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EXPLORING SEASONAL AND ORGANISATIONAL DETERMINANTS OF INJURY RECURRENCE AND BURDEN IN CROATIAN FOOTBALL AND HANDBALL

Utjecaj sezonskih i organizacijskih čimbenika na ponavljanje ozljeda i opterećenje ozljedama u hrvatskom nogometu i rukometu

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ABSTRACT

Background: Sports injuries challenge team sports by affecting athletes' availability and training. Seasonal and organisational factors may influence the occurrence, recurrence, and cumulative burden of injury**.** The aim of this paper is to explore the association between seasonal and organisational factors and injury recurrence and burden among Croatian male football and handball players.

Methods: This secondary exploratory analysis included 203 male athletes (114 football players and 89 handball players) competing in national leagues. Analysed variables included sport type, training volume, season phase, and access to a club physiotherapist. Associations between season phase and injury were analysed using chi-square tests; odds ratios (ORs) and relative risks (RRs) were estimated to explore links between organisational factors and recurrent injuries.

Results: Injuries occurred more frequently during the competitive phase of the season (58.9%) compared with the preparatory phase (41.1%) ($x^2(1)=10.68$, $p=0.001$, $OR\approx2.05$). Teams with access to a physiotherapist reported fewer recurrent injuries (43.9%) compared with teams without physiotherapy support (60.0%), corresponding to a 27% lower relative risk (RR=0.73), although the difference did not reach statistical significance. The estimated injury burden ranged between 7 and 11 lost weeks of training or competition per athlete annually, corresponding to approximately 15–20% of a standard competitive season.

Conclusion: The findings suggest that the competitive phase of the season may be associated with increased injury risk, while regular physiotherapy support may contribute to reducing injury recurrence and cumulative absence from sport. Continuous physiotherapy involvement, workload monitoring, and structured injury surveillance may be important for maintaining athlete health and season availability.

Keywords: Soccer; Handball; Athletic Injuries; Physical Therapy Modalities; Rehabilitation

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SAŽETAK

Uvod: Sportske ozljede predstavljaju izazov u ekipnim sportovima jer utječu na dostupnost sportaša i kontinuitet treninga. Sezonski i organizacijski čimbenici mogu utjecati na pojavnost, ponavljanje i ukupno opterećenje ozljedama. Cilj ovog rada je istražiti povezanost sezonskih i organizacijskih čimbenika s ponovnim ozljedama i opterećenjem ozljedama kod hrvatskih nogometaša i rukometaša.

Metode: Ova sekundarna eksplorativna analiza uključila je 203 muška sportaša (114 nogometaša i 89 rukometaša) koji su se natjecali u nacionalnim ligama. Analizirani su vrsta sporta, volumen treninga, faza sezone i dostupnost klupskog fizioterapeuta. Povezanost između faze sezone i ozljeda analizirana je hi-kvadrat testom, dok su omjer izgleda (OR) i relativni rizik (RR) korišteni za procjenu povezanosti organizacijskih čimbenika i ponovnih ozljeda.

Rezultati: Ozljede su se češće javljale tijekom natjecateljske faze sezone (58.9%) u odnosu na pripremno razdoblje (41.1%) ($\chi^2(1)=10.68$, p=0.001, OR≈2.05). Momčadi s fizioterapeutom imale su manji udio ponovnih ozljeda (43.9%) u usporedbi s momčadima bez fizioterapeutske podrške (60.0%), što odgovara 27% nižem relativnom riziku (RR=0.73), iako razlika nije bila statistički značajna. Procijenjeno opterećenje ozljedama iznosilo je između 7 i 11 izgubljenih tjedana treninga ili natjecanja po sportašu godišnje, što odgovara približno 15–20% standardne natjecateljske sezone.

Zaključak: Nalazi upućuju na to da bi natjecateljska faza sezone mogla biti povezana s povećanim rizikom od ozljeda, dok bi kontinuirana fizioterapeutska podrška mogla doprinijeti smanjenju ponovnih ozljeda i ukupnog izbivanja iz sporta. Kontinuirano uključivanje fizioterapeuta, praćenje opterećenja i strukturirani sustavi nadzora ozljeda mogu biti važni za očuvanje zdravlja sportaša i njihove dostupnosti tijekom sezone.

Ključne riječi: nogomet; rukomet; sportske ozljede; fizioterapijske metode; rehabilitacija

INTRODUCTION

Football and handball are contact team sports that require repeated high-intensity actions such as accelerations, decelerations, jumps, and abrupt changes of direction (1–3). These dynamic, repetitive movements, combined with frequent player-to-player contact, make both sports highly susceptible to musculoskeletal injuries. At professional and semi-professional levels, dense match schedules and heavy training loads can reduce recovery opportunities and elevate injury risk despite the recognised health benefits of regular physical activity (4).

Epidemiological evidence shows that contact team sports have higher injury incidence than non-contact individual sports, averaging about 2.6 injuries per 1000 hours of exposure (5). In football, muscle injuries account for approximately one-third of all cases, with about 92% affecting the lower limbs; reported rates increase from 3.7 injuries per 1000 hours during training to more than 30 per 1000 hours in competition (6,7). Recent data indicate that the overall incidence of injuries in professional male football players is approximately 7.75 ± 2.28 injuries per 1000 hours of exposure, while that of amateur players is 7.98 ± 2.95 injuries per 1000 hours. The incidence of match injuries (30.64 ± 10.28 injuries/1000 h) is about 7.7 times higher than training injury rates (3.97 ± 1.35 injuries/1000 h) in professionals and 5.5 times higher in amateurs (17.56 ± 6.15 vs. 3.22 ± 1.40 injuries/1000 h) (8). Aggregate lower-extremity injuries predominate in both groups, accounting for about 83% in professionals and 80% in amateurs, with the thigh, ankle, and knee being the most frequently affected sites. Handball demonstrates a similarly high injury incidence, ranging from 0.9 to 2.6 per 1000 training hours and 9.9 to 41 per 1000 competition hours (9–11). High injury rates are consistently observed across professional, amateur, and youth levels, both in training and match play (6,7,11). Increasing competitive demands, speed, and training intensity further contribute to this trend (12). Musculoskeletal injuries account for approximately 80% of football injuries and about 67% of handball injuries, with the remainder involving other body systems (13,14).

Beyond these sport-specific patterns, injury occurrence and recurrence in team sports are influenced by multiple contextual and organisational factors, including training load, competition phase, and the quality of healthcare support (12). Seasonal variation, typically a higher incidence during the competitive phase, reflects fluctuations in physical and psychological stress, while consistent physiotherapy involvement may enhance rehabilitation

and reduce time loss. Examining these seasonal and organisational determinants provides essential insight for mitigating injury recurrence and overall burden, particularly within smaller national contexts such as Croatia.

Building on previous findings (15), this study examined how seasonal and organisational factors are associated with injury recurrence and burden among Croatian male football and handball players. The following hypotheses were formulated: (H1) injuries would occur more frequently during the competitive phase than during the preparatory phase of the season, (H2) clubs employing a physiotherapist would show lower injury recurrence rates than those without one, and (H3) teams with a physiotherapist would have a smaller overall injury burden, expressed as the total number of time-loss weeks per athlete.

METHODS

This study represents an exploratory secondary analysis of data previously collected and published by Gosić et al. (15). The original research was a cross-sectional study designed to describe the prevalence, localisation, and contributing factors of musculoskeletal injuries among Croatian male football and handball players. The current analysis employed a more focused approach to explore the associations among seasonal phase, organisational support, and injury burden. The reporting of this analysis followed the general principles of the STROBE statement for cross-sectional studies (16).

All procedures of the primary study complied with the ethical principles outlined in the Declaration of Helsinki (17) and were approved by the institutional Ethics Committee for Biomedical Research at the Faculty of Health Studies, University of Rijeka. Participation was voluntary, and all respondents provided informed consent prior to completing the survey. Permission to conduct a secondary analysis of the anonymised dataset was obtained from the authors of the original publication (15).

The dataset included 203 male athletes (114 football players and 89 handball players) competing in national-level Croatian leagues. Eligibility criteria comprised: (a) age ≥18 years; (b) continuous training and competition participation within the previous 12 months; and (c) absence of acute illness or neurological disorders. Players who failed to complete essential injury-related questions were excluded. Data were collected via an anonymous, self-administered online questionnaire distributed through clubs and team staff, as described by Gosić et al. (15).

Variables were selected from the original dataset and grouped into four domains: demographic, training, organisational, and injury-related characteristics. Demographic variables included age and sport type (football or handball). Training variables comprised weekly training frequency, average session duration, and the rest period between sessions (in hours). The key organisational variable was the presence of a club physiotherapist, coded as yes or no. Seasonal factors were represented by the season phase at the time of injury, classified as preparatory or competitive.

Injury-related variables included lifetime injury occurrence (yes/no), reinjury (yes/no), and injury mechanism, dichotomised as contact or non-contact. In addition, the duration of absence (weeks) was recorded as a continuous measure to estimate the cumulative injury burden, representing the total time lost per athlete. An injury was defined as any musculoskeletal complaint sustained during sports activity that resulted in at least one day of restricted participation, consistent with international consensus definitions for injury surveillance in team sports (18). Re-injury was defined as a subsequent occurrence of the same or a similar injury at the same anatomical site following a full return to participation (19).

Descriptive statistics (mean, standard deviation, and proportions) were calculated for all variables. Group comparisons were performed using Pearson's chi-square (χ^2) test of independence to examine associations between categorical variables, such as season phase and injury occurrence or physiotherapist presence and re-injury rate. Effect sizes were quantified using Cramér's V, while relative risk (RR) and odds ratio (OR) were calculated to estimate the magnitude and direction of associations (20,21). Injury burden was derived by combining lifetime injury prevalence with the mean and median absence duration, providing an approximate indicator of cumulative time loss per athlete. Non-parametric correlations (Spearman's ρ) were used to explore relationships between continuous variables. A significance level of $p < 0.05$ was applied throughout, in line with conventional statistical practice (22). Analyses were based on complete cases (pairwise deletion) to account for item-level missing data. Graphical visualisations were produced to complement statistical analyses and to illustrate key effect-size estimates (RR, OR) and injury burden.

Data analyses were performed using Microsoft Excel and Jeffreys's Amazing Statistics Program (JASP) software (version 0.95.4, JASP Team, University of Amsterdam), using a two-tailed significance level of $p < 0.05$.

RESULTS

Participant characteristics

The sample (Table 1) consisted predominantly of young adult male athletes with comparable anthropometric and training characteristics across sports. Most participants (78.3%) had ≥9 years of competitive experience, reflecting an experienced sub-elite population. Average training volume was about 5 sessions per week, each lasting approximately 2.5 hours, with about 17 hours of recovery between sessions. Among athletes with a history of injury (n=176), 79% reported having access to a club physiotherapist, providing an appropriate organisational context for subsequent analyses.

Descriptive data derived from the original dataset (15). Minor rounding differences arise from secondary data processing and subgroup trimming to ensure complete cases. The variable "club physiotherapist present" refers to injured athletes only (n = 176).

Seasonal patterns of injury

As seen in Table 2, injuries occurred more frequently during the competitive phase (106/180; 58.9%) than during the preparatory phase (74/180; 41.1%), □²(1)=10.68, p=0.001, Cramér's V=0.24. The relative risk of sustaining an injury during competition was 1.43 (95% CI 1.15–1.77), and the odds ratio was 2.05 (95% CI 1.33–3.15), indicating a small-to-moderate association between season phase and injury occurrence. Contact injuries (99/181; 54.7%) were more frequent than non-contact injuries (82/181; 45.3%), but this difference was not statistically significant, $\chi^2(1)=2.83$, p=0.093 (RR = 1.21, 95% CI 0.96–1.53; OR = 1.46, 95% CI 0.94–2.27).

Valid cases: n = 180 for season phase and n = 181 for injury

Variable	Total	Football	Handball
Participants (n, %)	203 (100)	114 (56.2)	89 (43.8)
Age (years; M ± SD)	24.7 ± 4.8	25.1 ± 4.6	24.2 ± 5.1
Height (cm)	182.3 ± 6.7	182.9 ± 6.3	181.6 ± 7.2
Body mass (kg)	80.2 ± 7.9	81.1 ± 7.5	78.9 ± 8.2
BMI (kg/m²)	24.1 ± 1.9	24.2 ± 1.8	24.0 ± 2.0
≥ 9 years of sport experience (%)	78.3	79.1	77.3
Weekly training frequency (sessions/week)	5.25 ± 1.1	5.31 ± 1.0	5.18 ± 1.2
Session duration (hours)	2.46 ± 0.73	2.48 ± 0.71	2.43 ± 0.75
Rest between sessions (hours)	16.9 ± 2.5	16.8 ± 2.6	17.0 ± 2.4
History of injury during career (n, %)	176 (86.7)		
Club physiotherapist present (n, %)	139 (79.0)		

Table 1. Participant characteristics (N = 203)

Variable	n/N	%	χ^2 (df)	p value	Cramér's V	RR (95 % CI)	OR (95 % CI)
Season phase							
Competitive	106/180	58.9	10.68 (1)	0.001 **	0.24	1.43 (1.15 – 1.77)	2.05 (1.33 – 3.15)
Preparatory (ref.)	74/180	41.1	–	–	–	1.00 (ref.)	1.00 (ref.)
Injury mechanism							
Contact	99/181	54.7	2.83 (1)	0.093	0.13	1.21 (0.96 – 1.53)	1.46 (0.94 – 2.27)
Non-contact (ref.)	82/181	45.3	–	–	–	1.00 (ref.)	1.00 (ref.)

Table 2. Distribution of injuries by season phase and injury mechanism

mechanism. Data were analysed using Pearson's χ^2 test of independence, with Cramér's V reported as a measure of effect size. Relative risks (RR) and odds ratios (OR) with 95 % confidence intervals were derived from aggregated proportions using Woolf's method (Altman, 1990). Effect size interpretation followed Cohen's (1988) thresholds. Exposure-standardised incidence rates were not available. Significance level: **p < 0.01.

Organisational factors and re-injury

Athletes whose clubs employed a physiotherapist reported fewer re-injuries (43.9%) compared with those without such support (60.0%), corresponding to a 27% reduction in relative risk (RR=0.73) and nearly half the odds of recurrence (OR=0.52; 95% CI 0.25–1.07) (Table 3). Although not statistically significant, the magnitude and direction of the association may suggest a potentially beneficial effect of integrated physiotherapy support.

Valid n = 179 represents athletes with complete data for both variables (physiotherapist presence and re-injury status). Data were analysed using Pearson's □² test of independence, with Cramér's V reported as a measure of effect size. Relative risk (RR) and odds ratio (OR) with 95% confidence intervals (CI) were calculated from 2×2 contingency data using Woolf's method (Altman, 1990). Effect size interpretation followed Cohen's (1988) thresholds (V ≥ 0.10 = small, V ≥ 0.30 = medium). Statistical significance was set at p < 0.05.PT = physiotherapist; RI = re-injury; df = degrees of freedom; RR = relative risk; OR = odds ratio; CI = confidence interval.

Injury burden

As seen in Table 4, each athlete lost an estimated 7–11 weeks of training or competition time due to injury, representing approximately 15–20% of a standard 52-week training year. The lifetime injury prevalence of 86.7%, combined with an average absence duration of 12.3 weeks, indicates that injuries impose a substantial cumulative time-loss burden. The difference between the median (8.7 weeks) and mean (12.3 weeks) suggests that a smaller subgroup of athletes experienced extended absences, indicating a right-skewed distribution of absence durations driven by severe or recurrent injuries.

DISCUSSION

This secondary analysis examined how seasonal and organisational factors relate to injury recurrence and burden in Croatian football and handball players. Injuries occurred significantly more often during the competitive phase (58.9% vs 41.1%; □²(1)=10.68, p=0.001), corresponding to a roughly 40% higher relative risk compared with the preparatory phase. The strength of this association indicates that competitive periods are the most vulnerable time for injury occurrence, particularly in sub-elite settings where recovery may be inconsistent. The difference between contact and non-contact injuries (54.7% vs. 45.3%) did not reach statistical significance (p=0.093), suggesting that both mechanisms contribute comparably to the overall injury burden. Athletes whose teams employed a physiotherapist reported fewer re-injuries (43.9% vs. 60.0%), corresponding to a 27% lower relative risk, although this trend was not statistically significant.

PT	RI Yes	RI No	Total n	% RI	χ^2 (df)	p value	Cramér's V	RR (95 % CI)	OR (95 % CI)
Present	61	78	139	43.9	3.23 (1)	0.072	0.13	0.73 (0.49–1.09)	0.52 (0.25–1.07)
Absent (ref.)	24	16	40	60.0	–	–	–	1.00 (ref.)	1.00 (ref.)

Table 3. Re-injury rates by the presence or absence of a club physiotherapist

Indicator	Value
Lifetime injury prevalence	176/203 = 86.7%
Absence duration (weeks)	Median = 8.7; Mean = 12.28
Estimated lost weeks per athlete (median-based)	≈ 7.5
Estimated lost weeks per athlete (mean-based)	≈ 10.6

Table 4. Estimated injury burden expressed as total time-loss (weeks)
Derived by combining overall injury prevalence and absence duration. Multiple injuries per athlete were not considered.

Still, it indicates a potential benefit of structured physiotherapy support for safer recovery and reduced time loss. The estimated injury burden of about 7–11 weeks per athlete per year, roughly one-fifth of a competitive season, illustrates the substantial functional cost of musculoskeletal injuries in Croatian team sports. These findings extend previous observations (15) by identifying when injuries are most likely to occur and the organisational conditions under which their long-term impact may be mitigated.

The present secondary analysis identified a significantly higher incidence of injuries during the competitive phase, confirming that this period is the most vulnerable stage of the season for football and handball players. Similar trends have been reported internationally, where the intensity, match congestion, and psychological pressure of competition are recognised as major contributors to increased injury risk (6,23,24). The observed 40% higher relative risk during competitive play aligns with this evidence, emphasising the need for targeted load management and adequate recovery strategies during peak match periods. The absence of a significant relationship between rest duration and injury frequency in our data further supports the multifactorial nature of injury risk. As suggested by Gabbett (23) and Meeusen et al. (24), recovery time alone does not capture the complex interactions among physiological load, neuromuscular fatigue, and psychological stress.

Although not statistically significant, the observed reduction in re-injury rates may indicate a potentially beneficial effect of physiotherapy support. This finding aligns with evidence from controlled trials demonstrating that structured physiotherapy and strength-training programs can significantly decrease the likelihood of recurrent injuries (25,26). In the context of Croatian team sports, where around one-fifth of athletes lack direct access to physiotherapy services (15), this organisational disparity could represent a modifiable risk factor. The importance of such professional medical support has been repeatedly highlighted in European surveillance frameworks promoting standardised injury- and illness-monitoring systems (27).

The estimated injury burden of 7–11 lost weeks per athlete per year, equivalent to approximately 15–20% of a competitive season, illustrates the substantial performance and welfare cost of musculoskeletal injuries in sub-elite contexts. However, because multiple injuries per athlete were not accounted for, these estimates should be interpreted as approximate indicators of injury burden rather than precise cumulative burden measures. Comparable time-loss patterns have been documented in European football and handball studies (28–30). These consistent findings highlight the shared biomechanical and contextual challenges of high-intensity team sports, where cumulative exposure, competition schedules, and recovery constraints jointly shape injury outcomes. To mitigate these effects, comprehensive surveillance systems that integrate medical, training, and workload data are essential for evidence-based prevention and optimal athlete availability throughout the season.

From a national perspective on sports health, the findings highlight the potential importance of physiotherapy availability across competitive levels in Croatia. The present findings support further evaluation of broader physiotherapy availability and its potential role in reducing injury recurrence. Establishing a national injury surveillance registry would enable systematic monitoring and guide evidence-based prevention strategies across sports disciplines. Moreover, given that this study focused exclusively on male athletes, future research should address potential sex-based differences in injury mechanisms, recurrence, and rehabilitation outcomes among female players, who remain underrepresented in Croatian sports medicine research.

This exploratory secondary analysis expands on the original dataset by examining when and under what organisational conditions injuries occur. Unlike the primary study, which focused on injury frequency and location, this work analyzed associations between seasonal phases, physiotherapy support, and injury recurrence, including effect sizes via relative risks, odds ratios, and Cramér's V. It also introduced injury burden as total time-loss per athlete, offering a practical measure of functional impact. By combining organisational and temporal factors, the analysis provides a context-specific understanding of injury determinants in Croatian team sports.

As a secondary analysis, this study was constrained by the structure of the original dataset, which limited control over potential confounders and unmeasured variables such as injury type or severity. Exposure time was not standardised, preventing the calculation of incidence rates per 1000 hours of participation; therefore, the reported relative risks and odds ratios should be interpreted as measures of association based on injury distributions rather than true exposure-adjusted injury risks. The sample included athletes from different teams and competitive levels, introducing contextual variability in medical support and training load. Self-reported data may also have been affected by recall bias, which may have influenced estimates of injury frequency and time loss. The analysis was restricted to bivariate associations, as sample size did not permit multivariate modelling.

Future research should use prospective designs with systematic exposure tracking (like GPS and recovery indices) to clarify causal relationships. Larger samples would allow multivariate analyses of seasonal, organisational, and individual factors. Longitudinal studies on physiotherapy and strength-based prevention could assess

their effectiveness. A national injury surveillance system for team sports would support ongoing monitoring and prevention planning.

CONCLUSION

The findings of this exploratory analysis suggest that injuries in team sports may occur more frequently during the competitive phase of the season and that continuous physiotherapy support may contribute to lower injury recurrence and reduced time loss. The results additionally indicate a possible influence of seasonal workload and organisational factors on injury patterns among Croatian football and handball players. Continuous physiotherapy involvement, workload monitoring, and structured injury surveillance may be important components in maintaining athlete health and season availability.

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