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Preventing injuries among recreational adult volleyball players: Results of a prospective randomised controlled trial

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ABSTRACT

The objective was to evaluate the effectiveness of an exercise-based warm-up programme ("VolleyVeilig") on the one-season occurrence of musculoskeletal injuries among recreational adult volleyball players. A prospective randomised controlled trial was conducted over the 2017–2018 volleyball season. Recreational adult volleyball players were allocated either to an intervention or control group. The Dutch version of the Oslo Sports Trauma Research Centre questionnaire was used to register and monitor acute and overuse injuries. A total of 672 volleyball players were enrolled: 348 in the intervention group (mean age: 30) and 324 in the control group (mean age: 27). The incidence rate of acute injury was 21% lower in the intervention group, namely 8.9 versus 11.3 per 1,000 h in the control group (Cox mixed effects crude model: hazard ratio = 0.82 [95%CI: 0.69–0.98]; Cox mixed effects adjusted model: 0.85 [95% CI: 0.71–1.02]). No significant difference in mean prevalence of overuse injury was found between the intervention (4.8%) and control (4.2%) groups. The severity of injuries was not significantly different between groups, while injury burden was slightly lower in the intervention group. The exercise-based warm-up programme led to a trend in less acute injuries among recreational adult volleyball players.

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KEYWORDS
Volleyball; musculoskeletal injuries; prevention; prospective controlled trial

Introduction

Volleyball, one of the most popular sports in the world, is associated with a risk of musculoskeletal injuries (Fédération Internationale de Volleyball, 2018; Kilic, Maas, Verhagen, Zwerver, & Gouttebarge, 2017). The incidence of injuries among volleyball players ranges from 1.7 to 10.7 injuries per 1,000 h of play, occurring mostly in the ankles, knees and shoulders (Kilic et al., 2017). Every season in the Netherlands, around 25% of the recreational volleyball players get injured (about 29,000 injured players per season), while the incidence rate reaches up to 5.7 injuries per 1,000 hours (Dutch Consumer Safety Institute, 2015). Being either acute or overuse, these injuries in recreational volleyball players lead to substantial direct and indirect costs and are likely to induce impairments in daily life, sport and/or work (De Vries et al., 2017; Dutch Consumer Safety Institute (VeiligheidNL), 2015; Verhagen, van Tulder, van der Beek, Bouter, & van Mechelen, 2005).

In order to prevent or reduce the number of injuries among volleyball players, an exercise-based warm-up programme was developed in the Netherlands (Gouttebarge, van Sluis, Verhagen, & Zwerver, 2017). Although similar exercise-based programmes were found to be effective in reducing football (soccer) and rugby injuries, the necessary next step according to the Van Mechelen's "sequence of prevention" model is to evaluate the effectiveness of this specific volleyball programme (Hislop et al., 2017; Thorborg et al., 2017; Van Mechelen, Hlobil, & Kemper, 1992). Therefore, the primary objective of our study was to evaluate the effectiveness of an exercise-based warm-up programme on the one-season occurrence of injuries (acute and overuse) among recreational adult volleyball players. A secondary objective was to evaluate the effectiveness of the programme on the severity and burden of such injuries on players' availability to play.

Materials and methods

Study design

A prospective randomised controlled trial was conducted over the 2017–2018 volleyball season (September 2017 – April 2018). For practical reasons, and to avoid any contamination and competitive bias within a competition region, the two largest competition regions in the Netherlands (West and East) were selected for the study and randomly assigned to an intervention and a control region by tossing a coin. Ethical approval was provided by the Medical Ethics Review Committee of the Academic Medical Center (W17_048#17.065; Amsterdam, The Netherlands). The study protocol was published elsewhere and registered in the Dutch Trial Registry (ID: NTR6202) (Gouttebarge, Zwerver, & Verhagen, 2017).

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Participants and teams' recruitment

Participants were recreational adult volleyball players. Inclusion criteria were: (i) 18 years of age or older; (ii) playing in a volleyball team competing recreationally in one of the two competition regions involved in the study (West or East); (iii) practising volleyball (training and/or match) at least twice a week; (iv) speaking and reading Dutch fluently; (v) owning an email address. Between March and May 2017, eligible teams (N = 2,797) were contacted by the Dutch Volleyball Federation (Nevobo) and received detailed information about the purpose of the study and the procedures involved. Teams willing to be enrolled in the study were asked to sign in before the end of the 2016–2017 volleyball season. (Beforethe start of the 2017–2018 volleyball season (August 2017), coaches of the enrolled teams were invited to explanatory group meetings during which they received additional information about the purpose and procedures of the study (also additional written information to give to their players). After these explanatory group meetings, teams were informed about their study group allocation. Coaches and players of the enrolled teams gave their informed consent, agreeing then to participate voluntarily in the study.

Sample size

Analogous to previous studies concerning the effectiveness of preventive interventions in volleyball and in other sports, the assumption was that a 40% reduction in acute injury would be achieved over one season in the intervention group compared to the control group (Andersson, Bahr, Clarsen, & Myklebust, 2017; Thorborg et al., 2017; Verhagen et al., 2004). To achieve 80% power with a significance level of 0.05, an injury prevalence estimation of 0.25 in the control group and a loss to follow-up among players of 15% over one season, the sample size calculation revealed that 640 volleyball players were needed in the study (Dutch Consumer Safety Institute (VeiligheidNL), 2015). Consequently, we strived to enrol at least 64 teams (average of 10 players per team) assigned either to the intervention or the control group (with an equal number of 32 teams in each group). To anticipate potential loss to follow-up, the recruitment of teams was ended after the enrolment of around 70 teams.

Intervention group – an exercise-based warm-up programme

The intervention, called "VolleyVeilig", was developed as an exercise-based warm-up programme aiming to prevent or reduce the number of acute and overuse injuries (focus on shoulder, knee and ankle injuries) among adult recreational volleyball players (Gouttebarge et al., 2017). The warm-up programme lasts 15 min and is divided into a preparatory cardiovascular warm-up (i.e., lasting 2 to 3 min), core stability exercises (i.e., lasting 2 to 3 min; for instance, straight plank), exercises principally directed towards the prevention of knee injuries (i.e., lasting 4 to 5 min; for instance, squats), and exercises principally directed at preventing shoulder injuries (i.e., lasting 4 to 5 min; for instance, external rotation strength with resistance elastic). The exercises directed at preventing ankle injuries (i.e., lasting 2 to 3 min; for instance, one legged stance) are also embedded within the warm-up programme. The intervention was available (in Dutch) only for the intervention group via a website (https://www.volleyveilig.nl/) and an application for smartphone/tablet (secured access with password). Information and instructions about the exercises are available as texts and videos (including voice-over). Illustrations of the application for smartphone/tablet are presented in Figure 1. The systematic development, feasibility assessment and full description of the intervention are published elsewhere (Gouttebarge et al., 2017).

Control group – volleyball as usual

The teams and players in the control group did not have access to the intervention and were asked to perform their warming-up and volleyball activities as usual.

Measurements

Baseline characteristics

Players enrolled in the study completed a baseline questionnaire including the following descriptive variables: age, sex, height and weight. Players were also asked to report whether they had incurred an injury in the previous 3 months. An online form (2 min) was compiled and sent by email, which was anonymously coded for privacy reasons.

Exposure to volleyball activities

Every 2 weeks during the 2017–2018 volleyball season, coaches were asked to retrospectively report the participation of each player for each training and match (hours of volleyball exposure). For this purpose, an online form (2 min) sent by email was used (anonymously coded for privacy reasons). If no response was received within 4 days, a reminder was sent to coaches.

Injuries

Every 2 weeks during the 2017–2018 volleyball season, players were asked to complete the translated and modified Dutch version of the Oslo Sports Trauma Research Centre (OSTRC) questionnaire on health problems (Clarsen et al., 2015; Clarsen, Rønsen, Myklebust, Flørenes, & Bahr, 2014). The OSTRC questionnaire has been proposed and validated to register and monitor sports-related health problems over time, including injuries (Clarsen, Myklebust, & Bahr, 2013). In our study, an injury was defined as any physical complaint sustained by a player during a volleyball activity (training or match) that resulted in the player stopping his or her volleyball activity, irrespective of the need for medical attention or subsequent time-loss from volleyball activities (Bahr, 2009; Fuller et al., 2007). For the registration of injury, an online form (up to 2 min) was sent by email (anonymously coded for privacy reason), allowing the report of injury details such as body location, injury type and nature, and time-loss days (i.e., number of training and match days between injury and return to full participation). If no response was received within 4 days, a reminder was sent to players. An injury was classified to as an acute injury when resulting from a sudden and identifiable

Figure 1. Illustrations of VolleyVeilig.

event, or as an overuse injury when resulting from a non-sudden, non-specific and non-identifiable event (i.e., gradual onset) (Bahr, 2009; Fuller et al., 2007).

Adherence to the intervention

During the 2017–2018 volleyball season, coaches allocated to the intervention group were asked to keep track with their adherence to the intervention (McKay & Verhagen, 2016). The coaches' self-reported adherence was retrieved after the first half of the season and at the end of the season through an online form sent by email (anonymously coded for privacy reasons), adherence being operationalised as high (i.e., always or almost always using "VolleyVeilig" prior to volleyball activities), medium (i.e., sometimes using "VolleyVeilig" prior to volleyball activities) and low (i.e., barely using "VolleyVeilig" prior to volleyball activities) levels of adherence.

Statistical analysis

Data processing was performed in R version 3.4.1 and Microsoft® Excel® 2010 version 14.0, while data analyses were conducted with the R software and IBM SPSS Statistics 23.0 for Windows. Players' baseline characteristics were analysed for differences between the intervention and control groups by means of Mann–Whitney tests (variables: age, height, weight) and Pearson's chi-squared (variables: sex, previous injury) (Woodward, 2013).

Total, training and match incidence rate of acute injury (and its 95% Confidence Interval, 95%CI) were calculated in the intervention and control groups by dividing the number of acute injuries, including players' subsequent injuries (identified within a single athlete by a unique athlete code), reported during the follow-up by the sum of volleyball exposure in hours until the injury and multiplying the result by 1,000 (Fuller et al., 2006). Difference in incidence rate of acute injury between the intervention and control groups was assessed using Cox mixed effects models (crude; in the case of pre-existing differences between groups adjusted for age, sex and/or previous injury because those are known risk factors for injury) (Kilic et al., 2017; Woodward, 2013). Applying the intention-to-treat principle, the Cox mixed effects models (adjusted for team clustering) accounted for the number of player-specific hours spent on volleyball until the first injury and, after recovery, the hours spent until the second injury, and so on, if applicable. Prevalence (expressed as a percentage) of overuse injuries repeatedly measured over time was calculated for each 2-week period in both study groups by dividing the number of participants reporting an overuse injury during that period by the total number of responding participants during the same period (Clarsen et al., 2014). Subsequently, mean (and standard deviation, SD) prevalence (2-week) of overuse injury over the 2017–2018 volleyball season was calculated by dividing the sum of all 2-week prevalences by the number of 2-week periods. Difference in mean prevalence of overuse injury between the intervention and control groups was assessed using an independent T-test (Woodward, 2013).

Severity of injury was expressed as the number of time-loss days (i.e., cumulative days of non-full participation in volleyball activities) due to acute and/or overuse injury, summarised in the intervention and control groups as median and range (Fuller, Bahr, Dick, & Meeuwisse, 2007). Difference in severity of injury between the intervention and control groups was assessed using an independent T-test (Woodward, 2013). The injury burden (acute and overuse) on players' availability to play was operationalised as the number of cumulative time-loss days due to injury per 1,000 h of volleyball exposure, summarised in the intervention and control groups as mean and related 95%CI (Bahr, Clarsen, & Ekstrand, 2017).

Results

Participants' characteristics and volleyball exposure

A total of 672 volleyball players from 73 teams (64 coaches) provided consent forms and were enrolled in the study: 348 players from 37 teams (30 coaches) allocated to the intervention group and 324 players from 36 teams (34 coaches) allocated to the control group. The flowchart of the enrolled participants is shown in Figure 2, while Table 1 presents the baseline characteristics of the intervention and control groups as well as the summary of their total exposure to volleyball activities. Significant differences were found between the intervention and control groups for age (intervention group older) and sex (more male players in the intervention group). During the whole 2017–2018 volleyball season, the total exposure in hours was 28,654 in the intervention group and 25,479 in the control group.

Acute and overuse injuries

The incidence rate of acute injury was 21% lower in the intervention group, namely 8.9 (95%CI: 7.8–10.0) versus 11.3 (95%CI: 10.0–12.6) per 1,000 h in the control group. The Cox mixed effects crude model showed that the incidence rate of acute injuries (training and match) was significantly lower in the intervention group than in the control group (hazard ratio = 0.82 [95%CI: 0.69–0.98]). Other mixed effects Cox models (e.g., adjusted for age and sex) showed no significant differences between study groups (Table 2). Mean prevalence (2-week) of overuse injuries was 4.8% (95%CI: 2.18–6.44) and 4.2% (95%CI: 1.88–6.15) in the intervention and control groups, respectively. No significant difference in the mean prevalence of overuse injury was found between the intervention and control groups.

Severity and burden of injuries

The injuries (acute and overuse) in the intervention group led to 3,217 days of volleyball time-loss, with a median severity of 1 day of time-loss (range: 194). The injuries (acute and overuse) in the control group led to 2,934 days of volleyball time-loss, with a median severity of 1 day of time-loss (range: 117). The severity of injuries was not significantly different between the intervention and control groups ($p = 0.16$). The injury burden on players' availability to play was slightly lower in the intervention group than in the control group, namely 112.3 (95% CI 92.1–132.5) versus 115.2 (95% CI 91.0–139.3) days per 1,000 h.

Adherence to the intervention

Coaches allocated to the intervention group reported that their teams used VolleyVeilig during the 2017–2018 volleyball season prior to 73% of all volleyball activities on average (72% in the first half of the season; 76% in the second half of the season). Three teams (8%) reported a low level of adherence (barely using VolleyVeilig), nine (24%) a medium level of adherence (sometimes using VolleyVeilig), and 25 (68%) a high level of adherence (always or almost always using VolleyVeilig).

Discussion

Our prospective randomised controlled trial conducted over one volleyball season among a total of 672 recreational adult volleyball players showed that the exercise-based warm-up programme ("VolleyVeilig") led to a trend in less acute injuries (15–18%) in the intervention group compared to the control group. No difference between groups was found in the prevalence of overuse injuries, nor for severity and burden of injuries on players' availability to play.

The reduction for acute injuries was less than the reduction assumed originally, being potentially explained by the different levels of sport of the study populations (recreational in our study versus highly competitive in other studies) (Andersson et al., 2017; Verhagen et al., 2004). The reduction of acute injuries reached in our study is also less than the reduction achieved

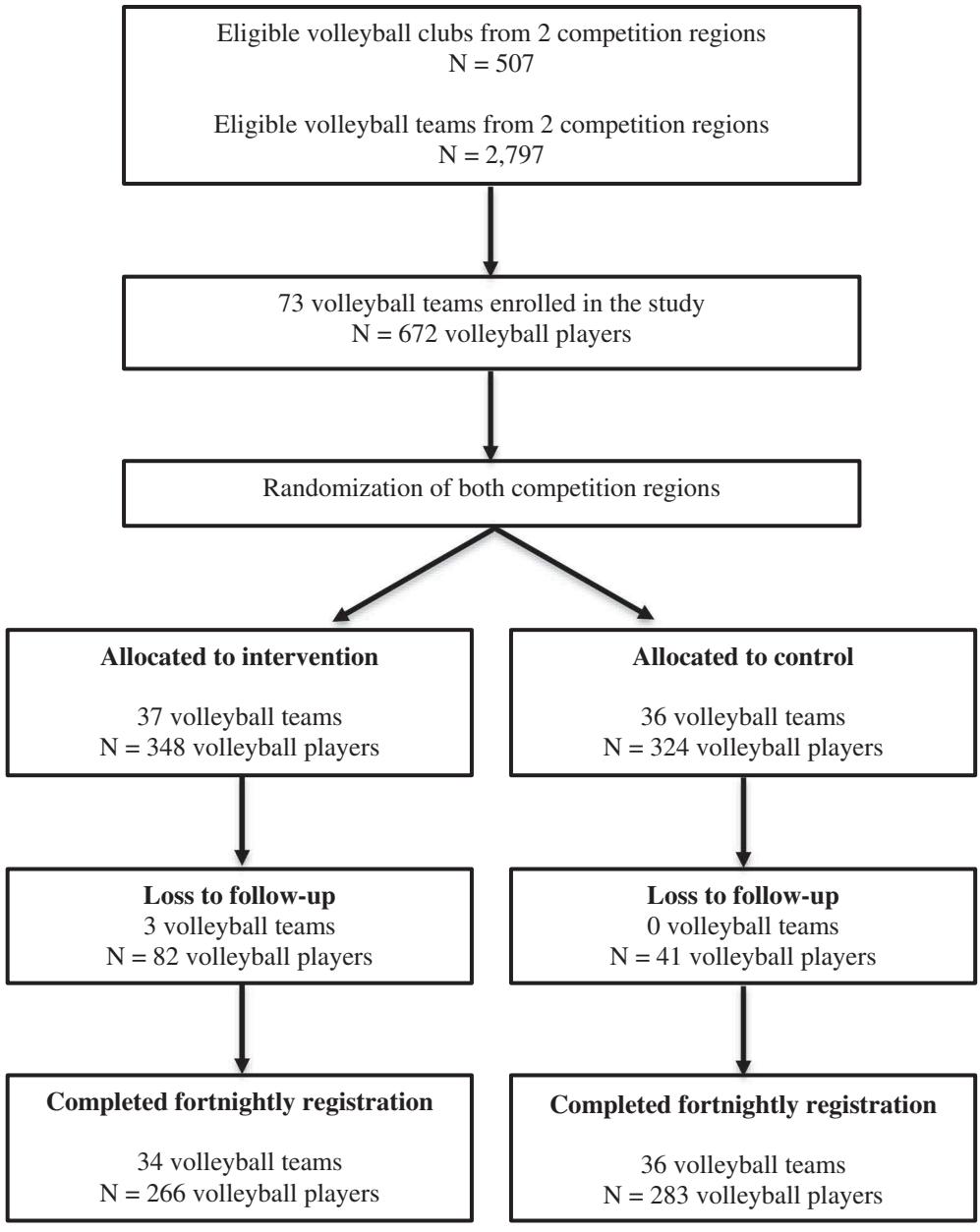

Figure 2. Flowchart of participants in the prospective controlled trial.

Table 1. Baseline characteristics of the intervention and control groups.

	Intervention group	Control group
Number of teams/players	37/348	36/324
Age (years; mean ± SD) *	30 ± 11	27 ± 10
Sex (male/female; %) *	38/62	24/76
Height (cm; mean ± SD)	175 ± 28	176 ± 22
Weight (kg; mean ± SD)	74 ± 13	73 ± 12
Exposure to volleyball (hours)		
Total	28,654	25,479
Training	18,545	15,761
Match	10,109	9,718
Injured in the previous 3 months (%)	42	36

SD, standard deviation; %, percentage; cm, centimetre; kg, kilogram
* difference between the intervention and control groups ($p < .05$).

with similar exercise-based programmes in other sports. A movement control exercise programme was found to reduce overall match injury incidence (72%) in youth rugby players, the 11+ injury prevention programme (originally from the Fédération Internationale de Football Association; FIFA) was shown to reduce the overall injury risk ratio by 39%, and the Warming-Up Hockey was found to lead to 36% reduction in injury rate in youth field hockey players (Barboza et al., 2019; Gouttebarge & Zuidema, 2018; Hislop et al., 2017; Thorborg et al., 2017). However, the aforementioned studies concern contact sports, which are in essence different to volleyball. The smaller reduction of acute injuries achieved through "VolleyVeilig" does not seem to be linked to compliance with the programme. The coaches in the intervention group reported an average compliance of 73% during the 2017–2018 volleyball season, with 25 out of the 37 teams classified as highly compliant (e.g., always or almost always using "VolleyVeilig"). Such a substantial compliance seems higher than the compliance found in other studies, for instance in football and handball with compliance rates ranging from 13% to 53% (Andersson

Table 2. Acute and overuse injuries: comparison between the intervention and control groups.

	Intervention group	Control group	Comparison	
	Incidence rate (95%CI)[†]		*Crude HR (95%CI)*	*Adjusted HR (95%CI)*[‡]
Acute injuries				
Total	8.9 (7.8–10.0)	11.3 (10.0–12.6)	0.82 (0.69–0.98)	0.85 (0.71–1.02)
Training	5.3 (4.3–6.4)	6.7 (5.5–8.0)	0.86 (0.64–1.14)	0.90 (0.67–1.22)
Match	7.0 (5.4–8.6)	8.1 (6.3–9.9)	0.89 (0.63–1.25)	0.84 (0.58–1.20)
	Mean prevalence (SD)			
Overuse injuries	4.8 (2.5)	4.2 (3.1)	p > .05	

95%CI, 95% Confidence Interval; HR, hazard ratio; SD, Standard deviation
[†]number of injuries per 1,000 h
[‡]Adjusted for age and sex

et al., 2017; Thorborg et al., 2017). However, one should keep in mind that: (i) the definition of compliance differs between studies; and (ii) compliance in our study was self-reported. An explanation for the smaller injury reduction found in our study might be that the coaches enrolled in the control group were already using injury-preventive strategies within their training routines (information not collected). Another explanation might be that some injuries occurred as a consequence of risk factors that could not be addressed within the exercise-based warm-up programme ("VolleyVeilig"), for instance landing on opponent's foot close to the net (nearly 20% of reported injuries occurred while landing).

The incidence rate of acute injury found in the intervention and control groups was 8.9 (95%CI: 7.8–10.0) and 11.3 (95%CI: 10.0–12.6) per 1,000 h, respectively. This is higher than most incidence rates reported in the literature. The systematic review of Kilic et al. (2017) mentioned several studies with incidence rates ranging from 0.5 to 6.5 per 1,000 h in amateur/recreational volleyball (Kilic et al., 2017). The potential explanation is that injuries in our study were self-reported through the OSTRC questionnaire, allowing all physical complaints to be recorded even if the only complaint is mild pain (Clarsen et al., 2013). Two other potential explanations might be that our study population was more prone to injury because: (i) it included more older volleyball players than in other studies (mean age: 30 years ± 10); and (ii) 35–40% reported that they had an injury in the 3 months prior to baseline (an injury being a risk factor for subsequent injury). In both study groups, acute injuries were reported mostly in the knees, ankles, fingers and shoulders, which concurs with the existing literature (Dutch Consumer Safety Institute (VeiligheidNL), 2015; Kilic et al., 2017). The mean prevalence of overuse injuries in our study groups was around 4.5%, which is lower than in the prevalence rates reported in other studies in volleyball and other team sports (Barboza et al., 2019; Clarsen et al., 2015).

Methodological considerations

Three main methodological limitations should be considered when interpreting the findings of the present study. Firstly, while the chosen design (i.e., prospective randomised controlled trial) fitted our objectives adequately and had already been used in a previous volleyball study, the randomisation was conducted at competition regions level in order to prevent bias in the Dutch volleyball competitions (Verhagen et al., 2004). Ideally, the randomisation should have been conducted at club or team level. Secondly, one might question the validity of the injury, exposure and adherence data collected as these were self-reported by either players or coaches. Injury data collected by medical staff members have been accepted as the gold standard in most epidemiological standards across sports (Bahr, 2009; Fuller et al., 2006, 2007; Pluim et al., 2009). Although the OSTRC questionnaire, completed in our study by volleyball players, has been validated to register and monitor injuries over time, it is likely that this fortnightly self-reported collection of injury data might have led to some level of recall bias (Clarsen et al., 2013). However, this method has been used successfully in a variety of studies on health surveillance since it captures health problems regardless of their consequences (e.g., medical attention or sport time loss). Additionally, Bolling, Delfino Barboza, van Mechelen, and Pasman (2018) mentioned that athletes' perception of a sports injury is influenced by contextual factors and therefore might differ within a group of participants (Bolling et al., 2018). With regard to exposure and adherence, one might suggest that random observations could have offered the possibility of checking the data self-reported by volleyball coaches. Lastly, we did not record what volleyball coaches and players in the control group did with regard to injury prevention. This information might have been useful when interpreting the results of our study but these reflect the real-world volleyball context in the Netherlands. A particular strength of our study was the relatively easy enrolment of the participants, while loss-to-follow-up during the volleyball season was very limited (three teams lost in the intervention group and none in the control group).

The exercise-based warm-up programme ("VolleyVeilig") led to a trend in less acute injuries among recreational adult volleyball players. No reduction was found for overuse injury, while injury burden on players' availability to play was slightly lower in the intervention group. The exercise-based warm-up programme ("VolleyVeilig") should be implemented in recreational adult volleyball in order to reduce acute injuries. According to the latest scientific standards, such an implementation should be thoroughly planned and an evaluation should be conducted according to the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) Sport Setting Matrix (SSM) framework (Finch, 2006; Finch & Donaldson, 2010). In addition to its implementation in recreational adult volleyball, the content of the exercise-based warm-up programme should be improved, while its effectiveness should be explored among youth volleyball players.

Acknowledgments

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Disclosure statement

VG, JZ and EV were involved in the development of "VolleyVeilig" in partnership with the Dutch Volleyball Federation (Nevobo). VG was employed as consultant by the Dutch Consumer Safety Institute, which owns "VolleyVeilig" together with the Dutch Volleyball Federation (Nevobo). SDB has no conflicts of interest to declare. The study was partly funded by the Netherlands Organisation for Health Research and Development (ZonMw).

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