Relationship between Movement Competence and Degree of Sports Specialization in 8- to 12-year-old Football Players

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ABSTRACT

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Catherine Matthews

An increase in youth sport specialization prevalence has been associated with an increase injury rate and a decrease in movement competence. However, movement competence has not been compared between the degrees of sport specialization in 8- to 12-year-old football players. The purpose of the study is to primarily observe the relationship between movement competence and the degree of youth sports specialization in 8- to 12-year-old football players using the Child Focused Injury Risk Screening Tool (ChildFIRST). Secondly, the study aims to observe the differences amongst positions and the association for injury prevalence. We hypothesize that youth football players with a higher youth sport specialization categorization will have a lower movement competency. We also hypothesize that there with be a difference in movement competency amongst football positions.

During practices in the 2023 football season, 8- to 12-year-old football players from the Montreal Regional Football League were asked to complete an injury and youth sport specialization questionnaire. Participants were then assessed using the ChildFIRST. There was no significant association between ChildFIRST composite score and youth sport specialization score. When looking at the differences amongst positions, linemen had a significantly lower ChildFIRST composite score mean than other positions. No association with injury and movement competence was observed. Future studies should continue observing the movement competency in 8- to 12-year-old football players differentiating by their playing position. Such findings could contribute towards the development of an evidence-based injury prevention program for youth football players.

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Introduction

Youth Sports Specialization

Youth sports specialization is becoming increasingly popular in youth sports (Matzkin & Garvey, 2019). A consensus panel of 17 multidisciplinary experts in pediatric sports medicine defined youth sports specialization 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" (Bell et al., 2021). Bell et al. (2021) list three criteria that an athlete would need to meet some or all to be considered specialized:(1) "Participation in a single sport for more than eight months of the year that includes regular organized practices, competitions, or other structured training"; (2) "the athlete may have limited or ended involvement in other sports to enable focused participation in a single sport. Alternatively, the athlete may have only ever been involved in one sport"; and/or (3) "Focused participation in a single sport limits the opportunities or time available for other activities, such as involvement in other sports, academics, extracurricular activities, time with friends, and community engagement" (Bell et al., 2021).

Based on the definition of youth sports specialization, an athlete can be classified according to their degree of specialization using a questionnaire. Presently, Jayanthi et al.'s (2015) "Sports Specialization Scale" is the most referenced questionnaire in sports specialization literature (Mosher et al., 2020). The 3-point scale survey categorizes an athlete as either low, moderate, or highly specialized. However, a cross-sectional study by Miller et al. (2019), highlighted that approximately 30% of highly specialized athletes are misclassified as moderately specialized when using Jayanthi et al.'s (2015) questionnaire. In addition, misclassifications were more frequent in individual- sport and female athletes compared with team-sport and male athletes. The authors hypothesize that though a measurable number of year-round, single sport athletes, who have never played more than one sport are viewed by experts as highly specialized, they are commonly inaccurately classified as moderately specialized when using the Jayanthi et al. 's (2015) questionnaire (M. Miller et al., 2019). To account for athletes who may not have played other sports, a modification of the current stratification questionnaire by Jayanthi et al. 's (2015) "Sports Specialization Scale" is required. M. Miller et al. (2019) recommend adding a fourth question, "Have you only ever played 1 sport?" to the Jayanthi et al. (2015) questionnaire. Athletes would still use the same classification system of low (0-1 points), moderate (2 points) or high (3 points), but highly specialized athletes would be divided into two

categories: those who quit other sports and those who never played other sports (M. Miller et al., 2019). Refer to the methods section for additional information.

Currently, the prevalence rates of sports specialization among youth athletes vary between 17% to 41% (Bell et al., 2016; Bell, Post, Trigsted, et al., 2018; N. A. Jayanthi et al., 2019; Post, Bell, et al., 2017). Factors including sex, age, sport, socioeconomic status, school size and geographic location can impact rates (Bell et al., 2016; Bell, Post, Trigsted, et al., 2018; N. A. Jayanthi et al., 2019; Post, Bell, et al., 2017). The incentive for youth sport specialization is multifaceted and varied but regularly includes aspirations of long-term success in a sport (Matzkin & Garvey, 2019). Athletes are motivated by the theoretical competitive advantage sport specialization has to enhance one's chances of obtaining college scholarships, professional status, and/or being an Olympian (Brenner & COUNCIL ON SPORTS MEDICINE AND FITNESS, 2016). Desire for recognition by coaches, parents, peers and society contribute to an athlete's decision to specialize in a sport (Brenner & COUNCIL ON SPORTS MEDICINE AND FITNESS, 2016; Güllich & Emrich, 2006; Padaki et al., 2017).

Whilst youth sports specialization is beneficial in certain sports that require an earlier peak performance, such as women's gymnastics and women's figure skating, it is not a requirement for all sports (Goodway & Robinson, 2015). A cohort study by Rugg et al. (2021), sent out an electronic survey to National Collegiate Athletic Association (NCAA) athletes who participated in their sport between 1960 to 2018. The study defines youth sports specialization as "specialization in a single sport before age 15 years". Of the 1550 NCAA athletes who participated, less than one-fifth (18.1%) of the athletes specialized before 15 years old. Football and baseball athletes were more likely to specialize later whereas, gymnasts, tennis players, swimmers, divers, and soccer players were significantly more likely to specialize early. The study found that neither the time-loss injury rate, career lengths nor scholarship attainment were affected by early specialization (Rugg et al., 2021). Similarly, a retrospective cross sectional survey study wanted to define when professional and collegiate ice hockey players began specializing in hockey (S. Black et al., 2019). Participants included 91 male athletes ranging from 18 to 39 years old. Participants included active members from one National Hockey League organization, and two NCAA organizations. The study observed that the mean age of specializing in hockey was 14.3 years old, and as a child, the participants participated in multiple sports. Moreover, in the professional group, the NCAA Division I group, and the NCAA

Division III group, the mean age of specialization was 14.1, 14.5, and 14.6 years, respectively. Thus, the more elite players did start specializing slightly earlier than the lesser elite subgroup of athletes, however neither group began prior to puberty. Nonetheless, the literature emphasizes that youth sport specialization before the age of 12 is not required for success in athletic performance (S. Black et al., 2019; Rugg et al., 2021).

The emphasis on youth sports specialization continues to increase among young athletes, despite discouragement from several sport and medical organizations (Rugg et al., 2021). The American Academy of Pediatrics clinical report recommends delaying intense training and specialization until after puberty for most sports, as no competitive advantage has been observed (Brenner & COUNCIL ON SPORTS MEDICINE AND FITNESS, 2016; Rugg et al., 2021). Notably, early sports specialization has been associated with increased burnout, overuse musculoskeletal injuries, and lower movement competence (S. Black et al., 2019; Law et al., 2007; Rugg et al., 2021).

Musculoskeletal Consequences of Youth Sport Specialization

A physical consequences of youth sport specialization is a higher rate of injury, notably overuse injuries (Brenner & COUNCIL ON SPORTS MEDICINE AND FITNESS, 2016; DiFiori et al., 2014; LaPrade et al., 2016). Overuse injuries occur from repetitive trauma over time causing tissue damage. Physiological immaturities exist in a developing athletes' bones and connective tissues (DiCesare et al., 2019). Therefore, growing athletes may not be capable of adequately handling the high load and volume from the continuous practice of sport-specific skills (N. A. Jayanthi et al., 2019). Biomechanically, highly specialized youth athletes repetitively perform a narrower and more homogenous spectrum of body movements than more diversified athletes (DiCesare et al., 2019; N. A. Jayanthi et al., 2019). Thus, the repeated stress on the connective tissue consequently increases the risk of overuse injuries.

The increase injury prevalence in specialized youth athletes is supported Jayanthi et al.'s (2019) narrative review of articles published from 1990 through 2018. A consistent finding observed was a correlation between higher rates of injury and higher degrees of sport specialization (N. A. Jayanthi et al., 2019). The self-reported injuries included strains, patellofemoral pain, Sinding-Larsen-Johansson syndrome, and Osgood-Schlatter disease. Furthermore, serious overuse injuries (defined as losing one or more months of participation),

were more common in young athletes with a higher degree of sport specialization. The serious overuse injuries recorded included osteochondritis dissecans, spondylolysis, stress fractures and elbow ligament injuries. Similarly, a case -control study of 2011 youth athletes between 12 to 18 years of age observed a significant association between injury history and youth sport specialization (Post, Trigsted, et al., 2017). The results from the questionnaire highlighted that highly specialized athletes were from 45% to 91% more likely to report a previous injury compared to athletes in the low specialization category. The injured locations most listed were the ankle, wrist/hand, head/neck, and knee. Specifically, athletes who played their primary sport for more than eight months of the year reported a higher rate of overuse injuries compared to the remaining participants. The most common locations for overuse injuries were the knee, shoulder, ankle, and hip. Moreover, when compared to athletes in the low specialization classification, highly specialized athletes were more likely to report the following: a history of any injury, an overuse injury, or an upper extremity overuse injury. The effects of youth sports specialization can also be seen at the level of National Collegiate Athletic Association (NCAA) Division I athletes (Ahlquist et al., 2020). In a cross-sectional study that involved 232 athletes, participants who had specialized in their eventual varsity sport before the age of 14 compared to athletes who did not specialize before 14 years old were not only more likely to report a history of injuries (86.9% vs 71.4%) and multiple injuries (64.6% vs 48.8%), but they also reported a greater amount of multiple college injuries (17.2% vs. 6.0%).

In conjunction, there appears to be a relationship between the degree of specialization and the number of injuries acquired by a young athlete (Bell, Post, Biese, et al., 2018). As stated in a systemic review with meta-analysis performed in 2018, athletes with high specialization were roughly twice as likely to sustain an overuse injury compared with athletes with low specialization (81% more likely) and moderate specialization (18% more likely) (Bell, Post, Biese, et al., 2018). Even when compared to low specialization, moderate specialization appeared to be about 39% more likely to sustain an injury. Comparable results were observed in a 3-year longitudinal clinical case-control study by Jayanthi et al. (2020), who observed the degree of sport specialization and their risk of injuries in young athletes between 7 and 18 years old. The authors note that compared to less specialized athletes, more specialized athletes had a greater likelihood of being injured (P=0.03) or had an overuse injury (P=0.02), even after adjusting for potential confounders. Notably, it was observed that young athletes who trained

twice as many hours as they spent participating in free play or who's weekly training hours exceeded the recommendation of that of their age group, they were significantly more likely to be injured (N. Jayanthi et al., 2020). Markedly, a recent cross-sectional study observing the twelve-month injury history on Canadian high school students 14 to 19 years old had similar findings (Whatman et al., 2022). The study states that highly specialized students have a significantly higher musculoskeletal injury rate (incidence rate ration = 1.36) but not a lower extremity injury or concussion rate compared with low specialization students.

There is currently limited research on the musculoskeletal effect of youth sports specifically on young football players. Current literature includes football players as participants in studies, but do not specifically isolate findings for solely football players (Post, Trigsted, et al., 2017; Rugg et al., 2021; Swindell et al., 2019; Whatman et al., 2022). Considering the high injury rate observed in football athletes, observing to see if youth sports specialization contributes to injury prevalence would be novel findings.

Movement Competence

Movement competence can be defined in the literature as "the development of sufficient skill to assure successful performance in different physical activities" (Bisi et al., 2017). Motor competence has been shown in the literature to be positively associated with enhanced physical capacities (Rogers et al., 2020). A greater injury resilience is acquired through an enhanced physical capacity (Rogers et al., 2020). The literature emphasizes that children with low movement competence are more likely to experience psychological and physical health problems, inactivity, inferior cognitive development and overall poorer-well-being (Barnett et al., 2009; Bisi et al., 2017; Kantomaa et al., 2013; Lubans et al., 2010).

The foundation of movement competence is functional motor skills (Bisi et al., 2017; Vameghi et al., 2013). Functional motor skills can be defined as "a group of motor behaviours which include locomotor, object manipulation and stability skills" (Eddy et al., 2021). Examples of such behaviours include running (locomotor), throwing a ball (object manipulation) and one-legged balance (stability skills) (Stodden et al., 2008). Studies have found that a child's confidence in future sports participation can be improved by good functional motor skills (Chen et al., 2022; Gagen & Getchell, 2006). The literature highlights that fundamental movement skills are the functional precursor movements to more specialized intricate skills in sports,

games, dance, and recreational activities (Lloyd et al., 2014). Inadequate development of functional movement skills during youth, preschool and elementary school years, has been associated with decrease physical abilities in adulthood (Vameghi et al., 2013). Llyod et al. (2014) conducted a 20-year mixed longitudinal cohort study investigating the actual motor skill proficiency at age six and the long-term association between the self-reported physical activity at age 26. Although limited in sample size, the study highlights that at age six, motor skill proficiency was related to self-reported proficiency at age 16 ($r = 0.77$, $p = .006$), and between 16 and 26 years ($r = 0.85$, $p = .001$) (Lloyd et al., 2014).

The most critical time for motor competence development is during childhood (Robinson et al., 2015). Notably, the literature emphasizes that motor skills do not develop innately (Logan et al., 2012; Morgan et al., 2013; Riethmuller et al., 2009). Appropriate practice, feedback, instruction, and reinforcement is required for proper movement competence development (Logan et al., 2012; Morgan et al., 2013; Pill & Harvey, 2019; Riethmuller et al., 2009). Greater increases in movement competence are seen in children who learn motor skills directed by specialist compared to children who solely engage in free play without specialist direction (Robinson, 2011; Robinson, Wadsworth, et al., 2012; Robinson, Webster, et al., 2012). Concerningly, as many as half of the children in some countries will leave school without a sufficient movement competency for successful engagement in physical activity and sports (MacNamara et al., 2015; Morgan et al., 2013; Pill & Harvey, 2019).

Youth sports specialization is negatively associated with movement competence (Myer et al., 2016). A study conducted by Fransen et al. (2012) observed the effect of gross motor coordination and physical fitness in boys aged 6 to 12 years old (Fransen et al., 2012). After comparing 735 boys, it was revealed that boys aged 10 to 12 years, with a diversified sports background, performed better on gross motor coordination and standing broad jump than boys specializing in a single sport (Fransen et al., 2012). Specialized youth athletes are focusing predominantly on the motor skills required for their primary sport. Thus, there is less or no focus on other motor skills typically developed with a more physically diversified routine; hence the reduced motor skill proficiency (DiCesare et al., 2019). Moreover, a cross-sectional study observed the jump-landing techniques in 8- to 14-year-old athletes (DiStefano et al., 2018). Athletes who had participated in multiple sports within the year of the study were 2.5 times as likely (95% CI, 1.9-3.1) to be categorized as having good neuromuscular control compared with

the single sport group (DiStefano et al., 2018). Therefore, youth sport specialization suppresses the development of a broad range of neuromuscular patterns, subsequently decreasing motor competence and increasing the risk of injury (N. A. Jayanthi et al., 2019).

The literature indicates a relationship between poor movement quality and an increase in injury when observing retrospectively for various sports. Notably, in a study performed by Koźlenia & Domaradzki (2021) a relationship between injuries with movement pattern quality and flexibility was observed. The study consisted of 176 athletes aged 22.44±1.64 years old that trained at least three times per week and had at least ten years of experience in sport. Quality of movement patterns were assessed using the composite score of the functional movement screen (FMS) test and the level of flexibility was measured using the sit and reach test. Injury data was acquired retrospectively through an injury history questionnaire regarding musculoskeletal injuries sustained during physical activity. Koźlenia & Domaradzki (2021) observed that the group most frequently injured were the athletes with poor quality movement pattern combined with poor flexibility. Comparably, Kiesel et al. (2007) observed the relationship between fundamental movement patterns measured by FMS and the risk of serious injury in professional football players. Severe injury was defined by the study as a player being on the injury reserved list and having a time loss of at least three weeks. FMS testing was performed during the 2005 pre-season and injury surveillance time was during the entirety of the 2005 season (~4.5 months). During data analysis, Kiesel et al. (2007) observed that when a player had an FMS score of 14 or less at the start of the season, they had an eleven-fold increased chance of injury when compared to a player with a preseason FMS score greater than 14 (specificity of 0.91 and sensitivity of 0.54).

Presently, the literature has begun showing evidence to support the relationship between dysfunctional movement patterns and injury frequency in adults, but research is limited for youth athletes. Children may use compensatory movement strategies when inadequate movement mechanics are developed (Cook & Burton, 2010; Jimenez-Garcia et al., 2020; Myer et al., 2014). If the compensatory movement strategies are not corrected, there is a greater risk of musculoskeletal injury. Therefore, examining movement competence throughout the maturation in childhood is critical to promote a healthy, injury resilient, and active lifestyle through childhood, adolescence and into adulthood.

Sports Injury and Public Health

In 2020, a national health interview survey found that 54.1% of American children aged 6 to 17 years old participated in sports during the past year (L. I. Black, 2022). A National Hospital Ambulatory Medical Care Survey in the United States estimated that sports-related injuries for individuals aged 5 to 24 years old contributed to 2.6 million emergency department visits (Burt & Overpeck, 2001). Notably, the ages 5 to 14 represented the peak incident of emergency department visits (Burt & Overpeck, 2001). The authors highlight many injuries go unreported or many do not seek medical attention, leading to the actual number of injuries potentially being larger (Burt & Overpeck, 2001). Similarly, a retrospective data analysis using data from the Canadian Hospitals Injury Reporting and Prevention program (CHIRPP) found that the greatest proportion of injuries were reported in the 10- to 14-year-old group (Fridman et al., 2013). Additionally, males reported the majority (71.1%) of sports-related injuries compared to females (Fridman et al., 2013). A descriptive epidemiology study identified the number of sports-related injury emergency department visits in patients aged 13 through 19 years old (Nalliah et al., 2014). Using a nationwide emergency department sample data set, the study observed 432 609 emergency department visits from sports-related injuries; 76.8% of total visits were from male patients (Nalliah et al., 2014). The authors highlight that the injuries most frequently occurring were contusion or superficial injury (n= 118 250); strains and sprains (n=105,476); fracture of the upper limb (n= 63 151); open wounds of the head, the neck and the trunk (n=46 176); as well as intracranial injury (n=30 726) (Nalliah et al., 2014). Football was one of the most frequent sports-related activities causing emergency department visits (Burt & Overpeck, 2001; Cheng et al., 2000).

The yearly cost of managing youth sport injuries in the health care system is difficult to measure. Many factors can impact the measurements, such as but not limited to the following: private vs public sector and the different regional systems for inpatient and outpatient care. Despite the complications, certain studies have performed estimations to help determine the economic burden sports-related injuries can have on the health system. Knowles et al (2007) conducted a North Carolina High school athletic injury study in varsity athletes. The estimates observed were $9.9 million in medical costs, $44.7 million in human capital costs (includes medical cost and loss of future earnings), and $144.6 million in compressive cost (medical cost, loss of future earnings and reduced quality of life costs) (Knowles et al., 2007). In the United

States, an annual charge of $113 million USD to $133 million USD were from sports injury hospitalization (Bell et al., 2019). Patients 10 to 18 years old are approximately 90% of the sport injury hospitalizations (Bell et al., 2019).

The economic burden of injuries from youth sports is apparent in the health care system. Aside from monetary consequences, injuries from sports utilize a variety of medical resources (equipment, beds, and medical staff's time) which further tax our currently overwhelmed medical sector. Evidence-based injury prevention programs should be used to help minimize preventable sports related injuries in young athletes. Specifically placing greater emphasize on prevention programs for athletes between 5 to 14 years old is warranted as they have the greatest risk for visiting the emergency department from sports related injuries (Burt & Overpeck, 2001).

Musculoskeletal Injuries in Football

American Football is one of the most popular sports among youth and high school athletes in the United States (Badgeley et al., 2013; Hoge et al., 2022). During the 2005-2006 to 2009-2010 academic years, over 1.1 million American high school athletes played football (Badgeley et al., 2013). A cross-sectional epidemiological study using data collected from the National Electronic Injury Surveillance System database was conducted by Lykissas et al. (2013). The study observed pediatric injuries presenting to the emergency department (Lykissas et al., 2013). Interestingly, the study found that football was amongst the top eight causes of injury in children 5 to 14 years old (Lykissas et al., 2013). Sports injuries consist of 23% of traumatic pediatric consults in the emergency room (Podberesky et al., 2009). Studies have shown that American football has the highest injury rates for both the high school and collegiate level athletes compared with other sports (Carter et al., 2011; Kerr et al., 2014; Rechel et al., 2008; Whiting, 2015; Yang et al., 2012). The injury rate has been shown to be between 4.08 to 11.67 per 1000 athletic exposures (Badgeley et al., 2013, p. 00; Centers for Disease Control and Prevention (CDC), 2006; Patel et al., 2017; Pelet et al., 2022). Injury rates are commonly higher during games than during practices (Pelet et al., 2022; Price, 2004). Factors including age, previous injury history and playing position impact the type and severity of injury (Pelet et al., 2022; Whiting, 2015).

An observational cohort study in Quebec, Canada by Pelet et al. (2022) observed the incidence, severity, and injury risk factors in high school football players. The study consisted of

707 male high school football players aged 13 to 17 years old from four participating high schools. As players got older, injuries were more frequent. Notably, nearly half of the events reported (40.69%) were players aged 15 to 17 years old (Pelet et al., 2022). The lower injury rate in younger football players may be due to different rules, smaller and/or weaker players and, a slower pace of play (Pelet et al., 2022). The study highlighted that the most influential factor in injury rate is the presence of previous injuries. Predisposition to sustaining an injury was increased with the presence of an active injury (RR= 2.25 (1.98-2.56}; p=0.00425). Similarly, a study conducted by Knowles et al., (2009), found that athletes with a prior injury had doubled the risk of subsequent injury.

Regarding the difference of musculoskeletal injuries between playing positions, Badgeley et al., (2013) completed an epidemiology of American high school football injuries during the 2005-2006 to 2009-2010 academic years. Using the assistance of certified athletic trainers from 100 American high schools, 10,100 football injuries were reported. The study found that running backs (16.3%) had the greatest injury rate followed by linebackers (14.9%) and wide receivers (11.9%) (Badgeley et al., 2013). In addition, 18.3% of all injuries were sustained by offensive linemen (center, offensive guard, and offensive tackle). The most common musculoskeletal injury diagnoses observed were strain/sprains (43.0%) and contusions (15.0%) (Badgeley et al., 2013). The lower extremity, predominantly the knee (15.4%) and ankle (13.3%) were the most common body sites injured throughout the study (Badgeley et al., 2013). The most frequent mechanism of injuries observed were player-player contact (64.0%) and player-surface contact (13.4%); notable when players are being tackled (24.4%) or tackling another player (21.8%). Interestingly, 6.5% of overall injuries required surgery with tight ends having the largest proportion (12.5%).

A gap in the literature exists pertaining to the effects of youth sports specialization on the movement competence in young football athletes; notably the difference amongst playing positions. Football includes twenty-four different positions that each require a specific subset of motor skills. Subsequently, an evidence-based injury prevention program for youth football players can be developed to reduce injury prevalence through better understanding the relationship between movement competence, the degree of sports specialization and playing positions. The current literature on football injuries primarily pertains to high school, collegiate or professional level football players. Younger football players, notably between 8 to 12 years

old are commonly excluded or neglected from musculoskeletal injury research. Research including difference in playing position is even more limited for football players aged 8 to 12 years old. Conversely, being able to identify variation in injury rate by playing position is a vital first step in the development of evidence based targeted injury prevention intervention.

Child-Focused Injury Risk Screening tool (ChildFIRST)

The Child-Focused Injury Risk Screening tool (ChildFIRST) is a process-based movement competence assessment tool. The ChildFIRST aims to identify lower extremity injury risk through the evaluation of movement competence in children aged 8 to 12 years old (M. B. Miller et al., 2020). Miller et al., (2020) designed the ChildFIRST "to help bridge the gap between physical literacy and injury prevention by evaluating a series of movement skills with a focus on evaluating movement technique and body positions that are associated with increased risk of injury" (M. B. Miller et al., 2020). The ChildFIRST includes ten movement skills and has four associated evaluation criteria for each movement (Jimenez-Garcia et al., 2020; M. B. Miller et al., 2020). The ten movement skills include: single-leg hop and hold, two-to-one foot hop and hold, bodyweight squat, vertical jump, single-leg hop, running, horizontal jump, 90-degree hop and hold, leaping and walking lunge (M. B. Miller et al., 2020). Users of the ChildFIRST assign a child performing each movement a score from 0 to 4 (M. B. Miller et al., 2020). Each of the ten movement skills has four evaluation criteria that are aimed to be observable movement characteristics (M. B. Miller et al., 2020). A score of one is given if the movement characteristic is observed (M. B. Miller et al., 2020). Therefore, a larger composite score correlates with a greater movement competence.

Prior to the ChildFIRST, no movement competence assessment tool for 8- to 12-year-old children had been designed to include musculoskeletal injury prevention concepts (M. B. Miller et al., 2018). Current musculoskeletal injury screening tools, such as the Y-Balance Test, Landing Error Scoring System and the Functional Movement Screen do not incorporate nor focus on musculoskeletal injury screening techniques for lower limbs (Jimenez-Garcia et al., 2020). Conversely, unlike other musculoskeletal injury screening tools, the ChildFIRST does not require specialized equipment and is feasible with a large group of children (Jimenez-Garcia et al., 2020). As such, the intended design of the ChildFIRST is to be used in group settings as an observational tool for sports teams and physical education classes (M. B. Miller et al., 2020).

Recommended testing environments include school gymnasium, clinic, soccer field, or other open areas (M. B. Miller et al., 2020).

A Delphi-study was performed to determine the preliminary validity of the 10 movement skills (Jimenez-Garcia et al., 2020). The Delphi study consisted of an international expert panel of 22 participants of primarily athletic training/ therapy (31.8%) and motor development and physical literacy (31.8%) expertise (Jimenez-Garcia et al., 2020). For 9 of the 10 movement skills, the ChildFIRST was determined to have moderate-to-excellent inter-rater reliability [(-0.306 to 9.380 ICC)], while intra-rate reliability [(-0.386 to 0.881 ICC)] and overall evaluation criteria reliability range from good to poor (M. B. Miller et al., 2020). Miller et al. (2020) recommends evaluators engaging in frequent trainings sessions to enhance reliability potential; notably if testing is on multiple days.

Literature Gap and Significance

Childhood is the most critical time for movement competence development (Robinson et al., 2015). Inadequate development of movement competence in childhood is associated with decrease physical abilities in adulthood (Lloyd et al., 2014; Vameghi et al., 2013). Decrease physical abilities is associated with an increased risk of musculoskeletal injuries (Rogers et al., 2020); further taxing the overburdened public health sector.

Although youth sports specialization prominence has increased in research, a system review including both nonempirical and empirical peer-reviewed papers highlights that the existing literature consists heavily of commentaries, editorials and review papers that reiterate previous findings (Mosher et al., 2020). Thus, there is a lack of practical application from the current literature. Notably, a large gap in the research consists of an absence of evidence-based injury prevention program that take into consideration the impact youth sport specialization has on young athletes to help mitigate risk. Interestingly, a standardized evidence-based injury prevention program, like the *FIFA 11+* (soccer) and the *Activate* (rugby), does not appear to exist for youth football players, despite football's popularity in young athletes.

Currently, the literature including youth football players between 8- to 12-years-old is limited. Notably, research involving movement competence differentiated by degree of sports specialization and playing position is absent in the literature. Considering the greater risk of injury after age 12 (Soligard et al., 2008) and high injury rate observed in football athletes

(Badgeley et al., 2013, p. 00; Centers for Disease Control and Prevention (CDC), 2006; Patel et al., 2017; Pelet et al., 2022), observing the movement competence in football players between 8- to 12-years-old could provide the framework for clinical application. Future research can use such findings to develop evidence-based injury prevention interventions used by team therapists, athletic trainers, and coaches to promote injury resilience in football players through childhood into adulthood.

Hypothesis

We hypothesize that youth football players with a higher youth sport specialization categorization will have a lower ChildFIRST composite score. We also hypothesize that there with be a difference in ChildFIRST composite scores amongst football positions.

Objectives

Primary Objective

To observe the relationship between ChildFIRST composite scores and the degree of youth sports specialization in 8- to 12-year-old football players.

Secondary Objectives

- To observe the differences in ChildFIRST composite scores amongst playing positions in 8- to 12-year-old football players.
- To observe an association between injury prevalence and ChildFIRST composite scores in 8- to 12-year-old football players.

Methods

Study Design and Participants

The participants were 55 youth football players between the ages of 8- to 12-years-old from LaSalle Minor League Football Association during the 2023 Montreal Regional Football League (MRFL) season. The study included two biological females and 53 biological males. Players completed the participating teams' registration at the start of the study for participation eligibility. Approval from the institutional human research ethics committee was received. Participants provided informed parental consent and athlete assent prior to testing.

Procedure

The testing was performed at the participants' training facility before and during the teams' practicing times. The training facility was a synthetic-turf football field. Testing was conducted from end of September to end of October of the 2023 Montreal Regional Football Association season. Examiners received a training on how to use the Child-Focused Injury Risk Screening Tool (ChildFIRST).

Prior to testing, we obtained informed verbal assent from the participants and informed written consent from their guardians. The participants and their guardians completed an injury questionnaire and a sport specialization questionnaire, as described below. An evaluator available to answer any questions while participants and their guardians completed the consent form and questionnaire. Participants then completed the ChildFIRST.

Questionnaires

Injury History Questionnaire

The injury history questionnaire was designed to consist of the following sections: sociodemographic (age, sex, educational level, years of experience in football and football position), injuries over the past 6 months (location, description, and amount of playing time lost to injury), and general medical history. See Appendix A. Fuller et al. (2006)'s definition of an injury was used: An injury is a physical complaint by a participant that has occurred in the past six months, irrespective of time loss from football activities or the need for medical attention. We excluded simple bruises (not associated with other injuries) because of the contact nature of the sport.

In the sociodemographic section of the injury history questionnaire, participants were asked to mark which playing position(s) they have played in the past year. Players were then divided into two positional categories of linemen and other. All players that had marked either centre, offensive linemen or defensive linemen were sorted in the "Linemen group". Players that had marked positions other than the positions previous listed were categorized as "Other group". The offensive linemen included the offensive guard and the offensive tackle. The defensive linemen included the defensive tackle, middle guard (nose tackle) and defensive end. Additionally, participants were further categorized into those that had played multiple positions

and those that had played a singular position. Those that had played multiple positions consisted of participants that had marked more than one position in the questionnaire.

Youth Sports Specialization Questionnaire

A modified version of the "Sports Specialization Scale" by Jayanthi et al. (2015) was used to categorize the participants' degree of sports specialization. Jayanthi et al. 's (2015) "Sports Specialization Scale" is the most used questionnaire in sports specialization literature (Mosher et al., 2020). The survey included the following three questions: "(1) Can you pick a main sport (i.e., single-sport training)? (2) Did you quit other sports to focus on a main sport (i.e., exclusion of other sports)? (3) Do you train more than 8 months in a year (i.e., year-round training)?" (N. A. Jayanthi et al., 2015). As shown in Appendix A, a fourth question established by M. Miller et al. (2019), "Have you only ever played 1 sport" was added to the "Sports Specialization Questionnaire" to account for a subset of highly specialized athletes. One point was given for every "yes" answer to a question. For a low specialization classification, a total scale of 0 to 1 point was obtained, 2 points was classified as moderate specialization, 3 points was considered high specialization. The highly specialized athletes were further divided into those who have never played other sports and those who have played other sports (M. Miller et al., 2019).

The Child-Focused Injury Risk Screening Tool

The Child-Focused Injury Risk Screening Tool (ChildFIRST) evaluates "movement competence and [identifies] lower extremity injury risk in children aged 8 to 12" (M. B. Miller et al., 2020). As shown in Appendix B, the ChildFIRST comprises of 10 movement skills with four evaluation criteria associated with each movement skill (M. B. Miller et al., 2020). The 10 movement skills include the following: body- weight squat, vertical jump, single-leg sideways hop and hold, walking lunge, two-to-one-foot hop and hold, 90- degree hop and hold, leaping, horizontal jump, running, and single-leg hop (M. B. Miller et al., 2020). The ChildFIRST is accessible as it requires minimal equipment and is feasible for a large group of children, unlike the Functional Movement Screen, Y-Balance Test, and Landing Error Scoring System (Jimenez-Garcia et al., 2020).

We followed the testing procedure, and the evaluation criteria as described by Jimenez-Garcia et al. (2020). However, a validity study by Jimenez-Garcia et al. (2024) found that

through observation leaping is not a valid skill to identify abnormal joint motion when using the ChildFIRST, thus leaping was removed as a tested movement skill. All testing that was done on a single leg were tested bilaterally.

All three examiners completed a training session prior to testing. The training was a 90-minute session instructing the three examiners on how to use the ChildFIRST and how to identify movement errors for each movement skills. Practiced trials were performed in the training session where examiners compared their scores amongst each other and to the standard scoring by M. B. Miller et al., (2020). The three examiners consisted of a Certified Athletic Therapist and two 4th year honour students of an athletic therapy program. All examiners had the same educational program background as the participants in M. B. Miller et al. (2020) study that assessed the reliability of the ChildFIRST. The same examiner rated the same individual movement skill(s) of the ChildFIRST for participants. It should be noted that due to logistical reasons, for seven participants, only one examiner evaluated all nine movement skills. All movement skills that are performed single-legged (single-leg sideways hop and hold, two-to-one-foot hop and hold, 90- degree hop and hold, and single-leg hop) were all tested bilaterally. Each criteria obtained was given one point, for a maximum overall score of 52. We conducted the ChildFIRST testing in a station approach for all groups during participants' practices.

Statistical Analysis

We performed descriptive statistics (mean, median, confidence interval, standard deviation, and interquartile range values) for the ChildFIRST composite scores, ChildFIRST individual skills scores and the youth sport specialization score. The Shapiro-Wilk tests and Kolmogorov-Smirnov tests were used to test for normality of the continuous variables. As normality was supported, a two- way ANOVA was conducted that examined the effect of youth sport specialization score and position category on ChildFIRST composite score. Independent T-Tests were done to compare the means of ChildFIRST composite score in linemen and other playing positions; and the means of ChildFIRST composite score in players who play multiple positions and players who play a single position. A one-way ANOVA was used to see if there is an association between ChildFIRST composite score and injury history.

Results

A total of 55 participants (mean age, 10.15± 1.353 years) completed the questionnaires and Child- Focused Injury Risk Screening Tool (ChildFIRST). Of the 55 participants, 22 participants were linemen and 33 played another position (Table 1). About half of the players played multiple position (n=28) compared to players who played a single position (n=27). All participants that were categorized as linemen only played a singular position. Demographics by position category can be found in Table 1. Eighteen participants scored a youth sport specialization score of two (median score, 2) with a minimum score of 0 and a maximum score of three was acquired by 10 participants (Figure 1). Of the 10 participants that were classified as "Highly Specialized" in the youth sport specialization scale, one had quit another sport to focus on football. As such, athletes that classified as highly specialized were not divided into separate groups as discussed in methods.

Table 1.

Descriptive statistics for YSS Groups	Score of 0	Score of 1	Score of 2	Score of 3	All participants
Total (n=55)	15	12	18	10	55
Linemen (n=22)	3	3	11	5	22
Others (n=33)	12	9	7	5	33
ChildFIRST Composite Score	38.60 ± 5.448	36.17 ± 6.177	32.56 ± 4.566	33.60 ± 5.420	35.18 ± 5.758
Injuries	3	2	5	2	12

When comparing the ChildFIRST composite score for each YSS categorization, participants with a YSS score of 0 had the highest composite score (mean, 38.60 ± 5.448) and participants with a score of 2 had the lowest score (mean, 33.60 ± 5.420), as shown in Graph 1. The lowest ChildFIRST composite score was 26 and the highest was 47 (median score, 35). Running had the highest mean score (3.82 ± 0.434) from the ChildFIRST skills and body weight squat had the lowest mean (1.93 ± 1.152). As shown in Table 2, all single-leg ChildFIRST skills had a higher mean when performed on the right leg than on the left leg : single-leg hop (mean left leg, 2.89 ± 0.854; mean right leg 2.95 ± 0.854) , single-leg sideways hop and hold (mean left leg, 2.45 ± 1.168; mean right leg 2.76 ± 0.942) , two-to-one-foot hop and hold (mean left leg, 2.16 ± 0.811; mean right leg 2.35 ± 0.799) and 90- degree hop and hold (mean left leg, 2.84 ±

0.811; mean right leg 2.93 ± 0.766). Notably, linemen had a lower mean score for all ChildFIRST movement skills compared to other positions as shown in Table 2.

Table 2.

Descriptive Statistics for ChildFIRST movement skills	ChildFIRST composite Score	Body Weight Squat	Walking Lunge	Single Leg Hop (Left)	Single Leg Hop (Right)	Two-to-One-Hop and Hold (Left)	Two-to-One Hop and Hold (Right)	Single Leg Sideways Hop and Hold (Left)	Single Leg Sideways Hop and Hold (Right)	90° Hop & Hold (Left)	90° Hop & Hold (Right)	Horizontal Jump	Vertical Jump	Running
Linemen (n= 22)	33.00	1.73	3.00	2.73	2.77	1.91	2.23	2.23	2.55	2.73	2.41	2.41	2.09	3.68
Others (n= 33)	36.64	2.06	3.09	3.00	3.06	2.33	2.42	2.61	2.91	3.06	2.85	2.85	2.33	3.91
All participants ChildFIRST Score	35.18 ± 5.758	1.93 ± 1.152	3.05 ± 0.731	2.89 ± 0.854	2.95 ± 0.756	2.16 ± 0.811	2.35± 0.799	2.45 ± 1.168	2.76 ± 0.942	2.84 ± 0.811	2.93 ± 0.766	2.67 ± 0.747	2.24 ± 0.607	3.82 ± 0.434

Normality was determined using Kolmogorov-Smirnov (p = 0.200) and Shapiro- Wilk (p= 0.066) tests. A two- way ANOVA showed no statically significant interaction (p= 0.319) between youth sport specialization score and position category on ChildFIRST composite score. An independent T-test found that the mean ChildFIRST composite score for linemen (33.00±4.690) was significantly lower than the mean ChildFIRST composite score for other positions (36.64±6.004) (t (53) =-2.393, p=0.02) (Figure 2). No significant difference was observed in the independent T-test for the mean ChildFIRST composite score for players who play multiple positions (34.04±5.267) compared to players who play a single position (36.37±6.096) (t (53) =-2.393, p=0.02).

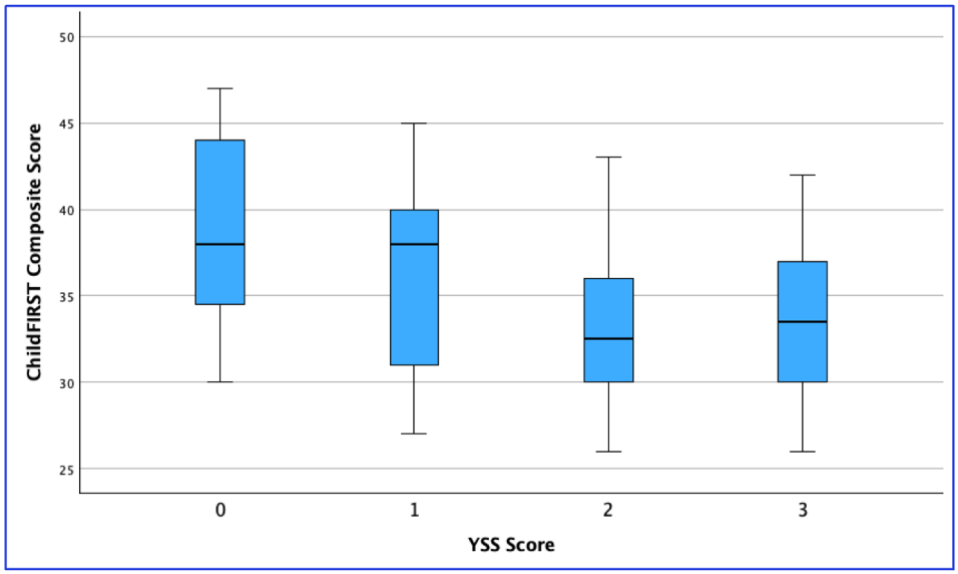

Figure 1. Comparison of ChildFIRST Composite Scores by YSS Score

Out of the 55 participants, 12 had sustained an injury in the past six months. A one-way ANOVA determined no significant difference between the mean ChildFIRST composite score for players who had sustained an injury (35.17± 6.351) compared to players who had not sustained an injury (35.19± 5.662).

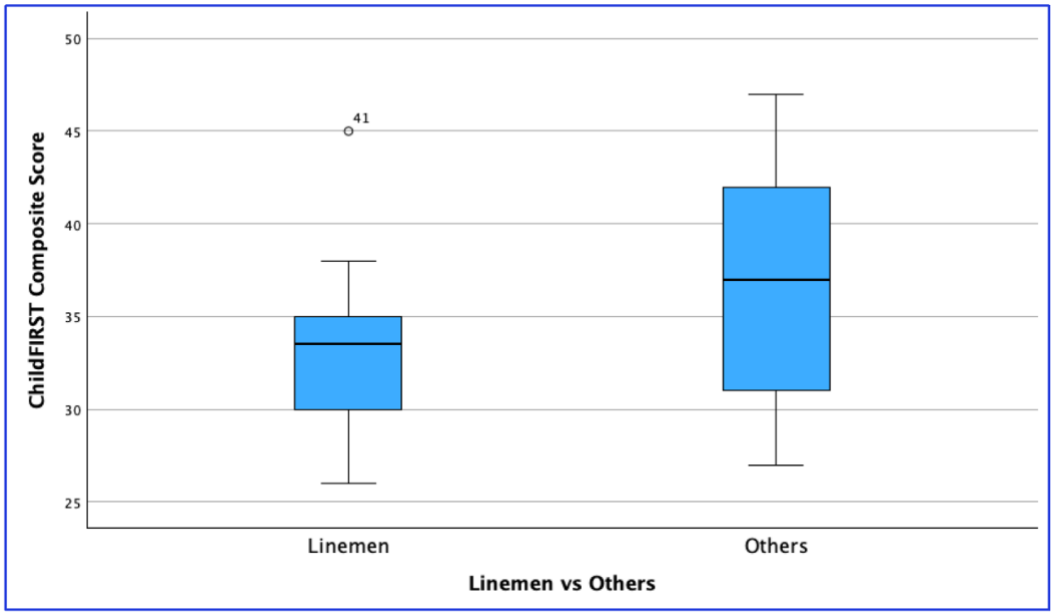

Figure 2. Comparison of ChildFIRST Composite Scores by Position

Discussion

The purpose of this study was to examine the relationship between movement competence and degree of sport specialization in 8- to 12-year-old football players. Additionally, the study aimed to look at the difference in movement competence amongst positions and to determine an association in injuries according to movement competence. Unlike DiStefano et al., (2018) and Fransen et al. (2012), no statistical relationship was observed between movement competence and degree of youth sport specialization in 8- to 12-year-old football players. Although, DiStefano et al., (2018) and Fransen et al. (2012) both observed children of similar ages, neither study appeared to observe any football players. While DiStefano et al., (2018) studied soccer and basketball players, Fransen et al. (2012) observed Belgian school children. Differences in observation could be a consequence of youth football players commonly specializing later than other sports (after the age of 15), whereas soccer players were found to

specialize earlier (Rugg et al. 2021). Thus, a variation in movement competence due to degree of youth specialization wouldn't be apparent in 8- to 12-year-old football players as they commonly specialize after the age of 15 (Rugg et al. 2021).

When comparing movement competence in linemen to other positions, linemen had a lower score for all ChildFIRST movement skills. Typically, the main role of a linemen (offensive and defensive) is to push through or block the opposing player. Whereas other positions have a more dynamic and expansive role. For example, a running back does not just block the opposing team but can also throw, catch and run a ball while trying to avoid being tackled. Such a position frequently must run a variety of routes and possibly require a more diverse set of skills, potentially increasing their movement competence which could contribute to a better performance doing the ChildFIRST movement skills. In comparison to other positions, a linemen's movement skillset is more limited, creating minimal versatility in acquired neuromuscular patterns and minimizing movement competence. Often, linemen are physical larger and haver higher body fat percentages compared to other football positions (Pincivero & Bompa, 1997). Children who are obese and overweight have shown to have lower motor skill abilities and an overall impaired motor performance (Barros et al. 2021). Although, height and weight were included in the Injury History Questionnaire, most participants and their guardians were uncertain of the participant's dimensions and left that section unanswered. Thus, we could not consider weight and height to establish confounding variables on ChildFIRST composite scores.

Of the 12 participants who reported an injury, four were ankle sprains, one elbow fracture, one thumb sprain, one hamstring strain, one concussion, one severe mandible laceration, a wrist sprain, a wrist fracture and a knee sprain (ligament undisclosed). Considering very few injuries were reported, an association between injury prevalence and ChildFIRST composite scores in 8- to 12-year-old football players could not be obtained. However, the study does give insight on the performance difficulty of each movement skill. Of the nine ChildFIRST movement skills, running and walking lunge had the best overall performance. It is interesting to note that most participants (n=46) scored a 4 for running in the ChildFIRST; potentially indicating a ceiling effect. Similar findings were seen in Miller et al (2023) cross-sectional study that looked at ChildFIRST composite score of 144 participants recruited from a local volleyball club, a local soccer facility, and a YMCA after school and summer day camp program. Running

had the highest ChildFIRST mean composite score compared to the other movement skills (mean, 3.40± 0.90). If a ceiling effect has occurred, the variability would be reduced, and the assumptions of normal distribution would be violated. Considering that running is present in most sports and is a prerequisite for other movement skills, many young athletes may not only be familiar but may also be more comfortable performing this locomotive skill compared to the remaining ChildFIRST movement skills (Goodway et al., 2019; Whitehead, 2001). Likewise, the walking lunge is a similar forward moving pattern that participating team's use in their warmups and conditioning sessions, allowing the participants to be more familiar with walking lunges versus the other ChildFIRST movement skills. In contrary, participants had the worst overall performance executing the bodyweight squats, the vertical jump and the two-to-one hop and hold respectively. The bodyweight squat is a basic human movement, but it has been shown to be sensitive to biomechanical deficit (Kritz et al., 2009; Tompsett et al., 2015). Notably, participants had a lower overall mean score for the bodyweight squat than participants in the study conducted by Miller et al., (2023) (mean, 2.65± 1.14). Moreover, movement skills that require landing mechanisms, such as the vertical jump and the two-to-one- hop and hold are an essential component to screening injury risks (Padua et al., 2009). However, jumping and landing are not skills commonly emphasized in skills training nor taught during football practice sessions, potentially contributing to the lower overall performance scores of these skills. Notably, it was found that comprehension of the two-to-one hop and hold was difficult as many participants couldn't grasp the concept of which direction to hop and which foot to land on. Even with a visual demonstration, numerous participants struggled understanding the movement, negatively impacting their performance. Like the bodyweight squat, participants had a lower overall mean score for both the vertical jump (mean, 2.38 ± 0.81) and the two-to-one hop and hold (mean, 2.31 ± 0.97) compared to the means observed in Miller et al. (2023).

Limitations

It should be noted that sample size was limited for testing due to time restrictions as most of the data was gathered near the participating teams' playoffs, increasing the difficulty in recruiting participants. Furthermore, participants all came from the same football association, further contributing to limited sample size. However, it should be noted that the LaSalle Minor League Football Association encompasses players form ten different Montreal boroughs

(LaSalle, Lachine, Île des Soeurs, Ville Emard, Côte-St-Paul, Montreal West, Côte-St-Luc, Hampstead, Westmount and Verdun) with diverse demographics, thus the generalizability of the results is maintained. As previously mentioned, only ten participants categorized as highly specialized, nine with a YSS of three who have never played another sport and only one who had quit other sports and has only ever played one sport. For that reason, data analysis didn't separate highly specialized athletes into those who quit other sports and those who never played other sports as previously mentioned in the methods. Additionally, due to the limited number of players who played a position other than linemen, a non-binary categorical separation of positions could not be done.

Another limitation of the study was not measuring the height and weight of participants with calibrated tools. Most participants left that section in the questionnaire unanswered, and those that did answer were uncertain with numbers. As such, height and weight were not able to be included in data analysis to determine if such variables impacted ChildFIRST composite scores. Lastly, the definition of injury used in the study was too broad and did not specify injuries solely occurring from football. As such, it is unclear if the injuries acquired were a consequence of football.

Future Studies

The findings from this study carry several implications for not only research but for practice as well. Further research of the movement competence in 8- to 12-year-old football players could develop insight into which movements should be included in an evidence-based injury prevention program. Notably, limb dominancy should be investigated. Although movement skills were tested bilaterally, limb dominancy was not requested in this study. Such findings could help identify any discrepancy or compensatory behaviours in participants. Additionally, having the height and weight measured prior to testing would allow for body compensation to be explored as a potential confounder variable for movement competence in young football players. Moreover, future research can continue to explore the differences in movement competence for each playing position. A larger sample size can allow movement competence findings to be observed for every playing position and not a binary separation of linemen and other positions. Conversely, once an evidence-based injury prevention program is

developed, future studies can compare injury rates after the program is applied to test its efficacy.

Conclusion

Youth sport specialization is becoming more prevalent in modern day youth sports. To our knowledge this is the first study to look at the relationship between movement competence in 8- to 12-year-old football players and their degree of youth sport specialization; differentiating by position. Our study found that although youth sport specialization scores do not have a significant impact on movement competence performance using the ChildFIRST; linemen compared to other positions did have a lower overall movement competency. No association with injury and movement competence was observed, however a larger sample size would allow for more accurate findings. Future studies should continue observing the movement competence in 8- to 12-year-old football players differentiating by their playing position in hopes of developing an evidence-based injury prevention program.

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Appendix A

Injury History Questionnaire

1. Demographic information

   Age _____ years

   Sex Female_____ Male_____

   Height _____cm or _____Inches

   Weight _____Kg or _____Lbs.

   Years of education _____ (i.e., 5th grade)

2. Level of competition

   Years of experience participating in football

   Less than a year _____
   1-3 years _____
   4-5 years _____
   More than 5 years _____

3. Current Team

   Mosquito (1st year) _____
   Mosquito (2nd year) _____
   Peewee (1st year). _____
   Peewee (2nd year) _____

4. Played football position(s) in past year:

Offence		**Defense**		**Special Teams**	
Quarterback (QB)	_____	Defensive Linemen	_____	Kicker (K)	_____
Running Back	_____	Linebacker (LB)	_____	Punter (P)	_____
Fullback	_____	Cornerback (CB)	_____	Kick Returner (KR)	_____
Tight End (TE)	_____	Safety (S)	_____	Punt Returner	_____
Center	_____			Long Snapper	_____
Offensive Linemen	_____				
Wide Receiver	_____				

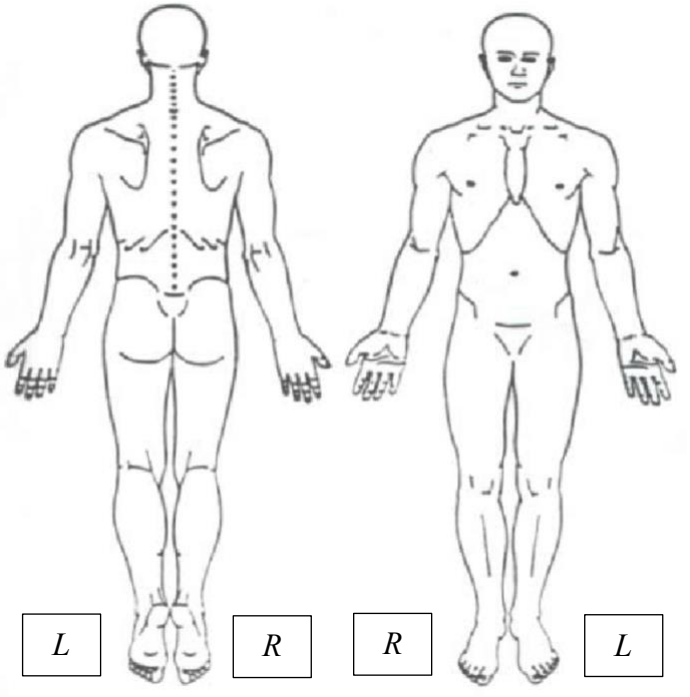
5. Injury status over the past 6 months

   Have you sustained any injury over the past 6 months?

   Yes _____ No _____

If answered "No" please go directly to the next survey

Location of injury



Head	_____	Wrist	_____
Neck	_____	Thumb	_____
Chest	_____	Finger	_____
Upper back	_____	Pelvis	_____
Abdomen	_____	Hip	_____
Lower back	_____	Thigh	_____
Pelvis	_____	Knee	_____
Hip	_____	Lower leg	_____
Shoulder	_____	Ankle	_____
Upper arm	_____	Foot	_____
Elbow	_____	Toe	_____
Lower arm	_____		

Please mark with an "X" the location of the injury:

Location of injury: Right side _____ Left side_____ Both sides_____

Problem/ Injury was classified as:

a. Sprain (ligament) _____
b. Strain (muscle) _____
c. Contusion/ Bruise _____
d. Fracture _____
e. Unknown _____

Stage of injury/problem (How long have you had the problem?)

a. 24-48 hours _____
b. 2- 7 days _____
c. 8 days – 21days _____
d. 21 days to 42 days _____
e. longer than 42 days _____

Medical attention

a. Visit to Hospital _____
b. Visit to Doctor _____
c. Visit to physical therapist or athletic therapist _____
d. Visit to chiropractor or massage therapist _____
e. Visit to alternative medicine practitioner _____
f. Treated yourself _____
g. No treatment performed _____

Did the injury require you to loss playing time in football?

Yes _____ No _____

If so, how long: _____

Please circle the number between 0 and 10 that best fits your current pain intensity. 0 means "no pain at all" and 10 is the "worst pain imaginable."

0 1 2 3 4 5 6 7 8 9 10

Thank you for participating in this survey.

Youth Sports Specialization Questionnaire

1) Can you pick a main sport (i.e., single-sport training)?

Yes _____ No _____

2) Did you quit other sports to focus on a main sport (i.e., exclusion of other sports)?

Yes _____ No _____

3) Do you train more than 8 months in a year (i.e., year-round training)?

Yes _____ No _____

4) Have you only ever played 1 sport?

Yes _____ No _____

Thank you for participating in this survey.

Appendix B

ChildFIRST Evaluation Criteria
Leaping was removed from evaluation

The ChildFIRST

Movement Skill	Evaluation Criteria
Bodyweight Squat	1. Push hips back and bend the knees until the thighs are approximately parallel with the ground 2. Hips, knees, and ankles aligned 3. Knees do not go too far in front of the toes 4. Keep the heels down all the time
Vertical Jump	1. Swing arms to assist the movement 2. Knees and hips bend to land softly in a controlled fashion 3. Land on both feet at the same timec 4. Hips, knees, and ankles aligned
Single Leg Sideways Hop and Hold	1. Knees and hips bend to land softly in a controlled fashion 2. Hips, knees, and ankles aligned 3. Foot flat on the floor 4. Stand up straight within three seconds after landing
Walking Lunge	1. Hips, knees, and ankles aligned 2. Upper-body straight and eyes focused in direction of travel 3. Front knee does not go too far in front of toes 4. No twisting nor bending back
Two-to-One Foot Hop and Hold	1. Knees and hips bend to land softly in a controlled fashion 2. Toes pointing forwardc 3. Foot flat on the floor 4. Hips, knees, and ankles aligned
90° Hop and Hold	1. Knees and hips bend to land softly in a controlled fashion 2. Hips, knees, and ankles aligned 3. Whole body turns together 4. Toes pointing forward
Leaping	1. Take off from one foot, land on the opposite foot 2. Knee and hip bend to land softly in a controlled fashion 3. Hips, knees, and ankles aligned 4. Swing bent arms in opposition to legs
Horizontal Jump	1. Swing arms to assist the movement 2. Knees and hips bend to land softly in a controlled fashion 3. Land on both feet at the same time 4. Hips, knees, and ankles aligned
Running	1. Upper-body straight and eyes focused in direction of travel 2. Swing bent arms in opposition to legs 3. Knee drives upward and forward to lift the foot off the ground 4. Knee and hip bend to land softly in a controlled fashion
Single Leg Hop	1. Hips, knees, and ankles aligned 2. Take off from one foot, land on the same foot 3. Knee and hip bend to land softly in a controlled fashion 4. Swing arms to assist the movement