Sport Sampling Is Associated With Improved Landing Technique in Youth Athletes

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Background: Sport sampling is recommended to promote fundamental movement skill acquisition and physical activity. In contrast, sport specialization is associated with musculoskeletal injury risk, burnout, and attrition from sport. There is limited evidence to support the influence of sport sampling on neuromuscular control, which is associated with injury risk, in youth athletes.

Hypothesis: Athletes who participated in only 1 sport during the previous year would demonstrate higher Landing Error Scoring System (LESS) scores than their counterparts.

Study Design: Cross-sectional study.

Level of Evidence: Level 3.

Methods: A total of 355 youth athletes (age range, 8-14 years) completed a test session with a jump-landing task, which was evaluated using the LESS. Participants were categorized as single sport (SS) or multisport (MS) based on their self-reported sport participation in the past year. Their duration of sport sampling (low, moderate, high) was determined based on their sport participation history. Participants were dichotomized into good (LESS <5) or poor (LESS ≥5) categories. Chi-square tests were performed to evaluate for the association between control category (good, poor) and participation (MS, SS), as well as sport-sampling duration (low, moderate, high).

Results: The MS group was 2.5 times (95% CI, 1.9-3.1) as likely to be categorized as having good control compared with the SS group ($\chi^2_{(355)} = 10.10$, $P < 0.01$). Recreational participants in the "high" sport-sampling duration group were 5.8 times (95% CI, 3.1-8.5) and 5.4 times (95% CI, 4.0-6.8) as likely to be categorized as having good control compared with the moderate and low groups ($\chi^2_{(216)} = 11.20$, $P < 0.01$).

Conclusion: Sport sampling at a young age is associated with improved neuromuscular control, which may reduce injury risk in youth athletes.

Clinical Relevance: Youth athletes should be encouraged to try participating in multiple sports to enhance their neuromuscular control and promote long-term physical activity.

Keywords: sport specialization; injury risk; sport sampling; sport diversification; physical literacy

Safe participation in sports is critical for keeping children physically active. With only 30% of adolescents achieving the daily recommended doses of physical activity,[8] there is a growing need to increase and maintain regular sport participation. Many children who are active in sports are choosing to specialize, or only participate in 1 sport at an early age, with goals of achieving elite athletic success.[25] Early sport specialization may be detrimental to a child's development for

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several reasons. In addition to burnout, social isolation, and overdependence, children who specialize in 1 sport early may be at an increased risk for injury.[5,18,25,35,42] Several position statements recommend that children should not specialize before adolescence, citing both psychosocial and physical reasons.[4,22]

In contrast to sport specialization, sport sampling, or participating in more than 1 sport, is encouraged to promote physical literacy and long-term physical activity. Physical literacy, often defined as the ability, confidence, and desire to be physically active, results in fundamental movement skill competency.[41] Proficient performance of fundamental movement skills, such as running, skipping, and balancing, is associated with increased physical activity levels and inversely associated with weight status in children.[1] Unfortunately, vast numbers of children fail to demonstrate physical literacy competency before the onset of puberty, which hinders physical activity participation during adolescence and may predispose children for future musculoskeletal injury risk.[40] The capability of a child to control his or her body during sport-specific movements, which is an aspect of neuromuscular control, influences their risk of injury.[19,28] During childhood, recreational play and sport participation likely allows for the development of global fitness and gross neuromuscular control. Based on the nature and intensity of the game, different sports and physical activities may facilitate the development of different components of neuromuscular control, including endurance, stability, movement quality, power, agility, strength, flexibility, and speed, to varying degrees. Underdevelopment of 1 or more of these components can lead to deficits in neuromuscular control, which may increase risk of injury and compromise future physical activity participation.

Understanding the impact of sport specialization and sport sampling on neuromuscular control and injury risk will optimize prevention efforts through enhanced, informed sport participation recommendations and promote long-term physical activity. The purpose of this study was to determine the effect of sport sampling on neuromuscular control, as measured by the Landing Error Scoring System (LESS), in youth athletes. A secondary purpose was to determine whether neuromuscular control differed between athletes participating at different competition levels (eg, recreational, elite) or was influenced by the amount of time a youth athlete had been exposed to participating in multiple sports. We further evaluated the effect of potential confounding variables, including sport performance measures (long jump, agility T-test), sex, age, and maturation stage, on differences between participants who played a single sport or multiple sports. Finally, we evaluated the agreement between the methods used to determine sport-sampling status in this publication and those previously published by Jayanthi et al[20] to categorize sport specialization. Based on previous literature regarding the effect of sport specialization on injury history, we hypothesized that youth athletes who participated in more than 1 sport during the previous year, and throughout their life, would demonstrate fewer landing errors, or better neuromuscular control, than those who participated in only 1 sport.

METHODS

Design and Setting

Prior to completing a single test session, participants and a parent or legal guardian completed informed consent forms, which were approved by the university's institutional review board.

A cross-sectional study design was used to evaluate the effects of sport sampling on neuromuscular control in recreational and elite youth athletes. Teams were recruited from 3 youth soccer and 1 youth basketball organizations to participate in this study and complete a single test session. Participants completed a baseline questionnaire that inquired about age, sex, maturation characteristics, and sport participation history with assistance from their parent/legal guardian, as necessary. All participants completed 3 trials of a standardized jump-landing task, which was evaluated using the LESS. The LESS score was used as the primary dependent variable to evaluate the impact of participating in a single sport, competitive level, and duration of prior sports participation.

Participants

Members of area recreational and elite soccer and basketball organizations from suburban/rural areas were recruited to participate in this study. An a priori power analysis demonstrated that at least 63 participants per sport participation group were needed to achieve 80% power and detect a 1-point change on the LESS. A total of 355 participants (122 boys, 233 girls) between the ages of 8 and 14 years volunteered to participate (approximate 65% participation rate). Recreational organizations (n = 2) were composed of soccer teams that competed against other towns (also known as "travel"), had parent volunteers as coaches, and practiced approximately 2 times per week. Elite organizations (n = 2) included both soccer and basketball teams, were regional instead of town-based, had paid coaches, and practiced 2 to 3 times per week. All participants were free from injury or illness at the time of testing.

Procedures

Participants attended a single, 15-minute test session at a local soccer field or gymnasium. With assistance from their parent or legal guardian, as necessary, all participants completed a baseline questionnaire. This questionnaire included the Pubertal Maturation Observational Scale (PMOS), which is a reliable assessment of maturation stage.[11] Participants were instructed to list every organized sport or physical activity (including dance) that they had participated in during their lifetime with the associated years or ages. We measured the height and mass of each participant. Participants performed 3 trials of a standardized jump-landing task, which required them to jump forward, from a 30-cm box, a distance of half their body height and jump for maximal height immediately on landing.

Participants were allowed as many familiarization trials as needed to feel comfortable with the task and perform it correctly. Trials were repeated if participants jumped up from the box instead of straight forward, if they did not jump off the box with both feet at the same time, or if they did not jump far enough. Digital video cameras placed in front of and to the side of the participant during the task captured movements in the frontal and sagittal planes. A single rater, blinded to sport organization and sport participation status, graded all trials using the LESS. The LESS is a valid and reliable clinical movement analysis tool used to evaluate specific lower extremity movements during a jump landing.[29] A high score indicates more errors and a score <5 is predictive of a low risk of anterior cruciate ligament (ACL) injury in youth soccer athletes, according to a study by Padua et al.[28] Smith et al,[34] however, did not find that the LESS was predictive of ACL injury in high school and collegiate athletes. Therefore, the ability of the LESS to predict risk of ACL injury may be age- and population-specific, but the LESS has consistently been demonstrated as a valid and reliable means to evaluate an aspect of neuromuscular control in field settings.

Youth soccer athletes completed 2 trials of a long-jump task in addition to the jump-landing task. During the long jump, participants were instructed to jump forward off of both feet as far as possible. The distance between the start line and the heel of the closest foot was measured and recorded for long-jump distance (in cm). Youth basketball athletes completed 2 trials of an agility test (T-test) that required them to sprint forward 10 m, side shuffle to the left 5 m, side shuffle to the right 10 m, side shuffle to the left 5 m again, and then back-pedal 10 m.[30] An electronic timing device (Brower Timing Systems) automatically measured the time (in seconds) for each participant to complete this test. In addition to the baseline questionnaire, a subsample of participants (n = 40) also answered 3 questions used by Jayanthi et al[20] and Bell et al[3] to identify sport specialization status to validate the sport specialization definition used in the present study: (1) Do you/your child participate in 1 main sport? (2) Did you/your child quit other sports to focus on this main sport? (3) Do you/your child train for any sports more than 8 months per year?

Data Reduction and Analysis

Participants were categorized into either a single-sport (SS) or multisport (MS) group based on their responses on the baseline questionnaire. Participants were assigned to the SS group if they indicated that soccer or basketball was the only sport they had participated in during the past calendar year. Those categorized to the MS group reported participating in more than 1 sport during the past year. Additionally, for the subset of participants who answered the questions outlined by Jayanthi et al,[20] the data were reduced according to the methods provided in that publication, where the 3 questions are summed to determine the degree of sport specialization for each participant: 3, highly specialized; 2, moderately specialized; and ≤1, low specialization.

The mean total LESS score (errors), agility time (s), and long-jump distance (cm) were used for analyses. Participants were divided into maturation stages using the PMOS. Scores from this questionnaire were tallied and prepubertal (total score, <2), pubertal (total score, 2-5), and postpubertal (total score, >5) stages were assigned for each participant. To ensure groups were similar regarding demographic and physical characteristics, the SS and MS groups were compared using independent Student *t* tests to evaluate differences in height, age, mass, long-jump distance, and T-test time, and chi-square tests were used to evaluate differences in sex and maturation stage between groups. An independent *t* test was also used to determine whether differences in LESS scores existed between sexes or sport populations.

To address the first purpose of this study, an independent *t* test was performed to compare the SS and MS groups regarding LESS scores. A neuromuscular control categorical dependent variable (poor, LESS ≥5; good, LESS <5) was created using an LESS score of 5 as the threshold since scores under this value have been shown to be predictive of a lower risk of ACL injuries in youth athletes.[28] A chi-square test was performed to evaluate the association between neuromuscular control category (good, poor) and sport participation groups (MS, SS).

To address the second purpose of this study, participants in the SS group were further separated into groups to evaluate differences between those with limited exposure to other sports ever in their life and those who recently had begun to only participate in 1 sport. A receiver operating characteristic analysis was used to identify an age when participants began participating in only 1 sport and the prediction of a poor neuromuscular control classification, based on the LESS. The area under the curve was 0.73 (95% CI, 0.55-0.91), and the cut-off point was 9.2 years (sensitivity, 67%; specificity, 65%). Therefore, participants who began participating in just 1 sport before the age of 9 years were categorized as having "low" duration in sport-sampling exposure and those who started participating in a single sport at 9 years of age or after were categorized as having a "moderate" duration in sport-sampling exposure. Participants who were currently engaged in more than 1 sport were classified as having a "high" duration of sport-sampling exposure.

A 2-way analysis of variance was used to examine differences in the mean total LESS score between sport-sampling exposure groups (low, moderate, high) and competitive sport level (recreational, elite). Five percent of the total sample of participants (n = 19) were 8 years old at the time of testing and were participating in more than 1 sport. These participants were classified into the high-exposure group since it represented their current status and it was impossible to know whether these participants would decide to only participate in 1 sport before they turned 9 years old. This classification was justified because most of these participants turned 9 before the end of the sport season. Separate chi-square tests for elite and recreational organizations were used to evaluate the association between neuromuscular control and sport-sampling exposure groups.

Table 1. Demographics for the sport participation groups

Group	Sample Size	Age, y (Mean ± SD)	Height, cm (Mean ± SD)	Mass, kg (Mean ± SD)	PMOS (n)	Long Jump, cm (Mean ± SD)	T-test, s (Mean ± SD)
Single sport	91	11 ± 2	151.1 ± 11.9	43.7 ± 12.3	Pre, 29 Pub, 43 Post, 21	130 ± 21 (n = 78)	12.0 ± 1.0 (n = 8)
Multisport	264	11 ± 2	153.2 ± 12.4	44.4 ± 11.7	Pre, 95 Pub, 87 Post, 21	139 ± 23[a] (n = 194)	12.2 ± 1.2 (n = 65)

PMOS, Pubertal Maturation Observational Scale (pre, prepubertal; pub, pubertal; post, postpubertal).
[a]Significantly higher than the single sport group ($P < 0.05$).

Separation of the 95% CIs was used to evaluate differences in significant findings. Additionally, a 3 × 2 chi-square analysis of association was used to determine the relationship between the previously cited definitions of sport specialization first developed by Jayanthi et al[20] and the questions used in this publication, as previously described, to determine whether the 2 definitions were valid against each other or evaluated different aspects of sport specialization. An a priori level of significance of $P \leq 0.05$ was used for all analyses.

RESULTS

A total of 91 participants (33 boys, 58 girls) were classified into the SS group, and 264 participants (89 boys, 175 girls) were classified into the MS group. The sport participation groups (SS, MS) were similar in the proportion of boys and girls, height, mass, age, and maturation stage ($P > 0.05$) (Table 1). There were no differences in LESS scores between soccer or basketball athletes or between boys and girls ($P > 0.05$). Consequently, subsequent analyses did not control for these factors. The groups differed in performance during the long-jump task, with the MS group jumping further than the SS group ($P < 0.01$), but there was no difference in T-test time between groups ($P > 0.05$) (Table 1).

There was a significant association between neuromuscular control (poor, good) and sport participation groups ($\chi^2_{(355)} = 10.10$, $P < 0.01$). The MS group was 2.5 times (95% CI, 1.9-3.1) as likely to have good control compared with the SS group (Figure 1). When evaluating the LESS as a continuous variable as a result of the mean total number of landing errors, which has been the traditional method, there was no statistically significant difference in overall LESS score between the MS (6.06 ± 1.84 errors) and SS groups (6.42 ± 1.74 errors) ($P = 0.10$).

Recreational participants in the high sport-sampling exposure group were 5.8 times (95% CI, 3.1-8.5) and 5.4 times (95% CI, 4.0-6.8) as likely to have good control compared with the moderate and low duration groups, ($\chi^2_{(216)} = 11.20$, $P < 0.01$) (Figure 2a). In elite participants, there was no significant association between neuromuscular control category and sport-sampling exposure group ($\chi^2_{(165)} = 1.06$, $P > 0.05$) (Figure 2b). When evaluating the continuous mean total LESS score, a significant interaction was detected between elite/recreational organization status and sport-sampling duration group ($P = 0.03$). Participants from recreational organizations who had only participated in 1 sport at any time (low, moderate) had higher LESS scores than all other groups. Participants from elite organizations with a moderate exposure to sport sampling demonstrated fewer errors than all other groups. All elite participants (5.82 ± 1.84 errors) had lower overall LESS scores compared with all recreational participants (6.46 ± 1.75 errors) ($P < 0.01$) (Table 2).

Our operational definition of MS athletes identified 94.7% of participants with a low degree of sport specialization per the definition put forth by Jayanthi et al[20] (18/19, $\chi^2_{(2)} = 6.37$, $P = 0.04$).

DISCUSSION

The most important findings of this study are that youth athletes participating in more than 1 sport demonstrate fewer movement errors during a landing task than youth athletes who have only participated in a single sport over the past year. The amount of exposure to different types of physical activity, or sports, during early childhood also influenced movement control. Specifically, SS elite athletes who were exposed to more than 1 sport until at least age 9 years as well as recreational youth athletes who still participate in more than 1 activity demonstrated greater control, or fewer movement errors, than their counterparts. These findings suggest that the number of different types of physical activity children are exposed to during childhood may be associated with neuromuscular control, which could influence their future risk of injury and lifelong physical activity participation. Sport sampling, or sport diversification, involves children trying a variety of sports and physical activities and has

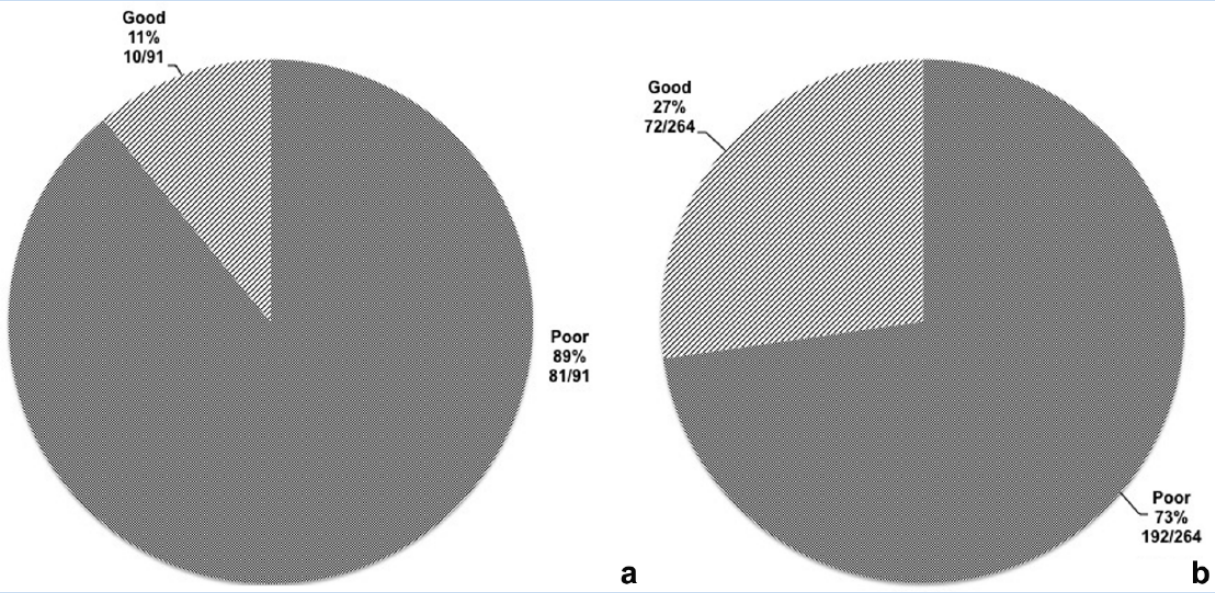

Figure 1. Neuromuscular control (good, poor) in (a) single-sport participants and (b) multisport participants.

Table 2. LESS scores between sport-sampling exposure groups

Sport Organization	Sport-Sampling Duration Group	Sample Size, n	LESS Score, Errors ± SD
Elite	Low	4 boys, 10 girls	5.88 ± 1.02
	Moderate	15 boys, 11 girls	5.24 ± 1.93[a]
	High	46 boys, 113 girls	5.89 ± 1.86
Recreational	Low	20 boys, 39 girls	7.02 ± 1.46[b]
	Moderate	3 boys, 10 girls	7.25 ± 1.20[b]
	High	81 boys, 87 girls	6.17 ± 1.83

LESS, Landing Error Scoring System.
[a]Significantly lower than all other sport-sampling groups ($P < 0.05$).
[b]Significantly higher than the "high sport-sampling" duration group ($P < 0.05$).

been emphasized in the literature as critical for appropriate motor and social skill development, future athletic success, lifelong physical activity, and reduced injury risk.[4,6,9,10,22] This may be the first study to directly provide evidence to support sport sampling as a possible means to improve neuromuscular control, which may decrease injury risk in youth athletes. Failing to engage in multiple different types of sports or physical activities may result in long-term consequences, including future musculoskeletal injury, physical inactivity, and compromised overall health and wellness. Based on these findings, all children may benefit from sampling a variety of sports or activities at a young age and continuing this diversification into adolescence.

Sport specialization is defined as intense participation in 1 sport at the exclusion of other sports.[20] Both Jayanthi et al[20] and Bell et al[3] reported that highly specialized high school athletes had an increased likelihood of overuse injuries. Similarly, Hall et al[17] reported an increased risk of patellofemoral pain and patellar tendinopathy in female adolescent athletes who only participated in 1 sport. These studies were able to evaluate the actual risk of injury due to their study populations of adolescent or high school–aged athletes. The current investigation did not evaluate injury history because of the low prevalence in this population of elementary and middle school–aged children (age, 8-14 years). However, neuromuscular control assessed using the LESS may be associated with lower subsequent injury

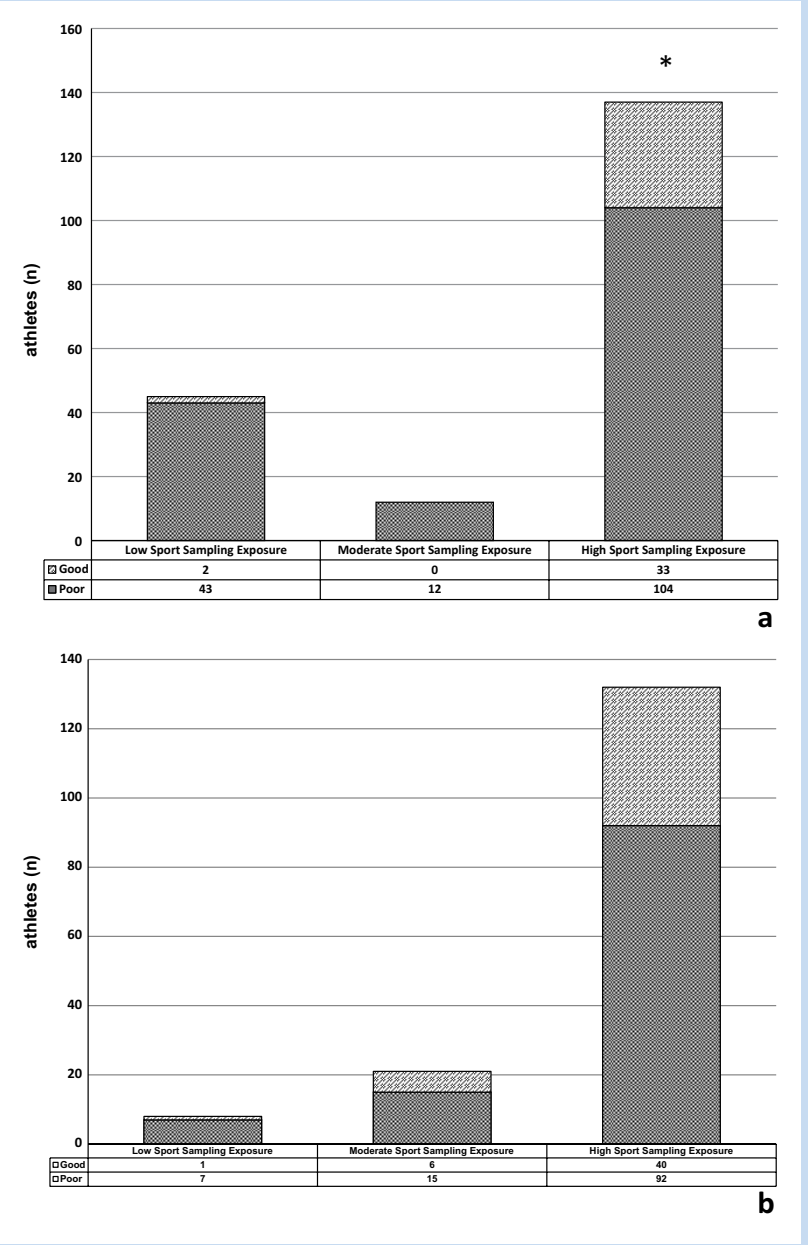

Figure 2. Neuromuscular control category (good, poor) by sport-sampling exposure group (low, moderate, high) in (a) recreational athletes and (b) elite athletes. *Significant association ($\chi^2_{(216)} = 11.20$, $P < 0.01$).

risk in this population and, consequently, may be considered an intermediate outcome associated with injury.

This may be the first study to demonstrate changes in movement control between SS and MS athletes. Beese et al[2] failed to detect differences in LESS scores between SS and MS athlete populations; however, that study[2] only included a small sample of high school female athletes compared with the current study sample of younger-aged male and female athletes. This difference in age group and sexes may account for the discrepancies between the current findings and those of Beese et al.[2]

Interestingly, the current study did not detect differences between athletes using the 3 levels of sport specialization.[20] However, the 2-level classification of "single sport" versus "multiple sport" did result in differences. Miller et al[27] observed similar discrepancies between the 3-level and 2-level sport specialization classification systems. Only the 2-level classification of either single- or multiple-sport participation yielded differences in dynamic balance, which is another measure of neuromuscular control often associated with injury risk.[7,26,31] The SS classification does not necessarily separate athletes who are highly specialized from those who are

moderately specialized, which is a unique aspect of the 3-level classification scale. Therefore, it is not known whether participants in the SS group intentionally chose to participate only in 1 sport at the exclusion of others, which may be an important factor related to injury risk. Consequently, a limitation of the 2-level classification is that it may not directly evaluate the influence of sport specialization but rather explores the impact of sport sampling. The current findings stress the importance of evaluating prior sport participation history, in addition to sport specialization, to comprehensively understand the influence of sport participation on a child's long-term health and physical activity.

Sport sampling during childhood is recommended to promote long-term physical activity participation.[12,32] Sport sampling may facilitate long-term participation in physical activity by promoting the development of physical literacy. The concept of physical literacy is becoming increasingly popular as a critical element for lifelong physical activity participation and is frequently defined as the ability, confidence, and desire to be physically active.[41] Evidence demonstrates that a child who does not develop physical literacy will avoid physical activity when possible, may be at an increased risk of becoming injured if he or she does choose to be active, and will not be motivated to be active in the future.[40] Sport sampling can have a major impact on all aspects of physical literacy as it is associated with lower rates of burnout in sport, improved social interactions, and leadership skills,[43] which all build motivation and confidence for physical activity participation. Sport sampling also teaches children a variety of fundamental motor skills, which are essential for a child to feel confident and have the necessary skills to transfer to sport performance. The results of the current study support this argument, as the children with the lowest amounts of diverse sports exposure also demonstrated the weakest neuromuscular control as measured by landing errors, which is considered to be a fundamental motor skill. In a small study, Fransen et al[14] observed that boys younger than 12 years who participated in more than 1 sport were stronger, faster, and had more advanced gross motor skills compared with boys who only participated in 1 sport. Consequently, sport sampling may be an important contributor for the development of physical literacy, and this exploration of sport and physical activities should be considered in future definitions of physical literacy.

Previous reports theorize that sport specialization may impair neuromuscular control and increase the risk of injury.[3,20] The current findings, however, suggest that this observed increased risk of injury may not be due to impaired neuromuscular control since elite-level athlete participants who were currently only participating in that sport possessed the greatest neuromuscular control. These participants may represent the best overall athletes in this study population. These are potentially the children who were exposed early to multiple sports, demonstrated early success, possibly in part due to enhanced neuromuscular control, and therefore were encouraged to specialize to enhance future athletic success. There are reports that sport specialization can improve athletic success,[9] but this early success does not always translate to long-term athletic success as an adult.[37] While these athletes may demonstrate appropriate neuromuscular control as a child, they are likely susceptible to the negative impacts of sport specialization that include burnout, psychological stress, lower enjoyment and motivation for sport participation, and potential injury as a result of overtraining.[16,23,39] Consequently, athletes who specialize early in sport frequently stop competing altogether.[15] Further research should investigate the contributing factors toward injury risk in sport-specialized athletes.

There was a discrepancy in findings with participants who currently were active in more than 1 sport. Overall, MS participants demonstrated better neuromuscular control during a jump-landing task. When divided between competition levels, however, elite-level athletes with a high sport-sampling exposure possessed poorer neuromuscular control than athletes belonging to a recreational/travel team with a high sport-sampling exposure. This study did not measure intensity or volume of training, but it is possible that the MS athletes at the elite level possess a high volume of training on a daily basis and this training negatively affected their neuromuscular control. Fatigue is consistently reported to impair neuromuscular control,[13] which may directly influence injury risk. The majority of sports-related injuries in youth are overuse in nature and related to weekly training hours.[35] In contrast, MS participants from the recreational/travel teams theoretically may be achieving a better balance of sport participation and training throughout an entire year. Further research should evaluate this difference between competition levels of youth athletes with regard to MS populations. These results are also specific to an athletic population younger than 15 years, and therefore, should not be generalized to the older ages of youth sport.

A strength of this study is that only 1 rater, blinded to sport-sampling exposure, evaluated all the videos, which reduces the risk of group differences occurring from scoring variability between raters. It is possible, however, that the single rater scored the entire study population higher than other raters have in the literature, and this limitation should be considered when interpreting the overall scores for the entire sample. Overall, only a minority of athletes in this study demonstrated good neuromuscular control, based on LESS scores <5. These high scores may be a result of the single rater bias or due to the age of the athletes included in the study. Padua et al[28] found that an LESS score <5 had 86% sensitivity and 64% specificity for predicting a low risk of an ACL injury in youth soccer athletes between the ages of 10 and 17 years. There is strong evidence that neuromuscular training that can be integrated regularly into sport practice as a 10- to 15-minute warm-up can reduce a substantial number of ACL and other musculoskeletal injuries.[21,33,36,38] Given the high LESS scores observed in this study and previous literature demonstrating no harm from preventive training programs, youth athletes may greatly benefit from performing preventive training exercises on a regular basis, regardless of competitive level or sport participation.

The LESS has traditionally been analyzed as a continuous variable and calculated as the mean total score from the number of errors present during a jump-landing task. A reduction of 1 point on the LESS represents complete improvement of a landing error. Compared with changing 3-dimensional kinematics, such as knee flexion angle, adjusting the LESS by an entire error is often challenging. For example, a participant may complete a jump with 10° more of knee flexion, but this improvement still may not demonstrate a complete elimination of the "knee flexion displacement" error on the LESS. While a significant change in LESS scores was observed when evaluating as a dichotomous variable (good, poor), no significant changes were detected with the LESS continuous variable. This finding is similar to the work by Beese et al,[2] which did not detect a difference in LESS scores between high school female athletes who participated in a single sport or in multiple sports. Although the current study population was different from the sample in the study by Beese et al,[2] both studies conclude that the continuous LESS variable is unable to detect a significant difference between SS and MS athletes. However, a different conclusion was reached when the LESS was evaluated as a dichotomous variable in the current study. These findings suggest analyzing the LESS as a dichotomous variable may enhance the ability to detect meaningful change and warrants further investigation.

Neuromuscular control can be measured in many ways, including movement control. The LESS is a valid and reliable measure of movement control during a jump-landing task and has been identified as a predictor of low risk of ACL injury in a single study by Padua et al[28] on youth soccer athletes of similar ages as those in the current study. However, the ability of the LESS to predict injury risk is likely only valid for a select population of athletes, since Smith et al[34] did not demonstrate that the LESS was able to predict subsequent injury. More research is needed to better understand the role of the LESS and movement control in predicting future musculoskeletal injuries in youth athletes.

This study was cross-sectional in design, which limits the ability to determine causality between sport participation and neuromuscular control. As discussed earlier, it is possible that the MS-classified athletes were generally more physically fit or possessed greater inherent motor skills resulting in greater desire and opportunities for sport/physical activity participation. Furthermore, no data about the volume or intensity of sport participation by the participants in this study were available. A limitation of this study is that the influence of sport specialization was not directly evaluated, but rather sport sampling was explored. The current results can likely be compared with previous research on sport specialization because the self-report classification of SS or MS participation was valid against the operational definition used by Jayanthi et al.[20] As such, these results further support the documented recommendations of many that children should avoid early sport specialization and rather participate in a variety of sports as youth athletes. The athletes in this study were between the ages of 8 and 14 years and involved in soccer or basketball. It is unknown whether the same results would be observed in populations with other ages or primary sports.

CONCLUSION

Youth athletes between the ages of 8 and 14 years who participated in more than 1 sport or activity demonstrated greater neuromuscular control than peers only participating in 1 sport. These findings support prior recommendations to discourage sport specialization in youth athletes and also highlight the importance of promoting sport sampling, or sport diversification. Children who improve neuromuscular control at a young age may have a reduced risk of musculoskeletal injury, possess the fundamental motor skills necessary to participate in a variety of physical activities, and be physically active throughout their lifetime. Further work is needed to identify the other contributing factors for the risk of lower extremity injury in youth athletes who specialize in sport to support or refine sport participation recommendations.

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