direct comparisons should be made with caution due to differences in methods of rating specialization, injury definitions and adjustments for confounding variables (sports hours are often not accounted for and the injury definition in the current study looks at injuries sustained over the previous year), this may again be due to the relatively younger group investigated in the current study. The proposed increased risk of injury caused by repetitive movements in a single sport may only occur following a certain period of exposure and younger students may not have reached this threshold. Additionally, early specialized children may receive better technique, move-

**Table 5. Multivariable linear regression showing mean performance outcomes by specialization group, and mean differences compared to low specialized group as reference.**

		Low Specialization	Moderate Specialization	High Specialization	
Vertical jump height (cm)	Girls	Mean (98.75% CI)	31.0 (23.6 to 38.3)	30.5 (22.5 to 38.6)	31.9 (26.1 to 37.7)
		Mean difference (98.75% CI)	Reference	-0.4 (-9.8 to 8.9)	1.0 (-1.4 to 3.3)
	Boys	Mean (98.75% CI)	35.9 (27.6 to 49.4)	38.0 (26.6 to 49.4)	35.6 (30.3 to 40.9)
		Mean difference (98.75% CI)	Reference	2.1 (-9.7 to 13.8)	-0.3 (-12.7 to 12.0)
Predicted VO <sub>2</sub> max (mL/kg/min)	Girls	Mean (98.75% CI)	41.7 (36.9 to 46.4)	44.7 (42.5 to 47.0)	44.2 (36.9 to 51.6)
		Mean difference (98.75% CI)	Reference	3.1 (-3.5 to 9.7)	2.6 (-6.3 to 11.4)
	Boys	Mean (98.75% CI)	45.3 (41.9 to 48.8)	48.2 (45.0 to 51.5)	47.6 (37.6 to 57.5)
		Mean difference (98.75% CI)	Reference	2.9 (-3.0 to 8.8)	2.2 (-6.4 to 10.8)
Foam pad unipedal eyes-closed dynamic balance time (sec)	Girls	Mean (98.75% CI)	6.8 (1.7 to 11.8)	7.5 (4.1 to 10.9)	7.6 (5.2 to 10.0)
		Mean difference (98.75% CI)	Reference	0.8 (-1.4 to 2.9)	0.8 (-2.9 to 4.5)
	Boys	Mean (98.75% CI)	6.0 (2.9 to 9.1)	7.9 (4.3 to 11.6)	6.5 (3.1 to 9.9)
		Mean difference (98.75% CI)	Reference	1.9 (-4.3 to 8.2)	0.5 (-1.0 to 2.0)
Y-balance normalized composite reach distance (%)	Girls	Mean (98.75% CI)	84.2 (68.9 to 99.4)	85.4 (71.1 to 99.7)	86.8 (65.4 to 108.1)
		Mean difference (98.75% CI)	Reference	1.2 (-6.5 to 9.0)	2.6 (-13.4 to 18.7)
	Boys	Mean (98.75% CI)	84.0 (78.8 to 89.1)	91.0 (74.9 to 107.1)	84.5 (78.3 to 90.8)
		Mean difference (98.75% CI)	Reference	7.0 (-10.1 to 24.1)	0.6 (-5.8 to 7.0)

Multivariable linear regression adjusting for total sport participation hours over the previous year, interaction by sex and clustering by school; CI=confidence interval

ment skill and strength and conditioning coaching which could offer protection from injury. In the development of the adolescent athlete, strength and skill competence are considered key components for both performance and injury prevention.<sup>24</sup>

Conversely given the younger average age of the group one might expect a greater impact of high specialization and greater injury risk due to the added effect of the growth spurt. While there is substantive variation in the chronological age at which adolescents experience peak growth rates it is generally thought to occur between the ages of 11 and 13.5 years.<sup>25</sup> A further complication during this period of rapid growth is the increased incidence of growth-related conditions such as Osgood-Schlatter syndrome which may be overuse related but equally could be of insidious onset. Interestingly, injuries reported in the current study were mainly acute in nature and this may also explain the lack of association with specialization level which has often been linked to overuse injuries previously.<sup>10</sup> Nonetheless,

the increased intensity of training and competition associated with early specialization potentially also increases the risk for acute injuries and this has been reported recently in a group of adolescents competing in a variety of organized sports.<sup>22</sup> Consistent with previous studies, this study found girls and those students with higher total hours of exposure to sports had larger odds of reporting a history of injury.<sup>10,20,26,27</sup> It has been reported that the association between sport specialization and injury in adolescents may differ by sex and by sport.<sup>22</sup> Specifically, high specialization was linked to injury in females but not males, potentially due to the differing impact of specialization on neuromuscular control. Additionally, the relationship is likely to be sports specific with recent evidence supporting a link between specialization and injury in volleyball but not in basketball or soccer.<sup>28</sup>

No differences were found in physical performance between high or moderately specialized students and low specialized students. Again, it is difficult to make direct com-

parisons to previous studies due to differences in analysis, ratings of specialization and physical tests. However, the lack of association found between specialization category and composite reach distance on the Y-Balance test has been reported previously in high school athletes.<sup>29</sup> Additionally, in a group of young gymnasts no association was found between level of fitness or functional performance and level of specialization.<sup>30</sup> Findings from the current study contrast the positive link between early sport sampling (low specialization) and cardiovascular fitness reported previously in a group of young boys.<sup>31</sup> It is thought that high specialization may negatively impact neuromuscular development due to reduced exposure to variety in movement patterns resulting in a reduction in physical abilities such as balance performance. Again, an alternate theory is that specialization could be beneficial as it may give students earlier exposure to more informed coaches (better facilitators of technique and skill) and superior training programs that better develop physical condition, including balance. Additionally, well designed programs (that may include some highly specialized students) often include exposure to a variety of movement experiences. This, combined with increased volumes of sport participation that provide an enhanced training stimulus (but are still appropriate for the phase of maturation), may improve physical capability and in fact protect specialized students against injury and reduce risk.

This study has several limitations that need to be acknowledged. The sample size is relatively small and thus the proportion of highly specialized students is likely not generalizable to the entire population of junior high school students. Additionally, there were many different sports included and thus the rates of specialization and association with injury may not be representative of the situation in individual sports. It is likely that variations in the structure and rules of various sports may influence specialization and injury rates. Previous studies have reported different specialization patterns across different sports.<sup>1</sup> Furthermore, the method for rating specialization based on self-report, while used in several previous studies, is limited with authors recently highlighting the need for further validation studies in sports specific contexts.<sup>32</sup> A strength of this study

was that each participant was spoken to individually to confirm the rating of specialization. This allowed clarification of any misinterpretations regarding the questions. For example, differentiating between training for a sport versus playing a sport for leisure when addressing year-round training. In other cases, some participants mentioned that they had only ever participated in one sport, and therefore had never quit other sports. This may have underestimated their total specialization score and contributed to the lower proportion of highly specialized students. This limitation of the rating system has recently been acknowledged by others and an additional question added.<sup>1</sup> Finally, as is always the case with retrospective injury data there is the potential for recall bias.

## CONCLUSION

There is evidence of sport specialization in Canadian junior high school students, but levels are lower than many previous reports. Increased specialization did not increase the odds of reporting a history of musculoskeletal injury nor was it associated with a range of physical performance measures. Participating in more total sports hours increased the odds of reporting a history of injury and girls had higher odds of reporting a history of injury compared to boys.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest in submitting this article.

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