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Review article

How healthy is the behavior of young athletes? A systematic literature review and meta-analyses

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Abstract

Participation in sports during adolescence is considered a healthy behavior. The extent to which adolescent athletes engage in other healthful (or risky) behaviors is less clear, however. We conducted a systematic literature review following the PRISMA Statement to assess the frequency of risky behaviors among athletes in this age group. We searched the PubMed, PsycINFO and SCA Sociological Abstracts databases for observational studies published in English over the last twenty years on the frequency of selected risk behaviors (alcohol consumption, smoking behavior, use of illicit drugs, unhealthy nutrition, and doping) in adolescent athletes. Two independent reviewers selected articles following the PRISMA Statement. Behavior frequency was assessed as was comparability of study design and methods. When possible, meta-analyses were performed using data from subgroups of studies in which operational indicators were comparable. Seventy-eight articles met eligibility criteria. Although report of risky behaviors varied across studies, we observed overall, that studies tend to report higher alcohol use, less smoking, less recreational drug use, and more smokeless tobacco use in (high-involved) athletes. Considerable heterogeneity was noted in study design, definition of target groups and use of operational indicators (I^2 ranged from 93.2% to 100%). Especially the higher prevalence of using alcohol and smokeless tobacco needs more attention in interventions targeted to this group. Overall, greater consensus on methods used to assess risky behaviors in adolescent athletes.

Key words: Adolescent; health behavior; alcohol; smoking; sport.

Introduction

Adolescence is a critical developmental period in the lifespan during which social and psychological norms are established and significant physical and emotional changes take place (Murray et al., 2011). To cope with these changes, many adolescents engage in risky behaviors (Richter, 2010), eventually leading to established behavioral patterns for some. In addition, other factors like genetic, environmental and intra-/interpersonal factors are associated with engaging in risky behaviors. Unhealthy behavior among adolescents represents an important public health problem with both long- and short-term effects. Early adoption and continued use of legal and illegal drugs, for example, may lead to lifelong dependency and negative health consequences as an adult (DeWit et al., 2000). Moreover, individuals who consume alcohol at an early age are more likely to experience employment problems and show criminal or violent behavior in later life compared with those who do not (Ellickson et al., 2003). In the short-term, risky behaviors such as under-age alcohol consumption have been associated with increased risk for bodily injury from traffic-related accidents (Beck et al., 2010).

Several theories help explain the development and nature of health-related risk behaviors in adolescence. The Deterrence Hypothesis, for example, focuses specifically on the association between risk behavior and sports. It proposes that participation in sports moderates delinquent behavior (Eitle et al., 2003; Leonard, 1995; Schafer, 1969) through exposures that promote conforming to rather than deviation from social norms (Begg et al., 1996). In organized sports, for example, adolescents are provided with structured time schedules, supervision and frequent exposure to normative behaviors associated with health benefits (Begg et al., 1996; Eitle et al., 2003). An expanded social network resulting from newly developed friendships may also promote development of group identities and cultures (Eccles et al., 2003) and sharing strategies for coping with daily problems (Sygusch, 2005) that also benefit health status. Some have proposed, therefore, that participation in sports may be protective against drug use (Lisha and Sussman, 2010).

Pressures that prompt young athletes to refrain from engaging in risky behaviors exist alongside those that promote unhealthy behavior, however. The Athletic Delinquent Hypothesis, for example, supports the notion that health-related risk behaviors may result from participation in sports activities (Begg et al., 1996). Due to a multitude of obligations, athletes are exposed to numerous pressures (Heyman, 1986). According to a literature review on athletic participation in high school and college, higher alcohol consumption was prevalent among athletes (Lisha and Sussman, 2010). This may have resulted from a sense of competition, stress resulting from frequent testing and performance evaluation, perceived norms based on assumptions that other athletes consume alcohol at high levels, and frequent exposure to commercials for alcohol products during sports events (Lisha and Sussman, 2010).

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While previous work provides insight into patterns of health behaviors among older adolescent athletes (Martens et al., 2006), their focus has been in specific areas: eating disorders (Forsberg and Lock, 2006; Gabel, 2006; Hildebrandt, 2005), use of performance-enhancing nutritional supplements (Lawrence and Kirby, 2002), the female athlete triad (a syndrome consisting of eating disorders, amenorrhea, and osteoporosis) (Golden, 2002), and the use of alcohol and drugs (Martens et al., 2007). Comprehensive and critical summaries on more common risky behaviors are less evident, especially for individuals 18 years and younger, an age considered to represent the main period of adolescence (Blos, 1962, 1979). Specific focus on these issues in this younger age group is important because risky behaviors can have immediate negative consequences on physical performance (e.g., bronchospasm in adolescent smokers) and social functioning (American College of Sports Medicine, 2007; Foulds et al., 2008; Leon et al., 1981). Although useful, two earlier reviews of risk behaviors in adolescent athletes (Lisha and Sussman, 2010; Mays et al., 2011) have important limitations: the former focused primarily on alcohol, tobacco and illicit drug use among high school and college athletes, while the latter was restricted to alcohol consumption in U.S. athletes. Although neither review addressed important issues such as eating and doping behaviors, both recommended the need for additional research especially on adolescent athletes across a broader age range and more diverse geographic settings and on common behaviors such as tobacco use (Lisha and Sussman, 2010).

If clear patterns of risky behavior exist for the main period of adolescence, their recognition would guide the development of programs for preventing or reducing health effects in adolescence and later in life. The purpose of this report, therefore, was to systematically examine international literature to identify the frequency of risk behaviors (i.e. use of alcohol, tobacco, drugs, performance enhancing drugs and nutrition) among younger adolescents being low and high-involved in sports.

Methods

Procedures used in this literature review follow the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) Statement (Moher et al., 2009), a more recent revision of the QUOROM (Quality of Reporting of Meta-analyses) Statement (Moher et al., 1999). To assess health behaviors of young adolescent athletes from multiple disciplinary perspectives, we chose PubMed, CSA Sociological Abstracts and PsycINFO as the medical, sociological and psychological databases, respectively, for the literature search. Search terms were based on the Medical Subject Heading (MeSH) system. Altogether, there were twelve search combinations performed in each database. The words *"adolescent"* and *"athlete* OR *sports*" built the base for each combination and were in each case accompanied by the following words: *"alcohol", "smoking", "cannabis OR marihuana", "eating behavior OR nutrition", "health behavior",* or *"doping"*.

Studies were selected if they contained one or more of the above-mentioned search terms in the title or abstract, represented original articles published in a peer-reviewed journal in English, reported quantitative results and appeared in printed or electronic form between January 1st, 1990 and December 31st, 2010. Given a focus on younger athletes in the main period of their adolescence (Blos, 1962; 1979), we included studies in which the maximum age of participants was 18 years or the sample mean age was less than 19 years. With this approach, it was possible to identify a wide range of studies including adolescents aged 18 years and younger. Articles focusing on specific configurations of behavior and disease, such as the female athlete triad (a syndrome consisting of eating disorders, amenorrhoea, and osteoporosis), were excluded. Additionally, we excluded reviews, case studies, book chapters, dissertations and essays in large part because comprehensive and consistent identification of these forms of "grey literature" is not possible through currently available electronic databases of scientific literature. Attempts to incorporate information of this sort would therefore have yielded a pool of studies with results that could not be reliably replicated by others. Secondly, a focus on original papers published in peer-review journals has the potential additional benefit of ensuring more uniform quality and reduced study heterogeneity.

The search took place on May 25th, 2011 and produced 2,159 hits (Pubmed 1,577 hits; CSA 296 hits; and PsycINFO 286 hits). After discarding duplicate publications of the same study, 2,057 articles remained (see Figure 1). Following review of references cited in each, seven additional articles were identified.

We reduced the pool of 2,064 potentially eligible articles to 97 following abstract review and to 78 upon detailed review of each manuscript. This two-step selection process (Figure 1) was conducted independently by the first (KD) and last (SvS) authors. After each step, decisions on eligibility were compared. Cohen's Kappa for inter-rater-reliability at this stage was 0.72 for the first selection step and 0.94 for the second (Cohen, 1960). In the few cases in which differences were noted, each was discussed and a final determination was made by the first author (KD).

Each article in the final analytic sample was evaluated using a standardized form. Outcomes of interest included the frequency of common health-related behaviors (i.e., consumption of alcohol, tobacco products, illicit drug use, eating behaviors, and doping) and the level at which adolescents participated in sports (e.g., high-involved athletes, low-involved athletes). Data on comparison groups (e.g., high-involved athletes vs. low-involved athletes; low-involved athletes vs. those not involved in sports [non-athletes]) were used for comparison when available. Our assessment also took note of several methodological aspects of each report including its study design, characterization of the groups targeted for study and the way in which risky behaviors were operationally defined and measured. Because our assessment revealed considerable heterogeneity across studies in nearly all study features and because the number of articles addressing specific risk behaviors was small, the

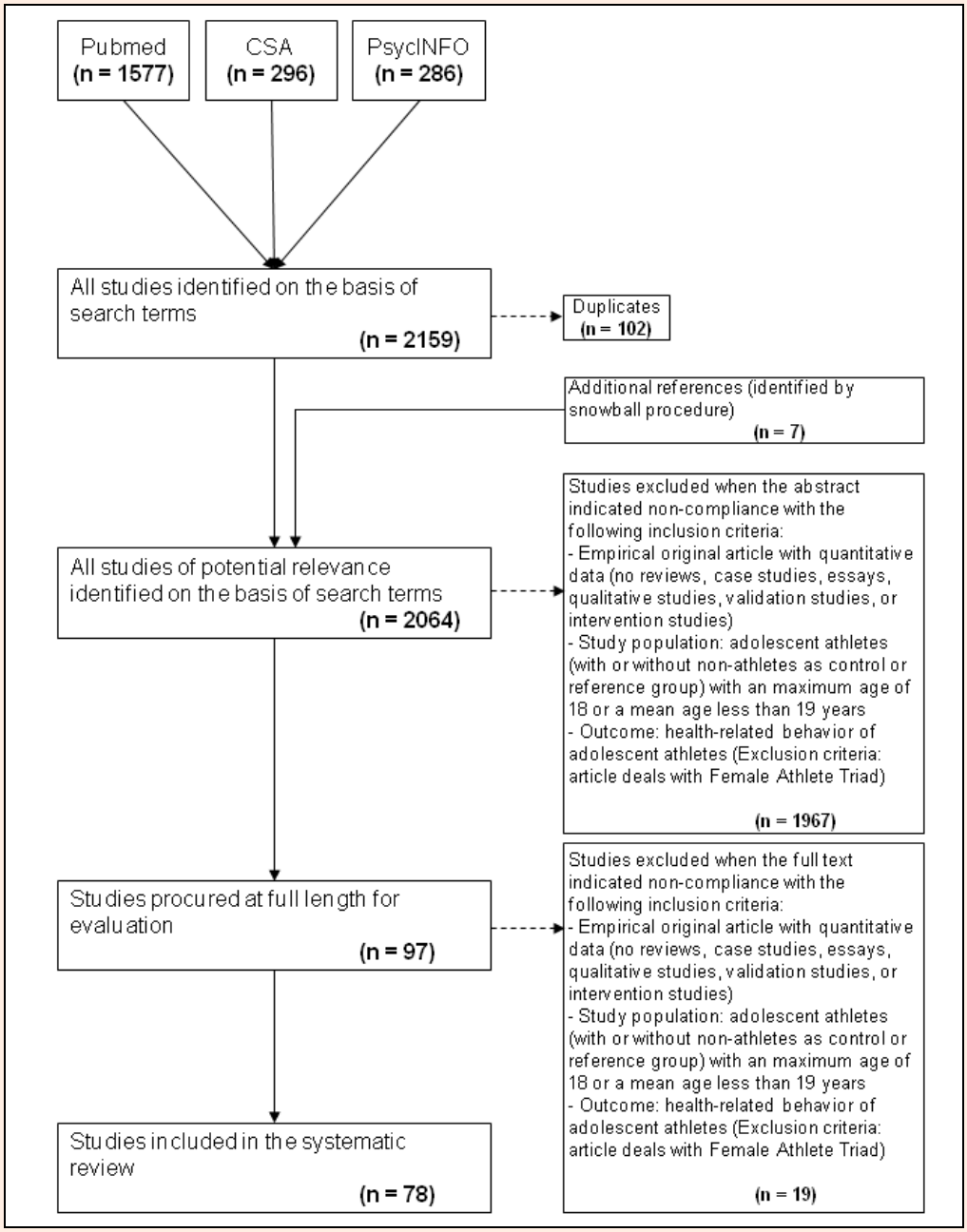

Figure 1. Flow-chart of the systematic literature search.

current report primarily provides descriptive statistics. In instances in which three or more studies used the same definition of a risk behavior, subgroup meta-analyses were performed to summarize prevalences. The I squared statistic is reported for each summary measure of prevalence or association as an indicator of study heterogeneity. Since all analyses showed a high I^2, we used random effects models. Additionally, we calculated pooled Odds Ratios (Mantel-Haenszel) for comparisons between athletes and non-athletes and high-involved and low-involved athletes, respectively.

Results

Of the 78 articles identified in our search, 62 (80%) dealt with a single health behavior (Table 1). An overview of the characteristics of these articles can be found in Table 1; detailed results are provided in the Supporting Information.

Study comparability

Studies differed in many general respects. Sample size, for example, ranged from 18 to 10,807 athletes (Peretti-Watel et al., 2002; Ziegler et al., 2002). In some instances, the total sample size or that of the athletic subsample was not provided. Target groups differed widely across studies with some focusing on high-involved athletes (i.e., those competing in sports on the national and/or international level) with others focusing on low-involved athletes (i.e. performing recreational sports). The label “low-involved

Table 1. **Study characteristics of the included articles.**

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Aerenhouts et al. 2008	Belgium	12-18	Track and field	60 (51.7% male)	Competitive athletes	Questionnaire, 7 day food record	Bivariate analyses
Aleixandre et al. 2005	unspecified	13-19 [15.67]	unspecified	1,378 (43.7% male) [NN; NN% male]	unspecified	unspecified	Linear modeling
Assanelli et al. 1991	North Italy	17-19	unspecified	696 (100% male) [330; 100% male]	Members of sports teams	Questionnaire	Logistic regression analyses
Bachner-Melman et al. 2006[a]	unspecified	18.9	Dancing, gymnastics, acrobatic, artistic (synchronized) swimming	458 (0% male) [111; 0% male]	unspecified	Questionnaire	ANCOVA
Baumert et al. 1998	Georgia, USA	Grades 9-12	unspecified	4,036 (58% male)	Students who have participated in organized sports, outside of gym class	Questionnaire	Multiple linear regression
Beals 2002	USA	14-17 [15.8]	Volleyball	23 (0% male)	Nationally ranked athletes	Questionnaire, anthropometric measurements, 3 day food records, blood analyses	Univariate analyses
Bergen-Cico & Short 1992	New York State, USA	11-16 [13.9]	Cross-country	44 (0% male)	unspecified	Questionnaire, anthropometric measurements, 3 day food records, 24 hour activity record	Univariate analyses
Berning et al. 1991	California, USA	14-18	Swimming	43 (51.2% male)	National athletes	Dietary food records	Bivariate analyses
Castrucci et al. 2004	USA	13-19	unspecified	16,357 (45.7% male) [10,015; NN% male]	Data for participation in organized sports were measured	Questionnaire	Logistic regression analyses
Cavadini et al. 2000	Switzerland	9-19	unspecified	3,540 (49.8% male) [NN; NN% male]	Non-athletic was defined as engaging in sports less than once a week	Questionnaire, in subgroup: 3 day dietary record & interview with dietician	Bivariate analyses
Crissey & Crissey Honea 2006	USA	12-21	Cheerleading/dance team, softball/baseball, basketball, field hockey, football, ice hockey, soccer, swimming, tennis, track and field, volleyball, wrestling, other sports	7,214 (0% male)	Students participating in school	Questionnaire	Logistic regression analyses

[a] only the athlete group AA was considered in this review as the mean age of the athlete group NAA was greater than 18 (mean age: 21.4)

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Croll et al. 2006	Minnesota, USA	11-18 [14.9]	Weight-related sports, power team sports	2,553 (52.9% male) [1,715; 57.5%]	Hours of physical activity were considered	Questionnaire, anthropometric measurements	Bivariate Analyses
Cupisti et al. 2002	Italy	14-18 [16.1]	Gymnastics, tennis, fencing	119 (0% male) [60; 0% male]	Elite national-level athletes	Anthropometric measurements and 3-day food recalls; non-standardized questionnaires	ANOVA
Davis et al. 1997	Lousiana, USA	[15.8]	unspecified	1,200 (100% male) [990; 100% male]	High school athletes	Questionnaire	Logistic regression analyses
Dlin et al. 1991	Israel	14-18	Strength-, endurance-, mixed-, skill- and non-competitive sports	2,447 (100% male) [822; 100% male]	Athletes undergoing routine testing at the Department of Sport Medicine at Wingate Institute	Questionnaire	Bivariate analyses
Donato et al. 1994	Italy	17-19	unspecified	696 (100% male) [330; 100% male]	Adolescents being in sports teams	Questionnaire	Logistic regression analyses
Donato et al. 1997	Italy	Grades 9 - 13	unspecified	1,462 (NN% male) [425; NN% male]	Sporting activity was defined as being engaged in out-of-school programs	Questionnaire	Logistic regression analyses
DuRant et al. 1995	USA	Grades 9 - 12	Strength training	12,267 (48.8% male) [8,245; NN% male]	Strength training was measured	Questionnaire	Logistic regression analyses
Elliot et al. 2007	USA	Grades 9 - 12	unspecified	7,544 (0% male) [3,847; 0% male]	Participating in team sport	Questionnaire	Logistic regression analyses
Escobedo et al. 1993	USA	Grades 9 - 12	unspecified	11,248 (NN% male) [4,568; NN% male]	Subjects participating in junior sports team during last 12 months	Questionnaire	Logistic regression analyses
Ewing 1998	USA	14-21	unspecified	1,458 (53.3% male) [675; 58.7% male]	Subjects participating in high school sports	Questionnaire	Logistic regression analyses
Ferrand et al. 2005	France	[Synchronized swimmers: 15.4; Other athletes: 16.5; Non-athletes: 16.3]	Synchronized swimming, basketball, handball, volleyball, soccer	132 (0% male) [82; 0% male]	Subgroup of national athletes	Questionnaire; anthropometric measurements	Multivariate analyses, regression analyses

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Forman et al. 1995	Chicago and Northwest Indiana, USA	13-19	Cross country, football, soccer, basketball, gymnastics, hockey, swimming, wrestling, baseball, tennis, track	1,117 (100% male)	High school students participating at least in one interscholastic sport	Questionnaire	Bivariate analyses
French et al. 1994	USA	Grades 7 - 10	"Leisure sports" (swimming, skating, golfing, sailing, canoeing, running), "conditioning sports" (running, sit-ups, weight lifting), and "atypical sports" (aerobics, gymnastics, dance, softball)	1494 (47.4% male) [NN; NN% male]	unspecified	Questionnaire	Principal component analyses
Grossbard et al. 2007[b]	West Coast of the USA	[18.4]	unspecified	1,360 (40% male) [335; NN% male]	Intramural athletes among first-year college students	Questionnaire	Linear models
Haase & Prapavessis 2001	New Zealand	[Group 1: 18.21; Group 2: 18.73; Group 3: 18.97]	Group 1: aerobics and diving; Group 2: lightweight rowing; Group 3: soccer	251 (0% male) [198; 0% male]	National or international competitors	Questionnaires	ANOVA
Hoffmann 2006	USA	Grades 10 - 12	Softball, football, basketball, baseball, swimming, other individual and team sports	9,893 (45.4% male) [NN; NN% male]	Subjects participating in sport as an extracurricular activity	Questionnaire	Multilevel regression analyses
Irving et al. 2002	Minnesota, USA	11-18 [14.9]	unspecified	4,746 (50.2% male) [NN; NN% male]	Hours of physical activity were considered	Questionnaire	Logistic regression analyses
Jerry-Szpak & Brown 1994	USA	[15]	Football, field hockey, track and field, gymnastics	75 (44% male)	Subjects spent at least 20 hours a week participating in organized sports	Repeated questionnaires and interviews with coaches	Bivariate analyses
Jonnalagadda et al. 2004[c]	USA	[15.5]	Figure skating	49 (46.9% male) [26; 0% male]	Elite figure skaters	Questionnaires, body measurements	Bivariate analyses
Karvonen et al. 1995	Finland	16 & 18	unspecified	T_1: 3,667; T_2: 3,175; T_3: 2,936 (100% male)	Leisure time physical activity organized by sport clubs	Questionnaire	Bivariate analyses

[b] only study I was considered in this review as the mean age of the participants in study II was greater than 18 (mean age: 21.2)
[c] only female athletes were considered in this review because the male athletes had a mean age of 19.0

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Kiningham & Gorenflo 2001	Michigan, USA	[16]	Wrestling	2,532 (NN% male)	High school competing athletes	Questionnaire	Bivariate analyses
Kokkevi et al. 2008	Bulgaria, Croatia, Cyprus, Greece, Slovak Republic, UK	[16]	unspecified	unspecified	Students doing exercise on almost every day	Questionnaire	Logistic regression analyses
Lindholm et al. 1995	Sweden	Athletes: 13-16 [14.8] Non-athletes: 14-15 [14.8]	Gymnastics	44 (0% male) [22; 0% male)	Elite athletes	Anthropometric measurements, food recording	Bivariate analyses
Lorente et al. 2004	France	[18.3]	Individual and team sports	816 (46.2% male) [621; NN% male]	Formal and informal sporting practice was measured	Questionnaire	Logistic regression analyses
Mays & Thompson 2009	USA	Grades 9 – 12	unspecified	13,956 (NN% male) [NN; NN% male]	Sport participation was measured	Questionnaire	Logistic regression analyses
Mays et al. 2010a	USA	[14.4 (males: 14.5, females: 14.3)]	unspecified	8,721 (43.7% male) [NN; NN% male]	Sport involvement was measured	Questionnaire	Growth models
Mays et al. 2010b	Georgia, USA	"≤14 years - ≥ 17 years" (Mays et al. 2010, p. 236)	Individual and team sports	378 (75.9% male)	Students engaging in school-based sports	Questionnaire	Regression analyses
McHale et al. 2005	Worcester, MA, USA	Seventh-grade students (91% were 12 or 13 years old)	Football, baseball, softball, basketball, soccer, other team sport	423 (51% male) [271; 62% male]	Students taking part in an organized sport during the previous year	Interview & questionnaire	Multivariate Analysis of Variance (MANOVA)
Melia et al. 1996	Canada	11-18	unspecified	16,169 (NN%male) [NN; NN% male]	Involvement in competitive sports was measured	Questionnaire	Bivariate analyses
Melnick et al. 2001	USA	[16.08 for females, 16.22 for males]	unspecified	16,251 (54.8% male) [9,363; 63.8% male]	Students participating in sports teams at school and/or outside of school	Questionnaire	Logistic regression analyses
Miller et al. 2002a[d]	USA	"14 and younger to 18 and older" (Miller et al. 2002b, p. 389)	unspecified	504 (71.4% male)	Students who played on a sports team in the past year	Questionnaire	Regression analyses

[d] only steroid users were analyzed

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Miller et al. 2002b	USA	"14 and younger to 18 and older" (Miller et al. 2002a, p. 476)	unspecified	16,181 (54.6% male) [9,685; 61.5% male]	Students who played on a sports team in the past year	Questionnaire	Logistic regression analyses
Miller et al. 2005	USA	14-18	unspecified	16,183 (NN% male) [NN; NN% male]	Activity in sports team and strength conditioning activity were measured	Questionnaire	Logistic regression analyses
Moore & Werch 2005	Florida, USA	[13.39]	Basketball, rollerblading, skateboarding, surfing, tennis, dance, cheerleading, gymnastics, football, swimming, wrestling	981 (42.6% male) [772; NN% male]	Out-of-school sports and school-sponsored sports were measured	Questionnaire	ANOVA, logistic regression analyses
Moulton et al. 2000	USA	Grades 7 – 12	unspecified	455 (42.0% male) [210; NN% male]	Athletic participation was measured	Questionnaire	ANOVA
Papaioannou et al. 2004	Greece	11, 13 & 16	unspecified	5,991 (49.2% male) [NN; NN% male]	Sport behavior and involvement in organized sports were measured	Questionnaire	Logistic regression analyses
Pate et al. 2000	Columbia, USA	9^{th} through 12^{th} grade students (≤16 to >16)	unspecified	7,821 (59,5% male) [6,400; 37.2% male]	Students participating in sports teams, run by the school and/or outside of school in the past year	Questionnaire	Multiple logistic regression analyses
Peretti-Watel et al. 2002	France	14-19	unspecified	10,807 (47.9% male)	Students with different intensity of sporting activity	Questionnaire	Multinomial logistic regression
Peretti-Watel et al. 2003	South-Eastern France	16-24 [18.3]	Individual, team and sliding sport	458 (65.3% male)	Elite-student-athletes	Questionnaire	Logistic regression analyses
Peretti-Watel et al. 2004a	South-Eastern France	16-24 [18.3]	unspecified	458 (65.3% male)	Elite student-athletes	Questionnaire	Cluster analyses and logistic regression analyses
Peretti-Watel et al. 2004b	South-Eastern France	16-24 [18.3]	unspecified	458 (65.3% male)	Elite-student-athletes	Questionnaire	Cluster Analysis, ANOVA
Peretti-Watel & Lorente 2004	France	18	unspecified	12,512 (29.0% male) [NN; NN% male]	Formal and informal sport practice were measured in hours per week	Questionnaire	Logistic regression analyses

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Pernick et al. 2006	California, USA	13-18 [15.7]	Track and field, cross-country running, tennis, volleyball, basketball, softball, soccer, swimming, lacrosse, field hockey	453 (0% male)	High-school athletes	Questionnaire	ANCOVA
Rainey et al. 1996	South Carolina, USA	Grades 9-12	unspecified	7,846 (48.6% male) [3,960; 60.9% male]	Different levels of activity were measured	Questionnaire	Linear models, logistic regression analyses
Rhea 1999	USA	13-19 [15.5]	Volleyball, basketball, cross-country, track and field, swimming, tennis, softball	1,034 (0% male) [571; 0% male]	High school athletes with at least 3 years of competitive experience	Questionnaire	MANCOVA
Ruiz et al. 2005[e]	Spain	[Team I: 14.0; Team II: 15.0; Team III: 16.6]	Soccer	unspecified (100% male)	Athletes that trained three times per week	Food diaries & questionnaire	ANOVA
Sabo et al. 2002	USA	[Athletes: 16.17; Non-athletes: 16.32]	unspecified	8,057 (100% male) [5,973; 100% male]	Sport participation was measured	Questionnaire	Logistic regression analyses
Scott et al. 1996	Nebraska, USA	Grades 7 – 12	unspecified	4,722 (45.2% male) [3,183; 49.9% male]	Sport participation was measured	Questionnaire	Bivariate analyses
Sherwood et al. 2002	Connecticut, USA	Grades 7, 9 & 11	Weight-related sports	5,174 (0% male) [1.164; 0% male]	Sport participation was measured	Questionnaire	Logistic regression analyses
Slater et al. 2003	Singapore	"<15 to >35" (Slater et al. 2003, p. 323)	30 different sports	160 (53.1% male)	Athletes competing at a national level	Questionnaire	ANOVA
Soric et al. 2008	Croatia	Athletes: 9-13 [11] Non-athletes: 10-12 [11]	Artistics, rhythmic gymnastics, ballet	54 (0% male) [39; 0% male]	Competitive athletes	Questionnaire, anthropometric measurements	ANOVA
Sundgot-Borgen 1996	Norway	13-20	Rhythmic gymnastics	24 (0% male) [12; 0% male]	National athletes	Questionnaire, interview, clinical examination, 4 day food records	Bivariate analyses
Taliaferro et al. 2010	USA	Grades 9 - 12	unspecified	T_1: 15,273 (48.7% male) T_5: 14,028 (49.8% male) [NN; NN% male]	Participation in one or more sports teams during last 12 months	Questionnaire	Logistic regression analyses

[e] only teams I to III were considered in this review as the mean age of team IV was greater than 18 (mean age: 20.9)

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Taub & Blinde 1992	Midwestern, USA	[Athletes: 16.2 Non-athletes: 15.9]	Volleyball, basketball, track/cross-country, tennis, softball	212 (0% male) [100; 0% male]	Participation in one or more sport was measured	Questionnaire	Bivariate analyses
Terney & McLain 1990	Chicago, USA	Grades 9 - 12	Track, swimming, soccer, basketball, tennis, volleyball, gymnastics, softball, field hockey, badminton, baseball, football,wrestling, and others	2,113 (48.7% male) [1,436; 58.0% male]	Sports participation was measured	Questionnaire	Bivariate analyses
Turrisi et al. 2007	North-Western USA	[18.8]	unspecified	835 (36,6% male) [204; 52% male]	Collegiate athletes	Questionnaire	Mediation analyses
Vertalino et al. 2007	Minnesota, USA	[14.9]	Weight-related sports	4,746 (50.2% male)	Participation in weight-related sports was measured	Questionnaire	Multiple logistic regression analyses
Walsh et al. 2000	California, USA	13-19	Baseball	1,226 (100% male)	High school athletes	Questionnaire	Logistic regression analyses
Wetherhill & Fromme 2007	USA	[18.4]	unspecified	2,138 (39.6% male) [NN; NN% male]	Participants spending ten or more hours per week in competitive athletics	Internet-based survey	Linear Modeling
Wichstrom & Pedersen 2001	Norway	14-25 [17.33]	unspecified	8,877 (46.2% male) [NN; NN% male]	Participating in strength or competitive sports	Questionnaire	Logistic regression analyses
Ziegler et al. 1998a	USA	11-16 [13.7]	Figure skating	21 (0% male)	Competitive athletes	Anthropometric measurements, questionnaire, 3 day food records	Bivariate analyses
Ziegler et al. 1998b	USA	[males: 16 females: 14]	Figure skating	34 (44.1% male)	Nationally ranked athletes	4 day food records, questionnaire, blood analyses	Bivariate analyses
Ziegler et al. 1998c	USA	12-23 [females: 15.9, males: 17.8]	Figure skating	39 (48.7% male)	Nationally ranked junior athletes	Questionnaires, recording of food intakes, blood analyses	Bivariate analyses
Ziegler, Nelson et al. 1999	USA	11-18	Figure skating	41 (51.2% male)	Elite athletes	Anthropometric measurements, blood analyses, 4 day food records	Bivariate analyses
Ziegler et al. 2001	USA	12-28 [overall: 17 males: 18 females: 16]	Figure skating	161 (49.7% male)	Elite athletes	Anthropometric measurements, 3 day food records, blood analyses	Multivariate regression analyses

Table 1. Continued.

Author	Study region	Included age groups [mean age]	Type of sports	Net sample size [athletic sample, if this is subgroup]	Kind of athletes	Method of data collection	Statistical method
Ziegler et al. 2002	New England, USA	14-16	Figure skating	18 (0% male)	Competitive athletes	Questionnaire, anthropometric measurements, 3 day food records, blood analyses	Bivariate analyses and range tests
Ziegler et al. 2005	USA	14-23 [17.0]	Synchronized skating	123 (0% males)	Competitive athletes	Questionnaire, anthropometric measurements, 3 day food records	Bivariate analyses

athlete" was applied differently across studies, with definitions ranging from any participation in sports teams during the last 12 months (Escobedo et al., 1993), participation in organized sports outside of gym class (Baumert et al., 1998) or an intensity-based definition using the number of hours of physical activity (Croll et al., 2006). Categories of sports participation were measured for different reasons in some studies. In several population-based studies, for example, sports participation was used and reported as a covariate rather than an outcome variable. Further, studies within the sample used a variety of operational approaches to measuring behavior (e.g. point prevalence, period prevalence, and frequency), applied statistical methods of varying complexity (e.g., univariate and bivariate analyses only, multivariable analyses, structural equation models, or other approaches) and often did not provide crude prevalence.

Alcohol consumption

Twenty-four (31%) studies examined alcohol consumption among young adolescent athletes (Baumert et al., 1998; Donato et al., 1994; Forman et al., 1995; Grossbard et al., 2007; Hoffmann, 2006; Jerry-Szpak and Brown, 1994; Lorente et al., 2004; Mays et al., 2010a; 2010b; Mays and Thompson, 2009; McHale et al., 2005; Miller et al., 2002a; Moore and Werch, 2005; Moulton et al., 2000; Pate et al., 2000; Peretti-Watel et al., 2002; 2003; 2004a; 2004b; Rainey et al., 1996; Sabo et al., 2002; Taliaferro et al., 2010; Turrisi et al., 2007; Wetherill and Fromme, 2007). Different measures of alcohol consumption were used (e.g. lifetime prevalence (Forman et al., 1995), alcohol consumption per occasion (Baumert et al., 1998), and report of "heavy" drinking (Peretti-Watel et al., 2004a)). However, all studies suggested that alcohol consumption was widespread among athletes. This applied for low-involved athletes but also for high-involved athletes.

Fifteen studies addressing this topic compared behaviors among either recreational athletes versus non-athletes or high-involved athletes versus low-involved athletes (Figure 2) and suggested a higher risk of drinking alcohol among athletes compared with non-athletes and high-involved athletes vs. low-involved athletes, respectively

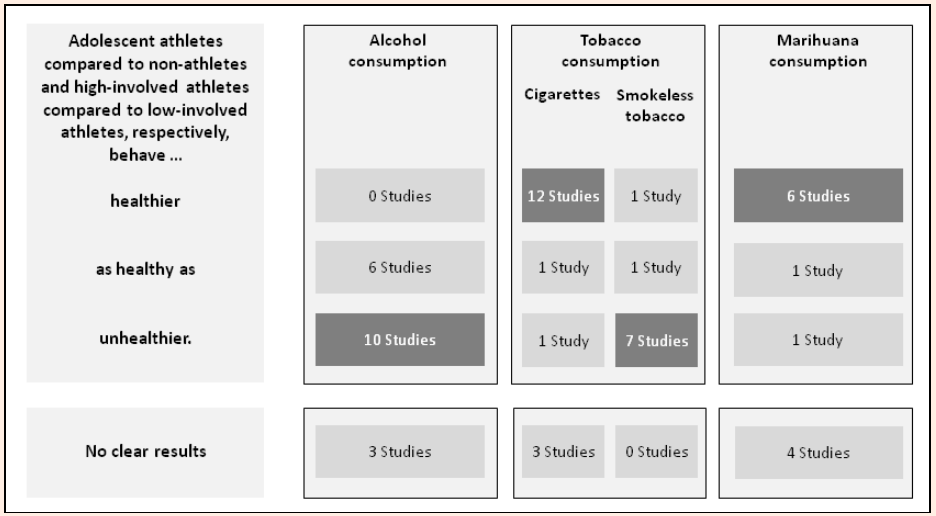

Figure 2. Comparisons between adolescent athletes and adolescent non-athletes concerning use of alcohol, tobacco, and marihuana. The figure combines results of studies that compared athletes with non-athletes and of studies that compared low-involved athletes (=recreational athletes) with high- involved athletes.

(Grossbard et al., 2007; Hoffmann, 2006; Mays et al., 2010a; Mays et al., 2010b; Miller et al., 2002a; Peretti-Watel et al., 2002; Rainey et al., 1996; Taliaferro et al., 2010; Turrisi et al., 2007; Wetherill and Fromme, 2007), including one demonstrating a dose-response between alcohol consumption and the number of hours of physical activity (Peretti-Watel et al., 2002). Six studies were unable to demonstrate similar findings (Aleixandre et al., 2005; Baumert et al., 1998; McHale et al., 2005; Moulton et al., 2000;

Pate et al., 2000; Sabo et al., 2002) and one study reported a lower risk for alcohol consumption among athletes (Donato et al., 1994). Meta-analysis revealed a pooled OR of 1.13 [1.10-1.16] indicating that athletes were significantly more likely to have a higher proportion of alcohol consumers considering different measurements (Baumert et al., 1998; Donato et al., 1994; Lorente et al., 2004; Pate et al., 2000; Peretti-Watel et al., 2002; Rainey et al., 1996; Sabo et al., 2002).

In three studies on binge drinking among adolescent athletes (Pate et al., 2000; Rainey et al., 1996; Sabo et al., 2002), prevalences ranged from 28% to 38% with a combined prevalence of 34% (I^2 = 98.0%) (Figure 3). Four studies focused on alcohol consumption over the preceding 30-day period in low- and high-involved athletes reported prevalences between 49% and 69% (Pate et al., 2000; Peretti-Watel et al., 2003; Rainey et al., 1996; Sabo et al.; 2002). The combined prevalence of binge drinking during the last 30 days was 55% (I^2 = 96.1%). A third group of studies investigated lifetime prevalence of any alcohol consumption (Forman et al., 1995; Jerry-Szpak and Brown, 1994; Sabo et al,. 2002), with a fourth focused on lifetime prevalence of beer consumption only (Forman et al., 1995). After combining results from these studies, the lifetime prevalence of alcohol consumption of athletes was 78% (I^2 = 97.5%).

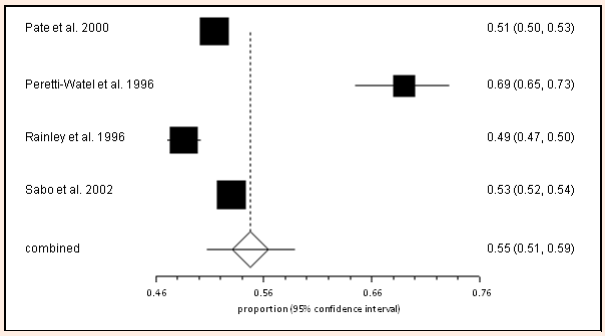

Figure 3. Results of meta-analysis on prevalence of binge drinking among recreational athletes (random effects). Size of the boxes differs due to sample size of the individual studies; lines represent the 95% confidence interval for the estimate of the individual studies.

A series of several additional specific findings on alcohol consumption among young adolescent athletes were reported in individual studies. Using the Adolescent Alcohol Involvement Scale (Jerry-Szpak and Brown, 1994), one study identified 9% of young adolescent athletes as alcohol misusers and 1% as having drinking patterns consistent with alcoholism. In this study, nineteen percent reported alcohol misuse to the extent that drinking interfered with psychosocial functioning or social relationships (Jerry-Szpak and Brown, 1994). Another single study showed that sport-involved youth were more likely to having consumed alcohol in the last 15 days compared to non-athletes; however, those who trained six to ten times a week or those who competed at the national or international level had a lower likelihood of reporting daily alcohol consumption compared to others (Lorente et al., 2004). Other studies examining alcohol consumption used a prevalent system of classifying sports activities (Sundgot-Borgen, 1994). In summary, these studies found that adolescents participating in ball games (Jerry-Szpak and Brown, 1994; Moore and Werch, 2005; Peretti-Watel et al., 2003), technical sports (e.g. alpine skiing, long jump) (Jerry-Szpak and Brown, 1994; Moore and Werch, 2005), and aesthetic sports (e.g. rhythmic gymnastics) (Jerry-Szpak and Brown, 1994) appeared more likely to consume alcohol compared to athletes in endurance, power and weight-dependent sports (e.g. swimming, javelin and weight lifting, respectively).

Tobacco consumption

Twenty-four (31%) articles from several industrialized countries assessed smoking behavior (Aleixandre et al., 2005; Assanelli et al., 1991; Baumert et al., 1998; Castrucci et al., 2004; Davis et al., 1997; Dlin et al., 1991; Donato et al., 1994; 1997; Escobedo et al., 1993; Forman et al., 1995; Karvonen et al., 1995; Melnick et al., 2001; Miller et al., 2002a; Moore and Werch, 2005; Papaioannou et al., 2004; Pate et al., 2000; Peretti-Watel et al., 2002; 2003; 2004a; 2004b; Rainey et al., 1996; Sabo et al., 2002; Taliaferro et al., 2010; Walsh et al., 2000). Use of different operational indicators (e.g. daily smoking (Peretti-Watel et al., 2004b); current smoking (Assanelli et al., 1991); and regular smoking (Melnick et al., 2001)) and various grouping strategies (single sports vs. categorization in groups of sports) were commonly found.

Most studies compared smoking behavior in recreational athletes with non-athletes or smoking behavior in high-involved athletes with low-involved athletes (Figure 2). The prevalence of a wide range of different measures of smoking was higher in non-athletes than in athletes (Aleixandre et al., 2005; Assanelli et al., 1991; Baumert et al., 1998; Castrucci et al., 2004; Donato et al., 1994; Escobedo et al., 1993; Melnick et al., 2001; Papaioannou et al., 2004; Pate et al., 2000; Rainey et al., 1996; Sabo et al., 2002; Taliaferro et al., 2010) with two exceptions. A single study showed a higher prevalence of smoking among young adolescent athletes in three specific kinds of sport (i.e. skateboarding, wrestling, tennis) (Moore and Werch, 2005). A second study limited to young adolescents who used steroid showed no differences between athletes and non-athletes (Miller et al., 2002a). Overall, meta-analysis including different measurements of smoking showed that athletes were less likely to smoke (OR = 0.69 [0.67-0.71]; Assanelli et al., 1991; Baumert et al., 1998; Castrucci et al., 2004; Davis et al., 1997; Donato et al., 1994; Escobedo et al., 1993; Pate et al., 2000; Rainey et al., 1996; Sabo et al., 2002; Peretti-Watel et al., 2002).

Estimates of prevalence for lifetime smoking, daily smoking, and current smoking (last 30 days) varied widely in meta analyses. Overall, lifetime prevalence of smoking varied between 4% and 66% (combined prevalence: 31%; I^2 = 100%). Lifetime prevalence in low-involved athletes ranged from 10% to 66% (I^2 = 99.9%) with a

combined prevalence of 41% (Baumert et al., 1998; Castrucci et al., 2004; Donato et al., 1994; Forman et al., 1995). Lifetime smoking in high-involved athletes was 4% (Dlin et al., 1991). Daily smoking in athletes varied between 10% and 26% (I^2 = 96.6%) with a combined prevalence of 17% (Assanelli et al., 1991; Peretti-Watel et al., 2002; Peretti-Watel et al., 2004a; 2004b). Having smoked during the last 30 days was analyzed in five studies. Overall, prevalence ranged between 3% and 35% with a combined prevalence of 23% (I^2 = 99.8%). Here, conflicting data exists on smoking prevalence in high-involved athletes. While Dlin et al. (1991) reported 3% of male high-involved athletes being current smokers, estimates from another study were much higher (24.5% and 22.1% for women and men, respectively; Peretti-Watel et al., 2004b). Among low-involved athletes, the prevalence ranged from 28% to 35% with a combined prevalence of 32% (I^2 = 98.3%) (Castrucci et al., 2004; Pate et al., 2000; Sabo et al., 2002; Figure 4).

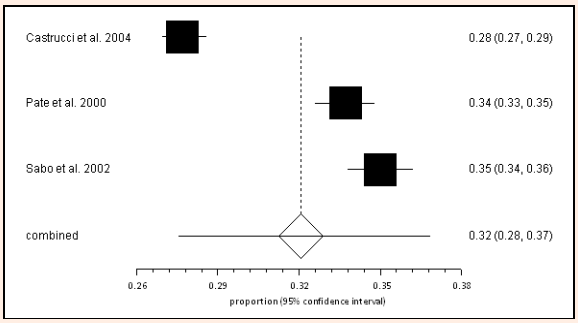

Figure 4. Results of meta-analysis on prevalence of current smoking among recreational athletes (random effects). Size of the boxes differs due to sample size of the individual studies; lines represent the 95% confidence interval for the estimate of the individual studies.

A study comparing the prevalence of smoking by the intensity of sports activities, those engaged in high- (e.g. soccer, tennis) and medium-intensity activities (e.g. football or baseball) had a lower prevalence of heavy smoking (Davis et al., 1997). Smoking prevalence in young adolescents engaged in lower intensity sports (e.g. golf, hunting) was much higher, however, at a level resembling that of non-athletes (Davis et al., 1997). In a separate sample of adolescent female athletes, Peretti-Watel et al. (2003) also found that females competing at the international level were more likely to report smoking compared with high-involved athletes competing at national level only.

Single studies provided information on a limited range of additional associated factors. In one study comparing regular sports participants in the 9-11th vs. 12-13th grades reported a higher prevalence of smoking in the younger age group (Donato et al., 1997). Another set of studies examined associations with the type of sporting activity (Dlin et al., 1991; Donato et al., 1997; Moore and Werch, 2005), although no clear associations could be identified. In a third study analyzing individual characteristics, education in a boarding school, duration of training sessions (for males) and competing on the international level (for females) was positively correlated with current smoking status (Peretti-Watel et al., 2003).

Ten studies focused on other types of tobacco products (Baumert et al., 1998; Castrucci et al., 2004; Davis et al., 1997; Forman et al., 1995; Karvonen et al., 1995; Melnick et al., 2001; Pate et al., 2000; Rainey et al., 1996; Sabo et al., 2002; Walsh et al., 2000). Five cross-sectional survey studies assessing use of snuff or chewing tobacco found a higher prevalence among athletes compared to non-athletes (Castrucci et al., 2004; Davis et al., 1997; Melnick et al., 2001; Rainey et al., 1996; Sabo et al., 2002; Taliaferro et al., 2010). A similar finding was demonstrated in a longitudinal study (Karvonen et al., 1995). Meta-analysis showed that athletes had a higher chance of using smokeless tobacco than non-athletes (pooled OR=1.61 [1.53-1.68]; Baumert et al., 1998; Castrucci et al., 2004; Davis et al., 1997; Pate et al., 2000; Rainey et al., 1996; Sabo et al., 2002).

Overall, lifetime prevalence of any use of smokeless tobacco ranged from 6% (Baumert et al., 1998) to 46% (Walsh et al., 2000). The lifetime prevalence of snuff was around 20% (Castrucci et al., 2004; Davis et al., 1997). For chewing tobacco the lifetime prevalence was between 21% and 32% (Castrucci et al., 2004; Davis et al., 1997; Forman et al., 1995) with a combined prevalence of 26% (I^2 = 97%). Having used any smokeless tobacco product during the last 30 days was indicated by 12% to 15% (Pate et al., 2000; Rainey et al., 1996; Walsh et al., 2000). The combined prevalence was 13% (I^2 = 84.3%, Figure 5). When asked for use of chewing tobacco during the last 30 days, prevalence ranged between 7% and 17% (Castrucci et al., 2004; Sabo et al., 2002; Walsh et al., 2000). The combined proportion was 10% (I^2 = 99.5%). For snuff use the 30-day-prevalence was between 8% and 13% (Castrucci et al., 2004; Walsh et al., 2000).

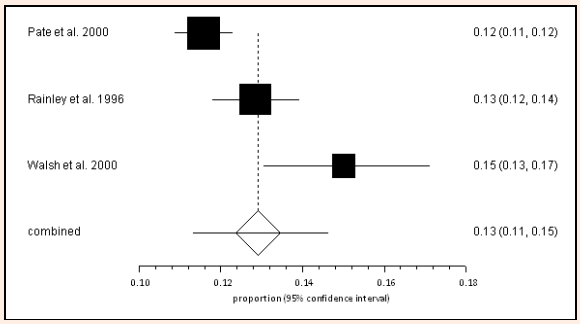

Figure 5. Results of meta-analysis on use of smokeless tobacco (last 30 days) among recreational athletes (random effects). Size of the boxes differs due to sample size of the individual studies; lines represent the 95% confidence interval for the estimate of the individual studies.

Illicit drug use

Seventeen (24%) of the articles in our sample examined illicit drug use (Aleixandre et al., 2005; Baumert et al., 1998; Ewing, 1998; Forman et al., 1995; McHale et al., 2005; Miller et al., 2002a; Moore and Werch, 2005; Papaioannou et al., 2004; Pate et al., 2000; Peretti-Watel et al., 2002; 2003; 2004a; 2004b; Peretti-Watel and Lorente, 2004; Sabo et al., 2002; Sherwood et al., 2002;

Taliaferro et al., 2010). The majority of studies comparing athletes with non-athletes (Figure 2) reported a lower prevalence for marijuana consumption among athletes (Baumert et al., 1998; McHale et al., 2005; Miller et al., 2002a; Pate et al., 2000; Sabo et al., 2002; Taliaferro et al., 2010). However, a single study reported more frequent and earlier marijuana consumption for male athletes compared to male non-athletes (Ewing, 1998), while another study could not detect differences (Aleixandre et al., 2005). In comparing athletes with non-athletes, one study demonstrated a U-shaped curve for marijuana use among males, but not females (Peretti-Watel et al., 2002), a finding that persisted after controlling for the number of hours of physical activity. To combine data on comparison between athletes and non-athletes, meta-analysis was calculated and showed athletes being significantly less likely to use marihuana (pooled OR = 0.79 [0.76-0.82]; Baumert et al., 1998; Pate et al., 2000; Peretti-Watel et al., 2002; Sabo et al., 2002).

The lifetime prevalence of marijuana use among athletes ranged from 1.5% to 49% (Baumert et al., 1998; Forman et al., 1995; McHale et al., 2005; Sabo et al., 2002) with a combined prevalence of 21% (I^2 = 99.7%). The 1-year-prevalence was between 8% (Sherwood et al., 2002) for females and 25% for both genders (Peretti-Watel et al. 2004b). In a series of studies on elite athletes in France, Peretti-Watel et al. (2004a; 2004b) observed that marijuana use appeared to be more common in female elite athletes attending boarding schools or among those who competed at the international level (Peretti-Watel et al., 2003). Young adolescents participating in skateboarding, football and swimming were reported to have a higher prevalence of marijuana use (Moore and Werch, 2005), whereas females in aesthetic sports (e.g. rhythmic gymnastics) were particularly more likely to report marijuana use if they also reported an eating disorder (Sherwood et al., 2002).

Patterns around the use of other drugs including cocaine are less clear as the prevalences in three studies addressing this topic (Baumert et al., 1998; Forman et al., 1995; Sabo et al., 2002) differed by a factor of more than three (2.4% (Forman et al., 1995) vs. 8% (Sabo et al., 2002)). While one study found no differences between athletes and non-athletes in use of cocaine (Baumert et al., 1998), another one showed a higher prevalence for non-athletes (8% vs. 13%) (Sabo et al., 2002).

Eating behaviors

Thirty-four studies (44%) assessed the topics of nutritional status, dieting behavior or body-esteem, either individually or in combination (Aerenhouts et al., 2008; Bachner-Melman et al., 2006; Baumert et al., 1998; Beals, 2002; Bergen-Cico and Short, 1992; Berning et al., 1991; Cavadini et al., 2000; Crissey and Crissey Honea, 2006; Croll et al., 2006; Cupisti et al., 2002; Ferrand et al., 2005; French et al., 1994; Haase and Prapavessis, 2001; Jonnalagadda et al., 2004; Kiningham and Gorenflo, 2001; Lindholm et al., 1995; Papaioannou et al., 2004; Pate et al., 2000; Pernick et al., 2006; Rhea, 1999; Ruiz et al., 2005; Sherwood et al., 2002; Soric et al., 2008; Sundgot-Borgen, 1996; Taliaferro et al., 2010; Taub and Blinde, 1992; Vertalino et al., 2007; Ziegler et al., 1998a; 1998b; 1998c; 1999; 2001; 2002; 2005). In large part, study samples were comprised of high-involved athletes and analyses were based on biochemical tests and/or food records in small samples (N = 16) or focused on anthropometric measurements (N = 14). The sample in 17 studies was restricted to females only.

Many studies reported that the eating behavior of athletes was healthier in some respects than those of non-athletes or less athletic young adolescents (Baumert et al., 1998; French et al., 1994; Papaioannou et al., 2004; Pate et al., 2000; Taliaferro et al., 2010). Several large studies demonstrated, for example, that self-reported fruit and vegetable consumption was higher among athletes (Papaioannou et al., 2004; Pate et al., 2000; Taliaferro et al., 2010). In contrast, studies employing biochemical tests suggested that both high-involved athletes and low-involved athletes had macro- and micronutrient intakes below recommended levels for essential minerals, carbohydrates, and overall caloric intake (Beals, 2002; Bergen-Cico and Short, 1992; Cupisti et al., 2002; Lindholm et al., 1995; Ruiz et al., 2005; Ziegler et al., 1999).

Although eating disorders were identified among young adolescent athletes participating in many kinds of sports (Pernick et al., 2006; Taub and Blinde, 1992), those engaged in aesthetic sports such as rhythmic gymnastics were identified as being at relatively high risk for eating disorders (Bachner-Melman et al., 2006; Haase and Prapavessis, 2001; Sundgot-Borgen, 1996), with 11.7% receiving a lifetime diagnosis of eating disorder not otherwise specified, 4.5% identified as having anorexia nervosa and 1.8% as having bulimia nervosa (Bachner-Melman et al., 2006). Concerns over weight control were also noted in participants of weight-dependent sports such as wrestling, with 58% of athletes reporting having induced emesis at least weekly to lose weight. (Kiningham and Gorenflo, 2001). Studies in the sample reported use of different methods for weight loss in addition to dieting (Ziegler et al., 1998c), including use of diuretics or laxatives (Kiningham and Gorenflo, 2001; Vertalino et al., 2007). These studies noted that such behaviors were common in both male and female athletes (Kiningham and Gorenflo, 2001; Vertalino et al., 2007).

Performance enhancing drug use

Performance enhancing drug use was discussed in 16 (21%) articles (Baumert et al., 1998; DuRant et al., 1995; Elliot et al., 2007; Forman et al., 1995; Irving et al., 2002; Kokkevi et al., 2008; Melia et al., 1996; Miller et al., 2002b; 2005; Pate et al., 2000; Peretti-Watel et al., 2004a; Scott et al., 1996; Slater et al., 2003; Terney and McLain, 1990; Vertalino et al., 2007; Wichstrom and Pedersen, 2001). The prevalence of ever having used anabolic steroids ranged between 2% and 6% (Baumert et al., 1998; DuRant et al., 1995; Forman et al., 1995; Pate et al., 2000; Terney and McLain, 1990), with a combined prevalence of 4% (I^2 = 93.2%, Figure 6). Furthermore, prevalence increased by the level of competition (Melia et al., 1996; Wichstrom and Pedersen, 2001). For instance, Wichstrom & Pedersen (2001) reported increasing prevalence of anabolic steroid use from community level (0.5%), over

county level (0.9%) and national level (1.3%) to international level (2.5%) of competition. Current use of steroids ranged between 2% and 3% (Baumert et al., 1998; Scott et al., 1996). Amphetamines use was reported as 4% in a single study (Forman et al., 1995).

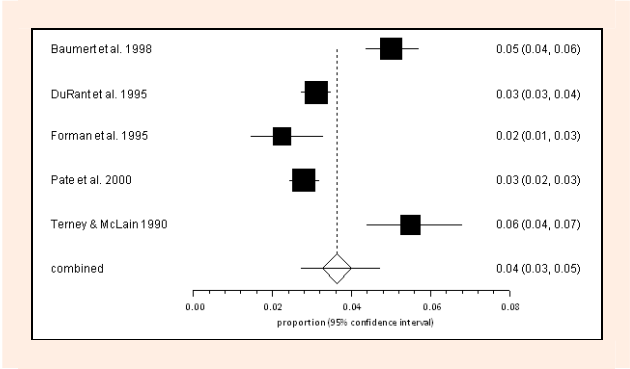

Figure 6. Results of meta-analysis on use of anabolic steroids among recreational athletes (random effects). Size of the boxes differs due to sample size of the individual studies; lines represent the 95% confidence interval for the estimate of the individual studies

Young adolescents engaged in strength training (DuRant et al., 1995; Miller et al., 2002b), football (Terney and McLain, 1990), and weight-dependent sports (Irving et al., 2002; Terney and McLain, 1990; Vertalino et al., 2007) were more likely to use anabolic steroids than athletes engaged in other kinds of sport. For example, athletes in weight-related sports showed 1-year-prevalences of 7% for females and 12% for males (Vertalino et al., 2007). A single study of young adolescent females suggested that participation in team sports was associated with a lower prevalence of anabolic steroid use than in females who did not (Elliot et al., 2007).

In general, the evidence in support of an association between anabolic steroid use and sports participation was mixed with five studies reporting a positive association (DuRant et al., 1995; Kokkevi et al., 2008; Melia et al., 1996; Scott et al., 1996; Vertalino et al., 2007) and four demonstrating no difference (Baumert et al., 1998; Irving et al., 2002; Miller et al., 2005; Pate et al., 2000). The pooled OR was 1.50 [1.34-1.69] indicating a higher risk of steroid use among athletes (Baumert et al., 1998; DuRant et al., 1995; Pate et al., 2000; Scott et al., 1996; Vertalino et al., 2007).

Discussion

This review is, to our knowledge, the first systematic assessment focusing on a wide range of different risk behaviors among adolescent athletes ≤18 years from different countries. Previous reviews focused on selected risk behaviors (Lisha and Sussman, 2010; Mays et al., 2011) and/or were restricted to the US (Mays et al., 2011). On the basis of included studies that compared athletes with non-athletes we could identify athletes being more likely to report drinking alcohol (OR = 1.13), to use anabolic steroids (OR = 1.50) and – as suggested by Lisha and Sussman (2010) – to use smokeless tobacco (OR = 1.61) than non-athletes. In addition, they were less likely to smoke cigarettes (OR=0.69) and to use marihuana (OR = 0.79). However, our analysis points to the need for caution in drawing conclusions given the presence of heterogeneity across studies in the operational indicators and target groups used. This suggests the need for greater consensus around key definitions and study methods in this field of research. Related to this, it would appear that plans to develop targeted interventions to promote healthy behaviors in adolescent athletes based on current evidence are premature.

A consideration of differences in methodology across studies may be useful in informing the direction of future research. One of the first challenges encountered in the current and previous studies was a difference in the way behaviors were measured (Mays et al., 2011). For example, studies examining alcohol and tobacco product consumption used a variety of approaches ranging from point prevalence or period prevalence to simple frequencies. Differences in the lengths of time used to capture behaviors across studies for both period prevalence and simple frequencies have the potential to complicate cross-study comparisons. There may be instances, however, in which consensus around a measurement approach could be established. Use of period prevalence, for example, may be particularly valuable in measuring episodic behavior, while point prevalence could be applied in measurements of chronic behavior prevalence. Similarly, routine use of standardized measures of behavior such as those that already exist for tobacco control (ITC (Fong et al., 2006)) or for school surveying (HBSC (Ravens-Sieberer, 2009)) might be useful. Based on a common conceptual framework on operational indicators and definitions, methods could be developed and translated for use in different countries (Fong et al., 2006; Ravens-Sieberer, 2009). Although reports in our sample provided a useful range of descriptive information, use of a common set of indicators would facilitate assessments of generalizability of specific findings across study settings (Mays et al., 2011). Moreover, such an approach would make it easier to take fuller advantage of the power of techniques such as meta-analysis.

Second, we observed that the majority of articles in this review dealt with a single health behavior. Future studies assessing multiple health behaviors may enable detection of patterns of behavior that co-occur or that interact to influence health to a greater extent than when present in isolation (Takakura et al., 2001). Demonstration of intercorrelations between different risk behaviors in previous work (Jessor, 1987) supports this suggestion. Therefore, more integrated analyses combining two or more health behaviors among athletes may be valuable and may improve the overall efficiency of research efforts in this area.

Third, the *nature* of sports activities (e.g., recreational, professional) differed considerably across studies and, in some cases, was not described. This observation is consistent with those found in a previous review analyzing studies conducted in the U.S. (Mays et al., 2011). In the absence of text that specifies the nature of sports activities, we were unable to clearly identify similar target groups across studies, thus limiting conclusions that could be drawn. Also, *intensity* of sport activity is important as

this may influence the adoption of health related risk behaviors. Adolescents competing at the national or international level may hold differing attitudes and therefore show other behaviors concerning use of tobacco, alcohol or weight control practices compared to low-involved athletes (Peretti-Watel et al., 2003). Studies are needed that clearly define the nature of sports activities to make clearer inferences possible for specific subgroups of adolescents (Bovard, 2008).

Fourth, many of the studies in our review failed to account for characteristics that may either confound the association between sports participation and risky behaviors or act as effect modifiers. In many instances, for example, sex was the only covariate used in the analysis. Aspects like age or education were often not considered, even though previous work suggests that both may influence health behavior (Peretti-Watel et al., 2003). The consequences of this approach are that associations of interest may be obscured or incorrect inferences may be drawn. Future research in this area should acknowledge and build upon evidence identified to date on factors with potential influence on sports participation and the adoption of health behaviors including the number of hours of sport activity per week (Peretti-Watel et al., 2003), the number of training sessions per week (Lorente et al., 2004), duration of training sessions (Peretti-Watel et al., 2003), level of competition (Lorente et al., 2004; Mays et al., 2010b; Peretti-Watel et al., 2003), and characteristics of the educational setting (Peretti-Watel et al., 2003).

Fifth, geographic representation in studies of health behaviors of adolescent athletes appears limited. The studies in our review, for example, were conducted in 19 industrialized countries, with more than 65% of the sample of studies from the U.S. This restricted investigative scope necessarily reflects the cultural and legislative norms found in specific parts of the globe and places further limits on the extent to which knowledge in these areas can be generalized to other settings. Previous work suggests, for example, that health risk behaviors can be influenced by cultural contexts in multiple ways (Howe, 2004; Loland et al., 2006; Young, 2004). Differences between national health care systems and policies, for example, might influence cultural norms and values related to healthy lifestyles, which, in turn, influence athletes' behavior in different societies (Coakley, 2003). The way in which sport is organized and integrated in social life also varies from one society to another (Coakley, 2003). Different formal and informal organizational structures and cultures of national sports federations, sports clubs, training centers, and universities must therefore be considered as potential factors influencing adolescent athletes' health risk behaviors (Howe, 2004; Loland et al., 2006; Young, 2004). As the nature of these contextual elements has not yet been fully defined, it might be useful for future reports to include descriptions of the sociocultural context in which the investigation takes place and its potential bearing on the results observed.

Sixth, responses to nearly all self-report items concerning risk behaviors may be affected to some degree by social desirability bias. The extent to which the actual prevalence or frequency of a specific behavior has previously been correctly estimated is unclear as a result. Use of multiple alternative approaches for acquiring data may be helpful, therefore, in future research on the health behaviors of young adolescent athletes and their peers. For example, use of the Randomized Response Technique (RRT) described by Striegel et al. in adult athletes (Striegel et al., 2010) may result in more candid and accurate responses to sensitive subjects (e.g. use of doping and illicit drugs) through the perception of greater anonymity. Moreover, multiple modes of assessment open the possibility for a process of triangulating on key insights: confidence that specific exposures or outcomes are present increases when confirmed through the application of appropriate combinations of measurements (Blaikie, 1991).

In interpreting results from this systematic literature review, it is important to consider several limitations. First, we cannot exclude the possibility of retrieval or publication bias: we chose not to include "grey literature" in our review as a way of ensuring that all studies had been subjected to peer review and that our results could be replicated. Although non-peer reviewed publications have the potential to provide valuable insights in this area, the quality of methods applied to data collection, analysis and interpretation may vary substantially, adding further to the heterogeneity we observed. As we focused only on articles written in English we can also not preclude language bias. Indeed, this may have accounted for the limited geographic representativeness of the studies in our sample. In consequence, our review provides a necessarily incomplete perspective on the association of sports participation and risky behaviors in young adolescents across different sociocultural contexts. Further, we assume that sample selection bias existed within the studies included in our review due to low or modest response rates. Reduced heterogeneity in other areas of study design and methodology will enable the application of meta-analytic techniques that account for this, to some extent, in future work. Related to this point, the development of a set of consensus guidelines to guide future studies may prove particularly useful in addressing the numerous knowledge gaps that persist in this field of study. Similar to the EQUATOR Network that aims to improve reporting in health research (Simera et al., 2010), a guideline for analyzing health-related risk behavior among athletes could be developed. Besides general goals like the reporting of methods and results in publications, check lists may be helpful in ensuring comprehensive reporting of relevant study characteristics.

Conclusion

Our study identified and reviewed several studies addressing the health behaviors of adolescent athletes. On the one hand, we found athletes being more likely to consume alcohol, smokeless tobacco and steroids than non-athletes. On the other hand, we identified athletes being less likely to smoke and to use marihuana. However, careful review of these reports suggests that significant heterogeneity in study design and methods exists, leaving large knowledge gaps unaddressed. We conclude that some degree of con-

sensus on approaching research questions in this area is needed to advance knowledge. Consistent use of a common set of operational indicators, examination of multiple health behaviors, clear definitions for the types of athletes under study, and more rigorous attention to the use of other characteristics that influence behaviors in young athletes are examples of issues to be considered in future work.

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Key points

- This is the first systematic review focusing on different health related risk behaviors of adolescent athletes aged ≤18 years from different countries.
- Health related risk behaviors such as alcohol consumption are common among recreational and elite adolescent athletes.
- Athletes were more likely to consume alcohol, smokeless tobacco, and steroids and less likely to smoke and to use marihuana than non-athletes.
- Studies show high heterogeneity in the operational indicators, statistical methods, and target groups. Therefore, greater consensus around key definitions and study methods is needed to advance knowledge.

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