

Sport Specialization and Risk of Overuse Injuries: A Systematic Review With Meta-analysis

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abstract

CONTEXT: Sport specialization is theorized to increase the risk of sustaining overuse musculoskeletal injuries.

OBJECTIVE: To complete a systematic review and meta-analysis of the literature to determine if sport specialization is associated with overuse musculoskeletal injuries.

DATA SOURCES: An electronic search was conducted using the search terms “specialization,” “year-round,” “overuse,” “repetitive stress,” “injury,” “young,” “pediatric,” and “sports.”

STUDY SELECTION: Studies were included if their population was ≤ 18 years of age, if they compared athletes with high or single-sport specialization with athletes with low or multisport specialization, and focused on overuse injuries.

DATA EXTRACTION: Of the 12 articles that were identified for full-text review, 5 studies met all the inclusion criteria. Four studies provided adequate data for the meta-analysis. Quality scores on the modified Downs and Black scale ranged from 69% to 81%.

RESULTS: Athletes with high specialization were at an increased risk of sustaining an overuse injury compared with athletes with low (pooled relative risk [RR] ratio: 1.81; 95% confidence interval [CI]: 1.26–2.60) and moderate (pooled RR: 1.18; 95% CI: 1.05–1.33) specialization. Athletes with moderate specialization were at a higher risk of injury compared with athletes with low specialization (RR: 1.39 [95% CI: 1.04–1.87]).

LIMITATIONS: Four of the 5 studies included in this systematic review were included in the meta-analysis because of the lack of access to the original data set for 1 article.

CONCLUSIONS: Sport specialization is associated with an increased risk of overuse musculoskeletal injuries (Strength of Recommendation Taxonomy grade: B).



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Participation in youth sports offers a number of benefits to children and adolescents, including improving fitness, academic performance, and self-esteem.^{1,2} However, recent evolution of youth sports has shifted focus from these positive attributes to concerns regarding scholarships and playing time,³ resulting in young athletes focusing on a single sport at a high volume or specializing in 1 sport. Sport specialization is commonly defined as “participation in a single sport at the exclusion of other sports.”⁴ Sport specialization is often associated with training at high volumes both in terms of hours per week and months per year and can result in a variety of negative consequences, such as burnout and overtraining.^{1,5} This topic is so concerning that several medical and sport organizations have released statements warning against the increasing trend toward sport specialization among youth.⁵⁻⁹

These statements address concerns regarding the psychological impact of sport specialization and possible physical consequences, including the potential risk of overuse musculoskeletal injuries.⁵⁻⁹ These injuries are problematic because physical activity or sport-related injuries account for up to 20% of injury episodes for persons between 5 and 24 years of age.¹⁰ Additionally, in recent data, the annual direct and indirect cost of adolescent athletic injuries is estimated to be at \$6.7 billion (US Consumer Product Safety Commission; Directorate of Economic Analysis, personal communication, 2006). However, this number may underestimate the total impact of overuse injuries, which often go unreported.¹¹ Finally, and perhaps most importantly, sustaining an injury has been linked with dropout from sport with slightly <10% of youth athletes who cease participation in sports doing so as a result of injury or fear of reinjury.^{12,13} Among elite youth athletes, the rate of dropping out

TABLE 1 Search Terms and Number of Articles Generated

Search Terms (Including MeSH Terms)	Reference Database	No. Identified Studies
1. (Specialization or specialization or single-sport or y-round)	EBSCO-CINAHL	7267
	Medline (Ovid)	41 719
	PubMed	41 739
	EBSCO-SPORTDiscus	2749
2. (Specialization or specialization or single-sport or y-round) AND (overuse OR injury OR chronic OR gradual onset OR repetitive stress)	Cochrane	81
	EBSCO-CINAHL	477
	Medline (Ovid)	1401
	PubMed	1879
3. (Overuse OR injury OR chronic OR gradual onset OR repetitive stress) AND (young OR youth OR pediatric OR high school OR child* OR adolescent)	EBSCO-SPORTDiscus	195
	Cochrane	55
	EBSCO-CINAHL	412
	Medline (Ovid)	380
4. (young OR youth OR pediatric OR high school OR child* OR adolescent) AND (athlete OR athletes OR sports)	PubMed	533
	EBSCO-SPORTDiscus	106
	Cochrane	53
	EBSCO-CINAHL	87
	Medline (Ovid)	73
	PubMed	108
	EBSCO- SPORTDiscus	98
	Cochrane	12

because of injury is close to 20% and represents the second most common reason to cease sport participation.¹²

Despite a number of recent publications in which the impact of specialization on overuse injury was investigated, the position and consensus statements that have been released to date have relied on expert opinion and not empirical evidence.⁵⁻⁹ Therefore, we believe that a more focused review of the literature is warranted. Our purpose in this study was to systematically review the literature to determine if sport specialization is associated with an increased risk of musculoskeletal overuse injuries. The following specific clinical question of interest framed our analysis: “Are highly specialized youth athletes at a greater risk of overuse injury compared to low specialization youth athletes?”

METHODS

This systematic review was completed in accordance with the guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The systematic review was registered in

PROSPERO (<https://www.crd.york.ac.uk/prospero/>) before beginning the search (registration number: CRD42017078750).

Data Sources and Searches

An electronic search was conducted in 5 databases, including the Cochrane Database of Systematic Reviews, EBSCO-hosted Cumulative Index to Nursing and Allied Health Literature (CINAHL), EBSCO-hosted SPORTDiscus, Educational Resources Information Center (ERIC), EBSCO-hosted Medline, and PubMed Central. The search terms included (specialization or specialization or single-sport or year-round) AND (overuse OR injury OR chronic OR gradual onset OR repetitive stress) AND (young OR youth OR pediatric OR high school OR child* OR adolescent) AND (athlete OR athletes OR sports). The authors also conducted a hand search from reference lists in other relevant articles. Results from the search strategy for each database are presented in Table 1.

Study Selection

All search results were transcribed into an Excel file, and the database

was sorted to find duplicates, which were removed. An initial screen of the titles and abstracts was performed by 4 of the authors (D.R.B., E.G.P., K.B., T.V.M.) independently and recorded in an Excel file. A meeting was held to discuss any studies for which consensus on inclusion was not obtained. During that meeting, a final list of studies to undergo full-text review was determined. Each of the authors independently completed a full-text review of the remaining manuscripts. A second meeting was held to discuss any studies that did not have consensus regarding inclusion. The final list of included studies was then moved to the data extraction phase.

Studies were included if they were peer-reviewed, published in English, published in the year 2000 or later, were original research, and included patients or participants ≤ 18 years of age. Excluded studies consisted of narrative (clinical) reviews, editorials, critically appraised topics, commentaries, abstracts, animal research, or original research that did not address the primary clinical question of interest.

Data Extraction and Quality Assessment

The authors, journal, year of publication, sample demographics, level of evidence, study period, type of sports examined, outcome measures (specialization and overuse injury rates), type of injuries examined, and main results (odds ratios or relative risk [RR] ratios with 95% confidence intervals [CIs] and *P* values) were extracted as appropriate from each study on a standard data collection form. Because many of the studies included primary and secondary outcomes, extraction of the outcomes and presentation of the results were limited to only those outcomes that fit the clinical question of interest (overuse injuries). Studies were assigned a level of evidence as

outlined by the 2011 Oxford Centre for Evidence-Based Medicine scale. The risk of bias was assessed by using the adapted Downs and Black scale, which is a 16-item version of the original Downs and Black Quality Index.^{14,15} The recommendations of Munn et al¹⁶ were used to evaluate the quality of the included studies. Studies that met fewer than 60% of the adapted Downs and Black criteria were considered to be of low methodologic quality, studies that met 60% to 74.9% of the criteria were considered to be of moderate methodologic quality, and studies that met $>75\%$ of the criteria were considered to be of high methodologic quality (Table 2).¹⁶ The Strength of Recommendation Taxonomy criteria were used to determine an overall recommendation on the basis of the findings of the included studies.¹⁷

Data Synthesis and Analysis

A narrative, qualitative synthesis of results was performed to evaluate and summarize the patients, methods, results, and conclusions of the included studies. A summary table was developed to present the results of these 5 included studies (Table 2).

Four of the 5 studies provided sufficient data for use in a meta-analysis. For 3 studies, logged RRs and SEs were calculated from data that were provided in the manuscripts. For 1 study, the authors provided raw data to allow for calculation of RRs and SEs. Three analyses were conducted: between low and moderate specialization, low and high specialization, and moderate and high specialization. The heterogeneity of the studies was assessed by using the I^2 index. MIX 2.0 Professional²³ was used to combine effect sizes across studies. A DerSimonian-Laird random-effects-model approach was selected for the analysis.

RESULTS

Results of Search

The results of the search are presented in Fig 1. The extensive literature search resulted in 381 potential studies. After the removal of 184 duplicates that were found across databases or with different search terms, 197 studies remained and were screened to meet the inclusion and exclusion criteria. After screening the titles and abstracts, 185 studies were removed (62 narrative reviews, 7 commentaries, 3 editorials, 2 case studies, 1 news article, 1 non-peer-reviewed article, 5 non-English articles, 5 consensus or position statements, 17 articles that were published before the year 2000, and 82 articles that were not relevant to the clinical question; Supplemental Table 3), leaving 12 articles for a full text evaluation. The application of the inclusion and exclusion criteria during the full-text review resulted in the exclusion of 7 studies. Two studies were removed because they were not explicitly focused on overuse injury,^{24,25} 1 was removed because the comparison was between athletes with high specialization in team sports and athletes with high specialization in individual sports,²⁶ 1 was removed because the authors did not directly compare specialized and nonspecialized groups and the measurement of specialization was not clearly defined,²⁷ and 3 studies were removed because the athletes fell outside of the established age range,^{28–30} leaving 5 studies from which data were abstracted and synthesized in the results.

Qualitative Review of the Articles

A summary of the final studies is found in Table 2. Of the studies that were identified, 1 study was a prospective investigation and 4 studies were retrospective investigations. The injury outcomes of interest included patellofemoral pain,¹⁹ overuse knee injuries,¹⁸ overuse lower extremity injuries,²¹

TABLE 2 Summary of High Specialization and Overuse Injury Rates Across Studies

Study	N	LOE	Adjusted Downs and Black Score, %	Study Period, mo	Type of Sport(s)	Age, Mean (SD)	Sex, n (%)	High Specialization, %	Injured for High Specialization, %	Type of Injury	OR (95% CI)	P
Bell et al ¹⁸	302	3	69	NR	Soccer, basketball, tennis, and women's volleyball	15.5 (1.2)	Female: n = 180 (59.6); male: n = 122 (40.4)	36.4	10.9	Overuse, knee injury	2.93 (1.16–7.36)	.018
Hall et al ¹⁹	546	NR	78	NR	Women's volleyball, soccer, and basketball	14.0 (NR)	Female: n = 546 (100)	34.6	28	Patellofemoral pain	1.5 (1.0–2.2)	.038
Jayanthi et al ²⁰	1214	3	75	36	NR	13.7 (2.3)	Female: n = 587 (49.3); male: n = 603 (50.7)	28.1	11.0	Serious overuse injury	1.36 (1.08–1.72)	<.001
McGuine et al ²¹	1544	2	81	12	Baseball, softball, basketball, football, soccer, tennis, track and cross country, volleyball, wrestling, and other	16.1 (1.1)	Female: n = 780 (50.5); male: n = 764 (49.5)	13.3	4.6	Lower extremity overuse injuries	4.74 (2.04–11.05)	<.001
Post et al ²²	2011	3	75	NR	Soccer, basketball, swimming and diving, ice hockey, volleyball, track and cross country, lacrosse, baseball, football, softball, cheer and dance, gymnastics, tennis, and wrestling	13.7 (1.6)	Female: n = 989 (49.1); male: n = 1022 (50.9)	37.5	19.2	Overuse injury	1.45 (1.07–1.99)	.011

LOE, level of evidence; NR, not reported; OR, odds ratio.

and overuse injuries of any type.^{20,22} Sport specialization status was classified on the basis of self-report of the number of sports played (single versus multisport)¹⁹ or a sport specialization scale. Four studies included a variety of sports (soccer, basketball, and volleyball), whereas 1 study²⁰ did not include the sports of the athletes in the study. Four of the studies were focused on both sexes, whereas 1 study¹⁹ only included girls.

Overall, in all 5 studies, a significant association between high levels of sport specialization and overuse injury was observed. In a retrospective study of high school athletes, Hall et al¹⁹ observed that athletes of a single sport were more likely to have a diagnosis of patellofemoral pain compared with athletes of multiple sports. When applying the 3-point specialization scale to high school athletes, Bell et al¹⁸ found that athletes with high specialization were more likely to have a previous history of overuse knee injury when examined in a cross-sectional manner. In 2 similarly designed studies of large samples of youth athletes, both Jayanthi et al²⁰ and Post et al²² observed associations between high levels of specialization and overuse injury. In the only prospective study, McGuine et al²¹ established high levels of specialization to be a prospective risk factor for overuse lower extremity injury but not for acute injuries.

Pooled Estimates

Participants who were categorized as highly specialized were at a significantly greater risk of overuse injury compared with participants who were categorized as moderately specialized (RR: 1.18 [95% CI: 1.05–1.33]; $I^2 = 0\%$; analysis sample size = 3005) and participants with low specialization (RR: 1.81 [95%

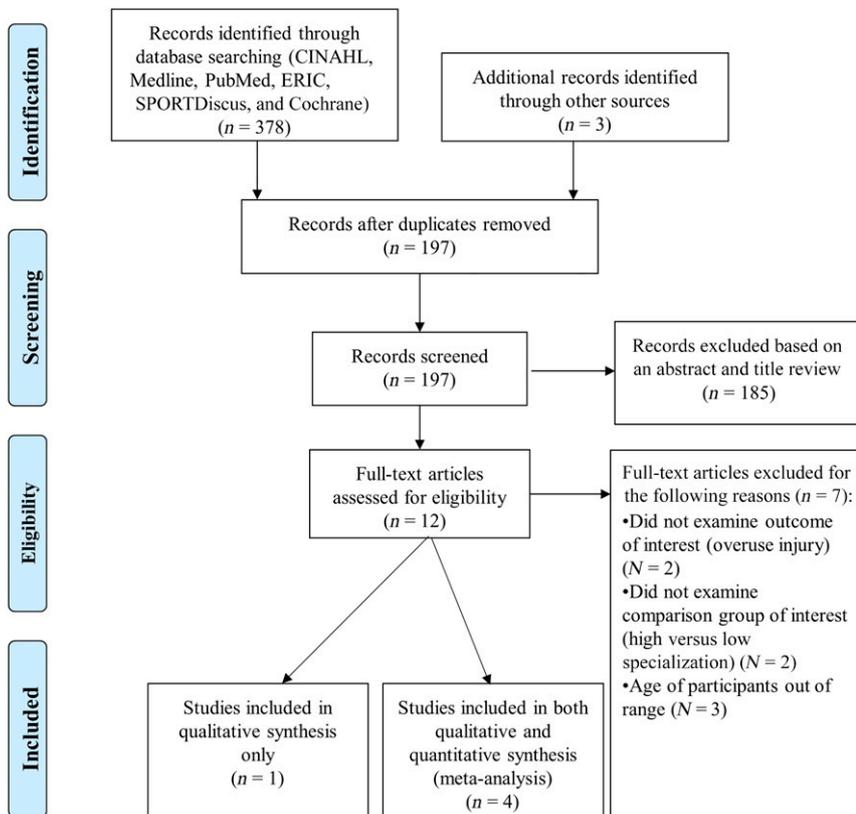


FIGURE 1 Flowchart of the articles that were reviewed for inclusion.

CI: 1.26%–2.60%]; $I^2 = 77.15\%$; analysis sample size = 3342). Those with moderate specialization were at a significantly higher risk of overuse injury compared with those with low specialization (RR: 1.39 [95% CI: 1.04–1.87]; $I^2 = 64.32$; analysis sample size = 3601). Forest plots for each analysis are provided in Figs 2–4.

Level of Evidence and Strength of Recommendation

The current review included 3 studies that were of level III evidence, 1 study that was of level II evidence, and 1 study that was of level IV evidence. By using the adjusted Downs and Black metric, 4 studies were considered to be of high methodologic quality, whereas 1 study was considered to be of moderate methodologic quality. On the basis of the level of evidence of the included studies, the Strength of Recommendation Taxonomy

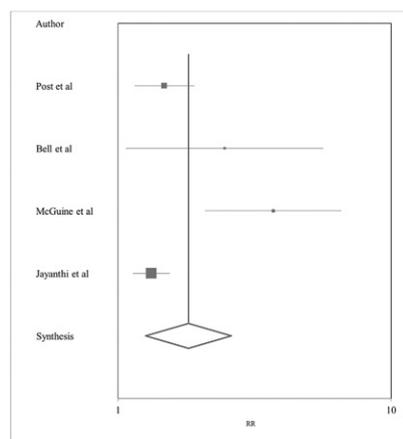


FIGURE 2 Pooled RR of high specialization versus low specialization.

criteria level of recommendation was B. Although there were consistent findings that sport specialization increased the risk of overuse injury across studies, there were not enough studies of level II evidence or stronger included in our review to allow us to provide a recommendation of A.¹⁷

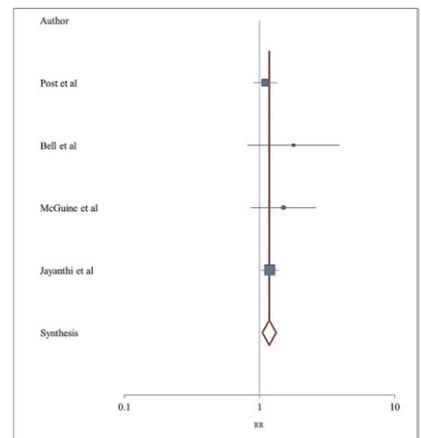


FIGURE 3 Pooled RR of high specialization versus moderate specialization.

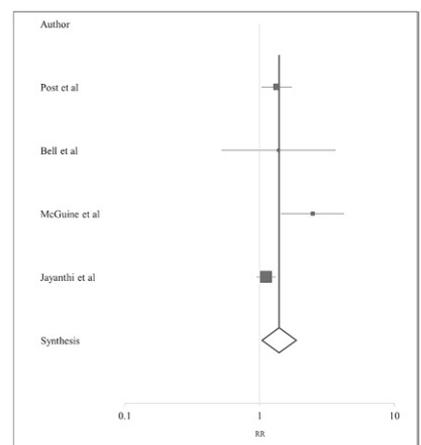


FIGURE 4 Pooled RR of moderate specialization versus low specialization.

DISCUSSION

The results of this systematic review reveal that although there is consistent evidence suggesting that high level of sport specialization is associated with a greater risk of developing an overuse injury, the quality of included studies is limited. This evidence is based on the 5 studies that were identified in the review. These studies yielded consistent results and were supported by the meta-analysis of 4 studies in which pooled estimates were calculated. Athletes with high specialization were nearly twice as likely to sustain an overuse injury compared with athletes with low

specialization (81% more likely) and even moderate specialization (18% more likely). Even moderate specialization appears to be associated with a greater risk of injury than low specialization (39% more likely). These results revealed a stepwise increase in risk with increasing levels of specialization.

Clinically, the results of this review are important because they provide evidence to support the notion that sport specialization increases injury risk. There is a large number of clinical reports and position statements that warn against this practice despite the limited evidence in this area.^{1,5-7,9} In fact none of the position and/or summary statements that are listed promote or endorse sport specialization. Our review supports the recommendation that athletes should delay specialization until late adolescence.⁶ Specialization has been proposed as a mechanism for attaining elite sport performance because of increased time spent in intensive training for that sport.³¹ However, comparisons of elite and nonelite athletes and studies of professional or collegiate athletes across a variety of sports indicate that elite athletes typically specialize later in adolescence and participate in more sports during high school than nonelite athletes.³²⁻³⁵ Medical providers and researchers believe that diversified training during early adolescence results in a more well-rounded athlete.^{1,5,7,36} Finally, 4 of the studies that are included in this review use a recently developed scale to classify athletes along a spectrum of specialization.^{4,20} This scale has high clinical utility given the simplicity of application. Physicians and other health care providers should consider using this specialization scale to classify their patients and help counsel youth athletes and their parents regarding the possible risks of specialization.

The findings of our systematic review and meta-analysis are in general

agreement with a previous review on this topic area by Fabricant et al.³⁷ The authors of that review also concluded that there was level B evidence to support the association between sport specialization and increased injury risk. The key difference between that review and the current review is that Fabricant et al.³⁷ chose to include articles that were focused on all musculoskeletal injuries. The authors were unable to focus on overuse injuries explicitly because of limitations in the literature. For example, they included an article in which rates of withdrawal from a tennis tournament due to injury were compared between athletes who played only tennis and athletes who reported playing multiple sports.²⁵ Although this is a logical and interesting approach, it was unclear from our review of the article how the injuries were classified. Therefore, we were unable to determine the number of injuries that were explicitly associated with chronic or overuse mechanisms and thus were unable to include this study in the current analysis. Thus, we were able to focus our review on studies with more consistent methodology. This reveals the growth in this area of literature and the recent improvement in methodology; however, there is still a need for more prospective studies on this topic.

One study was included in our systematic review (but not in the meta-analysis) and is worth discussing because of methodologic differences.¹⁹ This was a retrospective study in which specialization was defined by using a single- versus a multisport framework. The authors observed that female soccer, basketball, and volleyball players who participated in a single sport had a higher risk of developing overuse anterior knee pain disorders, such as patellofemoral pain. However, additional reading of the methods reveals that athletes who played

a single sport for a single season could have been classified as highly specialized. Participating in a single sport without the year-round component does not necessarily match the working definition of sport specialization. It is unclear how many cases this may have affected and how it might have influenced their results; however, it also reveals the difficulty of consistently applying sport specialization definitions.

Post et al.²⁴ examined the association between specialization and injury and found that athletes with specialization were more likely to report a history of any type of injury in the previous year. Unfortunately, the authors did not explicitly focus on overuse injury, and we were unable to include this article in the review. However, the primary findings of this study are in line with the conclusions of our systematic review and meta-analysis: specialization increases the risk of musculoskeletal injury.

There are several limitations to this systematic review and meta-analysis that should be considered. Of the final studies that were included in this review, 3 were conducted by a study team that included 2 of the authors of this review and meta-analysis.^{18,21,22} We attempted to control for potential bias on the part of these authors by adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, registering the study in PROSPERO with a clearly defined clinical question of interest before performing the literature search, and requiring a consensus from 4 of the authors (D.R.B., E.G.P., K.B., and T.V.M.) for all study inclusion decisions. Additionally, the final number of included studies in the review was small ($n = 5$), revealing the limited research in which the relationship between specialization and overuse injury is examined. Additional research is needed to continue to refine our understanding of the connection between sport specialization and

overuse injury, including interactions with other factors such as playing style, nutrition and recovery, and athleticism. Only 4 of the final 5 studies that were included in this systematic review were included in the meta-analysis because of the lack of access to the original data set for 1 article. Finally, there is ongoing debate regarding the best way to define and classify sport specialization, and limitations exist in both the 3-point scale and single- and multisport methods of classification.³⁸ However, we felt justified using

these classification methods as the basis for our clinical question of interest because these are by far the most commonly used methods for classifying sport specialization.

CONCLUSIONS

Sport specialization is associated with an increased risk of overuse musculoskeletal injuries. This conclusion is based on a qualitative review of the findings of the 5 articles that were included in this review and is confirmed by a meta-analysis of

4 of these studies. There appears to be a stepwise increase in the risk of overuse injury with increasing levels of specialization.

ABBREVIATIONS

CI: confidence interval
CINAHL: Cumulative Index to Nursing and Allied Health Literature
ERIC: Education Resources Information Center
RR: relative risk

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