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Evaluating the Impact of Youth Early Sport Specialization on Injury: An Evolution in Measurement

Todd Rockwood[1], Nicholas M. Edwards[2], Bradley Nelson[2], and Julie Agel[2]

Abstract

Objective: To track youth sports participation and injury occurrence accurately and longitudinally.

Results: An online survey tool that captures sports participation, frequency, level of competition, and tracks injury occurrence has been developed. The survey allows for longitudinal tracking of sports participation to evaluate the change from recreational to highly specialized sports participation. To maximize the utility of this research tool we identified swimmer plots which allow for clear visualization of the data as the best method for graphical representation.

Implication: Longitudinal measurement of sports participation to evaluate the impact of early sports specialization on injury is feasible with this tool and enhanced by the swimmer plots for visualization.

Keywords

early sport specialization, youth, measurement, swimmer plots, survey, injury risk

Background

Assessment of the link between youth early sport specialization (YESS) and injury is a complex task. A comprehensive analysis of sports participation and its influence on youth sports injuries is critical.[1-4] The foundational issues are the age of specialization, duration of sport participation, and injury. Obtaining robust data to evaluate sports participation history and the related issue of specialization is important.

There are instrument design and measurement issues which must be considered. Data have historically been collected by survey often with athletes recalling their sports participation and injury history. Much is collected without regard for known validity and reliability problems associated with survey error and recall.[2,4-8]

A viable, accurate assessment of injury is equally problematic. Who determines if an injury has occurred: the child or parent? If an injury does not limit play or only limits practice, how should it be classified? Defining injury may involve a designation of acute versus chronic for a date of onset.[9] Clarification of new versus subsequent injury is required.[10] Obtaining an accurate diagnosis from a nonclinician is difficult. Clearance for return to play can come from the clinician or allied health care professional, or self-determined by the athlete.

There is no broadly accepted definition of "specialization." Is specialization a subjective self-defined state where the athlete considers themselves to be specializing, but still plays other sports, or is sport specialization an objective state in which the individual stops playing all other sports?[11,12] Conversely participation in a single sport does not necessarily imply specialization.

Recent articles demonstrate the use of chronologic age or years of participation as the underlying factor to organize analysis, but rarely are both assessed.[13-15] Early work of Paffenbarger identified frequency, level, and duration of participation as key components for measurement.[16] These variables are the foundation for our online survey development that longitudinally tracks sports participation to determine if

[1] Division of Health Policy and Management, University of Minnesota, Minneapolis, MN, USA
[2] Department of Orthopedics, University of Minnesota, Minneapolis, MN, USA

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Corresponding Author:
Julie Agel, Department of Orthopedics, University of Minnesota, R200, 2450 Riverside Ave, Minneapolis, MN 55454, USA.
Email: agelx001@umn.edu

the hypothesized link between injury rates and YESS is valid.

Purpose

Variables that define chronologic age and years of participation are the foundation for our online survey development that longitudinally tracks sports participation to determine if the hypothesized link between injury rates and YESS is valid.

Methods

Under the University of Minnesota, institutional review board approval 3 rounds of survey development were undertaken. In all cases, survey participation was voluntary with informed consent being given by the survey respondent and assent by the child at the start of each survey administration as applicable. Three iterations were administered during the development of the survey.

A recall survey was available to a convenience sample of a professional team in the Spring of 2017 (round 1) using drop-off-pick-up administration of a paper and pencil (PAPI) survey. The focus of this survey was to document sport participation and the injury history of athletes who were already successful by capturing competitive sports participation history starting at age 3 and progressing annually through 23, with a catch-all for age 24+. Chronological age and years of participation were collected for each sport participated in as well as the ages at which an injury prevented participation for at least 12 weeks. Twelve weeks was chosen as a marker of the severity of the injury and to improve the accuracy of recall. Supplemental Appendix 1 provides the items used to assess participation history and injury in the elite sport and history of participation in additional sports. Forty-two questions were used to assess history and injury in the elite sport using the principles of visual design to simplify data collection.[3]

Round 2 of the survey development focused on understanding the current activity level of children and the rate of injury related to sports activity. Working with a local school district in the Fall of 2017, parents of children in first, third, and fifth grades were approached to enroll their child in The initial recruitment was done by the school district. Families were offered the option of computer-assisted self-interviewing (CASI) or PAPI.

The evolution of the survey to a current sports participation format included a qualifying filter item of sports participation Yes/No creating a group of participants who were not active at the time but might become active overtime (Supplemental Appendix 2). The survey allowed for reporting on 5 sports with frequency categorized as every day, 4 to 6 times a week, 2 to 3 times a week, once a week, and less than once a week and level of play categorized as league/club, school team, community program/league, playground/pick-up, and other. To assess the injury, specific items were asked to define the nature, time of injury, and impact on participation (Supplemental Appendix 2) and obtain a marker if current participation was impacted by the preexisting injury. These items were not directly tied to a particular sport, but were generic "injured while playing sports" and did not set a stringent standard as to time loss (missing a practice or a game). To evaluate the prospective longitudinal performance of the instrument a follow-up survey in which the activities/sports identified in the initial survey were merged into the follow-up survey to determine if there had been changes, verify continuance, and identify changes in frequency and level of play in activities/sports was sent to all respondents 3 months after the baseline survey.

In 2019 to evaluate the prospective longitudinal third iteration of this survey, we obtained an online panel (Dynanet) which meets ESOMAR (European Society for Opinion and Marketing Research) standards.[3] The survey was a proxy report by a parent or guardian. Two quotas were employed in the recruitment: active in sports/activities (2:3) versus not active (1:3) and equal proportions by sex.

Each round of survey administration built upon the previous data collected from recall to cross-sectional (present-time) to prospective addressing gaps in data or simplification of the survey, and an open recruitment from the general population in the summer of 2019 (round 3). Each round of survey administration built upon the previous data collected from recall to cross-sectional (present-time) to prospective.

Results

Recall Survey (Round 1)

A single survey in a convenience sample of professional athletes on one team (N = 107) were asked to recall their sport and injury history. The goal was to evaluate the extent of YESS in a pool of athletes by capturing competitive sports participation history starting at age 3 and progressing annually through 23, with a catch-all for age 24+.

Seventy-four athletes provided all the necessary data to evaluate sports history. Figure 1 is the synthesis of information presenting cumulative data for elite sports history/injury plus multisport participation. In the swimmer's plot, the vertical dashed line represents the year in which competition in the elite sport started. Relative to the overall history of participation in the elite sport (all lanes), the average career was 19 years (std. 4.4); with an average of 10 years (std. 3.0) in nonspecialized play, and 9 years (std. 4.7) in specialized play.

Of those 64 athletes who reported multiple sports participation 52% competed in at least 3 sports (top group dash-dot-dot lines). Within the multisport group, 24% started competing in other sports prior to participation in the elite sport, 15% started competing at the same point in time, and 61% started participation in other sports after starting the elite sport. On average, the athletes playing the elite sport and at least 2 other sports started other sports within 1.4 years (std. 3.8) of the elite sport; one individual played multi-sports for 8 years

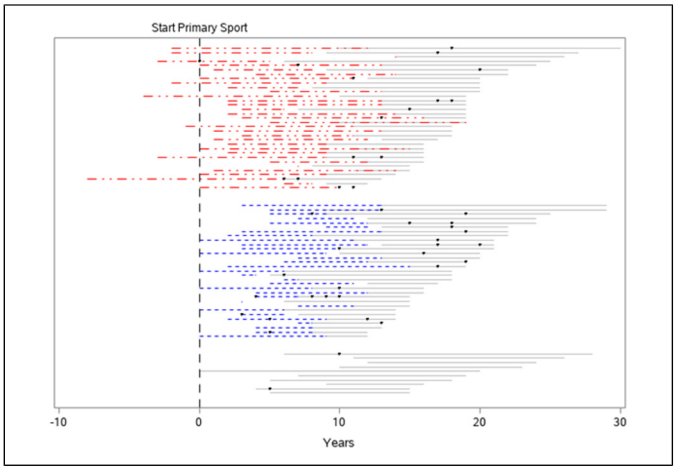

Figure 1. Dark or dashed line (left) is participation in a sport prior to specialization. Light line (right) is participation in a sport once specialized. For ease of visual interpretation, the graph is in 3 parts top compete in 2+ additional sports (dash), middle compete in 1 additional sport (short dash), and bottom (never competed in other sports). Footnote: Top group = 2+ sports, middle group = 1 additional sport, and bottom group—primary sport only.

before starting the elite sport and another starting 14 years after the elite sport. The multisport group spent an average of 9.5 years (std. 4.0) participating in 3 or more sports.

Those individuals who played one other sport in addition to the elite sport (48% of multi-sport athletes) are the middle group of Figure 1. None of these individuals' report participating in other sports prior to the elite sport. A total of 20% started in their one other sport the same year as the elite sport and the remaining 80% started in their one other sport at least 1 year after starting the elite sport. On average, this group participated in at least 2 sports for 5.9 years (std. 3.2). The final group in the graph is individuals who never competed in other sports.

Injury is the final core data point. Twelve weeks was chosen as the definition to limit recall bias focusing on more severe injuries. 43% reported at least one injury. Among those who reported an injury 72% reported only 1 injury, 25% had 2 injuries, and 1 (3%) had 4 injuries. On average, the first injury occurred 12.3 years (std. 5.4) after starting the elite sport. Of all the injuries, 6% occurred in those who never competed in another sport with 7.5 years to the first injury (std. 3.5). 56% who played the elite sport and only one other sport were 11.9 years (std. 5.6) to the first injury. 38% occurred in those that competed in the elite sport and at least 2 other sports, with an average of 12 years (std. 5.8) to the first injury.

Respondents recorded the age they started specialization in their elite sport. On average specialization occurs at age 16 (std. 2.2). The assumption that participation in other sports ceases at the time of specialization was not valid. 90% reported quitting other sports at least one year after starting specialization. One individual reported stopping other sports 3 years prior to the age they said specialization had begun and 5 continued to play other sports for 4.4 years (std. 2.7) after they had specialized. This represents 7% of the total subject population.

Athletes were asked to rate the impact of specialization on their current level of skill (Supplemental Figure 1). The average level of impact was 6.4 (std. 2.8) pointing to a perception of specialization being an important factor.

From this recall survey, we identified gaps in our initial characterization of sports participation history to evaluate the impact of YESS on the injury from the perspectives of chronologic age and years of participation. We determined that the following core data are necessary for a robust analysis and were incorporated into future iterations.

1. Current age of the athlete
2. For the focused sport:
   (a) Age the athlete began participating in the elite sport regardless of the level of participation
   (b) Age the athlete began competing in the elite sport
   (c) Age the athlete specialized in the elite sport
   (d) Age the athlete became an elite athlete
3. For additional sports:
   (a) Other sports participating in
   (b) Ages other sports participation occurred regardless of level
   (c) Ages other sports competition occurred
4. Injury (yes/no):
   (a) Age(s) of injury(ies)
   (b) Duration of injury(ies)

These elements allow for the calculation of secondary variables:

1. Years of participating in the elite sport at any level
2. Years competing in the elite sport
3. Years specializing in the elite sport
4. Years of multi-sport participation
5. Years of participation by the level of participation
6. Years of participation relative to injuries sustained while playing the sport.

Present Time Survey (Round 2)

A total of 293 families responded with 50 adult–child pairs completing the survey. Nineteen were girls and 24 were boys with 2 unspecified. 34% of the children were in first grade, 37% in third grade, and 29% in fifth grade.

Activity participation was reported by 43 of 50 respondents. No one sport/activity was predominant. Six of the 43 who reported participating in activities/sports reported an injury impacting their participation. 51% reported that at least one of their sports was played at the league/club level. No school team sport participation was reported indicating that this age group may not have school sports in this school district.

The analysis of this data identified the importance of specifying recreational physical activities not just structured sports. This real-time evaluation for prospective use shows for data integrity purposes, that the need to be able to carry forward prior responses for each activity/sport, frequency, and level is critical.

Round 2 identified more issues requiring improvement:

(a) Accurate diagnosis, impact of injury on participation, ability to close out an injury carried over between survey periods, and the ability to tie injury directly to sport participation.
(b) The inclusion of activity, as well as sports participation, requires tracking more than 5 sports.

In round 2, we relied on manually downloading and merging the data into the follow-up survey. This created administration logistical problems. The need to automate the population of data forward and to stage follow-up surveys at the appropriate interval led to the switch to only CASI.

Prospective Testing Round 3

To ensure accurate data tracking of sport/activity participation and the injury required an individualized follow-up survey. A web-based survey in Qualtrics in which key information sport/activity (team/location, level, and frequency of participation) and open-ended injury(ies) are carried forward to enable tracking, monitoring, and identification of changes in sport/activities overtime was launched (Supplemental Appendix 3). Figure 2 visualizes the complexity of the measurement required.

The baseline administration was done over a 2-month period with 977 surveys completed. Data quality checks for bad surveys (undecipherable answers, < 1 min to complete) and a mismatch between age and grade of more than 2 years left a sample of 919 children in the cohort (303 not active in sports/activities and 616 active). Round 3 identified a (Table 1) basic demographic profile of the child, parent, and household for the participants. The demographics of the children show there are no meaningful significant differences between those in the not active and active quotas. The age of the children ranged from 7 to 17 (mean = 12). Child ethnicity is predominantly White, White/non-Hispanic (not active: 69%, active 64%, and not/White, or Hispanic (not active 31% and active 36%). While there are no significant differences relative to the characteristics of the children, there are significant differences relative to parent and household characteristics. Parents of children who are active had higher educational attainment, and were more likely to be married, employed, and White/non-Hispanic with higher income. Relative to household composition the active and nonactive were similar relative to a number of children in the household (active 1.9 and not Active 2.2) and adults (active 2.2 and not active 1.9).

Table 2 provides the distribution of a number of sports and activities reported. On average children participated in 2.8 (std. 1.8) sports or activities. The most common level of activity was Free Play (mean 9, std. 1.4) and the most common frequency was 2 to 3X a week (mean 1, std. 1.0). Most of the sociodemographic characteristics evaluated showed no statistically significant impact on the number of sports/activities participated in. Competitive club sport participation was statistically significantly different by income as was free play participation. The lowest tertile of income had the greatest free-play participation and the least competitive club participation. Level of play was

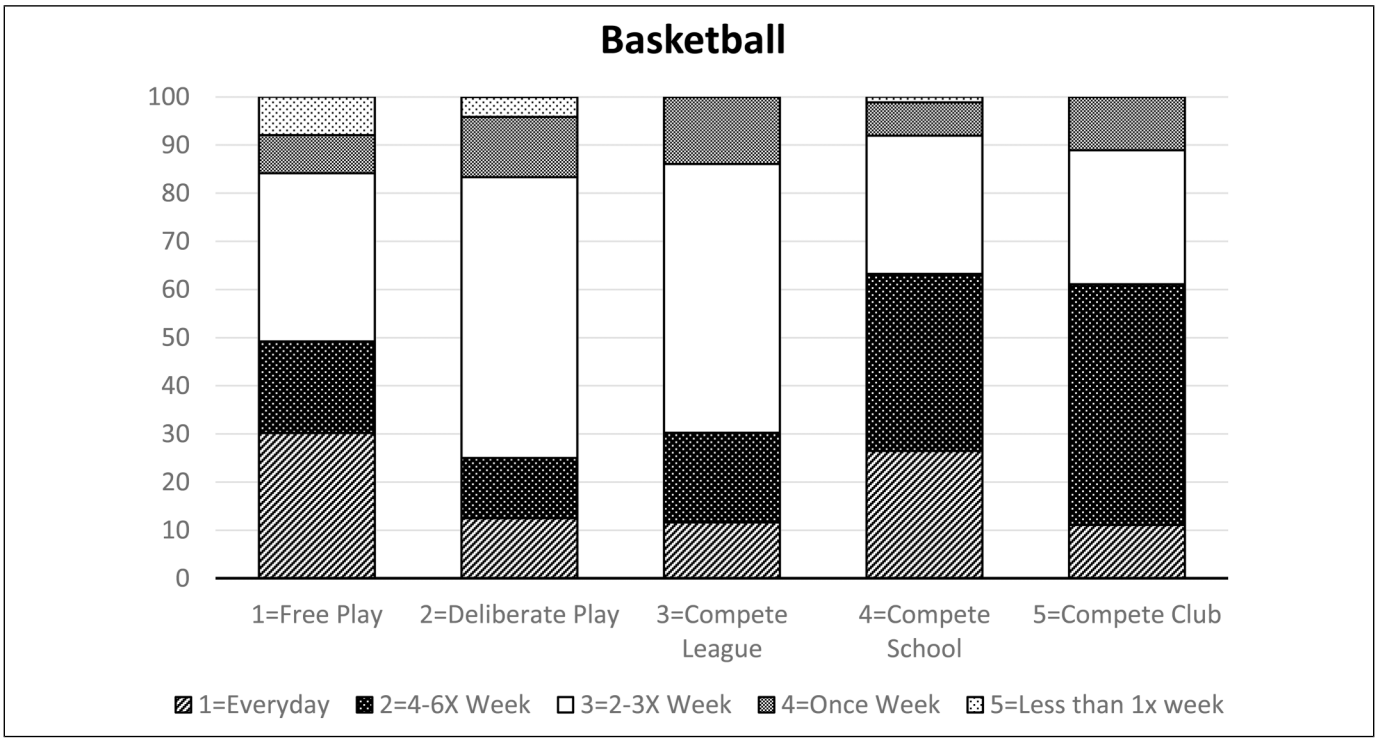

Figure 2. Distribution of frequency and level of play for those participating in basketball.

Table 1. Child and Reporting Adult Demographic Characteristics.

	Not active	Active
N	303	616
Child		
Child age		
7	4 (1.32%)	8 (1.3%)
8	34 (11.22%)	49 (7.95%)
9	41 (13.53%)	69 (11.2%)
10	34 (11.22%)	62 (10.06%)
11	9 (2.97%)	19 (3.08%)
12	54 (17.82%)	86 (13.96%)
13	29 (9.57%)	93 (15.1%)
14	13 (4.29%)	29 (4.71%)
15	33 (10.89%)	104 (16.88%)
16	44 (14.52%)	83 (13.47%)
17	8 (2.64%)	14 (2.27%)
(Mean/Std)	12/2.8	12.5/2.7
Child sex (X^2 $P = .73$)		
Male	153 (50.5%)	302 (49.03%)
Female	150 (49.5%)	314 (50.97%)
Child ethnicity (X^2 $P = .15$)		
White/non-Hispanic	208 (68.65%)	391 (63.58%)
Not White or Hispanic	95 (31.35%)	224 (36.42%)
Parent		
Parental education* (X^2 $P = .001$)		
Less than HS	13 (4.3%)	11 (1.79%)
High school/General Educational Development	64 (21.19%)	79 (12.82%)
Associate of Art/some college	148 (49.01%)	234 (37.99%)
Bachelor of Science/Arts or higher	77 (25.5%)	292 (47.4%)
Parent relationship to child (X^2 $P = .73$)		
Not biological	33 (10.89%)	61 (9.9%)
Biological	270 (89.11%)	555 (90.1%)
Parent marital status* (X^2 $P = .02$)		
Not married	108 (35.64%)	170 (27.69%)
Married/marriage like	195 (64.36%)	444 (72.31%)
Parental employment* (X^2 $P = .0001$)		
Not employed	142 (46.86%)	205 (33.33%)
Employed	161 (53.14%)	410 (66.67%)
Parental ethnicity* (X^2 $P = .003$)		
White/non-Hispanic	70 (23.18%)	204 (33.12%)
Not White or Hispanic	232 (76.82%)	412 (66.88%)
Household		
Size		
Adults (X $P = .008$)	2.2 (1.0)	2.0 (1.1)
Children (X = $P = .0001$)	2.2 (.8)	1.9 (1.0)
Household Income* (X^2 $P = .0001$)		
< US$25 000	72 (24.08)	76 (12.46)
US$25 000-US$50 000	101 (33.78)	143 (23.44)
US$50 000-US$75 000	57 (19.06)	126 (20.66)
US$75 000-US$100 000	34 (11.37)	96 (15.74)
$100 000 +	35 (11.71)	169 (27.7)
Activity/sport (maximum is 8)		
0	303 (100%)	0 (0%)
1		164 (26.62%)
2		174 (28.25%)
3		136 (22.08%)
4		59 (9.58%)
5		25 (4.06%)
6		21 (3.41%)
7		6 (0.97%)
8		31 (5.03%)

affected by grade in school with a transition from grade school free play to high school competitive school participation.

Specific Sport Analysis

For females, the most common sports were basketball and soccer, and for males, basketball and baseball. To evaluate the breadth of information available from this survey we focused on basketball. Supplemental Figure 2 visually demonstrates the differences in time spent at various levels of participation.

Athletes Playing on Multiple Teams in the Same Sport

Nine athletes reported participating in the same sport on more than one team. Five reported participating in more than one dance team and 2 reported participating in more than one track/field team. Two reported an injury that impacted their ability to participate. Supplemental Table 1 displays the socio-demographic features of those athletes. This enables us to determine the role socio-economic factors may play in the opportunity to play on multiple teams at higher levels of competition.

Injury

146 (12%) of the children had injuries in the year prior to the survey that limited their physical abilities. This data will enable us to capture the role of injury in dropout from sports participation.

Table 2. Activity and Sports Profile by Socio-Demographic Status (Not Active Excluded).

Child characteristics	Number of sports	Multiple teams same sport	Level					Frequency				
			Free play	Deliberate play	Competitive-league	Competitive-school	Competitive-club	Every day	4 to 6 X weeks	2 to 3 X weeks	1 X week	Less than 1 X week
Total	2.8 (1.8)		.9 (1.4)	.5 (.9)	.4 (.7)	.7 (1)	.2 (.5)	.5 (1)	.6 (.9)	1 (1)	.4 (.8)	.2 (.5)
Sex												
Male	2.9 (1.8)		1 (1.4)	0.5 (0.9)	0.5 (0.8)	0.7 (1.1)	0.2 (0.5)	0.5 (1.1)	0.7 (0.9)	1.1 (1)	0.4 (0.7)	**0.2 (0.6)**
Female	2.7 (1.8)		0.8 (1.4)	0.5 (0.8)	0.4 (0.8)	0.7 (0.9)	0.2 (0.5)	0.5 (1)	0.6 (1)	1 (1)	0.5 (0.8)	**0.1 (0.4)**
School												
Grade school (1-5)	3 (1.9)		**1.2 (1.6)**	**0.6 (1)**	**0.6 (0.9)**	**0.4 (0.8)**	0.2 (0.5)	0.5 (1)	0.5 (0.9)	**1.2 (1.1)**	**0.6 (0.8)**	0.2 (0.5)
Junior high school (6-8)	2.9 (1.9)		**0.9 (1.4)**	**0.5 (0.8)**	**0.5 (0.7)**	**0.8 (1)**	0.3 (0.6)	0.5 (1.1)	0.7 (1)	**1 (1)**	**0.5 (0.8)**	0.2 (0.5)
High school (9-12)	2.4 (1.6)		**0.6 (1.1)**	**0.4 (0.8)**	**0.3 (0.6)**	**1 (1)**	0.2 (0.4)	0.5 (1)	0.6 (1)	**0.9 (0.9)**	**0.3 (0.6)**	0.1 (0.6)
Ethnicity												
White/ non-Hispanic	2.7 (1.7)		0.8 (1.3)	0.5 (0.9)	0.5 (0.8)	0.7 (0.9)	0.2 (0.6)	0.4 (0.9)	0.6 (1)	1 (1)	0.5 (0.8)	0.2 (0.5)
Not White or Hispanic	2.9 (1.9)		1 (1.6)	0.5 (0.9)	0.4 (0.7)	0.8 (1.1)	0.2 (0.4)	0.6 (1.3)	0.7 (0.9)	1 (1)	0.4 (0.7)	0.2 (0.6)
Parent												
Income												
< US$25 000	2.7 (1.7)		**0.9 (1.3)**	0.4 (0.7)	0.4 (0.8)	0.8 (1)	0.2 (0.6)	0.5 (1.1)	0.6 (1)	1 (1.1)	0.5 (0.8)	0.2 (0.5)
US$25 000-US $50 000	3 (2)		**1.1 (1.7)**	0.5 (0.9)	0.5 (0.8)	0.7 (1)	0.2 (0.4)	0.6 (1.1)	0.6 (1)	1.1 (1)	0.5 (0.8)	0.2 (0.6)
US$50 000-US $75 000	2.6 (1.8)		**0.7 (1.3)**	0.4 (0.9)	0.5 (0.8)	0.8 (1)	0.2 (0.5)	0.4 (0.9)	0.6 (0.8)	1.1 (1)	0.4 (0.7)	0.1 (0.5)
US$75 000-US $100 000	2.8 (1.7)		**0.9 (1.3)**	0.5 (1.1)	0.4 (0.7)	0.7 (1)	0.2 (0.5)	0.4 (0.8)	0.7 (1)	1.1 (1)	0.3 (0.6)	0.2 (0.6)
US$100 000 +	2.7 (1.6)		**0.7 (1.3)**	0.4 (0.7)	0.5 (0.8)	0.8 (1)	0.3 (0.6)	0.4 (1.1)	0.7 (0.9)	0.9 (1)	0.5 (0.8)	0.2 (0.5)
Ethnicity*												
Not White or Hispanic	2.8 (1.8)		1 (1.6)	0.5 (0.9)	0.4 (0.7)	0.7 (1)	0.2 (0.4)	0.6 (1.2)	0.6 (0.8)	1 (1)	0.4 (0.8)	0.2 (0.6)
White/ non-Hispanic	2.7 (1.8)		0.9 (1.3)	0.5 (0.9)	0.5 (0.8)	0.7 (1)	0.2 (0.6)	0.4 (0.9)	0.6 (1)	1 (1)	0.4 (0.8)	0.2 (0.5)
Employment												
Not employed	2.9 (1.9)		**1.2 (1.6)**	**0.6 (1)**	0.4 (0.7)	**0.6 (0.9)**	0.2 (0.5)	0.6 (1.1)	0.7 (1)	1.1 (1.1)	0.4 (0.7)	0.2 (0.6)
Employed	2.7 (1.7)		**0.8 (1.2)**	**0.4 (0.8)**	0.5 (0.8)	**0.8 (1)**	0.2 (0.5)	0.4 (1)	0.6 (0.9)	1 (1)	0.4 (0.8)	0.1 (0.5)
Education												
Less than High School	3 (2.5)		**1.4 (1.1)**	0.5 (0.8)	0.3 (0.6)	0.8 (1.2)	0.1 (0.3)	0.2 (0.4)	0.4 (0.7)	1 (1.1)	0.8 (1.1)	0.6 (1)
High school/ General	2.5 (1.7)		**1.1 (1.4)**	0.4 (0.9)	0.3 (0.6)	0.6 (0.9)	0.1 (0.3)	0.6 (0.9)	0.6 (0.9)	0.8 (0.9)	0.4 (0.8)	0.2 (0.5)

(continued)

Table 2. (continued).

Child characteristics	Number of sports	Multiple teams same sport	Level					Frequency				
			Free play	Deliberate play	Competitive-league	Competitive-school	Competitive-club	Every day	4 to 6 X weeks	2 to 3 X weeks	1 X week	Less than 1 X week
Educational Development												
Associate Arts/ some college	2.8 (2)		**0.9 (1.6)**	0.4 (0.9)	0.5 (0.8)	0.8 (1.1)	0.2 (0.5)	0.6 (1.2)	0.6 (1)	1.1 (1.1)	0.4 (0.7)	0.1 (0.5)
Bachelor of ScienceArts or higher	2.8 (1.6)		**0.8 (1.3)**	0.5 (0.9)	0.5 (0.8)	0.7 (1)	0.2 (0.6)	0.4 (0.9)	0.7 (0.9)	1 (1)	0.5 (0.8)	0.2 (0.5)
Socio-Economic-Status – Income/ education												
Lowest tertile	2.8 (2)		**1.2 (1.6)**	0.4 (0.8)	0.4 (0.7)	0.7 (1)	**0.1 (0.4)**	0.6 (1)	0.6 (1)	1 (1.1)	0.4 (0.8)	0.2 (0.5)
Middle tertile	2.7 (1.8)		**0.8 (1.3)**	0.5 (1)	0.5 (0.8)	0.7 (1)	**0.2 (0.5)**	0.4 (0.9)	0.6 (0.9)	1.1 (1)	0.4 (0.7)	0.1 (0.5)
Upper tertile	2.7 (1.6)		**0.8 (1.2)**	0.5 (0.8)	0.5 (0.8)	0.7 (1)	**0.2 (0.6)**	0.4 (1.1)	0.7 (0.9)	1 (1)	0.5 (0.8)	0.2 (0.5)
Age												
7	2.4 (1.4)		0.4 (0.5)	0.8 (1)	1.3 (1.5)	0 (0)	0 (0)	0.8 (1.8)	0.1 (0.4)	1 (1.2)	0.4 (0.7)	0.1 (0.4)
8	2.9 (2)		1 (1.3)	1 (1.4)	0.5 (0.8)	0.3 (0.7)	0.1 (0.4)	0.3 (1.1)	0.6 (0.9)	1.2 (1.4)	0.7 (0.9)	0.1 (0.3)
9	3.2 (1.9)		1.3 (1.7)	0.5 (0.8)	0.7 (1)	0.4 (1)	0.2 (0.7)	0.6 (1)	0.4 (0.8)	1.2 (1.1)	0.7 (0.9)	0.3 (0.7)
10	2.9 (1.8)		1.3 (1.7)	0.5 (0.8)	0.5 (0.8)	0.4 (0.8)	0.2 (0.5)	0.4 (0.8)	0.6 (0.9)	1.3 (1)	0.5 (0.7)	0.1 (0.4)
11	2.4 (2.1)		0.9 (2)	0.3 (0.5)	0.6 (0.8)	0.3 (0.6)	0.3 (0.6)	0.3 (0.7)	0.5 (0.8)	0.9 (0.8)	0.5 (1)	0.1 (0.3)
12	3.2 (1.8)		1.1 (1.5)	0.5 (0.8)	0.5 (0.8)	0.8 (1)	0.4 (0.7)	0.5 (1.2)	0.8 (1)	1 (1.1)	0.5 (0.9)	0.3 (0.7)
13	2.8 (1.9)		0.9 (1.5)	0.4 (0.8)	0.5 (0.7)	0.8 (1)	0.2 (0.5)	0.5 (1.1)	0.7 (1)	1.1 (1.1)	0.4 (0.8)	0.1 (0.3)
14	2.3 (1.8)		0.6 (0.8)	0.5 (0.7)	0.4 (0.8)	0.8 (1.2)	0.1 (0.3)	0.4 (0.9)	0.6 (0.9)	0.8 (0.9)	0.3 (0.6)	0.2 (0.7)
15	2.6 (1.6)		0.6 (1)	0.4 (0.9)	0.3 (0.6)	1.1 (1.1)	0.2 (0.5)	0.5 (1.2)	0.7 (0.8)	0.9 (0.9)	0.3 (0.7)	0.1 (0.6)
16	2.1 (1.4)		0.5 (0.9)	0.3 (0.7)	0.3 (0.6)	0.9 (0.9)	0.1 (0.4)	0.4 (0.7)	0.7 (1.2)	0.8 (0.8)	0.2 (0.5)	0.1 (0.5)
17	2.9 (2.7)		1.3 (2)	0.4 (1.1)	0.1 (0.4)	0.9 (0.8)	0.1 (0.3)	0.5 (0.9)	0.5 (0.7)	1.3 (1.3)	0.4 (0.6)	0.2 (0.6)

Bold indicates a significant difference – within column grouping.

Discussion

This article highlights the complexities of addressing the impact of youth sports specialization on injury rates with historical recall and prospective data examples. Historical recall has a high likelihood of measurement error. The ability to specify dates and limitations associated with injury accurately is compromised. While visual design simplifies the presentation of questions, it does not remedy issues associated with errors in recall and could enhance reliance on heuristics in response formation which contributes to error.[17,18] These issues are exacerbated when asked about the history of participation in other sports. If asked serially question 7 in Supplemental Appendix 1 would require 168 questions.

Current data collection is simpler, requiring fewer questions, and allowing inclusion of individuals who will not achieve the elite level as a comparator group. The limitation of current data collection is that it comes with the cost of having to wait for data to accumulate. In addition, there will be attrition of participants over time.

Critical to prospective data is carrying forward information about participation in a sport and injury(ies) that occur and ensuring a current status of the impact of injury on participation. The following information has to be carried forward from the prior survey to ensure data quality in longitudinal studies:

- Sport/Activity
  - Level of participation
  - Frequency of participation
  - Team(s) played on
  - Seasonal transitions associated with the sport
- Unresolved injuries

The survey must allow the specification of transitions within a sport (change in level, frequency, team, etc), and also allow for new sport(s) and/or new teams which then get added to future surveys.

The ability to capture this data prospectively is critical to assess injury which as a central issue relative to sport specialization is implicated in the "reported" increase of youth injuries. Theorized as tied to the increase in children playing one sport on multiple teams—local teams, travel teams, elite level teams with no off-season or no variation in sport there is no definitive evidence that this is true. Advocacy groups have pushed for multiple sport participation for youth with a delay to single-sport participation.[17,18]

This survey evolution demonstrates our methodological development of an online survey tool for longitudinal tracking of sports participation to determine if children who participate in multiple sports differ from children who participate in only one sport quantifying by sport the level of participation by frequency of participation and intensity of competition.

The data presented demonstrates the variation across children. It highlights the overall low injury rate and the difficulties inherent in achieving an adequate sample size to draw conclusions about the impact of sports specialization on injury by individual sports.

Implications for Practice

This work demonstrates the evolution of an online survey tool that allows for longitudinal tracking of sport participation in children and associated injuries. By creating a defined list of minimum data points a comprehensive level of data collection for a longitudinal cohort study tracking sport and activity participation was solidified. The importance of having an instrument that allows for evaluation of specialization in a sport; understanding of the impact of age and or years of participation relative to injury occurs in a definable pattern is key. This survey will form the template for longitudinal work that addresses the impact of sport specialization on injury by collecting participation and injury data. If adopted large-scale collaborative work may bring sound methodology and evidence-based data to the field in a timely fashion allowing for decision making to be data driven.

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ORCID iD

Julie Agel https://orcid.org/0000-0002-4296-7389

Supplemental Material

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Author Biographies

Julie Agel, Certified Athletic Trainer, Research Coordinator, University of Minnesota Department of Orthopedics.

Todd Rockwood, PhD, associate professor, Division of Health Policy and Management.

Nicholas Edwards, MD, Pediatrician, University of Minnesota, Department of Orthopedics.

Bradley Nelson, MD, Orthopedic Surgeon, University of Minnesota, Department of Orthopedics.