

CHRONIC LACK OF SLEEP IS ASSOCIATED WITH INCREASED SPORTS INJURY IN ADOLESCENTS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background: Although sleep has been identified as an important modifiable risk factor for sports injury, the effect of decreased sleep on sports injuries in adolescents is poorly studied.

Purpose: To systematically review published literature to examine if a lack of sleep is associated with sports injuries in adolescents and to delineate the effects of chronic versus acute lack of sleep.

Methods: PubMed and EMBASE databases were systematically searched for studies reporting statistics regarding the relationship between sleep and sports injury in adolescents aged <19 years published between 1/1/1997 and 12/21/2017. From included studies, the following information was extracted: bibliographic and demographic information, reported outcomes related to injury and sleep, and definitions of injury and decreased sleep. Additionally, a NOS (Newcastle-Ottawa Scale) assessment and an evaluation of the OCEM (Oxford Center for Evidence-Based Medicine) level of evidence for each study was conducted to assess each study's individual risk of bias, and the risk of bias across all studies.

Results: Of 907 identified articles, 7 met inclusion criteria. Five studies reported that adolescents who chronically slept poorly were at a significantly increased likelihood of experiencing a sports or musculoskeletal injury. Two studies reported on acute sleep behaviors. One reported a significant positive correlation between acutely poor sleep and injury, while the other study reported no significant correlation. In our random effects model, adolescents who chronically slept poorly were more likely to be injured than those who slept well (OR 1.58, 95% CI 1.05 to 2.37, $p = 0.03$). OCEM criteria assessment showed that all but one study (a case-series) were of 2b level of evidence—which is the highest level of evidence possible for studies which were not randomized control trials or systematic reviews. NOS assessment was conducted for all six cohort studies to investigate each study's individual risk of bias. Five out of six of these studies received between 4 to 6 stars, categorizing them as having a moderate risk of bias. One study received 7 stars, categorizing it as having a low risk of bias. NOS assessment revealed that the most consistent source of bias was in ascertainment of exposure: all studies relied on self-reported data regarding sleep hours rather than a medical or lab record of sleep hours.

Conclusions: Chronic lack of sleep in adolescents is associated with greater risk of sports and musculoskeletal injuries. Current evidence cannot yet definitively determine the effect of acute lack of sleep on injury rates. Our results thus suggest that adolescents who either chronically sleep less than 8 hours per night, or have frequent night time awakenings, are more likely to experience sports or musculoskeletal injuries.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram

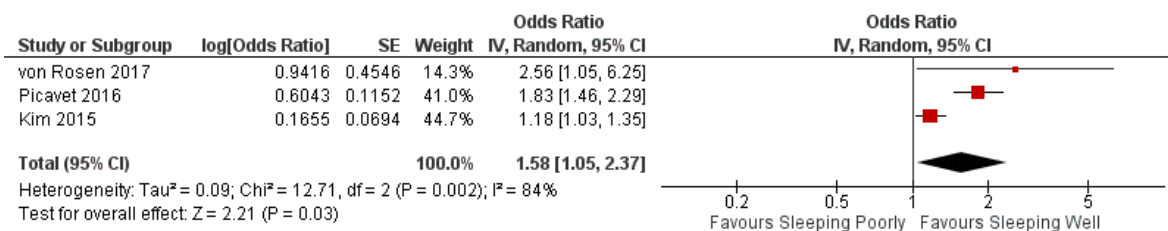
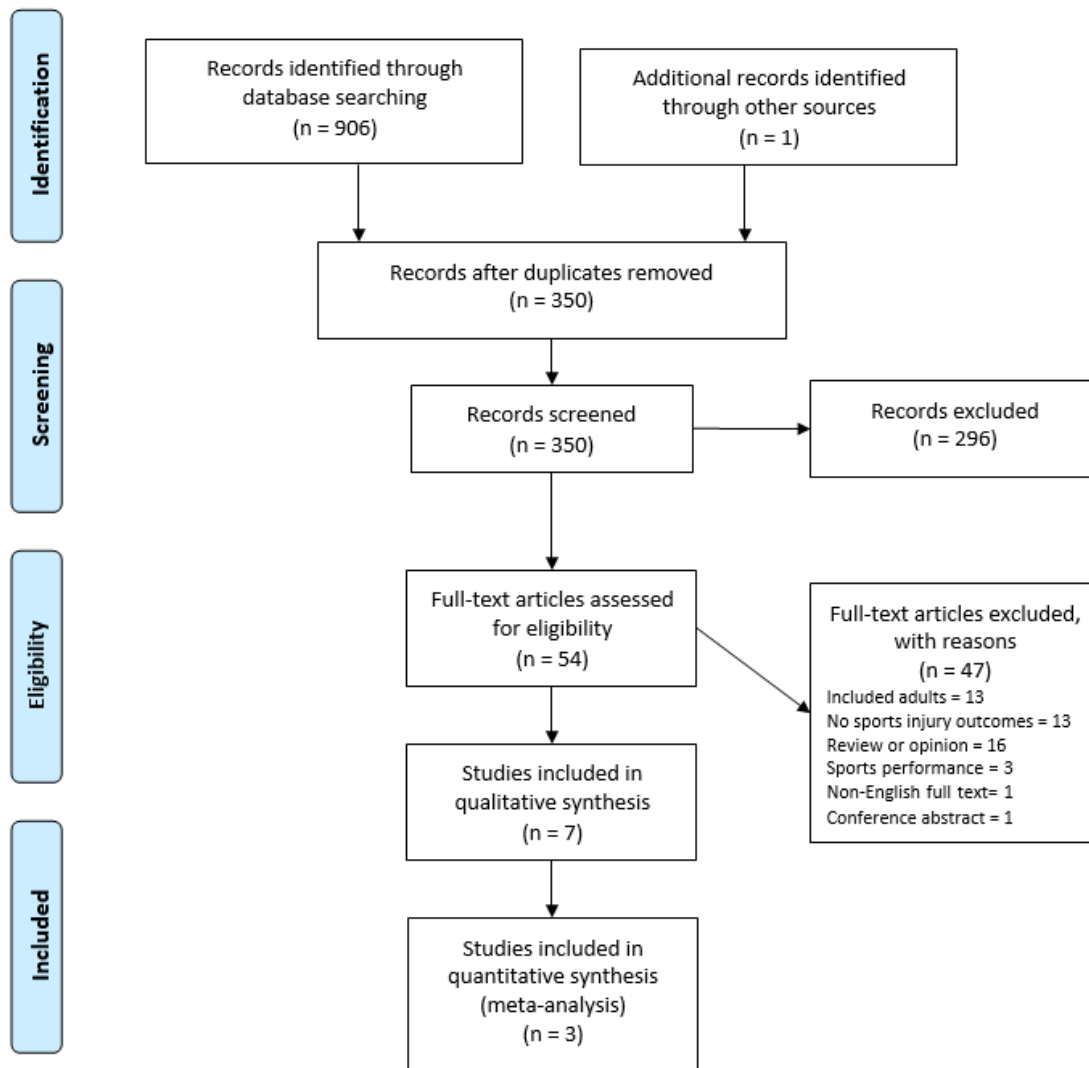


Figure 2. Random Effects Model Pooling the Following Studies: Von Rosen et al.¹⁷, Picavet et al.¹⁹, Kim et al.²⁰

Table 1. Study Characteristics, by publication year

Study	Year	Mean age (range), years	Questionnaire Timing	No. of Patient Respondents	No. of Females	Patient Population	Sport/Activity
von Rosen et al. ¹⁷	2017	17.1 (16-19)	1 questionnaire during "autumn semester" & 1 questionnaire during "spring semester"	340	162	"Swedish adolescent elite athletes" from 21 "National Sports High Schools"; "To attend the National Sports High Schools, the adolescent athletes must exhibit high national performance achievement and practice at the highest national level for their age group"	"Athletics, cross-country skiing, orienteering, handball, downhill skiing, ski orienteering, and freestyle skiing"
von Rosen et al. ¹⁸	2017	17 (15-19)	Questionnaires weekly or bi-weekly (depending on sport) for 52 weeks	496*	226*	"Swedish adolescent elite athletes" from 24 "National Sports High Schools"	Sports reporting weekly questionnaires: Skiing, Orienteering, Handball, and Athletics. Sports reporting bi-weekly questionnaires: Water ski, Canoe, Rowing, Wrestling, Bowling, Triathlon, Golf, Cycling, and American football.
Watson et al. ¹²	2016	15.5 (+/-1.6) [^]	Questionnaires given daily for 20 weeks (length of 1 soccer season)	75	75	"female youth soccer athletes"	Soccer
Picavet et al. ¹⁹	2016	(11-14) ^{^^}	Questionnaire given once at age 11 and again at age 14	2517	1251	Children & adolescents in the Netherlands	--
Kim et al. ²⁰	2015	14.50/14.81 (12-18) ^{^^^}	Unspecified	17232	Unspecified	Korean adolescents from 7th through 12th grades	Bicycle riding
Milewski et al. ⁴	2014	15 (12-18)	One time questionnaire	112	58	United States adolescent athletes in high school or middle school	Unspecified
Luke et al. ¹⁵	2011	13.8 (6-18)	One time questionnaire given during sports medicine clinic visit	360	Unspecified	Patients visiting university-based sports medicine clinics in the US & Canada	Football, basketball, hockey, Soccer, wrestling, running, gymnastics, baseball, softball, "other"

[^]Not specified whether 1.6 was absolute range or standard deviation

^{^^}no average reported

^{^^^}No overall mean was reported. Mean age of patients injured in bicycle accidents was 14.50 years; Mean age of patients not injured in bicycle accidents was 14.81

*30 of the total no. of patient respondents did not respond regarding sleep (unspecified how many of these 30 were female)

Table 2. Outcomes & Definitions, by publication year

Study	Year	Definition of "Poor" Sleep	Definition of Injury	Probability Statistic (univariate analysis)	Probability Statistic (multivariate analysis)	Multivariate Control Variable(s)/adjustment	Other Form of Outcomes reported
von Rosen et al. ¹⁷	2017	Chronic; proportion of athletes (failing) to reach "the recommendation of sleep" (<8 hours) during weekdays; average amount of sleep during weekdays	"Injury was defined any physical complaint resulting in reduced training volume, experience of pain, difficulties participating in normal training or competition, or reduced performance in sports [...] and was self-reported by the athletes"	OR 2.4 (95% CI: 1.0-5.9; p = 0.047)*	OR 2.6 (95% CI: 1.1, 6.3; p=0.038)*	"Proportion [of] athletes reaching the recommendation of nutrition intake of fish, fruits and vegetables." Authors define recommendation "as national recommendation" (Sweden), sex, age	--
von Rosen et al. ¹⁸	2017	Chronic; "Sleep ≤ 8 hours during weekdays"; Surveys emailed weekly in first year, surveys emailed bi-weekly in second year	"Any new physical complaint that affected participation in normal training or competition, led to reduced training volume, experience of pain, or reduced performance in sports. Thus, both acute/overuse injuries were included."	HR 1.32 (95% CI: 0.98-1.78; p = 0.064)	HR 2.25 (95% CI: 1.46-3.45; P<.01)	Nutrition Index, Competence-based self-esteem, increased training load, decreased sleep volume ("dichotomized variable," not defined)	--
Watson et al. ¹²	2016	Acute; "sleep volume in hours" of the night preceding the injury; no hour cut off given	"injuries [...] entirely acquired during soccer events"	RR 0.98 (95% CI: 0.58-1.7; p = 0.93)**	--	--	Sleep Hours On Days w/out an injury: 8.0 (SD: 0.65); Sleep Hours on Days w/ an injury: 7.97 (0.52); p- value 0.64; Cohen's d: 0.06
Picavet et al. ¹⁹	2016	Chronic; "Sleeping problems" was a composite variable based on the frequency and duration of nighttime awakenings. Those who reported being awake sometimes or every night, and reported being awake for a while or for a long time, were considered as having sleeping problems."	Injuries were musculoskeletal complaints (MSCs); "Musculoskeletal complaints were measured as part of a list of 15 conditions [...] in the past 12 months" (5 past year)."	--	Model 1: OR 1.83 (95% CI: 1.46-2.30); Model 2: OR 1.51 (95% CI: 1.15-1.97)	Model 1: Age, sex; Model 2: Not specified beyond "variables that were statistically significantly associated with a P value of 0.05 or lower."	--
Kim et al. ²⁰	2015	Chronic; Sleeping <7.5 but ≥ 6.5 hours across the past 7 weeks	"Bicycle riding accident"	OR 0.99 (95% CI: 0.87-1.12)	Model 1: OR 1.18 (95% CI: 1.03-1.34); Model 2: OR 1.17(95% CI: 1.03-1.33)	Model 1: Age, sex; Model 2: Age, sex, obesity, economic level, and region of residence	--

Milewski et al. ⁴	2014	Chronic; < 8 hours/night on average	"Any injury that necessitated a visit to the athletic trainer's room for evaluation and/or treatment...over a 21 month period"	RR 2.0 (95% CI, 1.3-3.2; P = 0.003)	RR 1.7 (95% CI, 1.0-3.0; P = 0.04)	Grade in School	--
Luke et al. ¹⁵	2011	Acute; <6 hours the night before	"A new sports-related or other physical activity-related injury [...] based on [a] physician's interpretation of whether the injury was related to sports or other physical activity."	--	--	--	No methods or results beyond: "Sleeping 6 or fewer hours the night before the injury was associated with all the fatigue-related injuries (P = 0.028)."

OR = Odds Ratio; HR = Hazard Ratio; RR = Relative Risk

*Calculated from reciprocal OR

**Authors ambiguous about whether OR or RR. Values were calculated from Poisson regression, therefore assumed to be RR. Authors ambiguous about size of confidence interval; assumed to be 95% because statistical significance was defined as p<0.05

Table 3. Oxford Center for Evidence-Based Medicine Level of Evidence (OCEM LOE) and Newcastle-Ottawa Scale (NOS) Assessment

Study	Oxford Criteria for Evidence-Based Medicine Level of Evidence, study design	Total Stars, Risk of Bias	Representativeness of the Exposed Cohort	Selection of the Non-Exposed Cohort	Ascertainment of Exposure	Demonstration That Outcome of Interest Was Not Present at Start of Study	Comparability of Cohorts on the Basis of the Design or Analysis	Assessment of Outcome	Follow-Up Was Long Enough for Outcomes to Occur	Adequacy of Follow Up of Cohorts
von Rosen et al. 2017 ¹⁷	2b, prospective individual cohort	5, moderate risk	c	a*	c	b	a*, b* (multiple confounders controlled in probability ratios)	c	a*	b*
von Rosen et al. 2017 ¹⁸	2b, prospective individual cohort	6, moderate risk	c	a*	c	a*	a*, b* (multiple confounders controlled in probability ratios)	c	a*	b*
Watson et al. 2016 ¹²	2b, prospective individual cohort	6, moderate risk	b*	a*	c	b	a*, b* (gender, age group, and sport matched in design)	c	a*	b*
Picavet et al. 2016 ¹⁹	2b, prospective individual cohort	6, moderate risk	a*	a*	c	b	a*, b* (multiple confounders controlled in probability ratios)	c	a*	b*
Kim et al. 2015 ²⁰	2b, cross-sectional/retrospective individual cohort	6, moderate risk	b*	a*	c	b	a*, b* (multiple confounders controlled in probability ratios)	c	a*	a*
Milewski et al. 2014 ⁴	2b, cross-sectional/retrospective individual cohort	7, low risk	a*	a*	c	b	a*, b* (age group and locality of adolescents matched in design, grade in school controlled for in probability ratios)	b*	a*	b*
Luke et al. 2011 ¹⁵	4, case-series	-	-	-	-	-	-	-	-	-

*indicates that this grade merits a star per NOS criteria

-, Luke et al.'s study was not a cohort study and thus did not qualify for Newcastle-Ottawa Scale Assessment

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