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ORIGINAL STUDY

A demographic study of acute injuries in basketball players

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Studies that analyse the epidemiology of acute injuries in basketball players in European countries are limited.
The purpose is to present an overview of the incidence of injuries and injury patterns in Flanders and to correlate them to possible intrinsic and extrinsic risk factors.
All acute injuries that occurred in Flanders during 2009-2013, collected by the insurance, were analysed. The incidence and parameters such as date of birth, date of occurrence of the injury, gender and diagnosis were evaluated.
Injury incidence varied from 7.40% up to 8.45%. Females and players at age 16-17, 14-15 and older than 30 are at higher risk. The ankle/foot region is most frequently injured. There is a higher risk of injury after season-and Christmas break.
Age, gender and chronometry are risk factors to get injured. Sprains are the most frequent, while the ankle/foot region is the most susceptible to injury.
Studies that analyse the epidemiology of acute injuries in basketball players in European countries are limited.
Female players and players at age 16-17, 14-15 and older than 30 are at higher risk to basketball injuries. The ankle/foot region is most frequently injured followed by lower arm and hand.
There is a higher risk of injury after season-and Christmas break.

Keywords : demographic study ; injuries ; basketball

INTRODUCTION

Basketball is one of the most popular sports all over the world and keeps gaining popularity. The game requires intermittent high intensity efforts of the basketball players *(13)*. Agility, explosive power and strength will partially determine whether or not a basketball player is successful *(17)*. With this in mind the power, intensity and aggressiveness of the game should not be underestimated *(7)*.Taking all this things into account it is not surprising that basketball is characterized by a relatively high injury rate compared to other non-contact sports *(18)*.

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Despite the increasing popularity and the high-perceived risk of injuries studies that analyse the epidemiology in European countries are limited *(2,3,6)*. Moreover, the few studies that have been conducted have put their focus on elite basketball players or on young players and targeted the occurrence of certain specific injuries such as ankle injuries and overuse knee injuries. In addition only season is covered, which is a short period of time compared to certain studies performed in the USA *(17,5,16,12)*.

The main purpose of this study is to present an overview of the incidence of basketball injuries in Flanders and to correlate them to certain possible intrinsic and extrinsic risk factors. The second aim is to describe injury patterns, particularly patterns seen in location, type and chronometry.

MATERIALS AND METHODS

The Flemish basketball association features an insurance system that covers every member. As a result, all acute injuries which were reported to the insurance company covering the competition years 2009-2013 are evaluated. The injuries are documented on a standardized leaflet, which consists of several parameters such as date of birth and injury occurrence, gender and diagnosis. The locations of injuries were subdivided as described by Borowski *(5)*.

Basketball players were subdivided in groups according to the age categories used by the Flemish basketball association : 12-13 year, 14-15 year, 16-17, 18-19 year, 20-21 years, between 22 and 30 and above 30 year.

The type of injuries was classified in distortion, contusion, fracture, dislocation, musculotendinous injuries and ligamentous injuries *(4)*.

The permission to conduct this study was obtained by the Flemish basketball association, Ethias insurances and the ethical committee of Ghent University Hospital in accordance with the institutional rules for human research and the Declaration of Helsinki for Medical Research (EC UZG 2014/0961) involving human subjects. Statistical analysis was performed with the JMP® (SAS) software package at a 5% significance level (if not specified otherwise).

A Pearson chi-squared test is performed to test statistically whether there is a difference in incidence across the different competition years 2009-2013. Since we are interested whether the pattern across the different competition years is similar for the males and females, a nominal logistic regression model is fit. In particular, the binary variable that registers whether a person had at least one injury is modeled as a function of competition year (season), sexe and the interaction between season and sexe (season*sexe). In case the interaction term proves a difference in pattern across the competition years for males and females it needs to be investigated what difference is causing that significance. Then further exploration of the incidence by sex is required. Therefore, profiler plots are used and additional contingency tables are made for males and females separately, with accompanying “analysis of means for proportions”

The distribution of injuries across the different age categories in which the injury occurs, is explored for all individuals by means of a frequency bar chart and accompanying confidence intervals for the frequencies per category. The same distribution is explored for males and females separately by means of a contingency table.

RESULTS

A total of 36185 injuries were reported of which 28332 and 7852 injury events were reported by males and females, respectively.

The incidence of injured individuals is described as a percentage of the total number of members (Table I). Across the different competition years there is a significant decreasing trend.

The incidence is significant higher in females compared to males across the different seasons ($p < 0.0001$).

When one gets injured while playing basketball the majority of the individuals gets injured only once (62%), 20% gets injured twice, 9% three times and only 9% gets injured four times or more (inclusive season 2002-2013). The mean (± standard deviation) number of injuries is 1.75 (±1.32) for

Table I. — Total number of members and the incidence of injured individuals described as a percentage of the total number of members

	Female	Male	Total
2009			
Number of members	7197	27479	34676
Incidence of injured members as a **percentage** of the total number of members	9.23	8.25	8.45
2010			
Number of members	7240	27774	35014
Incidence of injured members as a **percentage** of the total number of members	8.88	8.50	8.58
2011			
Number of members	7368	27933	35301
Incidence of injured members as a **percentage** of the total number of members	8.63	7.97	8.11
2012			
Number of members	7348	28063	35411
Incidence of injured members as a **percentage** of the total number of members	8.94	7.69	7.95
2013			
Number of members	7326	28240	35566
Incidence of injured members as a **percentage** of the total number of members	6.44	7.65	7.40

all injured individuals and 1.75 (±1.33) and 1.75 (±1.26) for males and females, respectively (season 2002-2013). There is no significant difference in mean number of injuries per person between males and females (p=0.8737) (season 2002-2013).

Furthermore the distribution of injuries across age is significantly different across male and female (p<0.0001). The analysis of means for proportions (Figure 1) shows that among the injured individuals the proportion of females is the highest at 12-13 years, followed by the 10-11 year and the 14-15 year categories. On the other hand the proportion of injuries in females is the lowest for the 28-29 year category, followed by the 18-19 category and > 30 year category. For the remaining age categories the proportion of injuries in female is close to 21.7%.

The proportion of male injured individuals is the highest for > 28-29 year category, followed by the

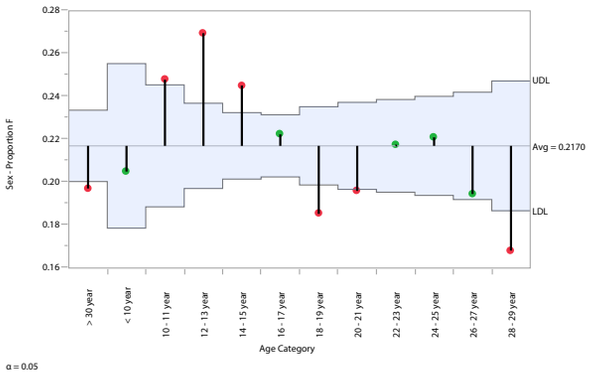

Figure 1. — The analysis of means for proportions (gender) according to age. UDL : upper decision limits (UDL). LDL : lower decision limits (LDL). Center line indicating the overall mean or root mean square error (or MSE when in variance scale). If a group mean falls outside of the decision limits, then that mean is significantly different from the overall mean. If a group standard deviation falls outside of the decision limits, then that standard deviation is significantly different from the root mean square error.

Table II. — Distribution of the number of injuries across the different body areas as a percentage of the total number of injuries

	Female	Male	Total
Head/ Face / Neck	8.22	10.65	10.11
Upper arm/ Shoulder	3.42	3.90	3.79
Lower arm/ Hand	22.81	19.98	20.62
Trunk	1.64	1.87	1.82
Hip/ Thigh/ Upper leg	3.38	3.95	3.82
Knee	16.18	13.29	13.93
Lower leg	2.74	3.00	2.94
Ankle/ Foot	41.60	43.35	42.96
Other	0.01	0.01	0.01
Total	100	100	100

18-19 category and > 30 year category. Injuries in males are the lowest for the category <10 year.

A large part of the injuries is located in the area of the ankle/foot (43%) and the lower arm/hand (21%), while a minor part of the injuries is located in the area of the knee (14%) and the head/face/neck (10%). Injuries located near the upper arm/shoulder and the hip/thigh/upper leg are each accountable for merely 4% of the injuries, while the lower leg and the trunk each represent only 3% and 2%, respectively.

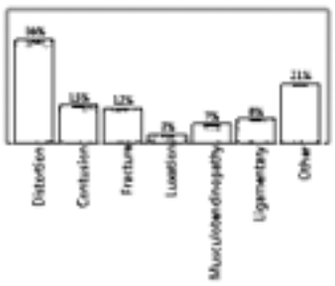

Figure 2. — Distribution of injury type

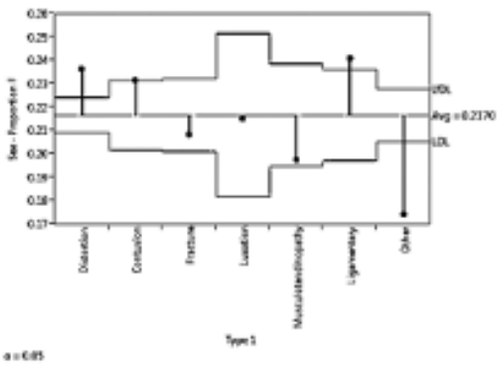

Figure 3. — The analysis of means for proportions (gender) according to injury type.

Furthermore, the distribution of number of injuries across the different body areas is significantly different across sexes ($p<0.0001$) (Table II).

There is a significant difference between age and location of the injury ($p<0.0001$). Lower arm injuries occur significant more frequently for age categories < 14 years.

The type of injuries is described in Figure 2. There is a significant difference between the type of injury and gender ($p<0.0001$). Concerning distortion and the ligamentous injuries the proportion of females among the injured individuals is larger (Figure 3).

The total number of injuries for both males and females after season break (September-November) and in the beginning of the year (January-March) is significantly higher than average while the number of injuries before season break (April-July) and December are significantly lower. Note that hypothetical probabilities are calculated as proportion of the total period (12months). Furthermore, the distribution of the number of injuries across the periods is significantly different among sexes ($p<0.0001$). The analysis of means for proportions figures out that the significant p-value is originating from the month April where among the injured individuals the proportion of females is much larger compared to other periods and the month August where the proportions of injuries is much larger for males compared to other periods.

DISCUSSION

A demographic study concerning the prevalence of basketball injuries in Belgium has never been conducted. Nevertheless in view of injury prevention, it is considered interesting to gain insight in the injury incidence and injury pattern in European players. One should keep in mind the different rules maintained by the FIBA (Fédération Internationale de Basketball) and the NBA. These are also partly responsible for the different nature of the game in Europe compared to the USA and the possible differences in injury patterns and injury risks between European/Flemish players and NBA players *(17)*. Moreover in Europe reliable information on injuries covering a long period of time is infrequent.

A review of the literature on injury incidences reveals inconsistencies in reporting methodologies ; therefore it is rather difficult to compare the outcomes of the studies and get a clear picture of the injury risk inherent to basketball. Some studies express the rates of injury as the ratio of injuries per 1000 athlete exposures *(5,11)*. An athlete's exposure has been defined as one athlete participating in one practice or contest while he or she is exposed to the possibility of injury *(21)*. Others report the injuries as a function of the total injuries divided by the total number of participants *(16,17)*. In this study we decided to report the injuries as a function of the total injuries divided by the total number of individuals, as the exposure time could not be retrieved.

A comparison of basketball injuries in different studies is listed in Table III. It can be noticed that the risk of getting injured is remarkable lower compared to the USA. The injury rate per 100 participants in Flanders covers a range from 7.4-8.4% for men and women in total and a range from 6.4-9.2% in females and 7.6-8.5% in male. It must

Table III. — A comparison of basketball injuries in different studies P : prospective, R : retrospective

	Design	Duration of the study	Team Type	Number of participants	Number of injuries	Injury Rate per 1000 AE	Injury Rate per 100 participants	Injury rate per 1000 hours of exposure
Borowski et al. (5)	P	2 years 2005-2007	High School	-	1518	1.94	-	-
Randall et al. (16)	R	16 years 1988-2004	College (Men)	-	12044	Practice: 4.3 Game: 9.9	-	-
McCarthy et al. (12)	R	8 years 2000-2008	WNBA	506	-	-	-	-
Deitch et al. (8)	R	6 seasons 1996-2002	NBA WNBA	703 443	2876 1570	19.3 24.9		-
Starkey (17)	P	10 years 1988-1997	NBA	1094	7449	21.0-21.7		-
Cumps et al. (7)	P	1 season	All levels	149	226	-	-	6.0
Gomez et al. (10)	P	1 season 1993-1994	High School	890 (Girls)	436	-	49	-
Messina et al. (14)	P	1 season	High School	973 (Boys) 890 (Girls)	543 436	-	55.8 49	3.2 3.6
Colliander et al. (6)	R	1 season 1981-1982	Swedish elite	-	-	-	-	2.5(women) 2.85 (men)
Yde et al. (21)	P	1 season 1985-1986	Sports club Danmark	56	-	-	-	3.3

be emphasised that these studies *(10,21)* focus on the high school level, while our study focuses on all age-categories. Nevertheless these are remarkable differences and need further investigation.

A significant difference in probability of injury between males and females was noted. In particular, females have a larger probability of getting injured than males. These findings were to be expected and are similar to the analysis conducted in the USA *(5,8,18)*. According to those studies, women sustained overall more injuries compared to men *(13)*, not only at high school level *(5)*, but also in professional basketball *(8)*. In 2013 a lower incidence of injured female is noticed compared to previous years. The reason why this remarkable gender difference is seen cannot be deducted from this study. However the higher injury risk in female players may be related to hormonal fluctuations resulting in an increased laxity of ligaments and muscles, which can be associated with joint instability, especially in muscle-controlled joints. Furthermore joint instability can be accompanied with loss of proprioception and a predisposition to incur traumatic injuries with a possible hyperextension of the knee and an inversion trauma of the ankle *(9,19)*. Anatomical and biomechanical factors could also be implicated *(19,22)*.

When evaluating the age at time of injury, usually the chronological age is used. It is commonly understood that there are great individual differences in development between adolescents and also the use of the Tanner stages has been proposed. A study, performed of players between 9 and 19 years reports how the injury risk seems to increase with pubertal development rather than chronological age ; more specifically adolescents in Tanner stages 4 and 5 have the highest injury risk *(15)*. However there is conflicting information on this topic. A Swiss study described that the risk increases with pubertal development *(15)*. However a study performed in Denmark concluded that injuries increase with chronological age *(21)*. A study in the USA noticed this pattern in both sexes separately *(11)*. In our study considering the overall injury incidence in men and

Table IV. — Comparison of the injured body regions in our study to other studies in the USA

	NBA (USA)	WNBA (USA)	Gomez Girls (USA)	Messina (USA)	Flanders
Head/ Spine /Trunk	20.2	18.1	14	Male: 20 Female:14	Total: 1.93 Male: 12.52 Female: 9.86
Upper extremity	14.8	15.1	15	Male: 16 Female:14	Total: 4.41 Male: 23.88 Female:26.23
Lower extremity	64.6	65.7	69	Male: 61 Female:69	Total: 63.65 Male: 63.59 Female:63.90
Other	0.5	1.1	2	Male: 3 Female: 3	Total: 0.01 Male: 0.01 Female: 0.01

women, there is a peek at the age of 14-15, 16-17 and in the category older than 30. When evaluating the distribution of the number of injuries across age in our study between males and females, the analysis shows that the proportion of female injuries is the highest at the age of 12-13, followed by 10-11 and 14-16 years. Whether or not this results can be addressed to pubertal development and Tanner stages cannot be derived from this study.

Reviewing the literature it is found that most injuries in basketball occur in the lower extremities. Harmer reports a range from 35.9-92% of the total injuries *(11)*. The single most frequent injured region is the ankle and foot region *(5,7,11)*. The knee is the second most injured body site *(5)*. Several studies suggest that women are at a greater risk for knee injuries than male athletes *(5,7,8,11)*, whereas NBA players and boys experience more trunk-related problems such as lumbar erector spinae back strains *(5,8)*.

A comparison between injury percentages for the different body areas according to different studies from the USA and this study is shown in Table IV.

When comparing the injured body regions in our study to other studies in the USA some differences can be noticed. (Table IV) First of all the percentage head/spine/trunk injuries are smaller compared to the USA. This pattern is seen both in men and women separately. Nevertheless the general trend of these injuries occurring more in male than female still exists. Second we see a remarkable higher injury incidence in the upper extremity compared to the USA. Finally the injuries in the lower extremity are very similar *(8,10,14)*.

Only one other study on injury location has been performed in Europe. It should be emphasized that the data of the study were conducted at the hospital emergency departments *(2)*. This is a different design than in this study. Nevertheless it is included in further discussion.

When comparing these data a notable difference can be seen. The study analysing data of 5 countries in Europe reports a range from 67.5-72 % of the total contributed to Upper extremity injuries *(3,11)*. This is in contrast with our study that reports a 24.4 percentage of the total injuries. A reversal of finding is repeated in the lower extremity *(2,11)*. Our study reports that 63.7 per cent of the total injuries can be attributed to the lower extremity, while Belechri et al. reports a range from 23.7-26 % of the total injuries in this region *(2)*. The reason for this extreme difference cannot be explained by this study, this could possibly be explicated by the different study design.

When looking at the categories by Borowski et al. design *(5)* both studies show the ankle/foot body region as the most frequently injured. The distribution of the number of injuries across body regions is significantly different between males and females.

Comparing the different injury incidences by injury location, in the same way as the records from

the Borowski et al. study (USA) we observe a higher number in the upper extremity (lower arm and hand). In male players the trunk area is more frequently injured, while in female players the difference in head/spine/trunk injuries can be related to the lower incidence in head/face/neck injuries.

Additional analyses on age and injury location were done to be able to compare the distribution with the existing literature. When comparing the age group : 14-18 (age of high school players in USA) with the Borowski study the same conclusion can be drawn as described above. This study has a higher incidence in lower arm/ hand region injuries at the <14 year- category. The reason why cannot be deducted from this study.

The differences in injured body regions were to be expected due to the different nature of the game since American basketball put emphasis on athletically skills and spectacular moves, whereas European basketball is more determined by the profit objective. However the true reason for this difference cannot be deducted from this study.

Assessing the literature sprains are the most common type of injury suffered by basketball players *(5,16,17,18)*. This is consistent with the results in our study. We take special notice of the ankle sprains. This has been reported by several studies as the most common musculoskeletal injury *(5,16,17,18)*. This is also confirmed by this study. The second most occurring injury type is the contusion, followed by fractures. Previous studies in the USA reported similar results. Fractures are most frequently seen in the lower arm and hand *(5)*, which consistent with this study.

Concerning injury type similar finding compared to the USA studies can be found. This can be due to the low number of studies examining injury type as a topic of interest. Often this is analysed together with the body area. Nevertheless musculotendinous injuries occur less frequent compared to a study conducted in the USA while the other types are frequenting similar *(5)*. Moreover in literature fractures are more commonly seen in males *(5,8)*. This analysis shows a similar result, but not to a significant level.

The studies which take into account the timing of the occurrence of a sports injury are scarce. However studies that focused on different sports disciplines, such as soccer, have shown that there is an injury peak in the first three months of the season *(4)* and it has shown to have its implication to adapt the sports training. Only one study focused on knee injuries in female high school basketball players, reported that most injuries occurred in the first half of the season *(20)*.

The total number of injuries after season break (September - November) is significantly higher than expected for both sexes. This is consistent with the soccer study from Bollars et al. *(4)*. Nevertheless it needs to be stressed that there is likewise seen an injury peak in January-March, after the Christmas break which wasn't seen in any other study performed on basketball or on other sports. A possible explanation could be that the break may lead to a short-term deconditioning of the players, resulting in an increased injury risk. This study is the first to investigate the differences in sexes concerning the chronometry in injuries. The number of injuries across the periods is significantly different across sexes. In particular, during the month of April more females are injured than in other periods. Male players have an injury peak in August. Further investigation is needed to uncover the reasons for this remarkable difference across sexes.

Assuming that intrinsic factors age and gender and extrinsic factor chronometry is a cause of injury, the best approach to prevent injuries is to change the risk factor. However some risk factors, such as gender, are non-modifiable but they may be equally important in injury prevention if used to target those players at risk *(1)*.

To conclude age, gender, chronometry are all risk factors to acquire an injury in basketball. Sprains are the most common injury, while the Ankle/Foot region is the region to be susceptible to injury. A different peak moment is seen among gender with a peak for females around April and August for males. These findings might be important in the prevention of injuries in basketball. Possible recommendations could be to maintain a good physical condition. Even during season break there is a need for a balanced fitness program with attention for strength training, flexibility and aerobic exercises. Basketball-specific

injury prevention programs for lower extremity injuries should be implemented by the coaches in their training schedule.

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