Do Children with Higher Levels of Sport Specialization Perform Fundamental Movement Skills Better than Children with Lower Specialization Scores?

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Abstract

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Introduction: To assess the degree of sport specialization of a children, there is the newly developed 4-point scale [24]. This tool has been used to observe the correlation between sport specialization levels and injury risk. The Child-Focused Injury Risk Screening Tool (ChildFIRST) is a process-based tool assessing 10 skills to evaluate movement competence of the lower extremity in children aged 8 to 12 years old. **Purpose:** The purpose of this study is to assess the relationship between the participants' level of sport specialization and their movement competence, scores they receive on the ChildFIRST. **Methods:** In this cross-sectional study, 70 participants (34 hockey players and 36 figure skaters), 8 to 12 years old, took part in a survey assessing their sport specialization level and were evaluated using the ChildFIRST tool. We analyzed the data using correlations, One-Way ANOVA, Kruskal-Wallis, Mann-Whitney U and descriptive statistics. **Results:** This study found that older athletes were more specialized and performed better on the ChildFIRST. However, it did not find a correlation between specialization level and ChildFIRST scores. When comparing the hockey to the figure skating group using non-parametric tests, we found that specialization levels and ChildFIRST scores are both significantly higher in the figure skating groups. **Conclusion:** These results suggests that in children aged 8 to 12 years old, there is no relationship between specializing early and movement competence in this study. They do however demonstrate that the figure skating group, across all ages, are more specialized and better at movement competence (performing better on lower limb motion and alignment movements).

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Introduction

Sport specialization in youth is a controversial topic that is gaining the attention of health care providers, parents, coaches and sports administrators all across North America over the past 2 decades [2, 27]. Youth sport specialization (YSS) defined it as "an intentional and focused participation in a single sport for a majority of the year that restricts opportunities for engagement in other sports and activities" [3]. Youth sports was previously focused around fun and maintaining good physical activity levels. However, this focus has shifted to technique acquisition and performance-oriented outcomes [25]. This change in youth sports is in part due to the belief that specializing at an early age is necessary to achieves elite athlete status, or to obtain a collegiate scholarship [2, 7]. With this ongoing mentality shift surrounding youth athletics, sport specialization has gained increased attention. Children are no longer sport sampling to be able to get ahead early in one sport [39]. Sport sampling is when a child engages in a diverse number of sports (2 or more) and who do not participate in only one sport year-round [11]. Youth athletes who sport specialize may be missing out on opportunities to develop a rich bank of motor skills and diversify their movement patterns.

The American Orthopedic Society for Sports Medicine suggests that overscheduling and excessive time commitment to one sport before puberty interferes with normal identity development [27]. Organized physical activity is when the activity is structured and is led by an adult authority figure [31]. The time commitment of sport specialization also increases the potential for overuse injuries, burnouts, and ultimately, termination of sport [27, 39]. The Canadian Fitness and Lifestyle Research Institute also revealed that 75% of school-aged children (5 to 12 years-old) participated in organized physical activity [16]. This percentage decreased to 61% in adolescents (15 to 19 years-old) [16]. In 2022, the ParticipACTION report card showed that 63% of five- to 17-year-olds, in Canada, participated in organized sport [28]. The report card also showed that after the age of 16, one out of three girls drop out of sport and one out of 10 boys [28]. Specializing early may be a contributing factor to the discontinuation of organized sport in adolescents [30, 32]. There is an increase in youth sport specialization due to the competitive and professional climate of sport culture [10], yet a small percentage of specialized athletes progress to professional or elite (Olympic) sports. A 7-year follow-up study monitored a

group of young German athletes who were training to be on the Olympic team in various sports and showed that 15 out of 4972 athletes (0.3%) were selected in their given sport and would eventually compete at an international level [33]. This low rate demonstrates the lack of progression to higher levels of sport.

The '10 000' hour rule, which is a popular belief in society, is used among coaches in the youth sports training industry to attain physical excellence. This relationship was developed by the psychologist Anders Ericsson and made famous by Malcolm Gladwell. They state that to achieve excellence in a particular skill set (i.e., athletic achievement), athletes must obtain 10,000 hours of deliberate practice [15]. The problem with this statement is that the definition of deliberate practice is not evidence based and there is no scientific evidence supporting the '10 000' hour rule. Gladwell states; "without 10 000 hours under of deliberate practice under their belt, there is no way a young hockey player can ever master the skills necessary to play at the top level" and "deliberate practice is not the thing you do once you are good, it is the thing that makes you good" [13, 16]. For example, a hockey player who deliberately practice his slap shot for '10 000' hours may be very good at it, but may not excel at stick handling or passing plays. There are many critiques to this theory because it is a difficult task to achieve. To accumulate '10 000' hours, a child must practice for four hours a day (including weekends), and this over the course of approximately 7 years. In children, it is shown that if a child participates in more hours of organized sport than their age in years, they are at higher risk for serious overuse injuries [22, 23, 24]. Parents and coaches who adopt this rule with their children/athletes may not be aware of the detrimental effects high training volumes could have on youth athletes.

Youth Sport Specialization

Many elements come into play when conceptualizing how youth sport specialization could impact athletic development [40]. These elements are the demands (physically) of various sports, sport specific skill, motivational and behavioural components, and starting practice at an early age. There is not much data representing children under the age of 12 in regards to sport specialization, but many age based recommendations use this cut off as a reference. For example, children under the age of 12 should practice organized sport less hours a week than their age in

years [24]. Understanding the effects of sport specialization at an early age (before the age of 12) is important to give an age-based recommendation with evidentiary support. Most studies have included athletes aged 7 to 18, but none have been done solely on children under the age of 12.

In March 2021, a consensus definition was developed to define sport specialization. They defined it as "an intentional and focused participation in a single sport for a majority of the year that restricts opportunities for engagement in other sports and activities" [3]. A highly cited tool in the literature to assess the degree of sport specialization of a child is the 3-point scale developed by Dr. Neeru Jayanthi [23, 24]. This tool has been mainly used to observe the correlation between sport specialization levels and the risk of obtaining injury (acute or chronic). This tool is made up of three dichotomous questions (see Appendix 1.). For every question the child answers 'yes' to, a score of one is given. If a child answers 'yes' to all three questions, he/she is categorized as highly specialized [22, 23, 24]. If a child gets two points, he/she is categorized as moderately specialized, and one point, low specialized. Jayanthi et al. have recently re-evaluated their questionnaire and determined that the three questions did not account for an athlete who has only ever trained in one sport [24]. They recognized that this athlete has not had to quit another sport to continue participating in their main sport. This revision of the tool was achieved by adding a fourth question; "Did you specialize in your main sport before the age of 12?". If the child replies "yes" to all four questions, they are termed extremely specialized. This study uses the revised 4-point scale to assess the level of sport specialization of the athlete participants. Jayanthi et al. have published the first longitudinal, clinical case-control study to explore the association between sport specialization and injuries in youth athletes [24]. They concluded that young athletes, particularly young females, were "more likely to be injured and sustain an overuse injury if they had a higher degree of sport specialization" [24].

There are many factors of specializing early that can be of concern. Children should be monitored for decrements in performance when they participate in more hours of organized sport that their age in years, when they have a ratio greater than 2:1 of organized sport versus free play, and when they train year-round in one sport [12, 18, 22, 23, 27, 42]. The consensus definition provides an "opportunity for researchers, clinicians, and other youth sport stakeholders

to apply a consistent definition of YSS to help guide their clinical research and policies" [3]. There are key elements in the definition that can be transformed into measurable outcomes. These elements are timing and length of specialized activity, the number of sports played, and the restriction that YSS has on other activities [2, 3]. Along with age, there are other factors that need to be considered when measuring YSS. These factors are the number of weekly hours of organized sport, the number of weekly hours of free play of the child, and the ratio between these two-hour values. Additional criteria are if a child travels outside of province or country to compete [6, 24, 44], how many rest days a child has [12, 24], and the child's level of enjoyment, [24, 45].

Injury Risk

Many sports have shown an increase in overuse injuries in their participants such as; soccer [8], basketball [8, 42], tennis [8, 10], swimming [30], hockey [10, 42], baseball [8, 10], gymnastics [10, 42], dance [10], figure skating [10] and track [10, 42]. In young athletes under the age of twelve, who have yet to reach puberty, and who specialize in one sport, there is an increased number of burn outs [19, 44]. Figure skating and hockey athletes are predisposed to high incidence rates of overuse injuries [19, 44, 49, 51]. Figure skating and hockey athletes are predisposed to high incidence rates of overuse injuries [19, 44, 49, 51]. In the literature, we also see that the athletes who participate in these sports specialize at an early age and show higher numbers of overuse injuries of the lower extremity [19, 44, 49, 51]. In figure skating, there are overuse injuries such as chronic low back pain, patellar tendinitis, and shin splints [19, 51]. In ice hockey, hip injuries and dysfunctions, groin and adductor strains, and femoroacetabular impingements [43, 44, 49]. However, research is predominantly done and adolescent or collegiate athletes and are retrospective in nature.

Within a sport, there are different levels of training and competition. In this study, we looked at hockey and figure skating. In hockey, the categories are termed by age (U7 through U21) with different competitive levels such as 'A', 'B', 'C' [20]., The more competitive the level is, the letters are doubled or tripled. For example, U11 'AAA' is more competitive than U11 'A'. For figure skating, the categories are termed STAR 1 to 10 in the recreational category and are

termed Juvenile, Novice, Junior and Senior in the competitive category [50]. There are no age limits in the recreational levels in figure skating, giving the athletes the opportunity to develop at their own pace. The competitive categories have an age group associated with them, Juvenile being the youngest (8 to 14 years old) to Senior (age 17 and up) [50]. There are time commitment differences and increased training hours in the competitive levels in both figure skating and hockey [7, 18, 49, 51] creating a greater risk of obtaining injury due to higher exposure to the sport (more games played and more hours spent in practice acquiring new skill).

There are numerous papers correlating sport specialization to high injury risk, however there are still many gaps. The threshold of obtaining when a child specializes in on sport remains unclear. There are raised concerns that the association found between YSS and injury risk is an effect of increased exposure to sport [45]. Research is lacking the investigation of the relationship between movement quality in youth athletes, injury risk and training volumes. Studies previously used performance-based tools to assess motor skill without assessing movement quality [27]. Physical literacy programs, movement quality and injury assessment tools have yet to be investigated in the realm of YSS.

Physical Literacy and Injury Prevention

Physical literacy is the "motivation, confidence, knowledge, understanding and adequate physical competence to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the course of life" [57]. A physically literate person is successful in responding to a new environment because they have a rich bank of established responses [57].

As children pursue physical activity endeavors, the exposure to physically challenging situations is more frequent, putting them at higher risks of getting injured [39]. Due to the potential increased risk of obtaining injury when specializing in one sport early, the physical competence component of physical literacy (quality and process that children use to perform fundamental movement skills) of a child should not be overlooked during training. To prevent injury from occurring, research suggest that young athletes should sample a variety of sports to support general physical fitness, and athleticism [2, 22, 27]. During the early developmental

stages of growth, before puberty, children will establish their own patterns of performing fundamental movement skills [2]. These skills provide the basis for later specialized and refined movements associated with sport-specific skills and increases their movement competence [25].

With the committed hours of training to only one sport, there is lacking opportunity for a child to develop a variety of movement patterns by participating in other sports. The main concern with YSS is that these athletes will have diminished capacities of performing a variety of fundamental movement skills, which may increase their risk of obtaining injury. Movement technique and body position are essential to evaluate the quality of fundamental movement skills which are also important in injury prevention strategies [39]. The ChildFIRST is a process-based tool that was recently developed at Concordia University. It includes 10 movement skills: body weight squat, vertical jump, single-leg sideways hop and hold, walking lunge, horizontal jump, two-to-one-foot hop and hold, 90-degree hold and hold, leaping, running, and single-leg hop. Each skill is associated with four evaluation criteria. This tool is meant for children aged 8 to 12 and was recently shown to be reliable and valid [25, 26, 35]. In a reliability study, the ChildFIRST had good to excellent inter-rater reliability (ICC=0.5-1.0) for 8 of the 10 movement skills that are evaluated [35]. The tool has demonstrated moderate to excellent reliability for the final score of each movement with the exception of the two-to-one foot hop and hold [35]. In the validity study, 9 out of 10 movement of the ChildFIRST were shown to be valid in evaluating movement competence for locomotion and dynamic balance in the lower extremity [26]. A limitation of this tool is that the evaluator must look at many body segments at once. Statistically, the distribution of the scores may not be wide enough, which leads to low random error [35]. A low random error causes the interclass correlation to be low as well. To increase the reliability of the tool, a training session is given to the examiners, who use the tool during testing.

This tool was developed to bridge the gap between physical literacy and injury prevention. Choosing a process-based tool, tools that can identify movement errors and risky body positions, is advantageous to assess how children move, rather than a product-oriented tool that assesses quantifiable results such as strength, force or endurance [35]. The ChildFIRST tool

has an important focus on evaluating technique and body position that are associated with increased risk of injury [25].

Understanding the relationship between sport specialization, injury risk, prevention, and physical literacy could lead to improvements in physical activity in children and help guide participation guidelines in childhood. The aim of this study is to look at children aged 8 to 12 who sport specialize compared to children that do not and see which group performs better on the ChildFIRST tool. We hypothesize that children with higher levels of YSS will have decreased scores on the ChildFIRST. Secondarily, we will analyze the following subsequent factors of YSS among the different specialization levels. These factors are as follows; 1) a child who practices more hours in a week than their age in years, 2) who has twice as much weekly hours of organized sport versus free play hours, 3) who travels out of province/country to compete in their main sport, 4) who has limited rest days (less than two for a child under 12), and their enjoyment of sport as measured by four questions from Dr. Neeru Jayanthi (see Appendix 2.) [22, 24] and to see if this correlates with lower scores on the ChildFIRST.

Methods

Ethics approval for this study was obtained from the Human Research and Ethics Committee of Concordia (certificate number # 30015776).

Study Design and Participants

This is a cross-sectional study that involves youth athletes aged 8 to 12, and who have participated in figure skating or hockey for the past year (at minimum). We compared their YSS level to the scores they obtained on the ChildFIRST tool to determine if there was a correlation.

The participants were from Hockey and Figure Skating clubs (competitive and recreational) in the Greater Montreal region. If the youth athlete is currently injured or if they have not participated in one of the two organized sport aforementioned in the past year, they were excluded from this study. In previous studies, participants were recruited from the same school and socioeconomic backgrounds or at a sporting event. For this study, the search was broadened to recruit participants from various organizations. These organizations were the Montreal Canadiens March break hockey camp, hockey teams from the south shore of Montreal and various figure skating clubs all around the Greater Montreal region. Initial recruitment was attained by being present at the hockey camp event and giving out flyers in person to the parents that explained what the study was about. For the figure skating clubs and other hockey teams, the researcher reached out via email and sent the organizations all necessary information about the study to forward to the parents of the participants. Once the parents gave consent to the organizations to give us their email addresses, they were sent the online survey assessing YSS. The survey had an integrated consent form along with the questionnaire assessing sport specialization levels, subsequent factors of YSS, injury history and demographics. Once the consent was given and the survey was completed, these participants were invited to a testing session, via their parents' email addresses, where they were evaluated with the ChildFIRST tool. Participants and their parents had already given consent through the survey but the participants provided verbal assent when they came in for testing, which was recorded on site by the

examiners. On site, all children athletes were evaluated, however, only the participants who fully completed the survey was kept and analyzed further.

Assessing Level of Youth Sport Specialization

The 4-point scale assessing the Level of Youth Sport Specialization created by Jayanthi et al [24] was integrated into the survey sent to the athlete's parents (see Appendix 1. For the questions). If the child answered "yes" to none or one of the four questions, they were placed in the Low category, if they answered "yes" to two of the four questions, they were placed in the Moderate category, if they answered "yes" to three questions they were placed in the High category and finally if they answered "yes" to all four questions, they were placed in the Extreme category. Subsequent factors of youth sport specialization linked to increased injury risk such as hours in organized practices per week, hours of free play per week, age at start of competition, travel outside of the province or country for main sport, rest days during the week and sport enjoyment questions [24] were also integrated in the online survey (see Appendix 2.).

Physical Domain Testing

To measure the physical domain of physical literacy, we used the ChildFIRST assessment tool [35]. We evaluated 10 fundamental movement skills to assess the physical competence of the participants; 1. Body weight squat, 2. Single-leg hop and hold, 3. Running, 4. Vertical jump, 5. Horizontal jump, 6. Walking lunge, 7. Two-to-one foot hop and hold, 8. Single-leg sideways hop and hold, 9. Single-leg 90˚ jump and hold, 10. Leaping. The evaluation criteria are provided in Appendix 3. For movements that are done bilaterally, the weaker score is taken into account (being the predominant risk factor) [35]. The examiners were graduate students from Concordia University with a background in physical education, athletic therapy, and kinesiology, that were all familiar with human movement. All the examiners went through a training session to ensure proper assessment of the participants [35]. The one-hour training session was intended to show the examiners how to implement the tool and identify movement errors [35]. The training included 60 practice trials using 60 videos (6 videos per movement

skill) and the examiners scores were compared and discussed based on the evaluation criteria [35] (see Appendix 3).

Procedure

The initial survey was sent out to all the aforementioned organizations and we received 112 responses which took four months to collect. Eligible responses were fully completed survey responses. We received 70 fully completed responses. Once the surveys were collected, 36 hockey players (Hky) and 34 figure skaters (FS) were contacted via their parent's email addresses to be evaluated in-person on the ChildFIRST (n=70) over the course of 6 months and 4 separate testing sessions.

We completed the in-person testing in gymnasium type setting at the arenas where the teams/camps training took place. We told the participants that they were taking part of a study to see how they perform fundamental movement skills that replicate movements that they complete in their physical education classes at school. The evaluators all completed the training session to be able to use the ChildFIRST tool. There was one evaluator at each station who was responsible for assessing two movement skills from the ChildFIRST. The participants were split into small groups of two to three children and each group started at a different station. Once all the participants in the group had completed the two movements they moved to the next station and the next evaluator. This was continued until the participant had completed all five stations and all 10 movements of the ChildFIRST. It was not always feasible to have five evaluators due to different testing session days. For the days where there were only two evaluators (lack of availability), the station set up was modified to have five movement skills per evaluator.

Statistical Analysis

In this study, descriptive statistics are provided as means, standard deviations and frequencies (percentages), to compare the results between the different sport specialization levels. Independent variables evaluated included YSS level, age and sex. Dependent variables were the ChildFIRST scores and the subsequent factors of YSS. Bivariate Pearson correlations were conducted to evaluate the strength of the relationships between YSS level and the ChildFIRST scores.

A One-Way ANOVA was also conducted to see the effect of sex on YSS level (Low, Moderate, High and Extreme) and ChildFIRST scores to determine if there was a statistical difference between the mean scores of the Hky group versus the FS group. Secondarily, we analyzed variance using Kruskal-Wallis non-parametric test to compare the means of YSS groups, the ChildFIRST scores and the subsequent factors of YSS due to the ordinal nature of the YSS variable. The data of the ChildFIRST scores across the participants was not normally distributed, therefore a Mann-Whitney U test was used to compare the differences between the Hky group and the FS group's ChildFIRST scores. All statistical analyses were done through SPSS version 29 with a significance set at $p \leq 0.05$ for all tests.

Results

A total of 70 participants (n=34 Hky, n=36 FS) completed both the questionnaires and the in-person testing (Table 1.). In the Hky group, the mean age is 9.91 years ± 1.190, the mean height is 138.00 cm ± 13.780 and mean weight is 34.176 kg ± 11.658. For the FS group, mean age is 10.17 ± 1.320, mean height of 138.89 cm ± 13.369 and mean weight of 33.292 kg ± 8.242 (Table 2.). There were 18 participants that were low specialized athletes (n=16 Hky, n=2 FS) which is 25.71% of participants placed in the Low group. The mean age, height and weight are as follows; 9.61 years ± 0.778, 133.50 cm ± 10.84, 29.44 kg ± 4.863. For the moderately specialized athletes, there were 23 (n= 9 Hky, n=14 FS) for a total of 32.86% of participants in the Moderate group. The mean age, height and weight are as follows; 9.52 years ± 1.283, 136.52 cm ± 14.94, 31.26 kg ± 8.320. For the highly specialized athletes, there were 19 (n=4 Hky, n= 15 FS) for a total of 27.14 % of participants in the High group. The mean age, height and weight are as follows; 10.79 years ± 1.273, 143.16 cm ± 12.89, 35.974 kg ± 4.927. Finally, there were 10 extremely specialized athletes (n= 5 Hky, n= 5 FS) which is 14.29% of all participants in the Extreme group. The mean age, height and weight are as follows; 10.60 years ± 1.429, 142.90 cm ± 14.77, 42.8.0 kg ± 4.467 (Table 1.). Age, height and weight are all higher in the High and Extreme groups.

For YSS total, the FS group had higher scores, with a mean of 2.64 ± 0.79 out of a total of four, compared to the Hky group who had a mean score of 1.94 ± 1.01 (Table 2.). In the Low group, they all scored one out of four. For question one, ‘Can you pick a main sport?’, 33.33% answered “yes”. For question two, ‘Have you quit other sports to focus on your main sport?’, 5.55% answered “yes”. For question three, ‘In your main sport, do you train more than 8 months in a year?’, 16.67% answered “yes”. For questions four, ‘Did you specialize in your main sport before the age of 12?’, all Low group participants answered “no”. For the Medium group who scored two on the 4-point scale, questions one and three were answered “yes” by 100% of the participants. For the High group who scored three on the 4-point scale, questions one and three were answered “yes” by all participants. For the other questions, 36.8% of all participants

answered “yes” to question two, and 63.2% answered “yes” to question four. For the Extreme group, all participants scored four on the 4-point scale, answering “yes” to all of the questions.

The scores on the ChildFIRST were higher in the FS group, with a mean of 30.25 ± 4.143, out of a potential score of 40. The Hky group had a mean of 29.47 ± 4.185 (Table 2.). The mean ChildFIRST score in Low and Medium groups are 28.44± 3.053 and 28.04± 4.258 respectively. In the High and Extreme groups, the mean ChildFIRST scores are 30.05 ± 4.927 and 30.20 ± 4.467 (Table 1.).

There was a correlation between age and YSS groups (Table 3). The older the athletes were more specialized (r=0.377, p= 0.001). There was also a weak correlation between age and the ChildFIRST score. The older the athlete, the better they scored on the ChildFIRST (r=0.237, p= 0.048). There was no correlation found between YSS groups and ChildFIRST scores (r=0.183, p=0.130). The Kruskal-Wallis test determined there were no significant differences between the mean scores of the ChildFIRST between the different YSS groups (H =3.359 p=0.340) (see Figure. 1). The One-Way ANOVA test showed that there was a significant difference between the means of the YSS scores [F (1, 68) = 9.308, p= 0.003] and ChildFIRST scores [F (1, 68) = 7.030, p=0.01] when placing sex as the dependent factor A Mann-Whitney U test was conducted and showed significant differences between the male and female ChildFIRST scores (U= 204, p=0.013) (see Graph 2.).

When looking at hours of organized sport per week, we found that High and Extreme groups train more hours in their main sport than the Low and Medium groups. Both higher specialization levels reported 0 hours for participation in other organized sports. In the Extreme group, 40% (4/10) of athletes practice more hours in organized sport than their age in years. The High group, the participants have the lowest mean for reported hours spent in free play per week at 2.894 ± 1.410 hours. The High group also has a higher ratio than twice as many hours per week of organized sports versus free play, 3.3 ± 2.193. A ratio of twice as much organized sport versus free play is recommended [2, 22, 23, 44, 45]. The Kruskal-Wallis non-parametric test showed a significant mean difference of the ratio of hours spent playing organized sports versus

hours spent in free play across the YSS groups (H= 12.02, p= 0.007) (see Graph 3.) For the Medium and High groups, 4.34% and 15.79% of participants reported to travel out of province/country to compete in their main sport. For the Low and Extreme groups, the participants did not report any sport related travel outside of the province or country. For the number of rest days per week, the Extreme group has the lowest mean at 1.81 days ± 1.02.

There was a weak correlation seen between YSS groups and enjoyment question. Higher specialization level agreed that practicing skill is more important than having fun (r=0.341, p=0.004), that they miss time with their family and friends due to practicing their main sport (r=0.377, p=0.001), and that they feel like they spend more than 75% of their weekly time practicing their main sport (r=0.2.92, p=0.014).

Discussion

In this study, we found that YSS levels are not associated with the movement competence as measured by the ChildFIRST tool which is clearly depicted in Figure 1. However, in both the Hky and FS groups, a weak positive correlation was seen between age and YSS groups, suggesting that athletes who sport specialize are older than athletes who do not sport specialize. These results suggest that in both sports, the older the athletes are, the more time they spend training in their main sport which is most likely due to the organizational framework of practices and or games. As a child ages, in both hockey and figure skating, they move up levels, which increases the number of hours they spend practicing? their sport. When looking at the organizational development of these two sports, it is seen that the older the child is, the more specialized they are.

The results demonstrated a weak positive correlation between athletes' age and their ChildFIRST scores. These results suggests that older athletes will demonstrate better movement competence as measured by the ChildFIRST tool. Following the finding above, it is clear that the older the child, the more they are exposed to sport, the better they are at movement skills of the lower extremity. This relationship can be due to the nature of both sports and the long-term athlete development module, but it could also follow the natural development of a child. As a child ages and matures, they become more aware and coordinated in their bodies [6, 10, 14, 17], allowing them to perform fundamental movement skills better as they get older. The question that remains is; where is the true limit when too much organized sport becomes an injury risk and a demotivational factor? We are still seeing increased overuse injuries, termination in sport and discontinuation of physical activity in youth athletes [26, 27, 37, 39]. Therefore, key elements that play a role in YSS are being missed.

When the Hky group to the FS group were compared, YSS scores and ChildFIRST scores were both higher in the FS group. It was also seen that there were significant mean differences in YSS total scores and ChildFIRST scores. These results demonstrated that the FS group of participants, across all ages, are more specialized and better at movement competence (performing better on lower limb motion and alignment movements). The FS group, was more

specialized, therefore the FS group could be exposed to more hours of sport, which could explain the higher scores on the ChildFIRST tool. The FS group was comprised of all females and the Hky group of all males, so this tells us that for this study, girls had significantly higher mean scores than boys on the YSS 4-point scale and ChildFIRST tool. These results may suggest that there is a difference between either nature of the sports or sex of the child with regards specialization levels and movement competence. However, it is clear from our study's data that more exposure to the sport as the child ages seems to have positive impact on movement competence, but more information and research is needed to confirm this. Although this study does not demonstrate it, the general recommendations found in previous studies is that engaging in multiple sports and activities can encourages youth athletes to have a balanced approach to acquiring a firm base of fundamental movement skills [2, 8, 12, 22, 23, 24]. It would be informative to follow these same athletes in a longitudinal study and compare their YSS scores and ChildFIRST scores as they get older.

When looking at the subsequent factors of YSS, it was seen that the higher the level of YSS, the more hours they spent practicing their main sport, the less time they spent playing other sports (the High and Extreme groups reported 0 hours in other sports). In the FS group, the ratio of twice as much organized sport hours per week versus free play hours per week was not respected (more than 2:1) and they had significantly higher mean ratios than the Hky group. The Extreme group had the lowest mean amount of rest days which may indicate that athletes who are practicing sport specialization do not follow the recommended 2 rests days. In athletes under the age of 12, 2 rest days and less can lead to burnout and overuse injuries [34, 37, 39, 42, 44]. These findings help to explain the enjoyment questionnaire results. Enjoyment and higher YSS scores correlate negatively, where the more the athlete was specialized, the more they felt like they were missing time with their families and friends. This may explain and be a projection to the likelihood of children who specialize early to abandon long-term participation in sport and especially in females [28].

Limitations

There are some limitations to this study that were found. Due to the nature of the study, the children had to be fully cooperative and focused during the ChildFIRST testing. This was not always the case, which may have affected the overall scores of the ChildFIRST. Furthermore, with some variables of this study being collected through a survey, there is a risk of recall bias. Participants may have responded inaccurately or falsely to the study's survey when recalling hours of sports played per week throughout the year or anthropometrics.

Furthermore, all the males were in the Hky group and all the females were in the FS group, linking the sex of the athlete to a specific sport. This sex bias was probably due to the nature of the sports where more females participate in figure skating and more males participate in hockey. Expanding the sample size to get female hockey players and male figure skaters may have led to a better outcome if sex of the child or sport played had an influence on YSS and the ChildFIRST scores. This will reduce sampling bias as well.

Another limitation was the pandemic. Restrictions of accessing public spaces, such as arenas, may have decreased hours of training for these youth athletes, therefor creating minor differences in training volumes of the Low group compared to the Extreme group. A year without participating in organized sport could lead to physical competence and motivational decrements. The pandemic stopped many of these athletes from practicing their main sport which may have affected their YSS scores and their movement competence due to the lack of exposure to sport.

Conclusion

There were no clinically meaningful differences between specialization level and movement competence (YSS groups and ChildFIRST scores). This suggests that there is no relationship between these variables in children who participate in hockey and figure skating. Further research is needed to continue to assess this relationship. A longitudinal study, to see if these results change during puberty (ages 13 to 17), could be interesting to determine what happens to children who sport specialize before the age of 12. With respect to age and sex, it was not surprising to find that most figure skaters (females) were highly or extremely specialized, as is seen in the literature [19]. It was clear that females had significantly better mean scores on the ChildFIRST tool compared the males, which could be due to YSS level and the increased exposure to sport.

It is known that repeated exposure to the physical demands of sport is an injury risk factor [5, 8, 10, 13, 22, 27, 34]. Further research on training volumes and physical demands assessment of sport specific training in youth athletes are still needed to continue building clear training guidelines. This will enable coaches and parents to have a better understanding of the effects of training volumes on youth athletes to create sustainable training regimens. As seen in this study, the enjoyment of practicing a main sport in youth athletes decreases and is impacted when they sport specialize. This may explain why athletes in adolescence discontinuing sports is more prevalent nowadays [30, 32].

Creating an environment where a child can be physically literate is giving them the motivation, confidence, knowledge, understanding and adequate physical competence to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the course of life [56]. Physical Literacy should be the basis of all training programs in youth sports.

Graphs and Tables

Table 1: Descriptive statistics for YSS Groups

	Low Group	Moderate Group	High Group	Extreme Group
Total (n=70)	18 (25.71%)	23 (32.86%)	19 (27.14%)	10 (14.29%)
Hockey Players (n=34)	16 (47.05%)	9 (26.47%)	4 (11.76%)	5 (14.71%)
Figure Skaters (n=36)	2 (5.56%)	14 (38.89%)	15 (41.67%)	5 (13.89%)
Mean Age (years)	9.61 ± 0.778	9.52±1.238	10.79 ± 1.273	10.60 ± 1.429
Mean weight (kg)	29.444 ± 4.863	31.261 ± 8.32	35.974 ± 77.848	42.80 ± 4.467
Mean height (cm)	133.5 ± 10.84	136.52 ± 14.494	143.16 ± 12.825	142.90 ±14.177
Mean ChildFIRST score	28.44 ± 3.053	28.04 ± 4.258	30.05 ± 4.927	30.20 ± 4.467

Table 2: Descriptive Statistics for Hockey vs. Figure Skating Groups

	Hockey (n=34)	Figure Skating (n=36)
Mean Age	9.91 ± 1.190	10.17 ± 1.320
Mean weight (kg)	34.176 ± 11.658	33.292 ± 8.242
Mean height (cm)	138.00 ± 13.780	138.89 ± 13.369
Mean YSS score	1.94 ± 1.099	2.64 ± 0.798
Mean ChildFIRST score (out of 40)	27.68 ± 3.967	30.25 ± 4.143
Lower Limb Alignment in Frontal and Sagital Planes (out of 18)	11.15±2.776	12.28±3.542

Table 3: Specialization Group Subsequent Factors Descriptive Statistics

	Low Group 0-1 (18)	Moderate Group 2 (23)	High Group 3 (19)	Extreme Group 4 (10)
In your sport's season, how many hours per week, on average, do you train in your main sport? (average)	1.138 h ± 1.813	6.370 h ± 2.337	7.420 h ± 2.714	7.550 h ± 3.862
In your sport's season, how many hours per week, on average, do you train in other sports?	5.640 h ± 2.970	7.170 h ± 2.289	0 hours	0 hours
Children who train more hours of organized sport in a week than their age in years	1/18 (5.56%)	3/23 (13.04%)	6/19 (31.58%)	4/10 (40%)
How many hours in a week, on average, do you spend playing sports for fun (not organized)?	4.17 h ± 2.007	4.43 h ± 1.830	2.894 h ± 1.410	4.30 h ± 1.767
Ratio of free play vs organized sport (2:1)	1.6 ± 0.788	2.2± 1.776	3.3 ± 2.193	2.7± 3.424
Do you travel out of country or province to compete in	0	1/23 (4.34 %)	3/19 (15.79%)	0

your primary sport?												
During your sport's season, how many rest days do you have, on average, per week?	3.22 ± 1.345 days			3.04 ± 1.783 days			2.63 ± 1.589 days			1.81 ± 1.02 days		
Enjoyment Questions	Low Group Agree	Neutral	Disagree	Moderate Group Agree	Neutral	Disagree	High Group Agree	Neutral	Disagree	Extreme Group Agree	Neutral	Disagree
During practice in my main sport, I think learning something new or improving my skill is more important than only having fun.	7 38.89 %	4 22.22 %	7 38. 89 %	8 34.78 %	10 43.48 %	5 21.7 4%	8 42.1 1%	7 36.8 4%	4 21.0 5%	5 50 %	3 30%	2 20%
I often miss spending time with my friends and/or family, that don't participate in my sport, because I have practice or competition.	5 27.78 %	2 11.11 %	11 61. 11 %	5 21.74 %	3 13.04 %	15 65.2 2%	7 36.8 4%	5 26.3 2%	7 36.8 4%	5 50 %	3 30%	2 20%
I spend more than 75% of my weekly training time in my main sport.	10 55.56 %	1 5.56%	7 38. 89 %	18 78.26 %	1 4.35%	4 17.3 9%	15 78.9 5%	0 0%	4 21.0 5%	7 70 %	1 10%	2 20%

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Appendix

Appendix 1: Youth Sport Specialization Questionnaire [23]

	For athlete to fill	**Description of answer**
Can you pick a main sport? Please list it and any other sport you par take in./ ***Pourrais-tu choisir un sport principal? Svp le noter et noter d'autres sports auxquels tu participes.***	Yes/ Oui: ❑ No/ Non: ❑ Other /Autres: _____ _____	Yes=1 No= 0
Have you quit other sports to focus on a main sport? If yes, at what age? / ***As-tu arrêté d'autres sports pour te concentrer sur ton sport principal? Si oui, à 32lais âge?***	Yes/ Oui: ❑ No/ Non: ❑ Age/Âge: ____	Yes=1 No= 0
In your main sport, do you train more than 8 months in the year? / ***Dans ton sport principal, t'entraines-tu plus que 8 mois dans l'année?***	Yes/ Oui: ❑ No/ Non: ❑	Yes=1 No= 0
Did you specialize in your main sport before the age of 12? /** ***As-tu spécialisé dans ton sport principal avant l'âge de 12 ans?	Yes/ Oui: ❑ No/ Non: ❑	Yes=1 No= 0
Total	/4	
Low specialization	0 to 1	
Moderate specialization	2	
High specialization	3	
Extreme specialization	4	

Appendix 2: Sport Specialization Subsequent Factors Questionnaire [41]

	For athlete to fill
In your sport's season, how many hours per week, on average, do you train in your main sport? /*Dans ta saison sportive, combine d'heures par semaine, en moyenne, tu t'entraines dans ton sport principal?*	_____
In your sport's season, how many hours per week, on average, do you train in other sports? /*Dans ta saison sportive, combien d'heures par semaine, en moyenne, tu t'entraines dans d'autres sports?*	_____
How many hours in a week, on average, do you spend playing sports for fun (not organized)? /*Dans une semaine, combien d'heures par semaine, en moyenne, consacres-tu à participer dans le sport pour le plaisir (pas organiser)?*	_____
At what age did you start competing in your primary sport? / *À quel âge as-tu commencé à compétitionner dans ton sport principal?*	_____
Do you travel out of province or country to compete in your main sport? / *Voyages-tu hors province ou pays pour compétitionner dans ton sport principal?*	Yes/ Oui: ❑ No/ Non: ❑
During your sport's season, how many rest days do you have, on average, per week? / *Pendant ta saison de sport, combien de journée(s) de repos as-tu, en moyenne, par semaine*?	1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑
During practice in my main sport, I think learning something new or improving my skill is more important than only having fun. / *Dans mes entraînements de mon sport principal, je crois qu'apprend quelque chose de nouveau ou améliorer ma technique est plus important qu'uniquement avoir du plaisir.*	Agree/ En accord : ❑ Disagree/ Pas en accord : ❑

I often miss spending time with my friends and/or family, that don't participate in my sport, because I have practice or competition. / *Je manque souvent pouvoir passer du temps avec mes amis et/ou famille, qui ne participent pas au même sport que moi, car je suis en entraînement ou en compétition.*	Agree/ En accord : ❑ Disagree/ Pas en accord : ❑
I spend more than 75% of my weekly training time in my main sport. /*Je consacre plus que 75% de mon temps d'entrainement hebdomadaire pour mon sport principal.*	Agree/ En accord : ❑ Disagree/ Pas en accord : ❑

Appendix 3: ChildFIRST Skill Description

Movement Skills
Bodyweight Squat
Single-Leg Hop
Running
Vertical Jump
Horizontal Jump
Walking Lunge
Two to One-foot Hop and Hold
Single-Leg Sideways Hop and Hold
Leaping
90-Degree Jump and Hold

Bodyweight Squat

Squatting involves flexing the knees and hips allowing the hips to move back while lowering the center of gravity. The feet are in a comfortable distance apart and the hands are placed either crossed on the chest or extended out in front of the body.

The movement should be smooth, and the child will have three trials.

Evaluation Criteria (Bodyweight Squat)
Push the hips back and bend the knees until the thighs are approximately parallel with the ground
Hips, knees, and ankles aligned
Knees do not go too far in front of the toes
Keep the heels down all the time

Single-Leg Hop

Single-Leg Hop is performed by small forward jumps taking off from one foot and landing on the same foot. The movement should be smooth, and performed equally on both sides.

Single-Leg Hop will be evaluated on a 10-meter space marked by cones, and the child will have two trials on each side.

Evaluation Criteria (Single-Leg Hop)
Hip, knee, and ankle aligned
Take off from one foot, land on the same foot
Knee and hip bend to land softly in a controlled fashion
Swing arms to assist the movement

Running

Running is faster than walking, but it is not sprinting. It will present the pattern of heel strike-midfoot-forefoot and a flight phase. The movement should be smooth.
Running will be evaluated over 20 meters marked by cones where the child will run and come back.

Evaluation Criteria (Running)
Upper-body straight and eyes focused in the direction travelled
Swing bent arms in opposition to legs
Knee drives upward and forward to lift the foot off the ground
Knee and hip bend slightly to land softly

Vertical Jump

Vertical jump is the action of propelling the body up into the air from the ground using both legs and landing with both feet.
The child will have three trials.

Evaluation Criteria (Vertical Jump)
Swing arms to assist the movement
Knees and hips bend to land softly in a controlled fashion
Land on both feet at the same time
Hips, knees, and ankles aligned

Horizontal Jump

Horizontal jump is the action of propelling the body forward using both legs and landing with both feet.
The child will have three trials.

Evaluation Criteria (Horizontal Jump)
Swing arms to assist the movement
Knees and hips bend to land softly in a controlled fashion
Land on both feet at the same time
Hips, knees, and ankles aligned

Walking Lunge

The lunge is a movement where the child takes an extended step forward and bends both the front and back legs to approximately 90 degrees. The front foot should be flat on the floor and the child should continue this movement over the 10-meter space, alternating legs with each step.
The movement should be smooth, performed equally on both sides, and the child will have three trials.

Evaluation Criteria (Walking Lunge)
Hips, knees, and ankles aligned
Upper-body straight and eyes focused in the direction travelled
Front-knee does not go too far in front of the toes
No twisting nor bending back

Two to One-foot Hop and Hold

Two to One-foot Hop and Hold is a movement where the child starts with *feet in a comfortable distance apart*, hops forward, and lands on one foot. The child tries to recover balance after landing, and maintains the position.
The child will have two trials on each side.

Evaluation Criteria (Two to One-foot Hop and Hold)
Knee and hip bend slightly to land softly in a controlled fashion
Toes pointing forward
Foot flat on the floor
Hip, Knee, and ankle aligned

Single-Leg Sideways Hop and Hold

Single-Leg Sideways Hop and Hold is a movement where the child starts in single leg stance, hops laterally and lands on one foot. The child tries to recover balance after landing, and maintains the position.
The child will have two trials on each side.

Evaluation Criteria (Single-Leg Sideways Hop and Hold)
Knee and hip bend slightly to land softly in a controlled fashion
Hip, Knee, and ankle aligned
Foot flat on the floor
Stand up straight within three seconds after landing

Leaping

Leaping is the action of propelling the body forward and is performed by taking off on one foot and landing on the other foot. The movement should be smooth, and performed equally on both sides.
Leaping will be evaluated on a 10-meter space marked by cones, and the child will have two trials.

Evaluation Criteria (Leaping)
Take off from one foot, land on the opposite foot
Knee and hip bend to land softly in a controlled fashion
Hip, knee, and ankles aligned
Swing bent arms in opposition to legs

90-Degree Jump and Hold

90-Degree Jump and Hold is a movement where the child stands on the right leg, hops and turn 90 degrees to the right, and lands on the right foot. The child tries to recover balance after landing, and maintains the position. Repeat this movement with the left leg on the left side. The child will have two trials on each leg.

Evaluation Criteria (90-Degree Jump and Hold)
Knee and hip bend slightly to land softly in a controlled fashion
Hip, Knee, and ankle aligned
Whole body turns together
Toes pointing forward