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REVIEW ARTICLE

Incidence, aetiology and prevention of musculoskeletal injuries in volleyball: A systematic review of the literature

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Abstract

Currently, there is no overview of the incidence and (volleyball-specific) risk factors of musculoskeletal injuries among volleyball players, nor any insight into the effect of preventive measures on the incidence of injuries in volleyball. This study aimed to review systematically the scientific evidence on the incidence, prevalence, aetiology and preventive measures of volleyball injuries. To this end, a highly sensitive search strategy was built based on two groups of keywords (and their synonyms). Two electronic databases were searched, namely Medline (biomedical literature) via Pubmed, and SPORTDiscus (sports and sports medicine literature) via EBSCOhost. The results showed that ankle, knee and shoulder injuries are the most common injuries sustained while playing volleyball. Results are presented separately for acute and overuse injuries, as well as for contact and non-contact injuries. Measures to prevent musculoskeletal injuries, anterior knee injuries and ankle injuries were identified in the scientific literature. These preventive measures were found to have a significant effect on decreasing the occurrence of volleyball injuries (for instance on ankle injuries with a reduction from 0.9 to 0.5 injuries per 1000 player hours). Our systematic review showed that musculoskeletal injuries are common among volleyball players, while effective preventive measures remain scarce. Further epidemiological studies should focus on other specific injuries besides knee and ankle injuries, and should also report their prevalence and not only the incidence. Additionally, high-quality studies on the aetiology and prevention of shoulder injuries are lacking and should be a focus of future studies.

Keywords: Injury and prevention, musculoskeletal, medicine

Highlights

- Ankle, knee and shoulder injuries are the most common injuries sustained while playing in volleyball.
- Measures to prevent musculoskeletal injuries were found to have a significant effect on decreasing the occurrence of volleyball injuries, especially ankle injuries.
- Further epidemiological studies should focus on the etiology and prevention of shoulder injuries.

Introduction

Volleyball is one of the most popular sports in the world and is played by 200 million people worldwide (Verhagen, Van der Beek, Bouter, Bahr, & Van Mechelen, 2004). Volleyball-specific tasks such as jumping, landing, blocking and spiking the ball need to be combined with fast movements, which demands a lot from the musculoskeletal system (Bere, Kruczynski, Veintimilla, Hamu, & Bahr, 2015). As a consequence, volleyball players are at risk for musculoskeletal injuries (Bere et al., 2015).

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Volleyball is also very popular in the Netherlands with a total of half a million players. The incidence of volleyball injuries in the Netherlands is estimated to be 170,000 per year (Volleybalblessures, 2014). Of these 170,000 injuries 4700 volleyball players with injury are treated in the Emergency room (E.R.) per year (Volleybalblessures, 2014). This equates to 12 E.R. treatments per 100,000 played hours (Volleybalblessures, 2014). This is more than the mean for average sports, which is 7.9 treatments per 100,000 played hours (Volleybalblessures, 2014). These specific injuries result in high costs for society, with direct medical costs at the E.R. or through hospitalisation for volleyball injuries amounting to 4.6 million euros a year, and indirect costs, due to absenteeism, of 11 million euros a year (Volleybalblessures, 2014). Effective preventive measures are needed not only to reduce the incidence of volleyball injuries but also the costs caused by these injuries. According to the four steps of van Mechelen's 'sequence of prevention' model, it is essential to know what the incidence and aetiology (=risk factors and mechanisms) of musculoskeletal injuries among volleyball players are, so that appropriate preventive measures can be developed and implemented (van Mechelen, Hlobil, & Kemper, 1992).

Currently, there is no systematic overview of the incidence and (volleyball-specific) risk factors of musculoskeletal injuries among volleyball players, nor any insight into the effect of preventive measures on the incidence of injuries in volleyball. Consequently, three research questions were formulated: (a) What are the most common volleyball-specific musculoskeletal injuries occurring among volleyball players? (b) What are the volleyball-specific risk factors and mechanisms of these most common musculoskeletal injuries among volleyball players? and (c) Which volleyball-specific programmes are effective for the prevention of musculoskeletal injuries occurring among volleyball players (participating in volleyball training and/or youth, adult, master competitions)?

Methods

A systematic review of the scientific literature was conducted, being reported accordingly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Liberati et al., 2009).

Search strategy and databases

A highly sensitive search strategy was built (Appendix 1) based on two groups of keywords (and related search terms): 'injury/epidemiology/aetiology/prevention' and 'volleyball'. Two electronic databases

were searched up to May 2016, namely Medline (biomedical literature) via Pubmed (from 1966), and SPORTDiscus (sports and sports medicine literature) via EBSCOhost (from 1985). Literature was limited to studies involving humans and to the Dutch, English and French languages. Within each keyword, all search terms were combined by the Boolean command OR, and the keywords (and respective search terms) were linked by the Boolean command AND. In Medline, we strived to use existing medical subject headings [MeSH]. Search terms were truncated with*.

Eligibility criteria

To retrieve articles relevant to the goals of this review, criteria for inclusion were:

1. The population of interest consists of volleyball players (participating in volleyball training and/or youth, adult, master indoor or outdoor competitions).
2. The article presents an original study.
3. The article is written in Dutch, English, French or German.
 - 4a. If related to descriptive epidemiology, prospective cohort design is used.
 - 5a. If related to descriptive epidemiology, incidence rate (relative to volleyball exposure) or prevalence rate (overuse injuries) is reported.
 - 4b. If related to aetiology, prospective cohort or case-control design is used.
 - 5b. If related to aetiology, a description of the injury mechanism is given and/or risk estimate is reported.
 - 4c. If related to prevention, randomised controlled trial is conducted.
 - 5c. If related to prevention, incidence rates and/or effect are reported.

Study selection

All studies identified through the search strategy were imported in a citation database (EndNote) and duplicates were removed. To identify potentially relevant articles, titles and abstracts were screened independently by two authors (KO and GV). If the title and abstract did not provide sufficient information to determine whether the eligibility criteria were met, it was included for the full text selection. Then, full text articles were assessed independently for eligibility by two authors (KO and GV). Any disagreements regarding the inclusion or exclusion of articles were resolved by consulting a third author (VE). To avoid missing any relevant publications, the references of included studies and/or retrieved literature reviews were screened.

Data extraction

Data from the included articles were extracted by two authors (KO and GV). To this end, three standardised extraction forms were used (one for each research question) in order to report: study information (author, year, reference number), study population and design (sample size, age, gender, level of sport, design, and, if applicable: follow-up duration), injury definition and registration, injury incidence (inclusive pathology), risk factors and mechanism (if applicable), preventive measure (if applicable) and main outcome (risk, effect).

Risk of bias assessment

The risk of bias of all included articles was assessed by two authors (GV and VE), independent from each other. If there was a difference in scoring an item, a consensus was reached by authors. For the articles related to descriptive epidemiology and aetiology, the Quality in Prognosis Studies (QUIPS) tool was used ([Appendix 2](#)), exploring six bias domains: study population, study attribution, prognostic factor information, measurement of and controlling of confounding variables, measurement of outcomes and analysis approaches). Each of the six bias domains was rated (if applicable) as having a high, moderate or low risk of bias. We considered a study to have an overall low risk of bias when the methodological risk of bias was rated as low or moderate in all domains, with at least four domains being rated 'low'. A study was rated as having an overall high risk of bias if two or more of the domains scored 'high'. In-between quality was scored as 'moderate'. For the articles related to prevention, the Cochrane Collaboration's tool was used ([Appendix 2](#)), exploring six bias domains (sequence generation, allocation concealment, blinding of participant and personnel, blinding of outcome, incomplete data and selective reporting). Each of the six domains was rated as '1' when the criterion was met and as '0' when the criterion was not met or unclear. A study was classified as having a low risk of bias when at least five domains were rated as '1'. A study was rated as having a high risk of bias if two or more domains were rated as '0'. In-between quality was scored as 'moderate'.

Synthesis of evidence

Because of the heterogeneity of the included studies (injury definition, statistical methods), no meta-analysis was conducted. The van Mechelen's 'sequence of prevention' model was used to visually present our findings, including only those studies having a low risk of bias (van Mechelen et al., 1992).

Results

Search strategy

A total of 1722 potentially relevant citations were retrieved from the literature search in Medline and SPORTDiscus. After deleting duplicates and applying the inclusion criteria to the titles and abstracts, 129 potentially relevant studies were included for the full text review. From those potentially relevant studies, 10 literature reviews were identified (Briner & Kacmar, 1997; Cools, Johansson, Borms, & Maenhout, 2015; Dugas, Chronister, Cain, & Andrews, 2014; Eerkes, 2012; Fong, Hong, Chan, Yung, & Chan, 2007; James, Kelly, & Beckman, 2014; Kox, Kuijer, Kerkhoffs, Maas, & Frings-Dresen, 2015; Magra, Caine, & Maffulli, 2007; Reeser, Verhagen, Briner, Askeland, & Bahr, 2006; Seminati & Minetti, 2013), while 90 studies were excluded for various reasons: mostly because these were not original studies or had an inappropriate study design, and data were not (solely) about volleyball. Since the reference check of the literature reviews and included studies did result in 5 additional relevant studies, 34 relevant original studies were included in our systematic review: 28 studies describe the incidence and/or prevalence of musculoskeletal injuries (Agel, Palmieri-Smith, Dick, Wojtys, & Marshall, 2007; Beneka et al., 2007, 2009; Bahr & Bahr, 1997; Bahr, Reeser, & Volleyball, 2003; Barber Foss, Myer, & Hewett, 2014; Bere et al., 2015; Beynnon et al., 2014; Bonza, Fields, Yard, & Dawn Comstock, 2009; de Loes, Dahlstedt, & Thomee, 2000; Fernandez, Yard, & Comstock, 2007; Junge et al., 2006; Kujala et al., 1995; Lanese, Strauss, Leizman, & Rotondi, 1990; Malliou et al., 2008; Nelson, Collins, Yard, Fields, & Comstock, 2007; Rechel, Collins, & Comstock, 2011; Rechel, Yard, & Comstock, 2008; Reeser, Gregory, Berg, & Comstock, 2015; Robinson, Corlette, Collins, & Comstock, 2014; Solgard et al., 1995; Swenson et al., 2013; Swenson, Yard, Collins, Fields, & Comstock, 2010; Tsigganos et al., 2007; Vauhnik et al., 2011; Verhagen et al., 2004; Wang & Cochrane, 2001; Zetou, Malliou, Lola, Tsigganos, & Godolias, 2006), 16 studies are related to the aetiology (Agel et al., 2007; Beneka et al., 2009; Bahr & Bahr, 1997; Bere et al., 2015; de Vries, van der Worp, Diercks, van den Akker-Scheek, & Zwerver, 2015; Malliou et al., 2008; Rechel et al., 2008, 2011; Robinson et al., 2014; Solgard et al., 1995; Swenson et al., 2010, 2013; Tsigganos et al., 2007; Verhagen et al., 2004; Visnes & Bahr, 2013; Wang & Cochrane, 2001) and 4 studies are related to prevention (Augustsson et al., 2011; Cumps et al., 2008; Verhagen, van Tulder, van

der Beek, Bouter, & van Mechelen, 2005; Visnes, Hoksrud, Cook, & Bahr, 2005). The flowchart of our search procedure and the results of the methodological quality description can be found as supplement material.

Incidence and prevalence

Of the 28 included studies concerning the incidence and prevalence of musculoskeletal injuries among volleyball players (data extraction in Table I), eight studies were scored with a low risk of bias (Bahr et al., 2003; Bahr & Bahr, 1997; Barber Foss et al., 2014; Bere et al., 2015; de Loes et al., 2000; Junge et al., 2006; Vauhnik et al., 2011; Verhagen et al., 2004) and 20 with a moderate risk of bias (Agel et al., 2007; Beneka et al., 2009, 2007; Beynnon et al., 2014; Bonza et al., 2009; Fernandez et al., 2007; Kujala et al., 1995; Lanese et al., 1990; Malliou et al., 2008; Nelson et al., 2007; Rechel et al., 2011, 2008; Reeser et al., 2015; Robinson et al., 2014; Solgard et al., 1995; Swenson et al., 2010, 2013; Tsigganos et al., 2007; Wang & Cochrane, 2001; Zetou et al., 2006). The incidence and prevalence of musculoskeletal injuries among volleyball players from the studies with a low risk of bias are presented in Figure 1.

The studies with a low risk of bias showed a total incidence rate of musculoskeletal injuries ranging from 1.7 to 10.7 injuries per 1000 player hours (Figure 1) (Bahr & Bahr, 1997; Bere et al., 2015). Especially ankle, knee and shoulder injuries are often reported (Bahr et al., 2003; Bahr & Bahr, 1997; Barber Foss et al., 2014; Verhagen et al., 2004). Both acute and overuse injuries occur among volleyball players, with acute injuries being located mostly in the ankle (ankle sprain). Where the majority of ankle injuries are acute injuries, knee and shoulder injuries occur both as acute and as overuse injuries. For instance, Verhagen et al. (2004) reported an injury rate for ankle injuries of 1.0 injuries per 1000 player hours and presented that all of these injuries, 1.0 injuries per 1000 player hours, were acute injuries. However, for knee injuries, 0.1 of 0.3 knee injuries per 1000 player hours were reported as acute injuries and another 0.1 of the reported 0.3 knee injuries per 1000 player hours were reported as overuse injuries. Bahr et al. (2003) reported a total of 2.5 injuries per 1000 hours exposure. Knee injuries accounted for 33% of the acute injuries, followed by ankle (17%) and shoulder (17%). For overuse injuries, no ankle injuries were reported, but knee and shoulder injuries accounted for respectively 24% and 12% of the overuse injuries.

Aetiology

Of the 16 included studies concerning the aetiology of musculoskeletal injuries among volleyball players (data extraction in Table II), five studies were scored with a low risk of bias (Bahr & Bahr, 1997; Bere et al., 2015; de Vries et al., 2015; Verhagen et al., 2004; Visnes & Bahr, 2013) and 11 with a moderate risk of bias (Agel et al., 2007; Beneka et al., 2007; Malliou et al., 2008; Rechel et al., 2008, 2011; Robinson et al., 2014; Solgard et al., 1995; Swenson et al., 2010, 2013; Tsigganos et al., 2007; Wang & Cochrane, 2001). The aetiology of musculoskeletal injuries among volleyball players from the studies with a low risk of bias are presented in Figure 1.

A risk factor for musculoskeletal injuries in volleyball often reported was gender (male vs. female). Bahr and Bahr (1997) showed that adult men have a higher risk for ankle injuries compared to adult women (RR of 3.2). de Vries et al. (2015) showed also a statistically significant risk for patellar tendinopathy in adult men (OR of 2.6) whereas in the study by Visnes and Bahr (2013) a statistically significant OR ranging from 2.89 to 4.03 was found for jumper's knee in adolescent men compared to adolescent women. Another risk factor for musculoskeletal injuries in volleyball reported by studies was the nature of activity (matches vs. training). Bahr and Bahr (1997) found a higher risk during matches for all musculoskeletal injuries (RR of 2.3) and for ankle injuries (RR of 2.1).

Ankle injuries are mostly the result of contact with another player, while non-contact trauma is the second most important factor for ankle injuries (Bere et al., 2015; Verhagen et al., 2004). Up to 59% of ankle injuries are contact injuries (Verhagen et al., 2004). A typical mechanism resulting in an acute ankle inversion injury is the conflict zone beneath the net where one player's foot lands on the foot of the opposing player (Bahr & Bahr, 1997; Verhagen et al., 2004). Finger injuries also often occur after contact, although finger injuries are the result of contact with a moving object such as the ball instead of contact with another player. Contact with a moving object is the cause of a finger injury in 76.6% of cases whereas contact with another player accounts for only 14.9% (Bere et al., 2015).

The study by de Vries et al. (2015) showed that a 5 cm increase in height, a 5 kg increase in weight and jumping at the workplace required by a physically demanding profession, were significant risk factors for patellar tendinopathy for adult volleyball players with an OR of respectively 1.3 and 1.2. According to Visnes and Bahr (2013), other significant variables for getting a jumper's knee for adolescents were training volume (OR = 1.61), volleyball training (OR = 1.72) and number of sets (OR = 3.88).

Table I. Injuries among volleyball players: incidence and prevalence.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Agel et al. (2007)	Moderate	N: 30–109 G: All females A: College L: Recreational D: Cohort (prospective) F: 16 years	Musculoskeletal injury: occurred as a result of participation in an organized intercollegiate practice or competition and (2) required medical attention by a team certified athletic trainer or physician and (3) resulted in restriction of the student-athlete's participation or performance for one or more calendar days beyond the day of injury. Registration: annual injury surveillance system	<ul style="list-style-type: none"> • Overall Training: 4.10 inj//1000 hours athlete 3.1% head/neck; 18.7% upper extremity; 17.4% trunk/back; 55.9% lower extremity; 4.9% other Match: 4.58 inj//1000 hours athlete 6.7% head/neck; 21.4% upper extremity; 10.8% trunk/back; 58.7% lower extremity; 2.4% other • Preseason Training: 6.19 inj//1000 hours athlete Match: 3.26 inj//1000 hours athlete • In season Training: 2.82 inj//1000 hours athlete Match: 4.52 inj//1000 hours athlete • Postseason Training: 1.17 inj//1000 hours athlete Match: 2.67 inj//1000 hours athlete • Ankle ligament sprain time loss (≥ 10 days) injury Training: 0.83 inj//1000 hours athlete Match: 1.44 inj//1000 hours athlete • Knee internal derangement time loss (≥ 10 days) injury Training: 0.22 inj//1000 hours athlete Match: 0.46 inj//1000 hours athlete • Patella time loss (≥ 10 days) injury Training: 0.15 inj//1000 hours athlete Match: 0.10 inj//1000 hours athlete • Shoulder muscle-tendon strain time loss (≥ 10 days) injury Training: 0.16 inj//1000 hours athlete Match: 0.17 inj//1000 hours athlete • Lower back muscle-tendon time loss (≥ 10 days) injury Training: 0.22 inj//1000 hours athlete Match: 0.16 inj//1000 hours athlete

(Continued)

Table I. Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Bahr (1997)	Low	N: 273 G: 130 males, 143 females A: 21.7–23.1 L: Amateur D: Cohort (prospective) F: One season	Musculoskeletal injury: resulted from a sudden event during organized volleyball training or match, and caused an absence of one or more day of training or match play. Registration: reported by coaches	<ul style="list-style-type: none"> • All injuries Total: 1.7 inj/1000 player hours Match: 3.5 inj/1000 player hours Training: 1.5 inj/1000 player hours 54% ankle, 11% back, 5% thigh/groin, 9% knee, 9% shoulder, 8% finger, 9% other • All injuries men Total: 1.7 inj/1000 player hours Match: 3.9 inj/1000 player hours Training: 1.5 inj/1000 player hours • All injuries women Total: 1.7 inj/1000 player hours Match: 3.0 inj/1000 player hours Training: 1.6 inj/1000 player hours • Ankle injuries Total: 0.9 inj/1000 player hours Match: 1.7 inj/1000 player hours Training: 0.8 inj/1000 player hours • Ankle injuries men Total: 1.0 inj/1000 player hours Match: 2.6 inj/1000 player hours Training: 0.8 inj/1000 player hours • Ankle injuries women Total: 0.8 inj/1000 player hours Match: 0.7 inj/1000 player hours Training: 0.9 inj/1000 player hours Total: 2.5 inj/1000 hours exposure Men: 3.8 inj/1000 hours exposure Women :0.0 inj/1000 hours exposure Acute injuries: 17% neck, 17% hip, 33% knee, 17% ankle, 17% shoulder Overuse injuries: 12% neck, 21% low back, 6% abdomen, 3% hip, 12% thigh, 24% knee, 3% lower leg, 12% shoulder, 3% arm, 6% fingers
Bahr et al. (2003)	Low	N: ? G: males, females A: Adults L: Elite D: Cohort (prospective) F: Two seasons	Musculoskeletal injury: causing cessation of the athlete's participation in competition or training for at least one day. Registration: reported by medical staff	<ul style="list-style-type: none"> • All injuries Total: 1.7 inj/1000 player hours Match: 3.5 inj/1000 player hours Training: 1.5 inj/1000 player hours 54% ankle, 11% back, 5% thigh/groin, 9% knee, 9% shoulder, 8% finger, 9% other • All injuries men Total: 1.7 inj/1000 player hours Match: 3.9 inj/1000 player hours Training: 1.5 inj/1000 player hours • All injuries women Total: 1.7 inj/1000 player hours Match: 3.0 inj/1000 player hours Training: 1.6 inj/1000 player hours • Ankle injuries Total: 0.9 inj/1000 player hours Match: 1.7 inj/1000 player hours Training: 0.8 inj/1000 player hours • Ankle injuries men Total: 1.0 inj/1000 player hours Match: 2.6 inj/1000 player hours Training: 0.8 inj/1000 player hours • Ankle injuries women Total: 0.8 inj/1000 player hours Match: 0.7 inj/1000 player hours Training: 0.9 inj/1000 player hours Total: 2.5 inj/1000 hours exposure Men: 3.8 inj/1000 hours exposure Women :0.0 inj/1000 hours exposure Acute injuries: 17% neck, 17% hip, 33% knee, 17% ankle, 17% shoulder Overuse injuries: 12% neck, 21% low back, 6% abdomen, 3% hip, 12% thigh, 24% knee, 3% lower leg, 12% shoulder, 3% arm, 6% fingers

Barber Foss et al. (2014)	Low	<p>N: 80</p> <p>G: males, females</p> <p>A: Youth</p> <p>L: Amateur</p> <p>D: Cohort (prospective)</p> <p>F: Three seasons</p>	<p>Musculoskeletal injury: causing cessation of participation in the current session and causing cessation of participation on the day after onset.</p> <p>Registration: reported by athletic trainer</p>	<ul style="list-style-type: none"> • All injuries <p>Total: 3.68 inj/1000 athlete exposures</p> <p>Practice: 5.55 inj/1000 athlete exposures</p> <p>Games: 0.75 inj/1000 athlete exposures</p> <p>81.6% knee, 7.9% ankle, 7.9% shoulder, 2.6% wrist</p> <ul style="list-style-type: none"> • Ankle sprain <p>Practice: 0.32 inj/1000 athlete exposures</p> <p>Games: 0.25 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Knee contusion <p>Practice: 0.0 inj/1000 athlete exposures</p> <p>Games: 0.25 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Knee plica <p>Practice: 0.32 inj/1000 athlete exposures</p> <p>Games: 0.25 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Knee fat pad <p>Practice: 0.16 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Patellofemoral dysfunction <p>Practice: 2.54 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Patella tendinosis <p>Practice: 0.63 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Patella subluxation <p>Practice: 0.16 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Osgood-Schlatter disease <p>Practice: 0.79 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Shoulder inflammation <p>Practice: 0.32 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Shoulder subluxation <p>Practice: 0.16 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p> <ul style="list-style-type: none"> • Wrist sprain <p>Practice: 0.16 inj/1000 athlete exposures</p> <p>Games: 0.0 inj/1000 athlete exposures</p>
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(Continued)

Table I. Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Beneka et al. (2007)	Moderate	N: 649 G: 318 males, 331 females A: 21.99–25.69 L: Elite and amateur D: Cohort (prospective) F: One season	Musculoskeletal injury: occurring during scheduled games or practices that cause an athlete to miss a subsequent game or practice session. Registration: reported by players during interview	<ul style="list-style-type: none"> • Elite Total: 0.8 inj/player/year Training: 1.89 inj/player/1000 hours Acute: 42% ankle/foot, 13% knee, 12% thigh. 12% shoulder, 7% hand, 6% spine, 2% elbow/arm, 4% leg Chronic: 1% ankle/foot, 13% knee, 16% thigh. 22% shoulder, 42% spine, 4% leg • Amateur Total: 0.61 inj/player/year Training: 2.8 inj/player/1000 hours Acute: 45% ankle/foot, 13% knee, 16% thigh. 8% shoulder, 11% hand, 2% spine, 4% elbow/arm, 2% leg Chronic: 12% knee, 2% thigh. 42% shoulder, 19% spine
Beneka et al. (2009)	Moderate	N: 407 G: All males A: 13.3–26.7 L: Elite and amateur D: Cohort (prospective) F: One season	Musculoskeletal injury: occurring during scheduled games or practices that cause an athlete to miss a subsequent game or practice session. Registration: reported by players during interview	<ul style="list-style-type: none"> • All players 0.6 inj/player/year 2.4 inj/player/1000 hours training or games Location: 39% ankle/foot, 24% knee/thigh, 14% spine, 13% shoulder, 10% hand Location acute (86.4%): 45% ankle/foot, 22% knee/thigh, 13% spine, 10% shoulder, 10% hand Location overuse (13.5%): 40% knee/thigh, 23% spine, 30% shoulder, 7% hand • Youth players (12–14 yrs) 0.3 inj/player/year 1.9 inj/player/1000 hours training or games • Junior players (15–18 yrs) 0.37 inj/player/year 1.8 inj/player/1000 hours training or games • Senior players (>18 yrs) 0.81 inj/player/year 2.8 inj/player/1000 hours training or games

Bere et al. (2015)	Low	<p>N: ? G: males, females A: Junior, senior L: Elite D: Cohort (prospective) F: Four years</p>	<p>Musculoskeletal complaint: newly incurred during match play and/or training during the event that received medical attention regardless of the consequences with respect to absence from competition or training. Registration: reported by team doctor</p>	<ul style="list-style-type: none"> • All players Total: 10.7 inj/1000 players hours Junior: 9.0 inj/1000 players hours Senior: 11.9 inj/1000 players hours 4.5% face, 1.6% head, 0.9% neck/cervical spine, 0.9% thorax/upper back, 0.7% sternum/ribs, 8.9% limbar/lower back, 1.4% abdomen, 1.4% pelvis/sacrum/buttock, 5.0% shoulder/clavicle, 0.5% upper arm, 0.9% elbow, 0.2% forearm, 1.1% wrist, 2.5% hand, 10.7% finger/thumb, 1.8% hip, 0.9% groin, 4.3% thigh, 15.2% knee, 4.5% lower leg, 1.8% Achilles tendon, 25.9% ankle, 3.9% foot/toe • Male players Total: 11.2 inj/1000 players hours Junior: 10.5 inj/1000 players hours 5.8% face, 1.0% head, 1.0% neck/cervical spine, 1.0% sternum/ribs, 6.7% limbar/lower back, 1.9% pelvis/sacrum/buttock, 9.6% shoulder/clavicle, 1.0% forearm, 3.8% hand, 14.4% finger/thumb, 2.9% hip, 1.0% groin, 1.0% thigh, 13.5% knee, 9.6% lower leg, 1.0% Achilles tendon, 17.3% ankle, 7.7% foot/toe Senior: 11.7 inj/1000 players hours 1.7% face, 2.6% head, 0.9% thorax/upper back, 0.9% sternum/ribs, 10.3% limbar/lower back, 2.6% abdomen, 1.7% pelvis/sacrum/buttock, 3.4% shoulder/clavicle, 0.9% upper arm, 1.7% elbow, 0.9% wrist, 2.6% hand, 7.8% finger/thumb, 2.6% groin, 3.4% thigh, 16.4% knee, 3.4% lower leg, 2.6% Achilles tendon, 29.3% ankle, 3.4% foot/toe • Female players Total: 10.3 inj/1000 players hours Junior: 7.8 inj/1000 players hours 5.6% face, 1.1% neck/cervical spine, 2.2% thorax/upper back, 4.5% limbar/lower back, 7.9% shoulder/clavicle, 1.1% upper arm, 2.2% elbow, 2.2% wrist, 2.2% hand, 12.3% finger/thumb, 1.1% hip, 6.7% thigh, 11.2% knee, 4.5% lower leg, 1.1% Achilles tendon, 30.3% ankle, 2.2% foot/toe Senior: 12.2 inj/1000 players hours 5.3% face, 2.3% head, 1.5% neck/cervical spine, 0.8% thorax/upper back, 0.8% sternum/ribs, 12.2% limbar/lower back, 2.3% abdomen, 1.5% pelvis/sacrum/buttock, 0.8% shoulder/clavicle, 1.5% wrist, 1.5% hand, 9.1% finger/thumb, 3.1% hip, 6.1% thigh, 18.3% knee, 1.5% lower leg, 2.3% Achilles tendon, 26.7% ankle, 2.3% foot/toe 0.447 inj/1000 person-days of exposure
Beynnon et al. (2014)	Moderate	<p>N: ? G: males, females A: College L: Amateur D: Cohort (prospective) F: Four years</p>	<p>First-time ACL injury: with complete grade 3 disruption of the ligament in a person with no previous ACL injury to either leg, occurring as a result of participation in an organized practice or game and not involving any direct contact to the knee from external forces. Registration: reported by study coordinator</p>	

(Continued)

Table I. Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Bonza et al. (2009)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Two years	Musculoskeletal injury: occurring as a result of participation in an organized practice or competition, requiring medical attention and resulting in restriction of the person's participation for at least one day beyond the day of the injury. Registration: reported by athletic trainer	Total: 1.07 inj/10 000 athlete-exposure Practice: 1.26 inj/10 000 athlete-exposure Competition: 0.72 inj/10 000 athlete-exposure
de Loes et al. (2000)	Low	N: ? G: males, females A: 14–20 L: Amateur D: Cohort (prospective) F: Seven years	Acute musculoskeletal injury: having been attended to by a physician. Registration: reported by physician	Males: 0.14 inj/10 000 exposure 11% ACL/PCL rupture, 11% patella luxation, 11% collateral ligament rupture, 33% meniscal rupture, 11% non-specific rupture, 6% chondral lesions, 17% other Females: 0.27 inj/10 000 exposure 16% ACL/PCL rupture, 2% fracture patella + condyle, 13% patella luxation, 15% collateral ligament rupture, 10% meniscal rupture, 37% non-specific rupture, 1% patella ligament rupture, 6% other 0.99 inj/1000 athlete exposures
Fernandez et al. (2007)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: One years	Lower extremity musculoskeletal injury: resulting from participation in an organized practice or competition, requiring medical attention and resulting in a restriction from participation in sports for one or more days beyond the day of injury. Registration: reported by athletic trainer	
Junge et al. (2006)	Low	N: ? G: All males A: ? L: Elite D: Cohort (prospective) F: 2004 Olympic tournament	Any physical complaint: incurred during the match that received medical attention from the team physician, regardless of the consequences with respect to absence from the match or training. Registration: reported by medical representative	11 inj/1000 player matches

Kujala et al. (1995)	Moderate	N: ? G: males, females A: ? L: Amateur D: Cohort (prospective) F: Two years	Traumatic acute musculoskeletal injury: during competition and training. Registration: reported by insurance company	<ul style="list-style-type: none"> • Total Overall: 60 inj/1000 person years of exposure Age <15: 12 inj/1000 person years of exposure Age 15–19: 51 inj/1000 person years of exposure Age 20–24: 215 inj/1000 person years of exposure Age 25–34: 145 inj/1000 person years of exposure Age >34: 171 inj/1000 person years of exposure Thigh: 1 inj/1000 person years of exposure Knee: 11 inj/1000 person years of exposure Leg: 1 inj/1000 person years of exposure Ankle: 19 inj/1000 person years of exposure Foot: 2 inj/1000 person years of exposure Upper arm and shoulder: 6 inj/1000 person years of exposure Forearm and elbow: 1 inj/1000 person years of exposure Palm and wrist: 1 inj/1000 person years of exposure Fingers: 5 inj/1000 person years of exposure Teeth: 1 inj/1000 person years of exposure Eye: 1 inj/1000 person years of exposure Head and neck: 3 inj/1000 person years of exposure Thorax and abdomen: 1 inj/1000 person years of exposure Back: 5 inj/1000 person years of exposure • Males Age <15: 6 inj/1000 person years of exposure Age 15–19: 52 inj/1000 person years of exposure Age 20–24: 236 inj/1000 person years of exposure Age 25–34: 155 inj/1000 person years of exposure Age >34: 67 inj/1000 person years of exposure • Females Age <15: 16 inj/1000 person years of exposure Age 15–19: 50 inj/1000 person years of exposure Age 20–24: 192 inj/1000 person years of exposure Age 25–34: 125 inj/1000 person years of exposure Age >34: 81 inj/1000 person years of exposure • Males 0.19 inj/100 person-hours of exposure 23% foot/ankle, 11% knee, 14% shoulder/upper arm, 12% thigh, 12% upper/lower back, 11% hand/wrist, 7% calf/shin, 3% head/neck, 3% elbow/forearm, 3% lower torso/abdomen, 1% chest/rib cage • Females 0.15 inj/100 person-hours of exposure 23% foot/ankle, 20% knee, 5% shoulder/upper arm, 12% thigh, 9% upper/lower back, 5% hand/wrist, 8% calf/shin, 8% head/neck, 2% elbow/forearm, 2% chest/rib cage
Lanese et al. (1990)	Moderate	N: ? G: males, females A: University L: Amateur D: Cohort (prospective) F: One years	Traumatic medical problem: due to sport participation and resulting in loss of time from practice or competition. Registration: reported by athletic trainer	<ul style="list-style-type: none"> • Males 0.19 inj/100 person-hours of exposure 23% foot/ankle, 11% knee, 14% shoulder/upper arm, 12% thigh, 12% upper/lower back, 11% hand/wrist, 7% calf/shin, 3% head/neck, 3% elbow/forearm, 3% lower torso/abdomen, 1% chest/rib cage • Females 0.15 inj/100 person-hours of exposure 23% foot/ankle, 20% knee, 5% shoulder/upper arm, 12% thigh, 9% upper/lower back, 5% hand/wrist, 8% calf/shin, 8% head/neck, 2% elbow/forearm, 2% chest/rib cage

(Continued)

Table I. Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Malliou et al. (2008)	Moderate	N: 689 G: All females A: >11 L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurred during scheduled games or practices that caused an athlete to miss a subsequent game or practice session. Registration: ?	<ul style="list-style-type: none"> • All players 0.59 inj/player/year 2.5 inj/player/1000 hours training or games Location: 50.4% ankle/foot, 15.7% knee/thigh, 10.6% spine, 9.6% shoulder, 8.8% hand Location acute (68.6%): 71.7% ankle/foot, 12.5% knee/thigh, 6.5% spine, 3.6% shoulder, 5.7% hand Location overuse (26.5%): 4.6% ankle/foot, 26.9% knee/thigh, 23.1% spine, 26.9% shoulder, 18.5% hand • Youth players (12–14 yrs) 0.38 inj/player/year 2.4 inj/player/1000 hours training or games • Junior players (15–18 yrs) 0.52 inj/player/year 2.6 inj/player/1000 hours training or games • Senior players (>18 yrs) 0.78 inj/player/year 2.5 inj/player/1000 hours training or games Total: 6.21 inj/10,000 athlete exposures Practice: 6.49 inj/10,000 athlete exposures Competition: 5.72 inj/10,000 athlete exposures
Nelson et al. (2007)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: One years	Ankle injury: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days beyond the day of injury. Registration: reported by athletic trainer	
Rechel et al. (2008)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days beyond the day of injury. Registration: reported by athletic trainer	<ul style="list-style-type: none"> Total: 1.64 inj/1000 athlete exposures Practice: 1.48 inj/10,000 athlete exposures Competition: 1.92 inj/10,000 athlete exposures
Rechel et al. (2011)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Six years	Musculoskeletal injury: requiring surgery, occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days beyond the day of injury. Registration: reported by athletic trainer	<ul style="list-style-type: none"> Total: 0.40 inj/10,000 athlete exposures Practice: 0.21 inj/10,000 athlete exposures Competition: 0.78 inj/10,000 athlete exposures 9% head/face/mouth, 2.1% shoulder, 2.3% hand/finger, 79.2% knee, 3.2% ankle, 4.2% other

Reeser et al. (2015)	Moderate	N: ? G: All females A: High school & College L: Amateur D: Cohort (prospective) F: Four years	Musculoskeletal injury: any condition resulting in the loss of at least one day of training or competition. Registration: reported by athletic trainer	High school: 12.4 inj/10,000 athlete exposures 5.4% head/face, 3.3% wrist, 9.0% hand, 8.3% shoulder, 6.4% lower back/spine, 1.9% hip, 2.8% thigh, 10.9% knee, 4.6% leg, 36.6% ankle, 3.8% foot College: 40.6 inj/10,000 athlete exposures 5.5% head/face, 2.0% wrist, 6.5% hand, 9.8% shoulder, 8.2% lower back/spine, 4.3% hip, 6.8% thigh, 13.1% knee, 6.6% leg, 19.9% ankle, 4.5% foot
Robinson et al. (2014)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Six years	Shoulder injury: (proximal humerus, scapula, clavicle, comion-clavicular joint, and surrounding tendons, ligaments, and musculature) occurring as a result of an organized practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days. Registration: reported by athletic trainer	Total: 0.81 inj/10,000 athlete exposures Practice: 0.97 inj/10,000 athlete exposures Competition: 0.50 inj/10,000 athlete exposures 9% head/face/mouth, 2.1% shoulder, 2.3% hand/finger, 79.2% knee, 3.2% ankle, 4.2% other
Solgard et al. (1995)	Moderate	N: ? G: males, females A: 11–45 L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurring during volleyball activities at a sport area, causing the athlete to consult the casualty wards within 24 h of the injury. Registration: reported by player (interview)	6.5 inj/1000 hours of exposures 5.0% arm/shoulder, 44.6% hands/fingers, 6.1 knee, 30.9% ankle, 5.8% foot
Swenson et al. (2010)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Five years	Fracture: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days. Registration: reported by athletic trainer	Total: 0.52 inj/10,000 athlete exposures Practice: 0.55 inj/10,000 athlete exposures Competition: 0.46 inj/10,000 athlete exposures 27.6% hand/finger, 13.5% wrist, 13.7% lower leg, 1.6% forearm, 8.9% foot/toe, 4.2% nose, 23.1% ankle
Swenson et al. (2013)	Moderate	N: ? G: males, females A: High school L: Amateur D: Cohort (prospective) F: Five years	Knee injury: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days. Registration: reported by athletic trainer	• Males Total: 0.28 inj/10,000 athlete exposures Competition: 0.84 inj/10,000 athlete exposures MCL: 0.28 inj/10,000 athlete exposures • Females Total: 1.42 inj/10,000 athlete exposures Practice: 1.13 inj/10,000 athlete exposures Competition: 1.99 inj/10,000 athlete exposures ACL: 0.28 inj/10,000 athlete exposures Meniscus: 0.19 inj/10,000 athlete exposures MCL: 0.25 inj/10,000 athlete exposures

(Continued)

Table I. Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Tsigganos et al. (2007)	Moderate	N: 72 (12–14), 109 (15–18), 268 (>18) G: All males A: 13.3, 16.1, 26.7 L: Competitive D: Cohort (prospective) F: One year	Musculoskeletal injury: occurring during scheduled games or practices that cause an athlete to miss a subsequent game or practice session. Registration: reported by player (interview)	Total: 2.4 inj//1000 hours of exposures per player 12–14: 1.9 inj//1000 hours of exposures per player 15–18: 1.8 inj//1000 hours of exposures per player >18: 2.8 inj//1000 hours of exposures per player 38.9% ankle/foot, 24.4% knee/thigh. 14% spine, 12.7% shoulder, 10% hand
Vauhnik (2011)	Low	N: 286 G: All females A: 18.1 L: Competitive D: Cohort (prospective) F: One year	Traumatic ACL injury: confirmed by a surgeon. Registration: reported by player and coach	0.019 inj/1000 hours of exposure

Verhagen et al. (2004)	Low	<p>N: 486 G: 158 males, 261 females A: 23.8–25.2 L: Competitive D: Cohort (prospective) F: One year</p>	<p>Musculoskeletal injury: occurred as a result of volleyball and caused the subject to stop this activity, or resulted in the subject not participating fully in the next planned sports activity. Registration: reported by player and coach</p>	<ul style="list-style-type: none"> • Overall Total: 2.6 inj/1000 hours of play Training: 1.8 inj/1000 hours of play Match: 4.1 inj/1000 hours of play • Males Total: 3.0 inj/1000 hours of play Training: 2.3 inj/1000 hours of play Match: 3.8 inj/1000 hours of play • Females Total: 2.4 inj/1000 hours of play Training: 1.5 inj/1000 hours of play Match: 4.2 inj/1000 hours of play • Ankle Total: 1.0 inj/1000 hours of play Acute: 1.0 inj/1000 hours of play • Knee Total: 0.3 inj/1000 hours of play Acute: 0.1 inj/1000 hours of play Overuse: 0.1 inj/1000 hours of play • Other lower extremity Total: 0.5 inj/1000 hours of play Acute: 0.4 inj/1000 hours of play Overuse: 0.1 inj/1000 hours of play • Back Total: 0.2 inj/1000 hours of play Acute: 0.1 inj/1000 hours of play Overuse: 0.2 inj/1000 hours of play • Shoulder Total: 0.2 inj/1000 hours of play Overuse: 0.2 inj/1000 hours of play • Other upper extremity Total: 0.2 inj/1000 hours of play Acute: 0.2 inj/1000 hours of play <p>New: 1.00 inj/ 1000 hours of exposure Re-injury: 9.29 inj/ 1000 hours of exposure Chronic: 2.98 inj/ 1000 hours of exposure</p>
Wang (2001)	Moderate	<p>N: 59 G: All males A: 24.9–27.6 L: Elite D: Cohort (prospective) F: Two year</p>	<p>New shoulder injury: occurred in the shoulder without any existing or history of similar injury. Shoulder re-injury: re-occurred in the shoulder within one month. Shoulder chronic injury: occurred in the shoulder and resulted in more than one month duration, without single traumatic event that caused the injury Registration: reported by coach</p>	

(Continued)

Table I. Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Incidence and pathology
Zetou et al. (2006)	Moderate	N: 114 G: 61 males, 53 females A: ? L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurred during scheduled games or practices that caused an athlete to miss a subsequent game or practice session. Registration: reported by players during interview	<ul style="list-style-type: none"> All players 0.63 inj/player/year Location: 46.3% ankle/foot, 19.8% knee/thigh, 12.2% spine, 5.5% shoulder, 1.1% elbow, 5.8% hand Location acute (80.4%): 54.5% ankle/foot, 21.2% knee/thigh, 15.1% spine, 1.7% shoulder, 0.3% elbow, 7.2% hand Location overuse (10.2%): 24.3% ankle/foot, 27.0% knee/thigh, 40.5% shoulder, 8.1% elbow, 56.8% hand

N, number; G, gender; A, age; L, level of play; D, design; F, follow-up period; inj, injuries; ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

Prevention

Of the four included studies concerning the prevention of musculoskeletal injuries in volleyball (data extraction in Table III), three studies were scored with a low risk of bias (Augustsson et al., 2011; Cumps et al., 2008; Verhagen et al., 2005) and one with a moderate risk of bias (Visnes et al., 2005), which is not represented in the results due to the fact it was not scored with a low risk of bias. The preventive measures and their effects from the studies with a low risk of bias are presented in Figure 1.

Augustsson et al. (2011) researched a supervised and individualised resistance training during 26 weeks and aimed to reduce musculoskeletal injuries among adolescents. During the season following the intervention, a 100% decrease of musculoskeletal injuries was found in the intervention group, while the number of injuries in the control group remained almost the same. Cumps et al. (2008) applied a preventive measure in order to reduce anterior knee pain among adult volleyball players that included isometric strength in an open kinetic chain in the first month, isometric strength in a closed kinetic chain in the second month, sports-specific skills and plyometrics in the third month, and eccentric load exercise in the fourth month. These measurements were carried out twice a week during the practice session in addition to normal training routine. Pre- and post-intervention were compared with each other and the OR showed a decrease of anterior knee pain in the intervention group as the OR decreased from 0.91 to 0.86. Another preventive measure was evaluated by Verhagen et al. (2005). The intervention consisted of 14 basic proprioceptive exercises on and off a balance board during 36 weeks (with variations on each exercise), or exercises using either no material, ball only, balance board only, or both ball and balance board, and was focused on decreasing ankle injuries in adult volleyball players. Four exercises a week were prescribed to the coach to carry out during the warming up, with the intensity being increased gradually. Verhagen et al. (2005) showed a significant decrease in risk for ankle injuries of RR 0.5.

Discussion

The aim of this study was to present a systematic overview of the incidence and volleyball-specific risk factors of musculoskeletal injuries among volleyball players as well as an insight into the effect of related preventive measures. Results of our review showed that ankle, knee and shoulder injuries are the most common injuries in volleyball. Concerning the aetiology, the results showed that the risk of musculoskeletal injuries is influenced by the nature of the activity

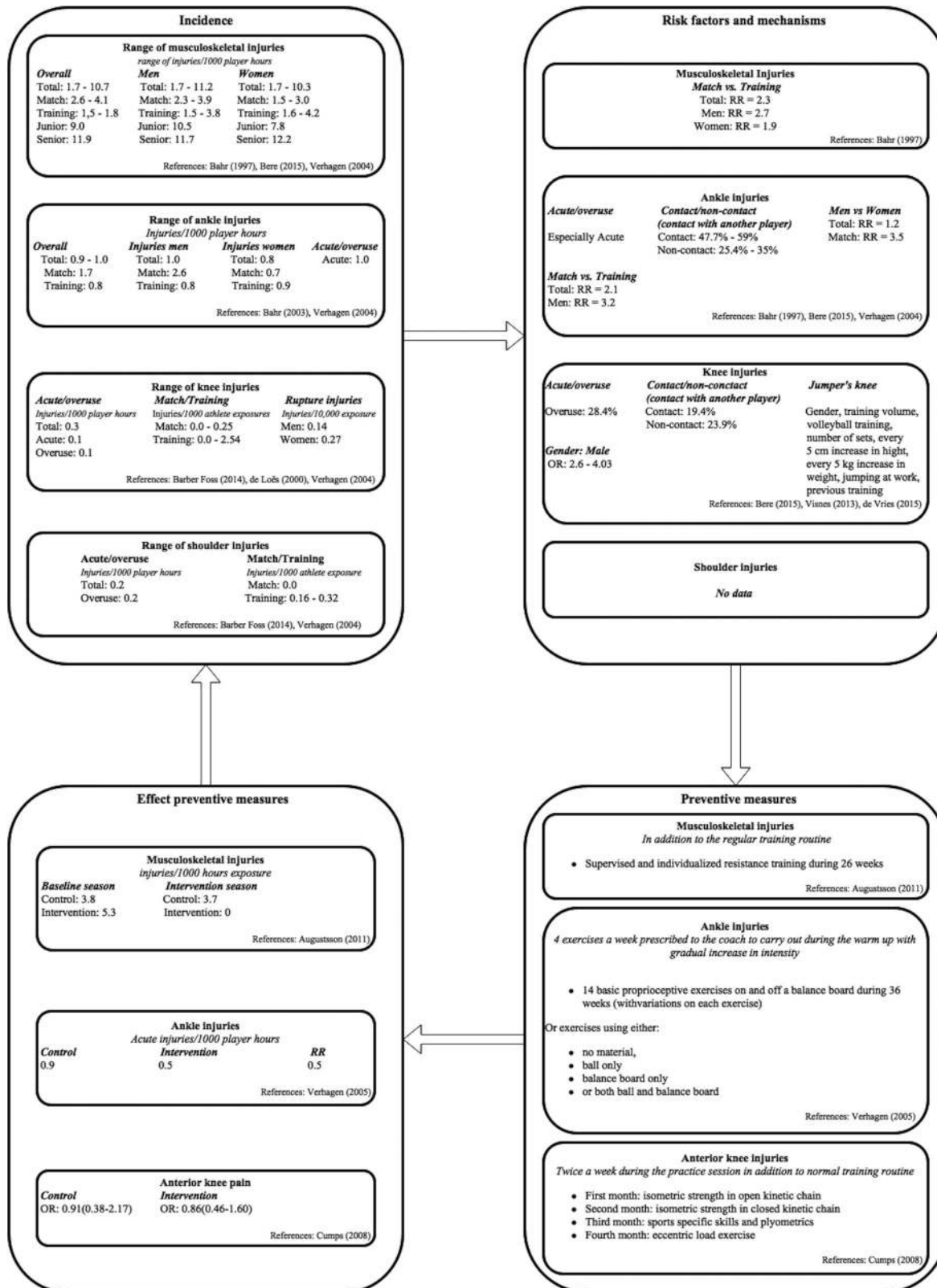


Figure 1. van Mechelen prevention model: available literature on incidence, aetiology and prevention of injuries among volleyball players.

Table II: Injuries among volleyball players: aetiology.

Study information	Total risk of bias	Participation and design	Injury definition	Risk factors and mechanism
Agel et al. (2007)	Moderate	N: 30–109 G: All females A: College L: Recreational D: Cohort (prospective) F: 16 years	Musculoskeletal injury: occurred as a result of participation in an organized intercollegiate practice or competition and (2) required medical attention by a team certified athletic trainer or physician and (3) resulted in restriction of the student-athlete's participation or performance for one or more calendar days beyond the day of injury. Registration: annual injury surveillance system	<ul style="list-style-type: none"> • No contact 54.0% of training injuries 32.7% of match injuries • Player contact 15.0% of training injuries 30.4% of match injuries • Other contact 27.0% of match injuries 35.4% of training injuries • Games injuries 21.1%: injured player coming down on another player 2.0%: another player coming down on injured player 6.5%: other contact with another player 0.8%: contact with standard 20.6%: contact with floor 9.0%: contact with ball 1.0%: contact with out-of-bounds apparatus 25.8%: no apparent contact 13.0%: unknown
Bahr and Bahr (1997)	Low	N: 273 G: 130 males, 143 females A: 21.7–23.1 L: Amateur D: Cohort (prospective) F: One season	Musculoskeletal injury: resulted from a sudden event during organized volleyball training or match, and caused an absence of one or more day of training or match play. Registration: reported by coaches	<ul style="list-style-type: none"> • All injuries: Match vs. training Total: RR = 2.3 ($P < .001$) Men: RR = 2.7 ($P < .01$) Women: RR = 1.9 ($P > .05$) • All injuries: Men vs. women Total: RR = 1.0 ($P > .05$) Match: RR = 1.3 ($P > .05$) Training: RR = 0.9 ($P > .05$) • Ankle injuries: Match vs. training Total: RR = 2.1 ($P < .05$) Men: RR = 3.2 ($P < .01$) Women: RR = 0.9 ($P > .05$) • Ankle injuries: Men vs. women Total: RR = 1.2 ($P > .05$) Match: RR = 3.5 ($P > .05$) Training: RR = 1.0 ($P > .05$)

Beneka et al. (2007)	Moderate	N: 649 G: 318 males, 331 females A: 21.99–25.69 L: Elite and amateur D: Cohort (prospective) F: One season	Musculoskeletal injury: occurring during scheduled games or practices that cause an athlete to miss a subsequent game or practice session. Registration: reported by players during interview	<ul style="list-style-type: none"> • Total injuries <ul style="list-style-type: none"> 23.3%: incorrect sprawls 10.8%: wrong technique 24.7%: stepping on others' feet 8.9%: ball contact 23.7%: fatigue 5.4%: inappropriate warm-up • Ankle injuries <ul style="list-style-type: none"> 4.4%: overuse (gradual onset) 47.4%: contact with another player 3.5%: contact with moving object 2.6%: contact with stagnant object 1.8%: overuse (sudden onset) 3.5%: field of play condition 25.4%: non-contact trauma 5.3%: recurrence of previous injury 1.8%: other • Knee injuries <ul style="list-style-type: none"> 20.9%: overuse (gradual onset) 19.4%: contact with another player 1.5%: contact with moving object 9.0%: contact with stagnant object 7.5%: overuse (sudden onset) 1.5%: field of play condition 23.9%: non-contact trauma 11.9%: recurrence of previous injury 3.0%: other • Finger/thumb injuries <ul style="list-style-type: none"> 14.9%: contact with another player 76.6%: contact with moving object 2.1%: contact with stagnant object 2.1%: non-contact trauma 2.1%: recurrence of previous injury
Bere et al. (2015)	Low	N: ? G: males, females A: Junior, senior L: Elite D: Cohort (prospective) F: Four years	Musculoskeletal complaint: newly incurred during match play and/or training during the event that received medical attention regardless of the consequences with respect to absence from competition or training. Registration: reported by team doctor	<ul style="list-style-type: none"> • All injuries: <ul style="list-style-type: none"> 26.8%: incorrect sprawls 9.3%: wrong technique 23.3%: step on other's foot 9.8%: ball contact 17.2%: fatigue 3.9%: inappropriate warm-up • Competition vs. practice (reference) RR = 1.30 (0.98–1.72)
Malliou et al. (2008)	Moderate	N: 689 G: All females A: > 11 L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurred during scheduled games or practices that caused an athlete to miss a subsequent game or practice session. Registration: ?	
Rechel et al. (2008)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days beyond the day of injury. Registration: reported by athletic trainer	

(Continued)

Table II: Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Risk factors and mechanism
Rechel et al. (2011)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Six years	Musculoskeletal injury: requiring surgery, occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days beyond the day of injury. Registration: reported by athletic trainer	<ul style="list-style-type: none"> • Competition vs. practice (reference) RR = 3.73 (1.80–7.74) • All injuries: 47.3: jumping/landing 13.4%: rotation around planted foot
Robinson et al. (2014)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Six years	Shoulder injury: (proximal humerus, scapula, clavicle, comion-clavicular joint, and surrounding tendons, ligaments, and musculature) occurring as a result of an organized practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days. Registration: reported by athletic trainer	<ul style="list-style-type: none"> • Competition vs. practice (reference) RR = 0.51 (0.31–0.85)
Solgard et al. (1995)	Moderate	N: ? G:males,females A: 11–45 L: Amateur D: Cohort (prospective) F: One years	Musculoskeletal injury: occurring during volleyball activities at a sport area, causing the athlete to consult the casualty wards within 24 hours of the injury. Registration: reported by player (interview)	<ul style="list-style-type: none"> • Arm/shoulder injuries 57%: non-contact jumping 21%: contact bruise object 14%: contact bruise person 7%: acute overwork • Hands/fingers injuries 9%: non-contact jumping 81%: contact bruise object 9%: contact bruise person 2%: acute overwork • Knee injuries 82%: non-contact jumping 18%: acute overwork • Ankle injuries 79%: non-contact jumping 2%: contact bruise object 9%: contact bruise person 10%: acute overwork
Swenson et al. (2010)	Moderate	N: ? G: All females A: High school L: Amateur D: Cohort (prospective) F: Five years	Fracture: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days. Registration: reported by athletic trainer	<ul style="list-style-type: none"> • Competition vs. practice (reference) RR = 0.84 (0.40–1.77) • All injuries: 32.1%: blocking 15.7%: conditioning 11.7%: digging 11.4%: passing 11.3% general play

Swenson et al. (2013)	Moderate	N: ? G: males, females A: High school L: Amateur D: Cohort (prospective) F: Five years	Knee injury: occurring as a result of an organized volleyball practice or competition, requiring medical attention by a team athletic trainers or a physician, and resulting in restriction of the athlete's participation for one or more days. Registration: reported by athletic trainer	<ul style="list-style-type: none"> • Competition vs. practice (reference) Females: RR = 1.75 (1.29–2.38) • Males: 100%: contact with playing surface • Females: 9.2%: contact with another person 42.9%: no contact 34.4%: contact with playing surface 9.2%: overuse/chronic • All injuries: 23.3%: incorrect sprawls 10.8%: wrong techniques 24.7%: step on others' foot 8.9%: ball contact 23.7%: fatigue 5.4%: inappropriate warm-up • Ankle 28%: contact with teammate 31%: contact with opponent 35%: no contact
Tsigganos et al. (2007)	Moderate	N: 72 (12–14), 109 (15–18), 268 (> 18) G: All males A: 13.3, 16.1, 26.7 L: Competitive D: Cohort (prospective) F: One year	Musculoskeletal injury: occurring during scheduled games or practices that cause an athlete to miss a subsequent game or practice session. Registration: reported by player (interview)	
Verhagen et al. (2004)	Low	N: 486 G: 158 males, 261 females A: 23.8–25.2 L: Competitive D: Cohort (prospective) F: One year	Musculoskeletal injury: occurred as a result of volleyball and caused the subject to stop this activity, or resulted in the subject not participating fully in the next planned sports activity. Registration: reported by player and coach	
Visnes and Bahr (2013)	Low	N: 141 G: 69 males, 72 females A: 16.8 L: Amateur D: Cohort (prospective) F: One year	Jumper's knee: a history of pain in the quadriceps or patellar tendons at their patellar insertions in connection with training or competition and tenderness to palpation corresponding to the painful area. Registration: reported by school physician and physiotherapist	<ul style="list-style-type: none"> • Gender (male) + total training volume Gender: OR = 4.03 ($P = .007$) Training volume: OR = 1.61 ($P = .02$) • Gender (male) + volleyball training Gender: OR = 3.65 ($P = .01$) Volleyball training: OR = 1.72 ($P = .005$) • Gender (male) + number of sets Gender: OR = 3.89 ($P = .01$) Sets: OR = 3.88 ($P = .001$) • Gender (male) + volleyball training + number of sets Gender: OR = 3.36 ($P = .02$) Volleyball training: OR = 1.39 ($P = .13$) Sets: OR = 3.21 ($P = .004$) • Gender (male) + volleyball training + previous volleyball training Gender: OR = 2.89 ($P = .058$) Volleyball training: OR = 1.96 ($P = .002$) Previous training: OR = 2.22 ($P = .011$)

(Continued)

Table II: Continued.

Study information	Total risk of bias	Participation and design	Injury definition	Risk factors and mechanism
de Vries et al. (2015)	Low	N: 295 G: 100 males, 195 females A: 25.1 L: Amateur D: Cohort (prospective) F: Three years	Patellar tendinopathy: having pain at the inferior pole of the patella and/or diagnosed by a physician or physical therapist with patellar tendinopathy. Registration: reported by player	<ul style="list-style-type: none"> • Gender (ref = female) OR = 2.6 ($P < .05$) • Age OR = 1.0 ($P > .10$) • Height (5 cm increase) OR = 1.3 ($P < .05$) • Weight (5 kg increase) OR = 1.2 ($P < .05$) • BMI (5 cm increase) OR = 1.0 ($P > .10$) • Playing level (ref = regional) OR = 0.4 ($P > .10$) • Years playing OR = 0.9 ($P < .10$) • Hours training per week (5 hours increase) OR = 1.2 ($P > .10$) • Playing surface (ref = vinyl/rubber) Wood/cork/parquet: OR = 1.1 ($P > .10$) • Training increase compared to last year (ref = no) OR = 0.6 ($P > .10$) • Other sports (ref = no) OR = 1.2 ($P > .10$) • Hours other sports OR = 1.2 ($P > .10$) • Profession (ref = mentally demanding work) Light/mixed physical work: OR = 1.5 ($P > .10$) Heavy physical work: OR = 2.3 ($P < .10$) • Student/other: OR = 1.7 ($P > .10$) • Squatting at work (ref = no) OR = 1.0 ($P > .10$) • Lifting at work (ref = no) OR = 0.7 ($P > .10$) • Jumping at work (ref = no) OR = 2.4 ($P < .05$)

Wang (2001)	Moderate	<p>N: 59 G: All males A: 24.9–27.6 L: Elite D: Cohort (prospective) F: Two year</p>	<p>New shoulder injury: occurred in the shoulder without any existing or history of similar injury. Shoulder re-injury: re-occurred in the shoulder within one month. Shoulder chronic injury: occurred in the shoulder and resulted in more than one month duration, without single traumatic event that caused the injury Registration: reported by coach</p>	All injuries: 87%: spike and serve
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Notes: N, number; G, gender; A, age; L, level of play; D, design; F, follow-up period; RR, relative risk; OR, odd ratio.

(match/training). They also show that men have a higher risk of ankle and knee injuries. All results are presented separately for acute and overuse injuries, as well as for contact and non-contact injuries. Only four articles were found concerning preventive strategies in volleyball (Augustsson et al., 2011; Cumps et al., 2008; Verhagen et al., 2005; Visnes et al., 2005). One of these studies was qualified with a moderate risk of bias (Visnes et al., 2005), leaving only three studies available to represent in the results (Augustsson et al., 2011; Cumps et al., 2008; Verhagen et al., 2005). These studies researched preventive measures concerning musculoskeletal injuries, anterior knee injuries and ankle injuries among volleyball players. These preventive measures all seemed to have a significant effect on decreasing the occurrence of these volleyball injuries.

The four steps of van Mechelen's 'sequence of prevention' model remain widely used when it comes to descriptive epidemiology, aetiology and prevention of sports injury (van Mechelen et al., 1992). In our review, we found that ankle, knee and shoulder injuries were the most common injuries in volleyball. Consequently, one might expect the aetiology of these injuries to have been thoroughly explored in order to develop evidence-based preventive measures. While our review showed that proprioceptive and strength exercises might prevent ankle and knee injuries, the scientific literature emphasises the lack of high-quality volleyball-specific studies on the aetiology of shoulder injuries, as well as the lack of prevention programmes. The Oslo Sports Trauma Research Center (OSTRC) recently developed a Shoulder Injury Prevention Programme to increase glenohumeral internal rotation, external rotation strength and scapular muscle strength, as well as improve kinetic chain and thoracic mobility (Andersson, Bahr, Clarsen, & Myklebust, 2016). The subsequent cluster randomised controlled trial in elite handball players showed a 28% lower risk of shoulder problems and a 22% lower risk of substantial shoulder problems in the intervention group compared with the control group (Andersson et al., 2016). Such an approach should be explored in order to prevent shoulder injuries among volleyball players, starting by identifying the mechanism and risk factors (intrinsic and extrinsic) for volleyball-specific shoulder injuries.

The findings of our systematic review emphasise the lack of integral measures aiming to prevent multiple (location and type) injuries among volleyball players, which is contradictory to the growing body of scientific evidence we have on integral programmes being embedded in the warming-up period. The FIFA11+ injury prevention programme was developed by the Fédération Internationale de Football Association (FIFA) in order to reduce injuries in the lower limbs

Table III: Injuries among volleyball players: prevention.

Study information	Total risk of bias	Population	Injury definition	Preventive programme	Outcome
Augustsson et al. (2011)	Low	N: 27 G: All females A: 16–18 L: Competitive D: comparison between groups over two subsequent seasons	Musculoskeletal injury: occurred as a result of participating in volleyball, forcing the player to leave the court for the rest of the game/training session and/or leading to an absence from or reduction in play lasting one day or more. Registration: reported by coach	Supervised and individualized resistance training during 26 weeks: • familiarization phase during 4 weeks (also for control group): 70% of 1 RM (15 repetitions), 1 training session/week • progression phase 1 during 10 weeks, 80% of 1 RM (10 repetitions), 1 training/week • progression phase 2 during 12 weeks, 90–100% of 1 RM, 2 training/week	• Baseline season: Control: 3.8 inj/1000 hours exposure Intervention: 5.3 inj/1000 hours exposure 13% shoulder; 13% wrist; 47% knee; 13% ankle; 13% lower leg • Intervention season: Control: 3.7 inj/1000 hours exposure Intervention: 0 inj/1000 hours exposure 12% shoulder; 12% thigh; 25% knee; 50% ankle
Cumps et al. (2008)	Low	N: 169 G: 91 males, 78 females A: ? L: Competitive D: comparison between groups over one season	Anterior knee pain: overuse injury that causes physical discomfort in the anterior part of the knee, and pain/stiffness of the musculoskeletal system which has an insidious onset and is present during and/or after volleyball activity for at least three volleyball active days. Registration: reported by player	Twice a week during the practice session in addition to normal training routine: • month 1: isometric strength in open kinetic chain • month 2: isometric strength in closed kinetic chain • month 3: sports-specific skills and plyometrics • month 4: eccentric load exercise	• Pre-post-intervention Control: 0.91 (0.38–2.17) Intervention: 0.86 (0.46–1.60)
Verhagen et al. (2005)	Low	N: 1127 G: 483 males, 644 females A: 24.2–24.4 L: Amateur D: comparison between groups over one season	Ankle injury: caused the subject to stop his or her volleyball activity or caused the subject to not fully participate in the next planned volleyball activity. Registration: reported by player	• 14 basic proprioceptive exercises on and off a balance board during 36 weeks (with variations on each exercise)/exercises using either no material, ball only, balance board only, or both ball and balance board • four exercises a week prescribed to the coach • to carry out during the warm-up • gradual increase in intensity	Acute injury: Control: 0.9 inj/1000 hours of play Intervention: 0.5 inj/1000 hours of play RD = 0.4 ($P < .05$) RR = 0.5 ($P < .05$)
Visnes (2005)	Moderate	N: 29 G: 19 males, 10 females A: 26.4–26.8 L: Elite and competitive D: comparison between groups over six months	Jumper's knee: a history of pain in the quadriceps or patellar tendons at their patellar insertions in connection with training or competition and tenderness to palpation corresponding to the painful area. Registration: reported by clinical physician	Eccentric training programme on a 25° decline board at home. • 3 sets of 15 repetitions twice a day • can be done without warm-up • eccentric component with the symptomatic leg and the concentric component with the asymptomatic leg • two seconds for each eccentric component	• VISA score: No significant difference between control and intervention ($P > .05$). • Counter movement jump: Improvement of 1.2 cm in the intervention group ($P < .05$).

Notes: N, number; G, gender; A, age; L, level of play; D, design; inj, injuries; RR, relative risk; RD, risk difference.

among young and adult footballers (Bizzini & Dvorak, 2015). The FIFA11+ is based on several exercises that are embedded within the warming up (Bizzini & Dvorak, 2015). Several randomised controlled trials have shown that the FIFA11+ was effective in reducing the occurrence of overall and lower-limb injury rates among both young and adult footballers (by up to 50%) (Bizzini & Dvorak, 2015).

In the Netherlands, an integral evidence-based intervention (more than 50 exercises; age- and gender-specific) was developed to prevent musculoskeletal injuries in the lower limbs among youth/adult hockey players (Gouttebarga & Zuidema, 2017). While an effect study is ongoing at the present time, this warming-up programme had a moderate effect on the level of knowledge and skills of hockey coaches/trainers about injury prevention. Analogously, a similar approach could be relevant in volleyball and an integral preventive programme embedded in the warming up might prevent the occurrence of shoulder, knee and ankle injuries.

Furthermore, it is unusual that there is no high-quality data concerning the prevalence of volleyball overuse injuries. However, although, overuse injuries occur gradually and players continue to play with pain, there should be data about the prevalence of volleyball injuries. Also some studies presented other volleyball-specific injuries than ankle, knee and shoulder injuries. We were not able to include these 'other injuries' in our results as these injuries were presented in studies that were scored moderate. More high-quality volleyball-specific studies need to be done on the incidence, prevalence, aetiology and eventually preventive strategies of these injuries. The same applies for shoulder injuries.

Since preventive measures that are represented in this review are shown to have a significant effect (for knee and ankle injuries), we hypothesize that volleyball-specific research concerning preventive strategies against other injuries, will also show a significant effect. The same hypothesis applies for volleyball-specific studies on preventive strategies against shoulder injuries.

Methodological aspect

In our systematic review, no study was scored with a high risk of bias. All the studies were scored with moderate or low risk of bias. Only the articles with a low risk of bias were used for the results to maintain the highest quality as possible. Unfortunately, most of the studies were scored moderate and thus a major part of the found studies are not represented in the results. It was hard to compare and represent the findings in one figure or as one result, since different studies reported the outcome in different descriptive

injury rates, such as injuries per 1000 hours per player (Bahr & Bahr, 1997; Bere et al., 2015; Verhagen et al., 2004, 2005), injuries per 1000 hours exposure (Augustsson et al., 2011; Bahr et al., 2003; Vauhnik et al., 2011), injuries per 10,000 exposures (de Loes et al., 2000) and injuries per 1000 athlete exposures (Barber Foss et al., 2014). Ideally, all studies should use the same descriptive injury rates to enable studies and their results to be compared with each other.

A potential limitation worth mentioning is that we did not include studies based on a cross-sectional or retrospective design. We are aware that these studies might be largely published in the scientific literature but we chose to focus exclusively on high-quality studies in order to formulate valid answers to our research questions. With regard to the use of a highly sensitive search strategy and the screening of the references of included studies and/or retrieved literature reviews, we remain confident that our review presents a thorough overview of the available scientific literature related to the incidence, aetiology and prevention of musculoskeletal injuries in volleyball.

Implications for practice and further research

Our findings show that three different volleyball-specific preventive strategies have a significant effect on musculoskeletal volleyball injuries. This means that effective preventive strategies are of great importance to reduce the numbers of musculoskeletal injuries in volleyball. Even though shoulder injuries are also a common injury in volleyball, no volleyball-specific preventive measures seem available for the prevention of shoulder injuries, as can be seen in Figure 1. As knee and ankle injuries are not the only injuries occurring in volleyball, more high-quality aetiological studies concerning preventive strategies regarding other volleyball-specific musculoskeletal injuries, especially shoulder injuries, are needed. In order to develop effective preventive strategies for volleyball-specific injuries, such as volleyball-specific shoulder injuries, more data about the aetiology of these injuries is needed. As can be seen in Figure 1, a lack of volleyball-specific high-quality studies concerning the aetiology in shoulder injuries persists and should be a focus for future studies. Subsequently, volleyball-specific preventive strategies regarding these injuries should be developed and researched in effect studies, after which proper strategies, about implementing these preventive programmes, should be chosen. In Appendix 3 wherein the scores of the risk of bias assessment can be found, can be seen that most studies score moderate especially on the items attribution (23 of 30), confounding (16 of 30) and participation (13 of 30). In order to improve the quality especially these items should be a focus for future studies.

Conclusion

Volleyball injuries occur very often. However, while preventive strategies have been shown to be successful, there are surprisingly few data available on this matter. Our systematic review showed that musculoskeletal injuries are common among volleyball players, while effective preventive measures remain scarce. Much more research needs to be done on preventive strategies regarding volleyball injuries, but these can only be done if there is enough significant evidence concerning the incidence, prevalence and aetiology of volleyball-specific injuries. The lack of this kind of data makes it hard to develop preventive strategies. Furthermore, high-quality studies on the aetiology and prevention of shoulder injuries are lacking and should also be a focus of future studies. Lastly, studies should focus on other specific injuries besides the most common knee and ankle injuries, and should report the prevalence and not only the incidence.

Disclosure statement

No potential conflict of interest was reported by the authors.

Supplemental data

Supplemental data for this article can be accessed here at <http://dx.doi.org/10.1080/17461391.2017.1306114>.

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Appendix 1. Search strategy.

Medline via Pubmed

#1 = Wounds and Injuries[Mesh] OR Epidemiology[Mesh] OR Prevalence[Mesh] OR Incidence[Mesh] OR Population[Mesh] OR injur* OR epidemiol* OR preval* OR inciden* OR occur* OR propor* OR distribut* OR populat* OR Causality[Mesh] OR Risk Factors[Mesh] OR caus* OR etiolog* OR aetiolog* OR mechanism* OR risk factor* OR predispos* OR Primary Prevention OR Secondary Prevention OR prevent* OR intervent*

#2 = Volleyball[Mesh] OR volleyball[tiab]

#3 = #1 AND #2

SPORTDiscus via EBSCOhost.

#1 = TX (injur* OR caus* OR epidemiol* OR etiolog* OR aetiolog* OR mechanism* OR preval* OR inciden* OR occur* OR propor* OR distribut* OR populat* OR risk factor* OR predispos* OR prevent* OR intervent*)

#2 = TI volleyball* OR AB volleyball*

#3 = #1 AND #2

Appendix 2. Risk of bias assessment.

Quality in Prognosis Studies (QUIPS)

1. Study participation

- Description of the source population or population of interest
- Description of the baseline study sample
- Adequate description of the sampling frame and recruitment
- Adequate description of the period and place of recruitment

2. Study attrition

- Adequate response rate for study participants
- Description of attempts to collect information on participants who dropped out
- Reasons for loss to follow-up are provided
- There are no important differences between participants who completed the study and those who did not

3. Prognostic factor (PF) measurement

- A clear definition or description of the PF is provided
- Method of PF measurement is adequately valid and reliable
- The method and setting of measurement of PF is the same for all study participants
- Adequate proportion of the study sample has complete data for the PF

4. Outcome measurement

- A clear definition of the outcome is provided
- Method of outcome measurement used is adequately valid and reliable
- The method and setting of outcome measurement is the same for all study participants

5. Study confounding

- All important confounders are measured
- Clear definitions of the important confounders measured are provided
- Measurement of all important confounders is adequately valid and reliable

- The method and setting of confounding measurement are the same for all study participants
- Important potential confounders are accounted for in the analysis

6. Analysis and reporting

- Sufficient presentation of data to assess the adequacy of the analytic strategy
- The selected statistical model is adequate for the design of the study
- There is no selective reporting of results

Cochrane Collaboration's tool

1. Sequence generation

- Describe the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.

2. Allocation concealment

- Describe the method used to conceal the allocation sequence in sufficient detail to determine whether intervention allocations could have been foreseen in advance of, or during, enrolment.

3. Blinding of participants, personnel and outcome assessors

- Describe all measures used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. Provide any information relating to whether the intended blinding was effective.

4. Incomplete outcome data

- Describe the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. State whether attrition and exclusions were reported, the numbers in each intervention group (compared with total randomized participants), reasons for attrition/exclusions where reported, and any re-inclusions in analyses performed by the review authors

5. Selective outcome reporting

- State how the possibility of selective outcome reporting was examined by the review authors, and what was found.

6. Other sources of bias

- State any important concerns about bias not addressed in the other domains in the tool. If particular questions/entries were pre-specified in the review's protocol, responses should be provided for each question/entry.

Appendix 3. Results of the risk of bias assessment.

Descriptive epidemiology of volleyball injuries							
Study	Participation	Attribution	Prognostic	Outcome	Confounding	Analysis	Total risk of bias
Agel et al. (2007)	Low	Moderate	N/a	Low	Moderate	Low	Moderate
Bahr and Bahr (1997)	Low	Moderate	Low	Low	Moderate	Low	Low
Bahr et al. (2003)	Low	Low	N/a	Low	N/a	Low	Low
Barber Foss et al. (2014)	Low	Low	N/a	Low	N/a	Low	Low
Beneka et al. (2007)	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Beneka et al. (2009)	Low	Moderate	N/a	Moderate	N/a	Moderate	Moderate
Bere et al. (2015)	Low	Low	Low	Low	Moderate	Moderate	Low
Beynnon et al. (2014)	Low	Low	N/a	Moderate	N/a	Moderate	Moderate
Bonza et al. (2009)	Moderate	Moderate	N/a	Low	N/a	Low	Moderate
de Loes et al. (2000)	Moderate	Low	N/a	Low	N/a	Low	Low
Fernandez et al. (2007)	Moderate	Moderate	N/a	Low	N/a	Low	Moderate
Junge et al. (2006)	Moderate	Low	N/a	Low	N/a	Low	Low
Kujala et al. (1995)	Moderate	Moderate	N/a	Low	N/a	Low	Moderate
Lanese et al. (1990)	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Malliou et al. (2008)	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Nelson et al. (2007)	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Rechel et al. (2008)	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Rechel et al. (2011)	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Reeser et al. (2015)	Moderate	Moderate	N/a	Low	N/a	Low	Moderate
Robinson et al. (2014)	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Solgard et al. (1995)	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Swenson et al. (2010)	Moderate	Moderate	Low	Low	Moderate	Low	Moderate
Swenson et al. (2013)	Moderate	Moderate	Low	Low	Moderate	Low	Moderate
Tsigganos et al. (2007)	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Vauhnik et al. (2011)	Low	Moderate	N/a	Low	N/a	Low	Low
Verhagen et al. (2004)	Low	Moderate	Low	Moderate	Low	Low	Low
Wan g and Cochrane (2001)	Low	Moderate	Moderate	Low	Moderate	Low	Moderate
Zetou et al. (2006)	Low	Moderate	N/a	Moderate	N/a	Moderate	Moderate
Aetiology of volleyball injuries							
Agel et al. (2007)	Low	Moderate	N/a	Low	Moderate	Low	Moderate
Bahr and Bahr (1997)	Low	Moderate	Low	Low	Moderate	Low	Low
Beneka et al. (2007)	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Bere et al. (2015)	Low	Low	Low	Low	Moderate	Moderate	Low
Malliou et al. (2008)	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Rechel et al. (2008)	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Rechel et al. (2011)	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Robinson et al. (2014)	Moderate	Moderate	Moderate	Low	Moderate	Low	Moderate
Solgard et al. (1995)	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Swenson et al. (2010)	Moderate	Moderate	Low	Low	Moderate	Low	Moderate
Swenson et al. (2013)	Moderate	Moderate	Low	Low	Moderate	Low	Moderate
Tsigganos et al. (2007)	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Verhagen et al. (2004)	Low	Moderate	Low	Moderate	Low	Low	Low
Visnes (2013)	Low	Low	Low	Low	Moderate	Low	Low
de Vries et al. (2015)	Low	Moderate	Low	Moderate	Low	Low	Low
Wang (2001)	Low	Moderate	Moderate	Low	Moderate	Low	Moderate
Prevention of volleyball injuries							
Study	Sequence	Allocation	Blinding	Incomplete	Selective	Other	Total risk of bias
Augustsson et al. (2011)	1	1	0	1	1	1	Low
Cumps (2008)	1	1	0	1	1	1	Low
Verhagen et al. (2005)	1	1	0	1	1	1	Low
Visnes (2005)	1	1	0	0	1	1	Moderate