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REVIEW

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Young football players have significantly more spinal changes on MRI compared to non-athletes

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Purpose: Evidence-based facts regarding spinal abnormalities and back pain in young athletes are needed in order to be able to adapt rehabilitation programs and preventive measures accordingly. The aim of this study was therefore to identify MRI changes in the thoracolumbar spine and the lifetime prevalence of back pain in young football players compared to non-athletes.

Methods: Young elite football players (n = 27) and non-athletes (n = 26) completed MRI examinations of the thoracolumbar spine. MRI images were evaluated for disk signal, height, bulging, herniation, Schmorl's nodes, spondylolisthesis, and vertebral wedging. All participants answered questionnaires regarding training hours and back pain.

Results: Disk degenerative changes were more commonly displayed by 89% of the football players compared to 54% of the controls ($P = .006$). Schmorl's nodes (22%), disk herniation (30%), and reduced disk height (37%) were more prevalent in football players compared to controls (0%) ($P = .023$ and $P = .001$, respectively). The lifetime prevalence of back pain was reported by 52% of football players and 44% of controls, a difference that was not statistically significant.

Conclusion: Young male football (soccer) players have more degenerative disk changes compared to non-athletes. Both groups displayed high lifetime prevalence of back pain.

KEYWORDS

athletes, back pain, disc degeneration, exercise, exercise-induced damage, exercise-induced pain, LBP, MRI, Schmorl's nodes, Soccer

1 | INTRODUCTION

Football is a very popular sport around the globe with a high incidence of trauma.[1,2] It is a multidirectional sport that requires running, twisting, cutting, and striking a ball.[3] The dynamics of this sport place rotational stress upon the axial spine and hip joints which may make individuals more susceptible to back injuries and back pain.[4] Injuries to the head, cervical spine, knees, ankles, tendons, and muscles[5-8] associated with football are well defined in the literature, but those involving the thoracolumbar spine have not been thoroughly described, especially using MRI. These spinal changes are thought to be secondary to repetitive micro-trauma, spinal overload, and rotational stress.

Overload to the spine in adolescents may result in changes in the morphology and functionality of the spine and pelvis.[9] A higher rate of radiological changes has previously been reported in the thoracolumbar spine in those athletes that place greater demands upon the spine such as wrestlers, gymnasts, weightlifters, divers, ice hockey, skiers, long-distance runners, football, and tennis players.[2,10-12] Examples of such changes are disk degeneration, disk herniation, apophyseal ring injuries, and pars interarticularis fractures; moreover, a higher incidence of radiological changes has been reported particularly during the growth spurt.[10,13-15]

Back pain has been found to be a common complaint in athletes with both spinal and extra-spinal causal factors described.[10,16-18] Variable results are reported in studies investigating the association between excessive physical exercise and back pain in young athletes.[15,19,20] In a recent review of 43 papers, the one-year prevalence of back pain was 26%-76%.[18]

The present study is needed because there are only a few studies that describe the radiological changes in the thoracolumbar spine of football players. Also, adolescent football players are not included in those studies. Evidence-based facts regarding spinal abnormalities and back pain prevalence in young football players may help in adapting rehabilitation programs and preventative measures accordingly. This would also provide the opportunity to compare the results with other sports.

Therefore, the purpose of the present study was to identify MRI changes in the thoracolumbar spine and back pain prevalence in young elite football players and the association between these variables in comparison with a non-athletic control group.

2 | MATERIAL AND METHODS

The study participants were football players (n = 31) from the Icelandic U16 national team. The non-athletes (n = 27) were first-year high school students recruited from high schools in Järpen and Östersund in northern Sweden. All participants and their parents received both written and oral information about the study.

The inclusion criteria for the non-athletes were no previous or present participation in any organized sport activities neither any strenuous physical activity more than 5 h/wk. Both football players and non-athletes were excluded if they had had an episode of traumatic injury of the thoracolumbar spine or a history of previous surgery on the spine, pelvis, or hip joints. In addition, the exclusion criteria included pregnancy and any history of systemic disease including inflammatory arthritis or pelvic inflammatory disorders.

The study participants were examined with MRI, questionnaires, and basic parameters such as gender, weight, age, and height.

2.1 | MRI examinations of the football players and controls

The MRI protocol included sagittal T1- and T2-weighted images of the thoracolumbar spine (T6-S1). The MRI examinations of the football players were performed at the National University Hospital of Iceland, Reykjavik, Iceland and for the controls at Östersund Hospital, Östersund, Sweden. Identical imaging protocols were adopted. All MRI examinations were evaluated by a radiologist with experience in this field.

The spine was evaluated according to a standardized protocol known to have high intra- and inter-observer agreement[10,21] (Table 1). The protocol included a wide spectrum of well-defined disk and vertebral changes such as Schmorl's

TABLE 1 Thoracolumbar spinal changes on MRI in young football players according to a standardized protocol

Disk signal	0 = Normal	1 = Moderately reduced	2 = Severely reduced	
Disk height	0 = Normal	1 = Reduction ≤ 50%	2 = Reduction 50%-90%	3 = Reduction > 90%
Disk bulging	0 = Normal	1 = Bulging disk		
Disk herniation	0 = Normal	1 = Disk extrusion		
Schmorl's nodes	0 = Normal	1 = Slight	2 = Moderate/severe	
Vertebral body configuration	0 = Normal	1 = Wedging	2 = Flattening	3 = Increased AP diameter
Apophyseal injuries	0 = Normal	1 = Slight	2 = Moderate/severe	
Stress fractures	0 = Absent	1 = Present		
High-intensity zone (HIZ)	0 = Absent	1 = Present		
Spondylolisthesis	0 = Absent	1 = Present		

nodes, disk height reduction, and disk signal loss. Disk degeneration (DD) as a separate category was defined as a combination and/or either of reduced disk signal, reduced disk height, and disk bulging.

In addition, all intervertebral disks were graded according to Pfirrmann classification, a well-validated classification for disk degeneration.[22] The total number of disks graded Pfirrmann ≥3 per individual was registered. Moreover, any individual with a disk graded Pfirrmann ≥3 was considered positive for disk degeneration.

2.2 | MRI protocols

The lumbar and thoracic spine was imaged with 1.5 T MRI scanner (Signa Twin-speed; EXCITE 16 channel system; GE Healthcare) with an eight-channel cervical-thoracic-lumbar spine coil (using the three lower elements; GE Healthcare). Following a 3-plane localizer acquisition of the lumbar spine, a high resolution sagittal T2-weighted FSE and sagittal T1-weighted FSE sequences of the thoracic and lumbar spine were acquired, accommodating vertebra levels from T6 to S1. The MRI machine was GE HDXt signa echospeed 1.5 T. The coil surface was HNS_CTLBOT by GE. Total time of examination was about 10 minutes.

Sag T2 = FOV 48 cm, Slice 4/1, TR 4463, TE 110, ETL 27, Matrix 448/224, Nex 4, Bandwidth 41.67.

Description: Place 15 images at Cor Loc. Phase superior-inferior, superior-inferior sat-pulse outside FOV + anterior sat-pulse inside FOV in front of sacrum.

FOV must accommodate S1-T6. Time 2.45.

Sag T1 = FOV 48 cm, Slice 4/1, TR 560, TE minfull, ETL 3, Matrix 384/224, Nex 3, B width 19.23.

Description: Copy the Sag T2. Phase superior-inferior. Only A sat-pulse inside the FOV in front of sacrum. Time 4.17.

2.3 | Reliability measures

The MRI evaluation was repeated after six months, blinded to the first one, to assess intra-observer reliability. Another experienced radiologist evaluated the MRI examinations in 40% of the subjects to assess the inter-observer agreement.

2.4 | Questionnaires

The back questionnaire has been developed and used by Swärd et al (1990) and Baranto et al (2006) and has been used in several previous studies.[12,21,23] It contains questions relating to previous and present levels of back pain in young athletes. The questions are also designed to map out the levels of sporting activity and general health. The current activity level was further categorized according to the number of training hours per week. The back pain questions evaluated the onset and duration of pain, if the pain was correlated with exercise or competition, and if any movements aggravated or relieved the pain. The location of the pain was mapped by schematic body figures. Back pain was self-assessed and graded mild, moderate, or severe. The intensity of pain was also investigated using the Visual Analogue Scale (VAS).

2.5 | Ethics considerations

The present study was approved by the Regional Ethical Review Board in Gothenburg at Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden (ID number: 692-13).

2.6 | Statistical analysis

The data were analyzed using IBM SPSS Statistics for Windows; version 22.0; IBM Corp. The description of data was expressed in terms of mean, standard deviation,[24] and range including frequencies and percentages. For comparison of continuous variables, the Student's independent *t* test was used. Pearson's chi-squared test was performed to compare the distribution of back pain between groups, and Fisher's exact test was performed to compare the distribution between groups when the expected cell count was less than 5. The statistical significance for all tests was set as $P < .05$. The kappa statistics were used to summarize the inter- and intra-observer reliability of the ratings. The schema of Landis and Koch was used to interpret the strength of agreement.[25]

Sample size calculations were based on previous studies of young athletes using the same method, demonstrating both clinical and radiological significant results. The previous studies used power calculations (0.8), and *P*-value (.05) with sample size (n) results around 20-30.[10,12,21]

TABLE 2 Demographic characteristics

	Football players (n = 27)	Controls (n = 26)
Gender, Female/male %	0/100	67/33
Age, years (SD)	17 (1.0)	16.4 (0.6)
Weight, kg (SD)	74 (7.4)	67 (17.9)
Height, cm (SD)	182 (6.1)	172 (8.5)

TABLE 3 Training hours per week stratified by football players and controls

Training hours per week	Football players (n = 31)	Controls (n = 23)
0-2	0	8 (34.8%)
3-5	0	11 (47.8%)
6-8	3 (9%)	4 (17.4%)
9-11	6 (19%)	0
>11	23 (72%)	0

3 | RESULTS

MRI examinations of 27 elite football players and 26 controls were available for the final data analysis. One control and four football players were not examined due to dropout. Reasons given were difficulties with timings for MRI appointments and claustrophobia. Two controls and four football players did not answer the back pain questionnaires.

3.1 | Group characteristics

Demographic characteristics of the participants are summarized in Table 2.

The majority of football players (91%) had an average of 9-11 or more training hours per week while 83% of controls had an average 0-5 training hours per week (Table 3).

3.2 | Radiological findings

Disk degeneration, according to both Pfirrmann and the standardized protocol, was more commonly displayed by 89% of football players compared to 54% of controls (P = .006) (Figures 1 and 2). There were significantly more Schmorl's nodes (22%) and disks with reduced height (37%) in football players compared with the control group (0%) (Table 4). Disk herniation and disk bulging were also significantly more prevalent in football players (30% and 78%) compared to the control group (0% and 46%), respectively (P = .004 and P = .024).

Thirty-seven percent of football players, as individuals, had at least one disk Pfirrmann grade ≥3 compared to 30% of controls, which was not statistically significant (P = .62). The total number of disks with Pfirrmann grade ≥3 was shown to be higher in the football players compared with the controls (Tables 4 and 5).

There were minimal or no findings in both football players and controls regarding spondylolisthesis, stress fractures, HIZ, apophyseal injuries, and abnormal configuration of the vertebrae. Statistical analysis was not amenable.

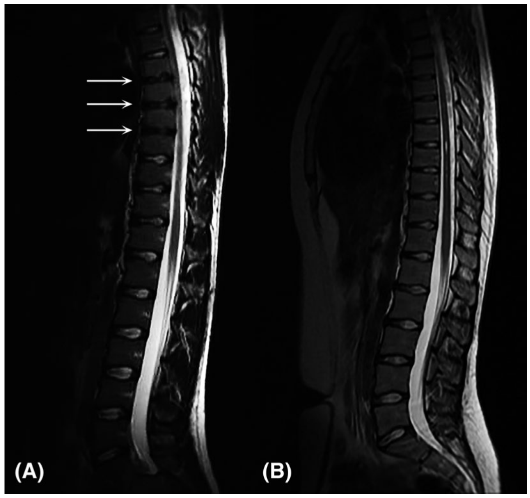

FIGURE 1 MRI T2-weighted sagittal images of the thoracolumbar spine. (A) Football (soccer) player with reduced disk signal and height at three levels (arrows), in T6-T7, T7-T8, and T8-T9. (B) Non-athlete without significant changes

3.3 | Back pain

The lifetime prevalence of back pain was reported by 52% of football players and 44% of controls; however, this was shown not to be statistically significant. The pain severity on VAS scale was low with average of 1.6 in football players and 2.4 in controls. There was no association between back pain and the MRI changes.

3.4 | Validity

The inter-observer agreement was good with Cohen's kappa coefficient ranging between κ = 0.70 and 0.81. The intra-observer reliability was very good with Cohen's kappa coefficient ranging between κ = 0.67 and 0.88.

4 | DISCUSSION

The present MRI study demonstrated a significantly higher prevalence of disk degenerative changes in the thoracolumbar spine of young football players (89%) compared to controls (54%). The football players also displayed a higher prevalence of Schmorl's nodes and other spinal changes compared to the controls. Back pain prevalence was shown to be high in football players and controls compared to general population, but without statistically significant difference between the groups.

The findings of the present study were in accordance with previous studies of athletes practicing other sports such as volleyball, skiing, ice hockey, and American football.[10,15,19,20,26]

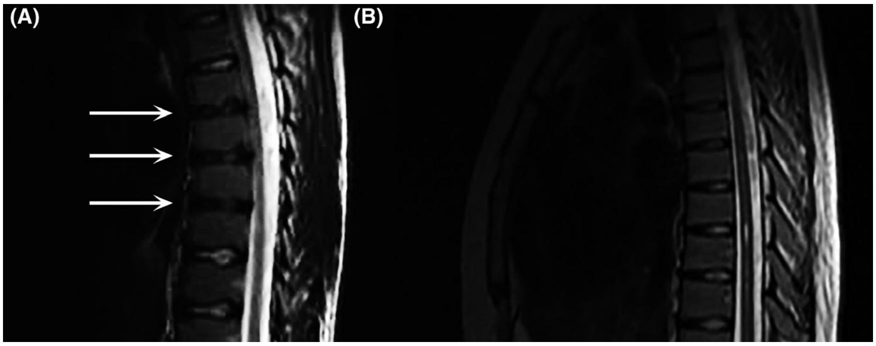

FIGURE 2 Zoomed view MRI T2-weighted sagittal images of the thoracic spine. (A) Football (soccer) player with reduced disk signal and height at three levels (arrows). (B) Non-athlete without significant changes

TABLE 4 MRI changes stratified by football players and controls

MRI changes	Football (n = 27)	Controls (n = 26)	*P*-value†
Individuals with disk Pfirrmann grade ≥ 3	10 (37%)	8 (30%)	*P* = .630
Total disks with Pfirrmann grade ≥ 3	26 (8%)	14 (4%)	*P* = .860
Reduced disk signal	13 (48%)	11 (42%)	*P* = .785
Disk bulging	21 (78%)	12 (46%)	***P* = .024**
Reduced disk height	10 (37%)	0	***P* < .001**
Schmorl's nodes	6 (22%)	0	***P* = .023**
Disk hernia	8 (30%)	0	***P* = .004**

Note: Bold style indicates statistical significance.
†Fisher's exact test.

TABLE 5 MRI changes stratified by football players and controls with exclusion of participants with scoliosis

MRI changes	Football (n = 27)	Controls (n = 18)	*P*-value†
Individuals with disk Pfirrmann grade ≥ 3	10 (37%)	4 (21%)	*P* = .250
Total disks with Pfirrmann grade ≥ 3	26 (8%)	7 (3%)	***P* = .029**
Reduced disk signal	13 (48%)	7 (37%)	*P* = .450
Disk bulging	21 (78%)	7 (37%)	***P* = .006**
Reduced disk height	10 (37%)	0	***P* < .001**
Schmorl's nodes	6 (22%)	0	***P* = .023**
Disk hernia	8 (30%)	0	***P* = .004**

Note: Bold style indicates statistical significance.
†Fisher's exact test.

It was reported in a previous study of professional beach volleyball players (mean age 28) that disk degeneration (79%) and spondylolysis (21%) were three times higher compared to the general population.[15] Yet, the football players in the present study were younger with mean age of 18 years.

Schmorl's nodes were shown to be less prevalent in football players (22%) in the present study compared to athletes from other sports such as alpine and mogul skiers (46%), gymnasts (71%), and orienteers (100%).[2,10] Disk height reduction was presented in 37% of the football players. The latter is similar to gymnasts (38%) but less than wrestlers (86%) and weight lifters (100%).[10] These differences may be related to the different load impact upon the spine from different sports. In football, there is both rotational stress and axial loading repetitive minor trauma upon the spine increasing the risk for disk degeneration and dehydration. While in other sports like weight lifting, axial overload upon the spine is the major stress component increasing the risk for disk height reduction.

According to Pfirrmann classification, the total number of dehydrated disks graded as Pfirrmann ≥3 was more prevalent in football players (8%) than controls (4%). There were also slightly more football players, as individuals, with at least one degenerated disk Pfirrmann grade ≥3 compared with controls (37% vs 30%, n.s.). Alpine and mogul skiers have been shown to have a higher prevalence of degenerated disks (56%) in previous studies.[2,27] It was hypothesized that this might be due to an undesirable tissue response to repetitive minor trauma during skiing.[2,27-29]

The higher level of degenerated disks and other spinal changes in young football players is believed to be secondary to overloading the spine with excessive lengthy training associated with rotational stress acting upon the spine due to the multidirectional dynamics of the sport.[30,31] This can be a reflection of the vigorous exercise performed by football players as the majority (91%) exercised more than 9-11 hours per week, compared with 78% of the controls that exercised 2-5 h/wk. In a study of gymnasts,[11] it was shown that 57% of the individuals who trained 15 hours or more per week were shown to have degenerative changes on MRI, compared to 13% of those who trained <15 h/wk, and it was, therefore, concluded that a correlation may exist between the volume of training and development of spinal injuries. It was found in female gymnasts that increasing the training period and intensity correlated with the level of abnormalities seen on MRI.[11] Future studies are needed to investigate the cutoff for athlete vulnerability and risk from overload training.

Detailed analysis of the present study data revealed that eight individuals from the control group had scoliosis (Cobb's angle > 10°) while none of the football players had similar findings. Scoliosis had been linked to increased spinal degenerative changes in previous studies.[32,33] Hence, a complementary analysis was run after excluding those individuals with scoliosis (Table 5). The results appeared confirmatory strengthening the primarily reported changes. The total disks with Pfirrmann grade ≥3 were shown to be significantly higher in football players (8% of the disks) compared to controls (3% of the disks) ($P = .029$).

The lifetime prevalence of back pain in young football players (52%) was concordant with previous studies of football players (28%-61%)[24,26,34-37] and other young athletes.[26,38-40] It was found in one study of young football players with mean age of 18 years that 47% reported a disabling low back pain episode lasting at least two consecutive days in the previous year.[24] In the present study, both football players and controls displayed high lifetime prevalence of back pain (52% and 44%, respectively) when compared to general population (up to 20%).[41]

The back pain in the present study was shown to be very mild with average VAS 1.6 for the athletes. Perhaps this may explain that most back pain in football to be a non-time loss injury when players can continue carrying on training and performance. On the other hand, this may explain that most of the severe time loss injuries related to football usually involve the lower extremities such as the knees and ankles.[7,8]

5 | PERSPECTIVE

The present study provides increased knowledge about the spinal changes of young football players. While injuries of the head and legs have been the focus in previous studies,[5-8] the present MRI study shows that injuries may extend to involve the thoracolumbar spine as well. Modifying training protocols and development of rehabilitation programs may be considered to prevent or reduce these spinal abnormalities in future.

6 | STRENGTHS AND LIMITATIONS

The participants were within the same age range and considered a good representative for adolescent age population. The height and weight displayed that the groups were probably in the same biological age as well as chronological age. However, the football players in the present study were all males while 67% of the controls were females. This is an important confounder that may have affected the results, although gender did not appear to significantly affecting the outcomes in previous studies.[2,14] Being an observational study, other unknown confounders can have biased the material and results.

Sample size can be considered another limitation, especially given the high prevalence of degenerative changes and back pain in an early age for both athletes and non-athletes.

The questionnaires are affected by recall bias. The questionnaires are in major parts subject-reported information and difficult to assess objectively. The VAS scale is also not validated for comparison between single measurements but rather pain intensity changes over time.

7 | CONCLUSION

Young male football (soccer) players are shown to have significantly higher levels of spinal changes and degenerative disk changes compared with non-athletes. Both groups displayed high lifetime prevalence of back pain compared to the general population, but without statistically significant differences between the groups.

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CONFLICT OF INTEREST

All authors confirm they have no conflict of interest.

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