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Handball players' training profile and its relation to potential injuries

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Abstract

Although injuries in handball show high frequency and severity, the training profile of handball players and its relationship to injuries has not been extensively investigated. The purpose of the study was to describe this relationship between players' training profile and injuries. In total, 216 male and female players from A1 Division teams and players from U19 and U17 teams answered a relevant questionnaire. The statistical analysis, including descriptive and inductive statistics (correspondence analysis, one-way analysis of variance [ANOVA], multivariate analysis of variance [MANOVA], chi-square test), revealed that injured players mainly had ligament injuries of the lower extremities, especially the knee, while the mechanism most frequently reported by the players was an unfortunate moment. The frequency of injuries was higher in the game than in training, especially in attack, resulting in many serious injuries (return-to-play [RTP] ≥ 4 weeks). In most cases diagnosis was made by doctors while the therapeutic methods were different for each athlete. Correspondence analysis revealed that injured players were differentiated in terms of their training content and daily training, as well as competition level. The ANOVA showed that the severity of the injury was independent of all quantitative and qualitative variables examined, while the chi-square test indicated that the frequency appeared to be related to engaging in another sport prior to handball, to the playing position, and to prevention training. Further research is needed to clarify this issue.

Keywords: *Training load, Exposure, Impacts of handball training and competition*

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Introduction

Modern handball is a fast-paced sport, with a high pace in defense and attack (Karcher & Buchheit, 2014). Injuries in this sport appear to show high frequency and severity in both men and women. The frequency of injuries in handball ranges between 4.1-12.4/1000 hours of training or competition, with 3-10 times more injuries during games, especially (85%) in official competitions (Bere et al., 2015; Luig & Henke, 2010; Mónaco et al., 2019). Many studies also show a high percentage of high severity, which leads to abstinence from training and competition for a long time (Bedo et al., 2019; Rafnsson et al., 2017). Raya-González et al. (2020) reported that male senior handball players had the highest values of incidence for injuries during training and matches. The same authors stated that male players suffered from ankle and knee injuries while female players suffered from knee injuries. Male players main-

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ly seem to have a high incidence of strains while female players seem to have contusions and sprains. Although in general injuries last fewer than seven days, it seems that female players have more serious injuries (Raya-González et al., 2020). This is because female players suffer mainly and especially from anterior cruciate ligament (ACL) injuries.

Furthermore, Mónaco et al. (2019) stated that regarding injury incidence there are no statistically significant differences between youth vs adult categories. The same authors also reported no statistically significant differences between immature vs mature players. Immature players have more apophysitis injuries than all the other players. Adults presented more ankle, muscle and head injuries than youth players, because in competitions adults play at a higher level than youths (Mónaco et al., 2019).

A review of the literature shows that, although handball injuries have been extensively analyzed, references to the players' training load and its relationship to injuries are lacking (Bjørndal et al., 2021). More specifically, although training elements such as warm-up, individual technique, stretching, general physical condition of a player, team tactics followed by the team, participation of the team in friendly matches and prevention training seem to be important factors in the occurrence or non-occurrence of injuries, they have not been extensively analyzed and need further investigation (Raya-González et al., 2020). In the present study we regarded the terms "training load" and "training profile" of a handball player as equivalent. Thus when we refer to the training profile of a handball player we mean the training load: all the elements (warm-up, individual technique, stretching, etc.) included during training.

It appears from the above that injuries and their relationship to the players' "training profile" are poorly described in the literature and there is a lack of information on this issue. This led to the goal of the present study, which was to describe the relationship between the training profile of handball players and the injuries that occur.

Methods

The study sample consisted of 216 handball players in A1 division teams and U19 and U17 players. Of the 216 players of our sample, 166 (76.9%) were males and 50 (23.1%) were females. Their mean age was 21.07 ± 5.16 years. Players' mean height was 180.64 ± 9.21 cm. Mean body weight was 79.71 ± 13.1 kg. The mean starting age of playing handball was 10.56 ± 2.53 years, while the total years of playing were 10.51. ± 5.13 years. Of our sample, 148 (68.5%) had played another sport before playing handball. Of those, 31.9% were back players, 31.9% wings, 20.4% pivots and 15.7% goalkeepers. Also 133 (61.6%) participated in more than 4 trainings per week, 62 (28.75%) in 2-4 trainings and 21 (9.7%) in less than 2 trainings. Moreover, 191 (88.4%) followed the whole basic stage of preparation and physical condition trainings, during the pre-season and before the start of the in-season obligations of the team. Of the sample, 137 (63.4%) had a participation of more than 50% in team games, 42 (19.5%) 25-50%, and 36 (16.7%) less than 25%.

All participants completed a questionnaire related to the training process and their injury history. The questionnaire included demographic and anthropometric characteristics, questions related to the training, and questions on the injuries suffered by the players in the previous season.

Descriptive and inductive statistics were used for the statistical analysis of the present study. More specifically, the frequency of the values and their corresponding percentage, as well as the mean value and standard deviation (SD) were used. Correspondence analysis was also applied in order to verify the differentiation of the injured individuals, in terms of their training content and their daily training on the one hand and their competitive level on the other. We divided the sample into injured and uninjured players. In order to determine the relationship between the severity of the injury and the competition level with all the qualitative and quantitative variables of the study, one-way analysis of variance (one-way ANOVA) was applied. Multivariate analysis of variance (MANOVA) was applied to find significant differences between injured and uninjured players. A chi-square test was used to identify the relation of severity with the quality variables. The significance level was set at 0.05. The statistical processing of the data was carried out using SPSS 22.

Results

In the previous season, 106 players were injured. The remaining 110 players did not suffer any injuries in the previous season. The MANOVA showed a borderline differentiation between injured and uninjured players while univariate analy-

Table 1. Statistically significant differences between injured and uninjured players

Variables	Last season injuries	N	Mean Rank	p
Warm-up	Yes	106	101.80	0.173
	No	110	114.96	
	Total	216		
Stretching	Yes	106	102.66	0.173
	No	110	114.13	
	Total	216		
Individual Technique	Yes	106	104.32	0.251
	No	110	112.53	
	Total	216		
Team Tactics	Yes	106	108.75	0.976
	No	110	108.26	
	Total	216		
Physical Condition	Yes	106	102.21	0.128
	No	110	114.56	
	Total	216		

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Variables	Last season injuries	N	Mean Rank	p
Friendly Games	Yes	106	96.83	0.004
	No	110	119.75	
	Total	216		
Prehab Training	Yes	106	96.78	0.005
	No	110	119.80	
	Total	216		

sis showed two variables which differentiate injured from uninjured athletes: "friendly games" and "prehab training". Table 1 shows the statistically significant differences between injured and uninjured players.

In players who had at least one injury, the most frequent injuries were 36.8% ligament injury and 22.6% muscle rupture. Regarding the location (injury point), the point with the most injuries (76 cases) was the lower extremities. More specifically, 27 players suffered injuries to the knee, 22 to the ankle, 10 to the tibia, 11 to the thigh, 3 to the hip and 3 to the toes. Regarding the mechanism of injury, the possible causes of injury reported by the players were mainly an unfortunate moment (44.3%), overtraining (33%) and collision with an opponent (22.6%).

The chi-square test showed that the situation (training or game) was independent of the time at which the players were injured (chi-square = 3.155 and p=0.207). Table 2 shows the frequency and the corresponding percentage of players in terms of the situation (training or game) and the time at which they were injured.

Table 2. Situation and time of injury in training and in game (game minute of injury)

	Number of players	Start – game minute of injury	Middle – game minute of injury	End – game minute of injury
Training	49	11 (22.4%)	29 (59.2 %)	9 (18.4%)
Game	57	18 (31.6%) 0-20′	25 (43.8%) 20-40′	14 (24.6%) 40-60′
Total	106	29 (27.3%)	54 (50.9%)	23 (21.6%)

Table 3 presents the situation in which the injury occurred both in training and in the game, the place and time of the diagnosis, the person who made the diagnosis, the treatment and the therapeutic means followed by injured players, and the players' return to the previous playing activity.

Table 3. Situation which the injury occurred, place, time and person of diagnosis, therapeutic means and return of the players to the previous playing activity

	Situation of Injuries		Place of diagnosis		Person of diagnosis		Therapeutic means		RTP	
		%		%		%		%		%
Defense	21	19.8								
Attack	44	41.5								
Counter attack	11	10.4								
Other	30	28.3								
Total	106	100								
Sports hall			11	10.4						
Hospital			25	23.6						
Private doctor's office			66	62.2						
Other			4	3.8						
Total			106	100						
Coach					1	1				
Physiotherapist					12	11.3				
Doctor					93	87.7				
Total					106	100				
Physiotherapy							73	68.6		
Kinesiotherapy							25	23.5		
Medical treatment							34	32		
Operation							18	16.9		
Other							12	11.3		
Total							106			
Immediately									1	1

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	Situation of Injuries	Place of diagnosis	Person of diagnosis	Therapeutic means	RTP	
1st week					16	15.1
2nd week					20	18.9
3rd week					18	16.9
4th week					13	12.3
> 4th week					38	35.8
Total					106	100

The correspondence analysis showed that the injured individuals in this study were differentiated in terms of their training content and their daily training. Thus, injured players were divided according to the volume of daily training into injured who competed with satisfactory training content and injured who competed with unsatisfactory training content. On the right of Figure 1, with the low values, is the incomplete training content, while on the left of the chart, where high values are observed, is the adequate training content. The injured were also distinguished according to competitive level, on the vertical axis of the diagram. They were divided into players (men/women) competing in the first divisions, shown in Figure 1 around a circle with the variables "A1" and "Seniors", and players (men/women) competing in the lower divisions, in the upper circle with the variables U19 and U17. Here it is important to mention that in the higher divisions line players are injured the most (the variable "pivot" is in the center of the lower circle), while in the lower divisions all the other playing positions are injured.

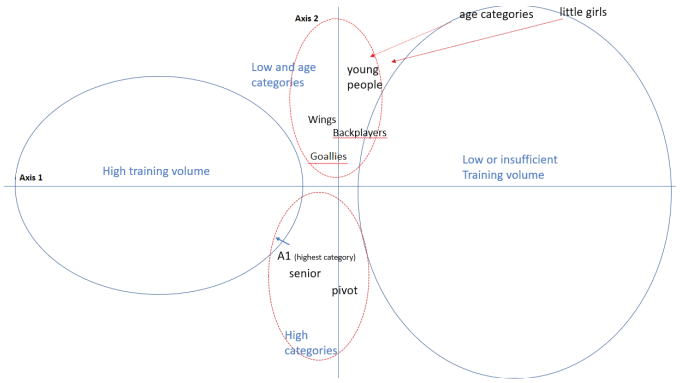

Figure 1. Correspondence analysis of injured players

The correspondence analysis revealed that the competitive levels of the injured players do not seem to affect the severity of the injury.

The one-way ANOVA showed that the severity of the injury measured in hospitalization time (no hospitalization, a week, between 1 and 2 weeks, between 2 and 3 weeks, between 3 and 4 weeks, over 4 weeks) is independent of all the other quantitative variables, such as the players' height (p = 0.881), weight (p = 0.475), age of starting handball (p = 0.723), and years of involvement in the specific sport (p = 0.132). Table 4

Table 4. Relationship between severity of injuries and other variables

Variables	Severity of injuries
	p
Category level	p=0.566
Team level	p=0.489
Previous sport	p=0.641
Playing position	p=0.721
Training frequency	p=0.547
Preparatory phase	p=0.612
Game frequency	p=0.283
Warm up	p=0.689
Stretching	p=0.479
Individual technique	p=0.114
Team tactic	p=0.136
Physical condition	p=0.647
Friendly game	p=0.556
Prehab training	p=0.750

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shows the relationship between severity of injuries and the other variables.

The chi-square test showed that the injury as a fact (injury/no injury) is independent of all the variables measured, except the variables of involvement in another sport before handball (previous sport), playing position (position) and prevention training (prehab).

More specifically, in players who were involved in another sport before handball, there were more injured than non-injured. Table 5 shows the injury as a fact (injury/no injury) and the chi-square test values.

Figure 2 shows the relationship of injured and uninjured with the playing position. Back players and line players (pivot) had more injuries than the other positions. Furthermore, it seems that the "status" (injured/uninjured) and the relationship with the playing position is statistically significant, and the significance is found mainly in the wings (with adjusted residual = 2) and secondarily in the pivots (with adjusted residual = 1.85).

Table 5. Injury as a fact (injury/non-injury) and chi-square test values

Injury during previous season	
Variables	p
Previous sport	p=0.038
Play Position	p=0.036
Play percentage	p=0.069
Friendly games	p=0.065
Prehab training	p=0.046

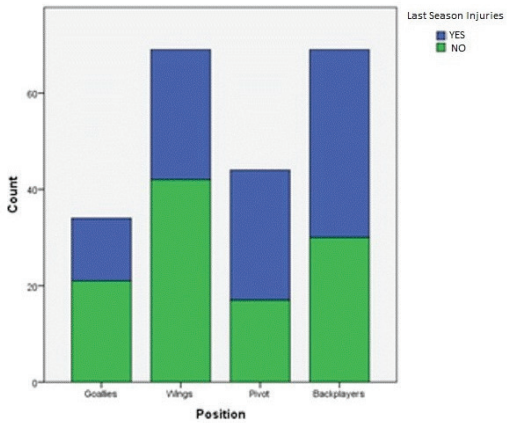

Figure 2. Relation of injured and uninjured players with playing position.

Concerning the relationship between injured/uninjured and prevention training, as shown in Figure 3, the less prevention training the more injuries. The high point is no prevention training, which means that everyone was injured, with an adjusted residual=2.3 and n = 5.

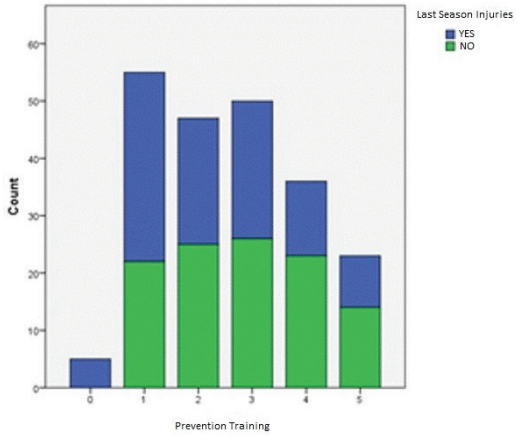

Figure 3. Relation of injured and uninjured players with prevention training.

Discussion

In the present study we had a borderline differentiation between injured and uninjured players, while it seems that two variables distinguish injured from uninjured athletes: "friendly games" and "prehab training". Regarding friendly matches, the results showed that the majority of players participate in

friendly matches a little to moderately. This makes sense, since the number of friendly matches decreases during the season (Kniubaité, 2020). Regarding prevention training, it appeared that 35.8% and 20.8% respectively did not use prevention training at all or did it moderately. Players should make use of basic prevention through preventive exercise programs (Instrumental or Physical-Exercise Rehabilitation – IPER). The main reasons preventing use of these exercises are lack of knowledge about injury risk and the benefits of prevention, lack of motivation, and coaching approaches and "policies" (Moller et al., 2018).

Regarding the type and location of injuries, the results of the present study are in line with the international literature (Mónaco et al., 2019). More specifically, in the sample of injured players, ligament injuries (36.8%) and muscle fractures (22.6%) are most frequent. The types of injuries to the lower extremities are usually sprains, bruises and fractures, as well as ligament injuries which occur mainly in the knee and ankle (Luig & Henke, 2010). Concerning the location of the injuries, 76 players suffered injuries in the lower extremities: 27 knee injuries and 22 ankle injuries. The injury mechanisms most frequently reported by the players were an "unfortunate moment" (44.3%) and "contact with an opponent" (40.5%), Handball, as a contact sport, has a high probability of injuries due to the frequent collisions between players (Tyrdal & Bahr, 1996).

The results of the present study also agree with those of other research stating that the frequency of injuries is higher in the game than in training, especially in attack (Mónaco et al., 2019; Luig et al., 2020; Laver et al., 2018). Moreover, the results are partly in line with another study (Luig et al., 2017) which found that injuries occur in the last ten minutes of each half. In our results this was only verified in the first half, in line with Bere et al. (2015). However, although there is a tendency for injuries to occur in the second half, this differs in the female population (Laver et al., 2018).

The results also showed that the situation of injury was mainly in attack, in accordance with the literature (Mónaco et al., 2019; Luig et al., 2020; Laver et al., 2018). Physicians are responsible for diagnosing injuries in a team (Mónaco et al., 2019). The results of the present study agree with the above, since in most cases the diagnosis was made by doctors. Various therapeutic methods were used, since they should be individualized according to the requirements of each player, the current situation, the functionality, the type and the severity of injury, the requirements of the sport, etc. (Laver et al., 2018). Regarding the time of return to the same competitive activity, most of the sample returned at 4 weeks or later. This classifies these injuries in terms of severity as very serious (Laver et al., 2018; Rafnsson et al., 2017).

The correspondence analysis revealed low values for the incomplete training content and high values for the adequate training content. This is logical because in the sample of the present study there were players who competed at a high level but also players in younger age teams. The same analysis showed that the injured were distinguished based on their competitive level. In our study the injury rate appears to be higher in the higher competition levels, probably due to the greater intensity of the game at this level (Mónaco et al., 2019). Raya-González et al. (2021) found no significant differences between divisions in terms of injury frequency; however, a higher rate of injuries was observed in the lower divisions during training and a higher incidence of injuries in the higher divisions during game. Our results also showed that in the top competitive levels, the line players (pivots) are injured the most, while in the low competitive levels all the other playing positions are affected. These results are in contrast to research stating that elite back players present the highest percentage of ACL ruptures (Laver et al., 2018). Furthermore, the correspondence analysis revealed that the severity of the injury does not seem to be associated with the competition level of the injured players. A recent study of Brazilian handball players found that handball has many acute and serious injuries resulting in players being out of training and games for a long time (Bedo et al., 2019; Rafnsson et al., 2017).

The one-way ANOVA and the chi-square test revealed that the severity of the injury was independent of all the quantitative and qualitative variables of the present study. The chi-square test showed that the fact of injury (injury/ no injury) was independent of all the variables measured, except the variables of involvement in another sport before handball (previous sport), playing position and prehab training. Engaging in other sport activities results in an additional burden that leads to health problems (Bjørndal et al., 2021). This is probably due to additional school sport activities, since in our sample there were a certain number of school students. Regarding the injuries per position in the present study, we found that back players and line players (pivots) suffer injuries more frequently than the other playing positions. This is in line with the findings of another study (Luig & Henke, 2010). Finally, regarding prevention training, the present study found a relationship between prevention training and injuries. This result is consistent with a meta-analysis study which showed that there was a significant reduction in the overall incidence of ACL ruptures in both the total number (50%) and the number of non-contact injuries (75%) in female players who followed prevention programs (Webster & Hewett, 2018). Moreover, one review states that prevention programs in team sports are effective in avoiding lower limb injuries, particularly knee, ACL, and ankle injuries (Brunner et al. 2019).

Although the strong point of the present study is the large sample examined for the relationship between injuries and training profile, the results have some limitations in terms of overall research. The first limitation is that our sample included both adult players (men and women) and younger players. This was due to the fact that the questionnaires were answered in the preparation period, when higher division teams include players of younger ages in order to give them the opportunity to participate with the men's or women's team and gain additional experience. Further research is needed on each individual age group in order to ensure the representativeness of the sample in the general population and make the results of the statistical analysis specific to each age group. The second limitation of the present study is the absence of previous research on this issue. Therefore, the purpose of this study was to develop a completely new research approach to the topic and to identify this gap in the literature, meaning that further research is needed.

Conclusions

In conclusion, we would say that although there was a borderline differentiation between injured and uninjured players, "friendly games" and "prehab training" differentiate injured from uninjured athletes. Injured players mainly had ligament

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injuries in the lower extremities, especially the knee, while the mechanism most frequently reported by the players was an unfortunate moment. The frequency of injuries was higher in the game than in training, especially in attack. In most cases diagnosis was made by doctors while the therapeutic methods were different for each athlete. Regarding the time of return to the same competitive activity, the highest percentage of the sample returned at 4 weeks or later. The injured individuals in this study were differentiated in terms of their training content and daily training, and also according to their competitive level. Another important finding was that the severity of the injury did not seem to be associated with the competitive level of the injured players. The severity of the injury was independent of all quantitative and qualitative variables of the study, while the chi-square test showed that the fact of injury (injury/no injury) was independent of all the variables measured, except the variables of involvement in another sport before handball (previous sport), playing position and prehab training. From the above it seems that although the training profile is related to injuries, further research is needed to clarify this issue.

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