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Injury incidence and injury patterns by category, player position, and maturation in elite male handball elite players

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ABSTRACT: The aim of this cohort study is to estimate the influence of position, category, and maturity status on the incidence and pattern of injury in handball players, across two seasons. Injury registration from 164 players-season (12-27 years) was conducted, and players were categorized into youth (133) and adults (31), and per position: 27 goalkeepers, 67 backs, 70 wings and pivots. Maturity status in youth players was also measured by testicular volume on clinical examination (32 immature, 101 mature). 190 injuries occurred during 34 221 hours of exposure. Injury incidence in youth was 6.0 per 1000 total hours [CI 95%, 4.8-7.2] (14.9 match [9.7-20.1] and 3.7 training hours [2.7-4.6]; n= 142 injuries), and in adults 6.5 per 1000 total hours [4.4-8.6] (22.2 match [8.8-35.6] and 3.0 training hours [1.3-4.6]; n=48 injuries). There were significant differences in knee (P=0.01) and cartilage injury (P=0.05) according to playing position. There were significant differences according to age category in ankle (P=0.03), head (P=0.01), thigh (P=0.05) and muscular injury (P= 0.02), and apophysitis (P=0.04) for biological maturity state. Adult handball players had more ankle and muscle injuries than youths. Pivot and wings (2nd line) had more knee and cartilage problems. A higher incidence of apophysitis was found in immature youth players.

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INTRODUCTION

Modern handball is a high-intensity sport with large physical demands and frequent contact between players – factors that may increase the risk of injury [1]. However, there are some methodological issues in the handball injury literature that make it difficult to compare results, including heterogeneity of study design, varying injury definitions and registration methods used, lack of clarity in exposure recording, observation period, as well as the level of competition and age. Nevertheless, the incidence of "time-loss" injuries in male handball is estimated to be 4.1 to 12.4 injuries per 1000 h, and 3 to 10 times higher during games than when training [2-8].

Regarding injury pattern, the most frequent locations reported are the ankle, knee, and thigh, and the most common types of injury are sprains and non-contact muscle injuries in all categories [6, 7, 9, 10]. Several researchers have examined whether age (or age category) is correlated with injury incidence in team handball, and the results are contradictory. In the latest studies, it seems that there is no difference between senior and youth players [6, 7, 9, 10]. Other factors related to injury incidence are gender, anthropometric variables, playing position and experience, but the results are still controversial [11-15].

The impact of maturity in sports injuries is unclear. Some authors have reported more risk of injuries in mature players in soccer [16, 17] and recreational sports [18], whereas others have reported higher rates for immature players in handball [8]. More advanced maturation and high body mass index in anthropometry influence physical performance and playing position in handball [19], but the role of position as a risk factor for injury is not clear. The aim of this study was therefore to estimate the contribution of position, age category, and maturity status on the incidence and pattern of injury in elite male handball players. The position was defined as goalkeeper or first or second attack line. The age category was divided into youth or adult, and maturity status was categorised as mature or immature.

MATERIALS AND METHODS

Study population

The present study was based on injury data collected as part of a previous study [8] (Monaco *et al.*). This is a prospective cohort study in male handball players performed during two consecutive seasons (2011-12 and 2012-13) by the same medical staff. The total sample consisted of 105 players who compete at the highest level in a national league (Spain). Two of the 105 players (who competed during both periods) were excluded for the second season (prior to completion) as they were released from the club. All participants were informed about the study purposes and procedures (including maturational assessment) before providing their written informed consent. The local research ethics committee (Consell Català de l'Esport, Barcelona, Generalitat de Catalunya Nº 00995/5954/2013) approved the study.

Fifty-nine players took part in both seasons, 24 in the first season only, and 22 during the second season only, corresponding to a total sample of 164 player-seasons observed during the study period (two players were released during the second season). These player-seasons are distributed according to age as follows: 31 adults (>18 years) and 133 youth academy players from different age categories (U14: n=41; U15: n=35; U16: n=29 and U18: n=28). It is a key factor in the organization of the club that all the teams develop a similar training model and technical skills. First team adult players were excluded, as they have a more intensive competition programme, with two matches per week. The adult players were recruited from the second team, which competes only once a week with same schedule workload as youth teams, yet their training model is practically at the same level as the first team. The training programme comprised 4 training sessions plus one game every week for all the teams involved. Players are selected for the club in the U14 category, coming for sport schools (10 to 13 years) linked with the club in terms of organization and training model. 87.3% of the players continue playing for the club in all stages, based on the same technical criteria applied in each category, until they reach the first or second team. Player age, weight, height, and BMI in the total sample grouped by position and age category are summarized in Table 1.

At the beginning of each season every player completed a medical screening protocol consisting of history, physical examination (including genital assessment and maturity status), anthropometry, spirometry, basal 12-lead ECG, submaximal cardiovascular exercise testing (with ECG and blood pressure monitoring), and cardiac echocardiography.

Anthropometric measures and maturity status

Anthropometric measures were taken by the same experienced anthropometrist. Height was measured with a stadiometer (±0.1 mm; Harpenden, Crosswell, United Kingdom) and weight with a balance scale (±0.1 Kg; Tanita WB 3000plus, Tokyo, Japan). The body mass index (BMI) was calculated as body mass (in kg) divided by height (in m) squared (kg/m^2).

Biological maturity was determined only in youth players according to sexual maturation status (testicular volume and Tanner stage) based on an annual examination by a paediatrics and sports medicine specialist. The testicular volume was measured using an orchidometer (Holtain, Prader, Crymych, United Kingdom) and Tanner stage (measure by genitalia and pubertal hair) as defined by Tanner et al. [20]. We classified players as immature (4-14 cm^3) or mature (≥15 cm^3) based on testicular volume [20, 21].

Tanner staging was only used as complementary data to describe each group. The genitalia stages are as follows: stage 1, same as early childhood; stage 2, enlargement of the scrotum and testes and change in texture of the scrotal skin; stage 3, growth of the penis

TABLE 1. Demographics of participants. Data are presented as mean (SD).

	Goalkeeper			1st Line			2nd Line			Total		
	Youth	**Adults**	**Total**	**Youth**	**Adults**	**Total**	**Youth**	**Adults**	**Total**	**Youth**	**Adults**	**Total**
Nº of player per seasons	23	4	27	53	14	67	57	13	70	133	31	164
Age Years	14.3 (1.5)	21.0 (3.2)	15.3 (3.0)	14.3 (1.4)	21.0 (3.3)	15.7 (3.3)	14.5 (1.3)	19.6 (1.9)	15.4 (2.5)	14.4 (1.4)	20.4 (2.7)	15.5 (2.9)
Weight Kilograms	73.4 (14.5)	87.4 (9.7)	75.5 (14.6)	69.6 (12.3)	84.5 (9.2)	72.7 (13.2)	68.7 (13.8)	85.2 (8.9)	71.8 (14.5)	69.9 (13.4)	85.2 (8.9)	72.8 (14.0)
Height Centimeters	177.5 (6.7)	191.4 (9.5)	179.6 (8.6)	178.0 (8.3)	188.6 (9.9)	180.2 (9.6)	177.2 (7.3)	184.1 (6.1)	178.5 (7.0)	177.6 (7.6)	187.1 (8.6)	179.4 (8.6)
BMI	23.2 (3.8)	23.8 (0.7)	23.3 (3.5)	21.9 (2.7)	23.7 (1.8)	22.2 (2.6)	21.7 (3.0)	25.0 (1.5)	22.3 (3.1)	22.0 (3.1)	24.3 (1.6)	22.4 (3.0)

BMI: Body Mass Index, SD: Standard Deviation.

(length and width) and growth of the testes and scrotum; stage 4, further enlargement and development of the gland; and stage 5, adult size and shape of genitalia. The pubic hair stages for boys are as follows: stage 1, no pubic hair; stage 2, sparse growth of hair at the base of the penis; stage 3, darker and coarser hair; stage 4, adult type hair but no spread to the medial surface of the thighs yet; and stage 5, adult genitalia in size and shape [20].

Injury data collection and injury incidence

The consensus on definitions and data collection procedures in studies of football injuries outlined by the UEFA [22] was followed, and has been used by the club for over 8 years. It defined an injury as any injury occurring during a training session or match, and causing an absence for at least the next training session or match (time-loss injury). For injury type, we coded injuries according to the Orchard Sports Injury Classification System (OSICS-10 codification). This classification is structured hierarchically with four characters assigned to each injury. The first (leftmost) character relates to the anatomical location, the second character to the specific injured tissue or the pathology or broadening of the diagnosis, and the third and fourth characters complete the specific diagnosis [23]. The coaches of each team recorded individual player exposure during training and matches.

The medical team comprised two sport physicians with experience in handball who were responsible for the daily health care of all players in their teams. Complementary imaging studies or specific rehabilitation treatment required was provided at Futbol Club Barcelona – Handball Medical Services. The physicians were responsible for diagnosis, rehabilitation, and return to play for each injury, and for recording and coding each injury in the electronic medical record (Gem_version 1.2, FCB, Spain) by medical experts in handball until the final stage. With this strategy, we limited the bias during recruitment and diagnosis. The institution was selected for the study because it allowed us to include top-class players of all categories – in the second year of the study, participants in all age categories were national champions.

Calculations and statistical analysis

We calculated injury incidence as the number of injuries per 1000 player h (Σ injuries/Σ exposure h$\times$1000). Injury patterns were compared between subgroups based on the number of injuries per player and season (IPS). Players were grouped according to their playing position as follows: goalkeepers (n=27), first line players (backs and centre backs, n=67) and second line players (wing and pivot players, n=70).

Injury incidence was compared according to age category (adults (≥18 years) vs youth (12-18syears)), position, and maturity status (mature versus immature) and evaluated using ANOVA and MANOVA tests. Age was included in the analyses to adjust for its potential role as a confounding factor. ANOVA was used to evaluate the relationship between injury incidence (total, training, or match) and age category, position, and maturity. MANOVA was used to evaluate the relationship between injury incidence during training and matches, both

TABLE 2. Number of injuries, hours of exposure, and injury incidence by player position and age-categories. Data are presented as mean (95% CI).

	Goalkeeper			1st Line			2nd Line			Total		
	Youth	Adults	Total	Youth	Adults	Total	Youth	Adults	Total	Youth	Adults	Total
Nº of injuries	17	6	23	63	21	84	62	21	83	142	48	190
						Exposure (hours)						
Total	4431	981	5412	1489	3173	15146	11443	3703	13663	26363	7857	34221
Training	4070	901	4972	9572	2938	13855	10425	3430	12510	24068	7270	31338
Match	360	79	440	917	235	1290	1017	272	1152	2295	587	2883
						Incidence (injuries per 1000 hours)						
Total	4.0 (2.0-6.0)	6.0 (0.0-17.8)	4.3 (2.3-6.3)	6.7 (4.9-8.8)	6.9 (4.1-9.7)	6.7 (5.0-8.5)	6.1 (4.2-8.0)	6.3 (2.2-10.3)	6.1 (4.5-7.8)	6.0 (4.8-7.2)	6.5 (4.4-8.7)	6.1 (4.8-7.2)
Training	2.9 (1.2-4.6)	2.3 (0.0-6.8)	2.8 (1.3-4.3)	4.4 (2.5-6.3)	3.2 (1.2-6.3)	4.3 (2.7-5.8)	3.3 (2.1-4.5)	2.3 (0.0-5.5)	3.1 (2.0-4.2)	3.7 (2.7-4.6)	3.0 (1.3-4.6)	3.5 (2.7-4.6)
Match	6.1 (0.0-14.9)	17.9 (0.0-75.0)	7.9 (0.0-16.9)	13.1 (4.6-21.6)	17.8 (0.0-38.6)	14.1 (6.3-21.8)	20.0 (11.3-28.8)	28.2 (4.5-51.9)	21.6 (13.4-30.0)	14.9 (9.6-20.1)	22.2 (8.8-35.6)	16.2 (11.3-21.2)

TABLE 3. Injury incidence by maturity stage and player position in Academy players. Data are presented as mean (SD) or (95% CI) as appropriate.

	Goalkeeper			1st Line			2nd Line			Academy Total		
	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total	Immature	Mature	Total
Nº of player-seasons	6	17	23	14	39	53	12	45	57	32	101	133
Age Years	13.3 (1)	14.6 (1.5)	14.3 (1.5)	13.6 (1.3)	14.5 (1.3)	14.3 (1.4)	13.8 (1.2)	14.7 (1.3)	14.5 (1.3)	13.6 (1.3)	14.6 (1.3)	14.4 (1.4)
Genital Tanner stage	3 (1.3)	4.8 (0.4)	4.3 (1.1)	3.3 (0.8)	4.7 (0.5)	4.3 (0.9)	3.8 (0.8)	4.8 (0.4)	4.6 (0.6)	3.4 (0.9)	4.8 (0.4)	4.5 (0.8)
Nº of injuries	5	12	17	24	39	63	10	52	62	39	103	142
	Incidence (injuries per 1000 h)											
Total	4.8 (0.0-9.5)	3.5 (1.5-5.5)	4.0 (2.0-6.0)	7.3 (3.6-11.0)	6.2 (3.7-8.7)	6.7 (4.6-8.2)	4.7 (2.1-7.2)	6.7 (4.2-9.2)	6.1 (4.2-8.0)	5.9 (3.9-8.0)	6.0 (4.5-7.5)	6.0 (4.8-7.2)
Training	4.4 (0.4-8.4)	1.9 (0.4-3.5)	2.9 (1.2-4.6)	4.0 (1.1-6.9)	4.8 (2.2-7.4)	4.4 (2.5-6.3)	2.9 (0.3-5.5)	3.6 (2.1-4.9)	3.3 (2.1-4.5)	3.6 (2.0-5.4)	3.7 (2.5-4.8)	3.7 (2.7-4.6)
Match	7.4 (0.0-24.5)	5.3 (0.0-16.7)	6.1 (0.0-14.9)	16.4 (5.3-27.5)	10.1 (0.0-23.4)	13.1 (4.6-21.6)	15.3 (2.6-27.9)	21.7 (10.5-34.0)	20.0 (11.3-28.8)	14.7 (7.4-21.5)	14.9 (7.7-22.6)	14.9 (9.6-20.1)

together, and age category, position, and maturity, and their interaction. Similarly, ANOVA was used to evaluate the relationship between selected injuries (expressed as injuries per season, IPS) and age category, position, and maturity. For single comparisons the Student-Fisher t-test was used. We used SPSS (v. 13.0) to run the statistical analyses and interpreted P-values of <0.05 as statistically significant.

RESULTS

Injuries, exposure and injury incidence

The number of injuries, exposure, and injury incidence are presented grouped by position and age category in Table 2.

In total, there were 190 injuries (142 in youth and 48 in adults), and 34 221 h of exposure (31 338 h of training and 2883 h of match play). The injury incidence across all teams was 6.1 per 1000 h (CI 5.0-7.1). Of the 190 injuries recorded, 98 (52%) occurred during matches, 63 (33%) during training and in 29 (15%) cases the injury was caused by sports participation, but the player could not specify if it occurred during training or a match or both. The injury incidence during matches was higher than during training (16.2 per 1000 h (CI 11.3-21.1) vs 3.5 per 1000 h (CI 2.7-4.4) (paired t-test: $P<0.001$). On average, a player sustained 1.2 (CI 1.0-1.3) injuries per season (15 injuries per team), 0.6 (CI 0.5-0.7) during training and 0.4 (CI 0.3-0.5) injuries per season in matches (paired t-test: $P=0.036$).

We detected no difference in total injury incidence ($P=0.29$), in match ($P=0.13$) or training ($P=0.33$) injury incidence, across player positions or age categories (youth vs adults) in total ($P=0.69$), match ($P=0.25$), or training injuries ($P=0.50$) (ANOVA).

Injury incidence by maturity state and position among youth players

Data concerning maturity status and injury risk among youth players are presented in Table 3.

We recorded 142 injuries in the youth cohort, resulting in a total incidence of 6.0 (CI 4.8-7.2) injuries per 1000 h ($P=0.69$ vs adult players, t-test). No differences were found in injury incidence per 1000 h in relation to maturity status ($P=0.76$) or player position ($P=0.36$). The distribution of location and type of injury are shown in Tables 4 and Table 5 (CI=95%).

The ankle, followed by the knee and thigh were the most common injury locations. Ligament/joint sprains and muscle strains were the most common injury types. The single most common injury subtype was ankle sprains, representing 18% (n= 34) of all injuries, followed by adductor injury (n=11, 6%) and posterior thigh strains (hamstrings, n=8%). Regarding playing position, the second line players had a greater risk of knee (0.31 IPS, CI 0.15-0.48) and cartilage injuries (0.11 IPS, CI 0.04-0.19, $P<0.05$, ANOVA). Ankle, thigh and muscle injuries were more frequent in adults (see Tables 4 and Table 5).

TABLE 4. Injury rate (no. of injuries per player season), with respect to location (OSICS 10) by age category and maturity status (Academy players). NS: No statistically significant differences. Data are presented as mean (95% CI).

	Total			ANOVA (P)		Academy (Youth) Total			ANOVA (P)	
	Youth	Adults	Total	Position	Category	Immature	Mature	Total	Position	Maturity
Ankle	0.21 (0.12-0.30)	0.45 (0.24-0.66)	0.26 (0.17-0.34)	NS	**0.03**	0.24 (0.08-0.38)	0.20 (0.09-0.30)	0.21 (0.12-0.30)	NS	NS
Head	0.02 (0.00-0.05)	0.13 (0.00-0.25)	0.04 (0.01-0.07)	NS	**0.01**	0.00(-)	0.04 (0.00-0.08)	0.02 (0.00-0.05)	NS	NS
Apophysitis	0.07 (0.01-0.12)	0.00(-)	0.05 (0.01-0.10)	NS	NS	0.14 (0.00-0.27	0.02 (0.00-0.06)	0.07 (0.01-0.12)	NS	**0.04**
Knee	0.14 (0.07-0.22)	0.29 (0.04-0.54)	0.17 (0.09-0.25)	**0.01**	NS	0.10 (0.01-0.18)	0.17 (0.06-0.29)	0.14 (0.07-0.22)	**0.01**	NS
Lumbar	0.13 (0.06-0.19)	0.06 (0.00-0.20)	0.12 (0.06-0.17)	NS	NS	0.12 (0.01-0.22)	0.13 (0.05-0.22)	0.13 (0.06-0.19)	NS	NS
Shoulder	0.07 (0.02-0.11)	0.03 (0.00-0.10)	0.06 (0.02-0.10)	NS	NS	0.02 (0.00-0.06)	0.10 (0.03-0.17)	0.07 (0.02-0.11)	NS	NS
Thigh	0.14 (0.06-0.21)	0.32 (0.07-0.58)	0.17 (0.10-0.25)	NS	**0.05**	0.18 (0.02-0.33)	0.11 (0.04-0.18)	0.14 (0.06-0.21)	NS	NS
Wrist-Hand	0.15 (0.09-0.21)	0.06 (0.00-0.16)	0.13 (0.08-0.19)	NS	NS	0.16 (0.05-0.26)	0.15 (0.07-0.23)	0.15 (0.09-0.21)	NS	NS

TABLE 5. Injury rate expressed per player season, categorized by injured tissue type (OSICS 10), by age-categories, and maturity (Academy players) NS: No statistically significant differences. Data are presented as mean (95% CI).

	Total			ANOVA (P)		Academy (Youth) Total			ANOVA (P)	
	Youth	Adults	Total	Position	Category	Immature	Mature	Total	Position	Maturity
Ligament Sprain	0.26 (0.16-0.37)	0.39 (0.16-0.61)	0.29 (0.19-0.38)	NS	NS	0.25 (0.06-0.44)	0.26 (0.15-0.40)	0.26 (0.16-0.37)	NS	NS
Cartilage Injury	0.06 (0.02-0.10)	0.06 (0.00-0.16)	0.06 (0.02-0.10)	**0.05**	NS	0.04 (0.00-0.09)	0.07 (0.02-0.13)	0.06 (0.02-0.10)	**0.04**	NS
Synovitis -Bursitis	0.11 (0.04-0.17)	0.10 (0.00-0.21)	0.10 (0.05-0.16)	NS	NS	0.08 (0.00-0.15)	0.12 (0.04-0.21)	0.11 (0.04-0.17)	NS	NS
Haematoma	0.11 (0.06-0.17)	0.19 (0.02-0.37)	0.13 (0.07-0.18)	NS	NS	0.14 (0.04-0.23)	0.10 (0.03-0.17)	0.11 (0.06-0.17)	NS	NS
Muscular	0.18 (0.10-0.26)	0.42 (0.16-0.68)	0.23 (0.15-0.30)	NS	**0.02**	0.24 (0.10-0.40)	0.15 (0.06-0.21)	0.18 (0.10-0.26)	NS	NS
Tendon	0.08 (0.03-0.12)	0.13 (0.00-0.34)	0.09 (0.03-0.14)	NS	NS	0.02 (0.00-0.06)	0.11 (0.04-0.18)	0.08 (0.03-0.12)	NS	NS

Injury patterns in academy handball players

We did not find differences between groups in anthropometric profile or injury incidence. Regarding maturity status in youth players, significant differences were found for apophysitis (Tables 4 and Table 5). The rate of apophysitis in immature players was higher than in mature players. However, similar to the total sample, the academy players varied in the incidence of knee and cartilage injuries according to player position. The second line players showed a higher rate of knee (IPS 0.26, CI 0.10-0.43) and cartilage injuries (IPS 0.11, CI 0.02-0.19, $P<0.05$, ANOVA) among youth.

DISCUSSION

This study has shown that second line handball players present with more knee and cartilage injuries in both adults and immature athletes. The influence of age was evaluated in a previous study [7]; this is not the aim of the present manuscript, although we controlled the analyses related to maturity status for age. The results show that the injury incidence is similar between different categories, playing positions and maturity status in this sample, but there are several significant differences in pattern (type and localization) for these variables. Specifically, we found that: 1) adult players have more ankle and muscle injuries than youth, 2) pivots and wings (second line) have more knee and cartilage problems, and 3) apophysitis is more frequent in immature players.

The results presented here, gathered by a single medical team with high level players, are difficult to compare to previous work given the methodological differences. Specifically, previous studies have been retrospective [24, 25], cohort study [26], or prospective [8, 9, 11], with different injury definitions ("medical attention" [25]), age groups or age categories [2, 6] and levels of competition (amateur, elite or even not clearly defined) [5, 8, 15, 24]. Regarding injury incidence, our results are in concordance with many previous studies; we did not find significant differences between categories [3, 5, 13]. However, there was a slightly higher match injury incidence in adults, probably due to the intensity of competition [15, 27].

Some authors describe the relationship between positional role and injuries with some limitations. Jørgersen [28] mentions higher incidence in goalkeepers and defenders, but the definition of injury used does not distinguish between those that cause "time-loss" and other "medical attention" injuries. Wedderkopp et al. [13] describe a link between playing position (in first line players) and a higher total injury incidence in female adolescents, but not in relation to localization. Other authors describe a common injury in goalkeepers, with high prevalence of elbow problems or lower back pain in females [29, 30]. The different playing positions require different motor skills and specific performance in handball [19, 31-33], but the relation of field playing position and injuries in male elite players with different age categories and maturity has not been studied thoroughly.

In the present study, among male elite players, there were no differences in the total injury incidence per hour of exposure according to playing position; however, there were differences in the pattern of injuries. Lower limb injuries, as documented by several authors [3, 7, 11, 34], are the most common in handball. In the current study, the most frequent sites were the ankle, knee, thigh, and head (as also described by Bere *et al.* [4] during 2015 World Cup), and all of these, except the knee, were significantly more common in adults than in youth players, presumably due to the demands of playing at a professional level. The majority of ankle injuries were joint sprains. Most muscle injuries were non-contact injuries [7], while those affecting the head were due to contact. Other authors have reported head injuries as being the most frequent in handball, to the face, nose, eyes, and teeth [4, 15], although this study included only matches, which are associated with higher intensity and risk of contact between players.

Most studies examining sports injuries and maturity state were in soccer, with conflicting results confounded by methodological issues [16, 17, 35]. Some authors describe more injuries during late maturity [17, 18] and others in the pubertal period during training [8]. However, most showed higher incidence of overuse injuries in immature players [36, 37]. In the present research, apophysitis was significantly more common in immature players, but without differences according to playing position. Knee injuries were more frequent in second line players in comparison to other playing positions, regardless of the maturity state in the group under 18 years. This shows that the knee is the most frequent injury location in all age groups. Knee injuries may be associated with long-term complications in handball players, such as osteoarthritis [38, 39]. Other authors record shoulder [40], hand, and finger injuries with high prevalence [3, 15]. Even though the above-mentioned injuries are among the eight most frequent injuries in our study, we detected no differences according to playing position, category, or maturity state, probably due to the preventive work routinely done in all categories.

The most frequent injury type in handball players is ligament sprains and muscle strains [8]. In our study group, as in similar studies, we found more muscle injuries in seniors and more ligament injuries in youth players [7]. In the present study the highest total values were for ligament sprains and muscles injuries with respect to other injuries but with no statistical differences between adult and youth or according to playing position, except that muscle injuries were more common in adults. Knee and articular cartilage injuries were more frequent in second line player as pivots in whom we speculate that their physically larger size and collision-related match play demands may contribute to these findings. By contrast, the wings have lower anthropometric measures [19] and they experience more distance running, sprints, and jumping with falls during the game [33]. Finally, the twisting movements combined with a high anthropometric profile and exposure to foul actions for pivots expose them to severe injuries [4, 33]. We suspect that these different match demands are likely causative of the observed differences in injury patterns.

Previous studies of handball injuries have included a higher number of injuries and individual participants. However, most of them were performed by questionnaire, with limited information about how

each injury was recorded. The present study, by contrast, tracks players in a longitudinal and personalized manner, collecting data on their injuries during two consecutive seasons, followed by the same medical and technical staff.

However, the selected population limited the number of participants in the study; hence we used the regular technical classification by position (three groups) instead of the 4-5 traditional specific positions. Moreover, a limitation could be related to the nature of the sport. Mature players (in morphology) are favoured more than others in different categories as a form of natural selection for the sport. Also the management of the training load in Futbol Club Barcelona Handball section is highly individualized in comparison with other models. For these reasons, the present results should not be compared with the general population. Also, the injury incidence per 1000 h takes into account the volume but not the intensity of exposure.

The study was limited to male players to avoid variability due to gender. We used testicular size and Tanner criteria to classify maturity, and not bone age, as used in some previous studies. This classification allowed us to obtain both quick and inexpensive information for clinical practice, which in turn makes it easier to reproduce the results obtained for future studies. In this regard, it is important to recall that a paediatric specialist or experienced doctor must take these measures (Tanner criteria) and no other health practitioners.

CONCLUSIONS

In conclusion, there are few studies determining the incidence or pattern of injuries in elite handball players specifically focusing on player position, youth and adults. The relationship between maturity and injuries in youth is probably not due to an isolated factor, and it must be understood as a consequence of less developed training and level of performance. Our study provides an overview in high-performance handball players of the relationship between several factors: age, maturity, and playing position, and injury pattern and incidence.

In our results, there are no significant statistical differences either between categories (youth vs adult), maturity state (immature/mature) or matches vs training, regarding injury incidence. Adults were found to suffer more ankle, muscle, and head injuries than youth players, probably due to a higher intensity level in competitions. Biologically immature players were found to have more apophysitis injuries than the rest of the players. Also the players in the second line playing position displayed more knee and cartilage injuries. Future research should include larger samples which may require multi-centre approaches, as well as controlling for individual variation in training contents and perhaps style of play.

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Conflict of interests

The authors declared no conflict of interests

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