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Descriptive study on injuries and illness in Dutch female adolescent and young adult handball players

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ABSTRACT

Objective This study describes the magnitude and burden of injuries and illnesses in elite Dutch female adolescent and young adult handball players.

Design A retrospective open cohort study.

Methods 10 consecutive seasons were studied using a database including all injuries and illnesses needing medical attention. In total, 102 handball players, who participated in a full-time programme of the Dutch Handball Academy between August 2009 and July 2019, were included. Injuries were classified according to the consensus statement of the International Olympic Committee. Exposure hours were categorised into training and competition exposure. Training exposure included all handball and strength and conditioning sessions. Burden was defined as the injury duration in days divided by the total exposure hours.

Results In total, 916 injuries in 101 players and 95 illnesses in 59 players were reported. The average seasonal prevalence was 83.2% for acute injuries and 78.7% for repetitive injuries. The overall incidence rate was 4.24/1000 exposure hours with an incidence of 23.06/1000 competition hours and 2.19/1000 practice hours. The highest average seasonal prevalence and burden were observed for repetitive injuries of the lumbosacral spine, knee and lower leg and acute injuries of the ankle and knee.

Conclusion High injury prevalence proportions and competition incidence rates were observed. Repetitive injuries of the lumbosacral spine, knee and lower leg, as well as acute injuries of the knee and ankle, formed the largest problem. Future prevention programmes in elite Dutch adolescent and young adult female handball players should therefore focus on these injuries.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Injury rates in handball are high due to high physical demands of the sport, together with the high training load and high match intensity.

WHAT THIS STUDY ADDS

⇒ High overall injury prevalence proportions and high competition incidence rates over 10 consecutive seasons were observed in elite Dutch female adolescent and young adult handball players.

⇒ Repetitive injuries of the lumbosacral spine, knee and lower leg and acute injuries of the ankle and knee formed the largest problem.

⇒ Magnitude and burden of specific injury groups have been identified.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides insight into the specific injury patterns in Dutch adolescent and young adult female handball players, creating a starting point for context-specific prevention programmes.

⇒ Future prevention programmes in elite Dutch adolescent and young adult female handball players should focus on the lumbosacral spine, knee, ankle and lower leg.

INTRODUCTION

Handball has grown to become a very popular Olympic team sport.[1] Handball is known for its dynamic character, combined with a requirement of players' physical coordination and complex playing techniques.[2] Furthermore, physical contact is, more than in other team sports, allowed in one-on-one situations. This complex of physical demands, together with high training loads and high match intensity, leads to high injury rates.[2]

Injury rates vary in literature due to different study designs. Nevertheless, competition injury rates seem to be higher than training injury rates.[3] Furthermore, competition injury rates seem to be higher in elite compared with amateur players, higher in senior compared with youth players and higher in male youth players compared with female youth players.[3 4] However, injuries among female handball players are associated with significant time loss, which negatively impacts individual and team performance.[4–6] Consequently, female handball athletes represent a key target group for injury prevention. Moreover, female youth handball athletes may be of even greater significance due to the considerable potential of their future careers.[4–6] Although several epidemiological studies have been conducted, many

lack context-specific data on injuries in Dutch elite female adolescent and young adult handball players.[4] Context-specific information is essential for this group of athletes, as it facilitates the development of tailor-made interventions to prevent handball injuries in Dutch female adolescent and young adult handball players.[7 8] To our knowledge, no previous epidemiological studies on Dutch adolescent female handball players have been conducted. Therefore, this study aims to describe the magnitude and burden of injuries in elite Dutch female adolescent and young adult handball players.

METHODS

Study design and population

We performed a retrospective analysis covering 10 seasons of injuries and illnesses registered in the Handball Academy medical database in an open cohort study. We included all female athletes who participated in the full-time programme of the Dutch Handball Academy between August 2009 and July 2019 aged between 14 and 21 years. All athletes screened were found eligible for the study. This study does not fall within the scope of the Medical Research Involving Human Subjects Act (WMO). This exemption from the WMO was approved by the Medical Ethics Committee of the Vrije Universiteit Medical Centre, Amsterdam. Informed consent of the athletes and their parents was not feasible, since the data were fully anonymised and therefore impossible to trace back to individuals.

Context

The handball players all played for the Dutch Handball Academy. This is a multiyear programme for the most promising Dutch talents. On weekdays, they trained and lived at the national training centre in Papendal. Most of them combined this with studies in the vicinity, limiting travelling time to a minimum. During weekends, they played at their handball clubs at junior or senior elite level. Throughout their years at the Academy, the handball players were prepared for national or international elite competitions in the future. Their weekday training programme consisted of four handball-specific training sessions, four strength and conditioning sessions at the Academy and one handball-specific training session at their club. Practice exposure hours comprise all training hours, including the strength and conditioning. Competition exposure hours include the weekly match at their club.

Injury and illness definitions

All injuries and illnesses that required medical attention from a physiotherapist or physician were registered in the database. In retrospect, injuries and illnesses were classified according to the guidelines of the International Olympic Committee (IOC).[9] Injuries were defined as concerns due to tissue damage that resulted from a handball-related activity. Illnesses were defined as concerns that were not related to injury, including physical and mental problems. The IOC guidelines were also used to classify the anatomical location, injury type and mode of onset.[9] The registered injuries were classified as either acute or repetitive, based on the injury type and medical report. Acute injuries were defined as injuries resulting from a single and clearly identifiable event. Repetitive injuries were defined as injuries resulting from the accumulation of repetitive trauma with a sudden or gradual onset. In addition, acute injuries were divided into practice-related and competition-related injuries. As we only had availability of medical records, the severity of injuries and illnesses had to be defined as the duration in days of the injury being under treatment. This is the number of days between the date of reporting the injury to the medical staff and the date of the final consultation for that same injury. This duration does not necessarily reflect the severity in days of time-loss.

Exposure

Total training exposure was estimated based on standard training schedules within the Handball Academy. Exposure hours were estimated by multiplying the number and average duration of training sessions at group level per season, excluding the total missed training sessions at group level due to injury. For the competition exposure, an approximation was made based on the average weekly competition exposure at individual level of the last available season, assuming that this was representable for earlier seasons.

Study parameters and study endpoints

The magnitude of injuries and illnesses was expressed in prevalence proportions, and for acute injuries also in the incidence rate of injuries per 1000 handball hours. The prevalence proportions and incidence rates were calculated for the entire period as well as per season, by anatomical location and by injury type.

The severity was expressed as the duration of the injury or illness being under treatment in days, and the burden of injuries and illnesses was consequently defined as the number of days injuries being under treatment per 1000 hours of exposure.

Data collection

All injuries and illnesses were registered in the Handball Academy medical database. All injuries that occurred between 2009 and 2019, including information about injury location, injury type and injury severity, were documented and coded by health professionals. In addition, demographic characteristics and anthropological measures were registered for each player when they entered the cohort.

Statistical analysis

The seasonal injury prevalence was calculated by dividing the total number of injured players by the total number of players during each Academy year. The overall injury prevalence was calculated by averaging the seasonal prevalence proportions. The incidence rate was calculated

Table 1 Baseline characteristics of handball players at the time of admission into the Handball Academy programme. Continuous variables are presented as means with 95% CI. Categorical variables are presented as total numbers with the respective percentage of the total population. Due to rounding, the totals may add up to more than 100%

Baseline characteristics	
Players (number)	102
Age (years)	16.7 (16.4 to 17.0)
Height (cm)	173.2 (172.2 to 174.2)
Weight (kg)	67.5 (66.2 to 68.8)
Body mass index (kg/m^2)	22.4 (22.0 to 22.8)
No. seasons in the programme	
One	24 (24%)
Two	33 (32%
Three	34 (33%)
Four	11 (11%)
Dominant hand	
Right	76 (75%)
Left	22 (22%)
Unreported	4 (4%)
Playing position	
Goalkeeper	14 (14%)
Back	46 (45%)
Wing	24 (24%)
Centre runner	14 (14%)
Unreported	4 (4%)

for acute injuries by dividing the total number of acute injuries by the total hours of handball exposure. For injury severity, the median duration in days and the IQR were determined. The burden was calculated by dividing the total duration in injury days by the total hours of handball exposure. All continuous data were presented as means with 95% CIs, or as median with IQR when non-Gaussian distributed. Categorical data were presented as frequency with corresponding percentages. All statistical analyses were conducted in IBM SPSS Statistics V.26.

RESULTS

Population

Over 10 seasons, a total of 102 female handball players participated in the Handball Academy programme. Players' participation duration in the Handball Academy programme ranged from one to four seasons. The baseline characteristics at the time of admission into the programme are presented in table 1.

Injury and illness prevalence proportions

Over 10 seasons, 916 injuries in 101 handball players (prevalence proportion: 99.0%) and 95 illnesses in 59 handball players (prevalence proportion: 57.8%), were reported. Of the total recorded injuries, 488 (53.0%) were acute and 428 (47.0%) were of repetitive nature. The average seasonal prevalence proportion was 83.2% for acute injuries, 78.7% for repetitive injuries and 31.1% for illnesses, with small variations between seasons (figure 1).

Exposure hours and injury incidence rate

The total exposure over 10 seasons was estimated to be 115 029 handball hours, corresponding to 103 711 practice hours and 11 318 competition hours. For acute injuries, this resulted in an overall incidence rate of 4.24 injuries per 1000 handball hours (95% CI: 3.87 to 4.62). The competition incidence rate was 23.06 per 1000 competition hours (95% CI: 20.26 to 25.86), whereas the practice incidence rate was 2.19 per 1000 practice hours (95% CI: 1.90 to 2.47). Variations between the seasons exist, but without a clear trend or pattern (figure 2).

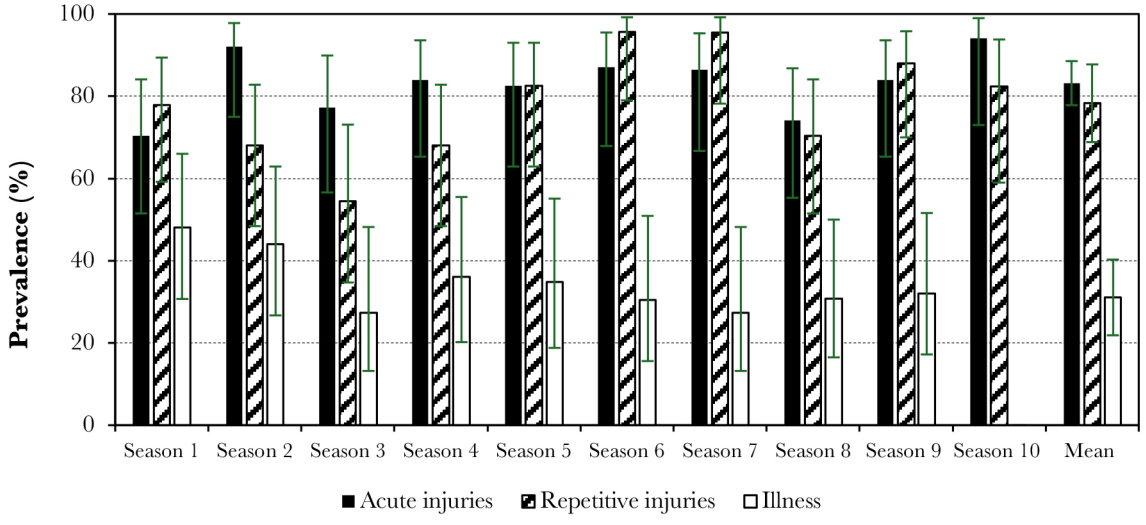

Figure 1 Prevalence of acute injuries, repetitive injuries and illnesses, expressed as % per season. Error bars represent 95% CIs.

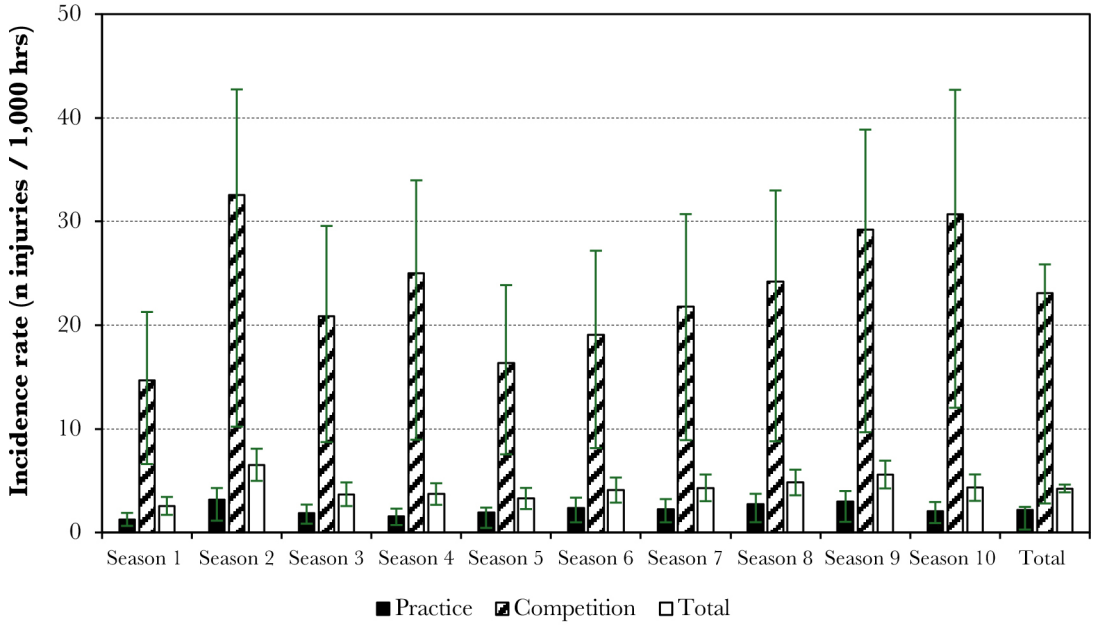

Figure 2 Acute injury incidence rates expressed as number of injuries per 1000 handball hours. Vertical error bars represent 95% CIs.

Injury location and injury type

Table 2 describes the injury location and injury type with their average seasonal prevalence proportion and burden. The most affected injury sites were the knee (n=140; 15.3%), ankle (n=117; 12.8%) and lower leg (n=104; 11.4%). Furthermore, the most reported injury types differed per anatomical region. For the knee, the most reported injury types were tendinopathies (n=49; 35%) and ligament injuries (n=40; 28.6%). For the ankle, ligament injuries (n=93; 79.5%) were most reported. Lastly, the most reported injury types for the lower leg were muscle injuries (n=41; 39.4%), followed by bone stress injuries (n=27; 26.0) and tendinopathies (n=16; 15.4%).

As illustrated in online supplemental figure 1, most acute injuries (n=242; 49.6%) were incurred without contact through an object or another handball player, while 219 (44.9%) acute injuries occurred through contact.

Injury severity and burden

The severity was higher for repetitive injuries (17 days; IQR: 2–98), compared with acute injuries (11 days; IQR: 2–98) and illness (3 days; IQR: 0–21). In addition, the burden was higher for repetitive injuries (63.25 days per 1000 hours; 95% CI: 61.80 to 64.71) when compared with acute injuries (46.67 days per 1000 hours; 95% CI: 45.42 to 47.91) and illnesses (2.48 days per 1000 hours; 95% CI: 2.19 to 2.77). As illustrated in table 2, the burden of the lumbosacral spine (35.53 days per 1000 hours; 95% CI: 34.44 to 36.62), knee (31.64 days per 1000 hours; 95% CI: 30.62 to 32.67) and ankle (24.41 days per 1000 hours; 95% CI: 23.51 to 25.31) comprised the highest burden.

In the risk matrix (figure 3), the average seasonal prevalence proportion is plotted against the burden for the five most prevalent acute and repetitive injuries. The repetitive injuries of the lumbosacral spine, knee and lower leg were among the injury locations with the highest average seasonal prevalence proportion. In addition, the burden of these repetitive injuries was the highest. Moreover, the acute ankle and knee injuries were the injury locations with the highest average seasonal prevalence proportion and the highest burden.

DISCUSSION

In this study, the magnitude and burden of injuries and illnesses in elite Dutch female adolescent and young adult handball players were studied. We reported high injury prevalence proportions and incidence rates over 10 consecutive seasons. Variations in injury prevalence proportions and incidence rates between seasons were observed, but without a clear trend or pattern. The average seasonal prevalence proportion was the highest for acute injuries, followed by repetitive injuries and illnesses. Furthermore, the competition incidence rate was higher compared with the practice incidence rate. Moreover, more acute than repetitive injuries were reported, and most acute injuries were incurred without contact. Lastly, repetitive injuries of the lumbosacral spine, knee and lower leg and acute injuries of the ankle and knee formed the largest problem based on their high average seasonal prevalence proportion as well as their high burden.

Injury prevalence proportions

We showed an average seasonal prevalence proportion of 83.2% for acute injuries, 78.7% for repetitive injuries and 31.1% for illnesses. In previous studies, this distinction between acute and repetitive injuries has not been made. Nevertheless, some studies among youth handball

Table 2 The average seasonal prevalence per anatomical region, including the severity (expressed in the median duration in days of the injury being under treatment) and the burden (expressed in duration in days per 1000 handball hours). For the most common injured anatomical regions, their most frequent injury types are presented

Region **Injury type**	**Injuries n (% of total injuries)**	**Average seasonal prevalence in % (95% CI)**	**Duration in median number of days (IQR)**	**Burden as duration in days per 1000 hours (95% CI)**
Head	39 (4.3)	16.1 (5.9 to 26.2)	5.0 (1.0–15.5)	1.70 (1.46 to 1.93)
Concussion	23 (59.0)	9.8 (5.2 to 14.4)	5.0 (2.0–17.0)	1.00 (0.82 to 1.18)
Neck	26 (2.8)	10.0 (4.7 to 15.2)	5.0 (0.8–24.5)	1.13 (0.94 to 1.32)
Shoulder	92 (10.0)	34.6 (26.4 to 42.8)	15.0 (2.0–69.5)	12.00 (11.36 to 12.63)
Dislocation/subluxation	5 (5.4)	2.5 (0.4 to 4.6)	66.0 (57.0–260.5)	2.87 (2.56 to 3.18)
Ligament injury	7 (7.6)	3.0 (0.0 to 6.7)	8.5 (1.0–105.5)	0.52 (0.39 to 0.65)
Muscle injury	47 (51.1)	17.9 (13.2 to 22.6)	9.0 (1.0–50.0)	3.68 (3.33 to 4.03)
Tendinopathy	15 (16.3)	6.8 (2.4 to 11.2)	12.5 (8.8–100.8)	1.63 (1.40 to 1.87)
Upper arm	2 (0.2)	0.8 (0.0 to 2.0)	31.0 (31.0–31.0)	0.54 (0.40 to 0.67)
Elbow	47 (5.1)	17.8 (11.4 to 24.3)	25.5 (1.8–67.0)	10.42 (9.83 to 11.01)
Ligament injury	32 (68.1)	12.4 (18.1 to 6.8)	23.0 (3.0–60.0)	6.40 (5.94 to 6.86)
Muscle injury	5 (10.6)	2.0 (0.0 to 4.1)	66.0 (25.0–78.5)	2.87 (2.56 to 3.18)
Tendinopathy	5 (10.6)	2.3 (0.0 to 4.7)	48.0 (5.5–216.5)	2.09 (1.82 to 2.35)
Forearm	2 (0.2)	0.8 (0.0 to 2.1)	–	–
Wrist	15 (1.6)	5.9 (1.4 to 10.3)	12.5 (0.0–27.0)	1.63 (1.40 to 1.87)
Hand	7 (0.8)	3.5 (0.0 to 7.7)	30.0 (3.0–44.0)	1.83 (1.58 to 2.07)
Finger	48 (5.2)	16.0 (10.2 to 21.7)	5.0 (1.0–27.0)	2.09 (1.82 to 2.35)
Bone contusion	23 (47.9)	9.4 (4.5 to 14.3)	5.0 (1.0–20.0)	1.00 (0.82 to 1.18)
Ligament injury	16 (33.3)	5.3 (2.7 to 7.8)	9.0 (0.8–29.8)	1.25 (1.05 to 1.46)
Chest	12 (1.4)	5.1 (0.8 to 9.3)	7.0 (3.3–55.8)	0.73 (0.57 to 0.89)
Thoracic spine	6 (0.7)	2.7 (0.4 to 4.9)	10.5 (0.0–145.0)	0.55 (0.41 to 0.68)
Lumbosacral spine	67 (7.3)	26.5 (17.1 to 35.9)	61.0 (7.0–161.3)	35.53 (34.44 to 36.62)
Muscle injury	57 (85.1)	23.5 (12.9 to 34.1)	61.0 (7.3–153.5)	30.23 (29.22 to 31.23)
Abdomen	1 (0.1)	0.37 (0.0 to 1.2)	–	–
Hip/groin	63 (6.9)	22.7 (15.0 to 30.4)	9.0 (1.0–42.0)	4.93 (4.52 to 5.33)
Muscle injury	41 (65.1)	16.2 (9.0 to 23.5)	8.5 (1.0–50.5)	3.03 (2.71 to 3.35)
Bone contusion	9 (14.3)	3.7 (2.1 to 5.4)	4.0 (0.5–93.0)	0.31 (0.21 to 0.42)
Thigh	85 (9.3)	30.8 (21.7 to 40.0)	9.0 (2.0–43.0)	6.65 (6.18 to 7.12)
Muscle contusion	15 (17.6)	6.0 (1.9 to 10.2)	4.0 (1.0–10.0)	0.52 (0.39 to 0.65)
Muscle injury	65 (76.5)	22.7 (14.5 to 30.9)	10.0 (3.0–60.0)	5.65 (5.22 to 6.09)
Knee	140 (15.3)	43.8 (30.4 to 57.2)	26.0 (3.0–139.8)	31.64 (30.62 to 32.67)
Bone contusion	20 (14.3)	7.9 (1.6 to 14.2)	10.0 (3.0–95.0)	1.74 (1.50 to 1.98)
Cartilage injury	10 (7.1)	4.1 (1.3 to 6.9)	36.0 (1.5–113.3)	3.13 (2.81 to 3.45)
Ligament injury	40 (28.6)	15.8 (9.4 to 22.2)	33.0 (4.8–254.8)	11.48 (10.86 to 12.09)
Tendinopathy	49 (35.0)	17.9 (10.5 to 25.3)	35.0 (7.0–162.8)	14.91 (14.20 to 15.61)
Lower leg	104 (11.4)	35.8 (29.3 to 42.2)	18.0 (2.0–80.0)	16.27 (15.54 to 17.01)
Bone stress injury	27 (26.0)	10.2 (4.1 to 16.3)	80.0 (26.0–318.0)	18.78 (17.99 to 19.57)
Muscle injury	41 (39.4)	14.6 (8.1 to 21.0)	8.0 (1.0–30.8)	2.85 (2.54 to 3.16)
Tendinopathy	16 (15.4)	6.6 (2.3 to 11.0)	27.5 (7.3–117.0)	3.83 (3.47 to 4.18)
Ankle	117 (12.8)	39.1 (30.7 to 47.4)	24.0 (3.0–70.3)	24.41 (23.51 to 25.31)
Ligament injury ankle	93 (79.5)	31.4 (21.2 to 41.6)	19.0 (3.0–63.0)	15.36 (14.65 to 16.08)
Foot	42 (4.6)	14.5 (6.5 to 22.5)	11.5 (2.0–22.5)	4.20 (3.82 to 4.57)

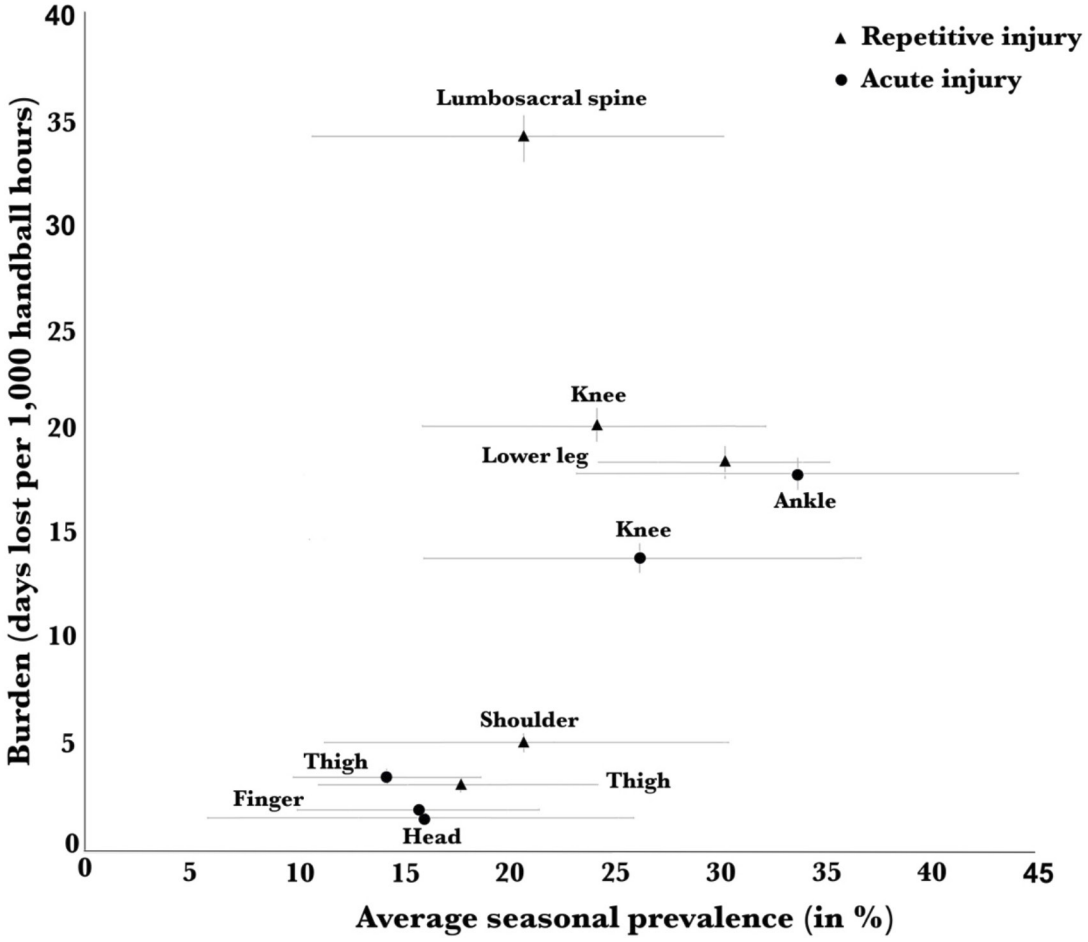

Figure 3 Risk matrix of illustrating the average seasonal prevalence (in %) and the burden (injury duration in days per 1000 handball hours) of acute and repetitive injuries. The horizontal and vertical error bars represent 95% CIs.

players reported overall seasonal prevalence proportion.[5 10 11] Regardless of their injury definition, their reported seasonal prevalence proportions were considerably lower compared with our study, with prevalence proportions ranging from 23% among recreational players to 50% and 60% among elite players.[5 10 11] The prevalence proportion seems to increase by level of play. Therefore, our higher seasonal prevalence proportions might be explained by the higher level of play in our study. Moreover, our high prevalence proportions could imply that there was a low threshold for the provision of treatment for minor injuries and problems.

Injury incidence rate

We observed an overall incidence rate of 4.24/1000 hours, which is comparable to previous studies.[3] Moreover, in accordance with previous studies, the absolute competition incidence rate (23.06/1000 hours) was higher compared with the absolute practice incidence rate (2.19/1000 hours).[5 12–15] This might be explained by a higher playing intensity and more physical contact during matches.[5 14] Our other findings are challenging to compare to previous studies, given the different study designs, study populations and different injury definitions. Nevertheless, Olsen *et al*[13] and Moller *et al*[15] reported similar practice incidence rates among young female handball players. Conversely, both reported lower competition incidence rates, respectively, 10.4/1000 hours and 13.0/1000 hours.[13 15] The lower competition incidence rates might be the result of the different contextual aspects of the study populations. In this case, the level of play is the most obvious contextual difference. The level of play in the studies of both Olsen *et al*[13] and Moller *et al*,[15] respectively, amateur level and juniors' elite level, is lower compared with our study in which players compete at juniors' or seniors' elite level. This assumption is supported by the higher competition incidence rate (17.9/1000 hours) among female players competing at seniors' elite level in the study of Moller *et al*.[15]

Injury pattern

In accordance with previous studies, more acute (53%) than repetitive (47%) injuries were reported.[12–15] However, Wedderkopp *et al*[14] and Olsen *et al*[13] reported considerably lower rates of repetitive injuries among youth amateur players, respectively, 7% and 21%.[1] However, the amateur level is associated with fewer practice hours and a lower practice intensity, which might result in lower rates of repetitive injuries. Therefore,

both the lower level of play and the difference in practice hours studies might explain these lower rates of repetitive injuries. This assumption is supported by the studies of Moller *et al*[15] and Rafnsson *et al*,[12] reporting, respectively, 37% and 38% of repetitive injuries among elite players. These percentages are still slightly lower compared with our study, which might be explained by our broader injury definition. Both studies only reported injuries if they led to time loss or to missing handball-related activity.[12 15] However, repetitive injuries do not always lead to time loss, and therefore the injury definitions of both studies result in an underestimation of the actual number of repetitive injuries.[12 15 16]

Lastly, most acute injuries were incurred without contact between players or objects. This is in line with previous studies among handball players in a regular competition.[5 12 14] However, during major international handball tournaments, most acute injuries seem to result from contact between players or objects.[17–19]

Injury burden and risk matrix

In our risk matrix, the repetitive injuries of the lumbosacral spine, knee and lower leg, as well as the acute injuries of the ankle and knee, stood out based on the high average seasonal prevalence proportion and the high burden. Consequently, these injuries formed the most relevant problem in this group of handball players. This implies that future prevention programmes for this group of handball players should explicitly focus on these injuries. These injuries, in particular ankle and knee injuries, are known for their ability to compromise careers and decrease quality of life in the long-term due to injury-induced health issues, such as post-traumatic osteoarthritis.[20 21] Several prevention programmes concerning ankle and knee injuries have already been developed for handball players.[22–26] Prevention programmes for lower leg and lumbosacral spine are not available for handball players. However, the FIFA 11+warming up programme has been proven to reduce lower leg injuries in elite youth soccer players.[27] In addition, proprioceptive training programmes reduce the number of lower back injuries in elite basketball players, and core stability programmes are suggested to prevent lower back injuries in athletes.[28 29] The programmes should be adjusted for contextual aspects to implement these prevention programmes in elite Dutch adolescent and young female handball players.[8]

Strengths and limitations

Following the IOC guidelines for reporting injury and illness in sports is the most important strength of this study, ensuring consistency in handball injury reporting.[9] Studying injuries and illness over 10 consecutive seasons is another strength. Furthermore, a strength of our study is that we included injury-specific diagnoses. Lastly, the context-specific results are relevant for developing prevention programmes for this specific group of handball players. At the same time, this limits the generalisability to other settings.

There were several methodological limitations. First, due to the way injuries were reported, it was not possible to categorise the repetitive injury presentation into sudden or gradual onset as advised by the IOC guidelines.[9] The same limitation applies to the reporting of subsequent injuries, recurrent injuries and exacerbations.[9] Our study was also limited by the potential risk of bias from both physiotherapists and physicians reporting injuries in the database. Although dual reporting is common in elite sports settings, errors remain possible. However, data collectors verified the data, and the similar training of these professionals minimises the likelihood of significant discrepancies and double reporting. Another limitation is the injury definition we used. While the broad injury definition allowed us to include both time-loss and non-time-loss injuries requiring medical attention, we still missed concerns and injuries that did not require medical attention. Therefore, this might result in an underestimation of especially repetitive injuries, because these injuries do not always result in medical attention.[16] Furthermore, there were no individual data available on exposure hours. Therefore, we calculated the exposure hours based on the standard practice and match schedules, which adequately represent the exposure hours. The relatively small sample size in our study forms a limitation, restricting the ability to perform subgroup analyses, including those based on age. Lastly, our definition of severity, expressed in the duration of the injury being under treatment, is not in accordance with the IOC guidelines and is different from previous studies.[9] The duration of time-loss from practice or competition was not registered, and we defined severity by the duration of the injury being under treatment. This duration approximates the severity in days of time-loss.

CONCLUSION

High average seasonal prevalence proportions were observed for acute injuries (83.2%) and repetitive injuries (78.7%) in elite Dutch adolescent and young adult female handball players, as well as high competition incidence rates of 23.06/1000 competition hours. Repetitive injuries of the lumbosacral spine, knee and lower leg, as well as the acute injuries of the knee and ankle, formed the most clinically relevant problem in this group of handball players. Future prevention programmes should therefore focus on these injuries.

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Contributors RE, MVdB, LVM-C and EV were responsible for the conception and design of the study. RE and LVM-C were responsible for the data collection. RE, MVdB, LVM-C and EV were involved in the processing and statistical analysis of data. RE, MVdB, LVM-C and EV were involved in the drafting of the manuscript; and all authors contributed to the interpretation of the data for the work and revising it critically for important intellectual content. All the authors finally approved the manuscript. All authors have read and agreed to the published version of the manuscript. Guarantor: RE.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants but Medical Ethics Committee of the Vrije Universiteit Medical Centre, Amsterdam, Netherlands exempted this study. First, this retrospective database study does not fall within the scope of the Medical Research Involving Human Subjects Act (WMO). This exemption from the Medical Research Involving Human Subjects Act was approved by the Medical Ethics Committee of the Vrije Universiteit Medical Centre, Amsterdam. According to the Dutch Guidelines, informed consent for retrospective database studies should be acquired if this is reasonably possible. However, since we received our data fully anonymised, the contact details of the participating handball players were not known. It was impossible to trace back the data to individual handball players. Since many players have left the Handball Academy it is unfortunately not possible to trace the exact contact details. Therefore, acquiring informed consent is not feasible and not required by Dutch guidelines.

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