



Original Article

## Factors associated with low back pain in elite high school volleyball players

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**Abstract.** [Purpose] To determine the relationship between low back pain and a range of demographic, environmental, and injury history factors to identify potential factors for the management of low back pain. [Participants and Methods] The participants were 123 elite high school male and female volleyball players. They answered an extensive questionnaire regarding demographic details, low back pain in the previous year, volleyball-specific movements, previous regional injuries, and years of volleyball experience. Questionnaire responses were analyzed. Data were analyzed using a multivariate logistic regression analysis using the presence and absence of low back pain within 1 year as the explanatory variable. [Results] Of the 123 volleyball players, 48.0% reported low back pain. The volleyball-specific movements that induced pain were diverse (e.g., spike, serve, and pass) with no common factor. The factors associated with low back pain were an ankle injury within the previous year and years of volleyball experience. [Conclusion] The associations found in this survey indicate that particular attention should be given to more experienced players with a history of ankle injury to manage low back pain in high school volleyball players.

**Key words:** Low back pain, Volleyball, Injury prevention

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### INTRODUCTION

Volleyball is a game that rarely involves collisions between players, which might explain a lower prevalence of injuries compared to other competitive team sports<sup>1, 2)</sup>. Despite this, volleyball has a high prevalence of low back pain (LBP)<sup>3–7)</sup>. Playing sport increases the risk of LBP in adolescence<sup>1)</sup>. However, as the physical and mental benefits of doing sports are significant<sup>8)</sup>, and it is important to prevent LBP in volleyball players to enable them to continue to play.

Patel et al. suggested that while causes of LBP differ among different types of competitive sports, the most common underlying cause of LBP is lumbar spondylolysis in adolescent athletes<sup>9)</sup>. However, Bartolozzi et al. reported that volleyball players had significantly more abnormalities of their lumbar intervertebral discs on MRI, and the incidence of lumbar spondylolysis is also higher in volleyball players than in the general population<sup>10)</sup>. Despite this evidence, it is difficult to identify the underlying tissue origin of LBP in the majority of cases. On the other hand, it is reported that injury patterns among world-class volleyball players differ between player's positions<sup>11)</sup>, suggesting the potential that specific volleyball movements in each position has some impact on injury development. Hence the nature of volleyball specific movements (spike, serve, block and pass) may be a factor in the development of LBP and requires further investigation.

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In general, it has been shown that the prevalence of LBP increases with age<sup>12)</sup>. In addition, LBP prevalence increases in people who play sport after the age of 17 years<sup>6)</sup>, and this is confirmed in volleyball, where the presence of LBP is greater among collegiate volleyball players than high school volleyball players<sup>13)</sup>. This may be due to the duration or amount of training (hours per week) which has been investigated as a related factor to LBP in school children and young athletes<sup>14, 15)</sup>. It would therefore appear logical that the prevention of LBP in high school players may reduce LBP in older players. In addition, previous studies have shown that body weight or BMI may increase LBP in adolescents<sup>16, 17)</sup>. A recent systematic review of injuries associated with volleyball concluded that future studies should focus on other specific injuries besides the more common knee and ankle injuries<sup>18)</sup>. Furthermore, sleep problems are also associated with chronic LBP<sup>19)</sup>. Insufficient sleep in 16 year-old boys and girls has been shown to predict LBP<sup>20)</sup>, but this is not clear in high school volleyball players.

Little is known about LBP and its associated factors in younger athletes, such as high school students. Despite a number of previous reports on the prevalence of volleyball injuries in different body regions there are few studies reporting on the factors associated with LBP. Of particular interest are whether volleyball specific movements and injury of other body parts play a role in the development of LBP in volleyball players. This information may lead to the development of further studies on the prevention and management of the LBP by explore factors relating to LBP in younger athletes. The purpose of this study was to examine by questionnaire a broad range of factors that may be associated with LBP during volleyball. We hypothesized that BMI, years of volleyball playing experience, volleyball court position, spike form, average volleyball practice time, presence or absence of stretching before and after volleyball, sleep time, and previous injury to other body parts are related to LBP in volleyball players. The results of this study may provide information towards designing rehabilitation programmes for players with LBP.

## PARTICIPANTS AND METHODS

This study was a cross-sectional research design. A questionnaire was developed based on previous studies<sup>21–24)</sup>. The inclusion criteria were high school male and female volleyball players of aged 15–17 years old who were playing and training for their volleyball club team, who gave informed consent to be included in this study.

We invited elite high school volleyball teams in Saitama, Japan to take part in this study, with detailed study information sent to each team. A total of 123 volleyball players (63 males, 60 females,  $15.8 \pm 0.7$  years old) formed a sample of convenience recruited from eight public high schools. The purpose of the study was explained by a letter and verbal explanation to the school principal and volleyball club coach in each high school, and the principal's written consent obtained. A similar explanation was also provided to the participants and their parents, and again written consent obtained. The study was approved by the Ethics Committee at Faculty of Health and Medical Care, Saitama Medical University, Japan (M-73).

The questionnaire, was filled out by the volleyball players in the gymnasium at their high school. The survey items were demographic details, environmental factors, and injury history in the previous year. Demographic details include gender, age (years), height (cm), body weight (kg), dominant hand, and years of experience as a volleyball player. In addition, we calculated the players body mass index (BMI;  $\text{kg}/\text{m}^2$ ). Hand dominance was determined by the arm used to spike or serve. Environmental factors assessed were volleyball court position (wing spiker, WS [strong side, WSS; weak side, WSW]; middle blocker, MB; setter, S; libero, L), spike form (bow and allow, circular, or straight), average volleyball practice time, practice days per week, presence or absence of stretching before and after playing, and average sleep time. We assessed for the presence of LBP, as well as injuries to the shoulder, elbow, knee, and ankle region in the previous year during volleyball. LBP was defined as pain or discomfort in the low-back region, within the region between the lowest rib and the buttocks. Those with neurological symptoms and pain associated with menstruation were not classified as LBP. Participants replied with "yes/no" to the question of lower extremity pins and needles or numbness, which was used to identify neurological symptoms. Players were also asked if they had been examined by a medical doctor who had identified neurological features. No definition of injury was provided in the questionnaire; therefore, participants answers were dependent on their own judgment. In players who experienced LBP in the previous year during volleyball, we sought a subjective report that LBP induced performance degradation, consultation with doctors and coaches, absence from a practice session, and the timing of LBP (practice time, game, daily living). In addition, we investigated whether LBP was related to a volleyball-specific movement (e.g. spike or serve) and if so the timing of movement when LBP occurred (approach, take off, back swing, fore swing, and/or landing for spike, approach, take off, back swing, fore swing and/or landing for serve, approach, take off, and/or landing for block, underhand pass, dive, roll, and/or overhand pass for pass). For those who answered spike, we additionally asked them whether they felt they had a high proportion of landing on one leg, and whether they hit the ball with their hand behind the frontal plane (Table 1). Based on the questionnaire data, participants were divided into 2 groups; those with LBP during volleyball within the previous year and those without.

To decide an adequate sample size to accomplish statistical significance with 80% power ( $1-\beta$ ), we performed priori power analyses. Sample size was calculated by power analysis application (G\*Power 3.1.9.2, <http://www.gpower.hhu.de/>). In order to compare the questionnaire items between the LBP and asymptomatic group, the effect size  $d$  was set to 0.5 ( $\alpha=0.05$ ,  $1-\beta=0.8$ ) in the independent t-test and the effect size  $w$  was set to 0.3 ( $\alpha=0.05$ ,  $1-\beta=0.8$ ) in the  $\chi^2$  test. We estimated that the level of effect size was medium for both analyses. As a result, the number of subjects required were 128 cases (64 per group) for the t-test and 88 for the  $\chi^2$  test. Furthermore, the sample size of the logistic regression was determined according

**Table 1.** Questionnaire items for patients reporting low back pain (LBP) during volleyball in the previous year

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Please choose one that is the most applicable.

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Q1: Did you feel subjective performance degradation in volleyball practice when LBP occurred?	Yes/No
Q2: Did you consult with doctors for your LBP when LBP occurred?	Yes/No
Q3: Did you report LBP to your coach when LBP occurred?	Yes/No
Q4: Did you miss practice sessions when LBP occur?	Yes/No
Q5: When did your LBP occur?	Practice/Game/Daily living
Q6: In what game-specific movement and timing of movement did your LBP occur?	Spike/Serve/Block/Pass
If you answer spike, please answer the following questions.	
Q6-1: In what part of the spike did your LBP occur?	Approach/Take off/Back swing/ Fore swing/Landing
Q6-2: Did you more frequently land on one leg after spike?	Yes/No
Q6-3: Did you feel that hitting the ball with their hand behind the frontal plane is more likely when you spike?	Yes/No
If you answer serve, please answer the following question.	
Q6-4: In what part of the serve did your LBP occur?	Approach/Take off/Back swing/ Fore swing/Landing
If you answer block, please answer the following question.	
Q6-5: In what part of the block did your LBP occur?	Approach/Take off/Landing
If you answer pass, please answer the following question.	
Q6-6: In what part of the pass did your LBP occur?	Underhand pass/Dive/ Roll/Overhand pass

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to Altman's formula ( $n \geq 10 \times \text{number of independent variables}$ ). Therefore, we tried to recruit at least 128 participants at the beginning of this study.

For statistical analysis we first performed simple tabulation for each questionnaire item reporting frequencies, and in the case of continuous variables means were calculated with standard deviations. Comparisons between groups were made using independent t-test for continuous variables and  $\chi^2$  test for categorical data. Following this, we used multivariate logistic regression analysis with presence and absence LBP within the previous year as an explanatory variable after determining independent variables that were significant in a simple logistic regression analysis. We used forward selection by likelihood test ratio as variable selection for a multivariate logistic regression analysis. All statistical analyses were conducted using the IBM SPSS Statistics 25 (IBM Japan Ltd., Tokyo, Japan), and the level for significance was set at  $p < 0.05$ .

## RESULTS

We obtained informed consent from the parents of 123 participants. 123 high school volleyball players completed the questionnaire with a 100% response rate.

Table 2 shows the demographic details and environmental factors in questionnaire items for all participants. The percentage of categorical variables in Table 2 was calculated using all subjects as denominator. Table 3 shows the questionnaire items for players who experienced LBP playing volleyball in the previous year. Table 4 shows the comparison between groups for questionnaire items. The sample size was sufficient based on post power analysis. There were more than four items correlating with LBP. Table 5 shows the results of simple logistic regression analysis with LBP experienced in the previous year and each questionnaire item. These analyses indicate a significant association among LBP and a history ankle ( $p < 0.001$ ) or knee injury ( $p = 0.045$ ) in the previous year, the years of experience as a volleyball player ( $p = 0.002$ ). The results of multiple logistic regression analysis are showed in Table 6. In this analysis, significant items from the simple logistic regression analysis were entered with adjustment factors of gender and BMI. Based on the results of this analysis, factors related to LBP were a history of ankle injury in the previous year together with the years of experience as a volleyball player. The odds ratio of each item were 4.06 (95% CI: 1.81 to 9.14) for the injury history of ankle, and 1.29 (95% CI: 1.04 to 1.61) for the years of experience as a volleyball player. The results of the Hosmer-Lemeshow test in this model were shown to be compatible with  $p = 0.72$ , with the percentage of correct classifications being 68.3%.

## DISCUSSION

The purpose of this study was to determine the factors that were associated with LBP in high school volleyball players. Presented are the frequency of injury in different body regions over the previous year and the 1 year prevalence of LBP. LBP

**Table 2.** Basic attributes and environmental factors of the participants in the study (n=123)

Gender, n (%)	M: 63 (51.2)	F: 60 (48.8)	
Age (years)	M: 15.7 ± 0.7	F: 15.9 ± 0.7	Total: 15.8 ± 0.7
Height (cm)	M: 172.3 ± 5.2	F: 158.2 ± 4.7	
Body weight (kg)	M: 60.1 ± 5.9	F: 51.7 ± 4.5	
BMI (kg/m <sup>2</sup> )	M: 20.2 ± 1.5	F: 20.7 ± 1.7	
Dominant hands, n (%)	Right: 113 (91.9)	Left: 10 (8.1)	
Experience as a volleyball player (years)	M: 2.9 ± 1.9	F: 4.2 ± 1.9	Total: 3.5 ± 2.0
Court position, n (%)	Wing spiker [strong side]: 32 (26.0) Wing spiker [weak side]: 26 (21.1) Middle blocker: 25 (20.3) Setter: 14 (11.4) Libero: 24 (19.5) Unknown: 2 (1.6)		
Spike form, n†	Bow and allow: 63 Circular: 13 Straight: 20		
Average practice time/week on weekdays (hours)	M: 2.8 ± 0.5	F: 3.1 ± 0.5	Total: 3.0 ± 0.5
Average practice time/week during holidays (hours)	M: 3.5 ± 0.5	F: 4.1 ± 0.2	Total: 3.8 ± 0.5
Practice days/week (days)	M: 6.1 ± 0.9	F: 6.1 ± 1.0	Total: 6.1 ± 0.9
Stretching before practice, n (%)	Presence: 106 (86.2)	Absence: 17 (13.8)	
Stretching after practice, n (%)	Presence: 91 (74.0)	Absence: 32 (26.0)	
Average sleep time/week (hours)	M: 6.5 ± 1.0	F: 6.3 ± 0.8	Total: 6.4 ± 0.9
Injury history in the previous year during volleyball, presence, n (%)	LBP: 59 (48.0) Shoulder: 11 (8.9) Elbow: 6 (4.9) Knee: 24 (19.5) Ankle: 51 (41.5)		

M: Male; F: Female. Continuous variables are represented as means ± standard deviation (SD); categorical variables are represented as numbers (percentage, %).

†As only wing spiker and middle blocker answered items related to spike form, the actual number does not accord with the total number.

**Table 3.** Questionnaire items for patients reporting low back pain (LBP) during volleyball in the previous year (n=59)

Subjective performance degradation, n (%)	Presence: 35 (59.3)	Absence: 24 (40.7)	
Consultation with doctor about LBP, n (%)	Presence: 21 (35.6)	Absence: 38 (64.4)	
Reports LBP to coach, n (%)	Presence: 21 (35.6)	Absence: 38 (64.4)	
Absence from a practice session, n (%)	Presence: 59 (100)	Absence: 0 (0)	
Timing of LBP, n (%)	Practice: 46 (78.0)	Game: 4 (6.7)	Daily living: 9 (15.3)
Game-specific movement and a timing of movement when LBP occurred, n (%)†	1. Spike: 28 (47.5) Approach: 0 Take off: 5 Back swing: 6 Fore swing: 7 Landing: 10 + Landing on one leg Presence: 16 (57.1) / 28 + Ball is often hit behind the shoulder Presence: 23 (82.1) / 28 2. Serve: 14 (23.7) Take off: 2 Back swing: 9 Fore swing: 3 3. Pass: 13 (22.0) Underhand: 10 Dive: 3 Overhand: 0 4. Undescribed: 4 (6.8)		

†Due to undescribed answers, the actual number does not accord with the total number.

was experienced by 48% of the sample while playing volleyball in the previous year. A previous study of athletes from 31 different sports (mean age 15.4 years) reported the 1 year prevalence of LBP was 56.0% in males and 58.4% in females<sup>6</sup>. It was also reported that LBP prevalence increased after the age of 17 year<sup>6</sup>. The lower prevalence of LBP in our patients could be explained by differences in sporting activity and age range.

This survey revealed that LBP was experienced more commonly than injuries to other body regions including the shoulder, elbow, knee and ankle. Interestingly, more than 60% of players with LBP complained of a subjective performance degradation, but despite this they frequently failed to consult with doctors or their coaches about this pain. These results are similar to previous studies which showed that athletes frequently report pain, although there is no history of injury<sup>25</sup>. In one study, diagnostic imaging in adolescent athletes with LBP showed that 50% of the sample had signs of lumbar spondylolysis, which may explain the ongoing nature of LBP in volleyball players<sup>26</sup>. Understanding the causes of LBP is important as it was reported that time lost to sport due to injury to the lumbar spine in collegiate volleyball players is 12.9% for males and 8.5% for females<sup>23</sup>. Thus, it would seem plausible to suggest that managing LBP in high school volleyball players might reduce

**Table 4.** Comparison of questionnaire items between the low back pain (LBP) and asymptomatic group

Variables	LBP (n=59)	Non-LBP (n=64)	p value	Power (1-β)
Gender, n (%)	Male: 28 (47.5)	Male: 35 (54.7)	0.42	0.36
Age (years)	15.8 ± 0.7	15.8 ± 0.7	0.53	0.05
Experience as a volleyball player (years)	4.2 ± 2.0	2.9 ± 1.8	<0.001*	0.96
BMI (kg/m <sup>2</sup> )	20.7 ± 1.5	20.2 ± 1.7	0.051	0.40
Court position, n	WSS: 18 WSW: 10 MB: 13 S: 7 L: 11	WSS: 14 WSR: 16 MB: 12 S: 7 L: 13 Unknown: 2	0.73	0.65
Spike form, n (Only Spiker)	Bow and allow: 24 Circular: 6 Straight: 11	Bow and allow: 30 Circular: 5 Straight: 7	0.44	0.58
Average practice time/week on weekdays (hours)	3.0 ± 0.5	2.9 ± 0.6	0.53	0.17
Average practice time/week during holidays (hours)	3.8 ± 0.5	3.8 ± 0.5	0.87	0.05
Stretching before practice, n (%)	Presence: 50 (84.7)	Presence: 56 (87.5)	0.66	0.14
Stretching after practice, n (%)	Presence: 44 (74.6)	Presence: 47 (73.4)	0.89	0.06
Average sleep time /week(hours)	6.3 ± 1.0	6.5 ± 0.8	0.38	0.23
Injury history within one year during volleyball, n (%)	<Presence>	<Presence>		
Shoulder	8 (13.6)	3 (4.7)	0.09	0.82
Elbow	3 (5.1)	3 (4.7)	0.62	0.06
Knee	16 (27.1)	8 (12.5)	0.04*	0.95
Ankle	36 (61.0)	15 (23.4)	<0.001*	1.00

WSS: wing spiker strong side; WSW: wing spiker weak side; MB: middle blocker; S: setter; L: libero; UN: unknown. Continuous variables are represented as means ± standard deviation; categorical variables are represented as numbers and percentages.

**Table 5.** Factors associated with low back pain (LBP) in the previous year in high school volleyball players (simple logistic regression analysis)

	B	SE	p value	Odds	95%CI of odds	
					Min	Max
Gender (M=0, F=1)	0.29	0.32	0.42	1.34	0.66	2.72
Experience as a volleyball player	0.36	0.11	0.002*	1.43	1.15	1.78
BMI	0.23	0.12	0.054	1.25	1.00	1.58
Court position	-0.05	0.13	0.68	0.95	0.74	1.21
Spike form	0.34	0.27	0.21	1.41	0.83	2.40
Average practice time/week during weekdays	0.21	0.33	0.53	1.23	0.64	2.37
Average practice time/week during holidays	0.06	0.35	0.87	1.06	0.54	2.10
Stretching before practice <sup>†</sup>	-0.23	0.52	0.66	0.79	0.29	2.21
Stretching after practice <sup>†</sup>	0.06	0.41	0.89	1.06	0.47	2.38
Average sleeping time/week	-0.19	0.21	0.38	0.83	0.55	1.26
Shoulder <sup>‡</sup>	1.16	0.70	0.10	3.19	0.80	12.65
Elbow <sup>‡</sup>	0.09	0.84	0.92	1.09	0.21	5.62
Knee <sup>‡</sup>	0.96	0.48	0.045*	2.61	1.02	6.65
Ankle <sup>‡</sup>	1.63	0.40	<0.001*	5.11	2.34	11.15

M: male; F: female; B: regression coefficient; SE: standard error.

<sup>†</sup>Stretching before and after practice; N=0, Y=1.

<sup>‡</sup>Injury history in the previous year affecting the shoulder, elbow, knee, or ankle; N=0, Y=1.

**Table 6.** Factors associated with low back pain (LBP) in the previous year in high school volleyball players (Multiple logistic regression analysis)

	B	SE	p value	Odds	95%CI	
					Min	Max
Ankle <sup>†</sup>	1.40	0.41	<0.001	4.06	1.81	9.14
Experience as a volleyball player	0.26	0.11	0.02	1.29	1.04	1.61
Constant	-1.57	0.45	<0.001	0.21		

Likelihood ratio test,  $p < 0.01$ ; Hosmer-Lemeshow test,  $p = 0.724$ ; percentage of correct classifications was 68.3%.

B: regression coefficient; SE: standard error.

<sup>†</sup>History of ankle injury in the previous year;  $N=0$ ,  $Y=1$ .

time lost to sport in the future. Furthermore, it is important to create an environment where players do not suffer LBP, and that they feel able to report LBP to their team doctor and coach to enable timely management. By doing so, it is expected that LBP and other injuries will be reduced by raising awareness of the pain to coaches and medical staff.

The present study showed that the player reported volleyball specific movement patterns inducing LBP were diverse. Pain provoking movements considered important were for example, unilateral lumbar spine impact during the spike, or lumbar extension during serving, and lumbar flexion during passing. These results perhaps suggest a variety of tissues as potential causes of LBP. Identifying the pain provocative movement pattern is important, as players may have to stop practicing in the future if they repeat the pain-causing movements<sup>25</sup>. Therefore, when volleyball players report the onset of LBP, it would seem prudent to analyze the game-specific movement and timing of movement causing LBP, to see if there any issues with the player's technique and movement patterns. This information may be helpful in designing rehabilitation programs and thereby help promote recovery and prevention of recurrence.

Buchanan et al. reported that instability following an ankle sprain was associated with decreased competition ability<sup>27</sup>. Logistic regression analyses identified the factors from the questionnaire that were associated with LBP within the previous year. A significant relationship was found between ankle injury in the previous year as well as the years of experience as a volleyball player and presence of LBP in the previous year. Ankle sprains are the most common injury to occur in volleyball<sup>11, 13, 21, 22, 24, 28</sup>. Freeman et al. reported that when adequate care is not given after an ankle sprain, the proportion of joint instability remaining after ankle injury is up to 40%<sup>29</sup>. Moreover, it was concluded in a systematic review that a relationship exists between LBP and ankle instability, suggesting that clinicians should consider a history of ankle injury when managing volleyball players with LBP<sup>30</sup>. Future studies should consider the relationship between ankle instability and LBP in volleyball players.

The years of experience as a volleyball player was found to be correlated with LBP among volleyball players. In recent years sports specialization among junior athletes is becoming more prevalent, and it is conceivable that repeated game-specific movements during volleyball practice and games over prolonged time periods without undertaking movement in other patterns in other sports may not be healthy. In addition, it is reported that volleyball has longer practice sessions than other competitive team sports<sup>2</sup>. It is a possibility that longer game-specific training is a factor in the development of LBP.

Our study has several limitations. First, we relied on the honesty of the participants to report all injuries, hence accuracy of this data cannot be determined. Second, in players with a history of injury it was not possible to diagnose the type of tissue disorder. Future research may seek a more detailed evaluation of the injured players to determine this. Third, the sample was obtained from high school volleyball players in Saitama, Japan. Since volleyball practice sessions may differ in other countries, it may not be possible to extrapolate this research to all players.

In conclusion, our results provide some indication that volleyball players who start volleyball at younger age need educational guidance on the prevention of lumbar injury and need monitoring for the development of LBP, particularly if the player has an ankle injury. Such players may require specific rehabilitation. Taking these matters into account, more attention should be paid when managing volleyball players to the occurrence of ankle injury and the individuals years of experience. It is hoped that these findings will contribute to a better understanding of the management of LBP in high school volleyball players.

### *Conflict of interest*

In this study, the authors have no conflict of interest.

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## REFERENCES

- 1) Junge A, Langevoort G, Pipe A, et al.: Injuries in team sport tournaments during the 2004 Olympic Games. *Am J Sports Med*, 2006, 34: 565–576. [[Medline](#)] [[CrossRef](#)]
- 2) Junge A, Engebretsen L, Mountjoy ML, et al.: Sports injuries during the Summer Olympic Games 2008. *Am J Sports Med*, 2009, 37: 2165–2172. [[Medline](#)] [[CrossRef](#)]
- 3) Hangai M, Kaneoka K, Okubo Y, et al.: Relationship between low back pain and competitive sports activities during youth. *Am J Sports Med*, 2010, 38: 791–796. [[Medline](#)] [[CrossRef](#)]
- 4) Noormohammadpour P, Rostami M, Mansournia MA, et al.: Low back pain status of female university students in relation to different sport activities. *Eur Spine J*, 2016, 25: 1196–1203. [[Medline](#)] [[CrossRef](#)]
- 5) Sato T, Ito T, Hirano T, et al.: Low back pain in childhood and adolescence: assessment of sports activities. *Eur Spine J*, 2011, 20: 94–99. [[Medline](#)] [[CrossRef](#)]
- 6) Schmidt CP, Zwingenberger S, Walther A, et al.: Prevalence of low back pain in adolescent athletes—an epidemiological investigation. *Int J Sports Med*, 2014, 35: 684–689. [[Medline](#)] [[CrossRef](#)]
- 7) Triki M, Koubaa A, Masmoudi L, et al.: Prevalence and risk factors of low back pain among undergraduate students of a sports and physical education institute in Tunisia. *Libyan J Med*, 2015, 10: 26802. [[CrossRef](#)]
- 8) Penedo FJ, Dahn JR: Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Curr Opin Psychiatry*, 2005, 18: 189–193. [[Medline](#)] [[CrossRef](#)]
- 9) Patel DR, Kinsella E: Evaluation and management of lower back pain in young athletes. *Transl Pediatr*, 2017, 6: 225–235. [[Medline](#)] [[CrossRef](#)]
- 10) Bartolozzi C, Caramella D, Zampa V, et al.: [The incidence of disk changes in volleyball players. The magnetic resonance findings]. *Radiol Med (Torino)*, 1991, 82: 757–760 (in Italian). [[Medline](#)]
- 11) Bere T, Kruczynski J, Veintimilla N, et al.: Injury risk is low among world-class volleyball players: 4-year data from the FIVB Injury Surveillance System. *Br J Sports Med*, 2015, 49: 1132–1137. [[Medline](#)] [[CrossRef](#)]
- 12) Hoy D, Bain C, Williams G, et al.: A systematic review of the global prevalence of low back pain. *Arthritis Rheum*, 2012, 64: 2028–2037. [[Medline](#)] [[CrossRef](#)]
- 13) Reeser JC, Gregory A, Berg RL, et al.: A comparison of women’s collegiate and girls’ high school volleyball injury data collected prospectively over a 4-year period. *Sports Health*, 2015, 7: 504–510. [[Medline](#)] [[CrossRef](#)]
- 14) Skoffler B, Foldspang A: Physical activity and low-back pain in schoolchildren. *Eur Spine J*, 2008, 17: 373–379. [[Medline](#)] [[CrossRef](#)]
- 15) Kujala UM, Salminen JJ, Taimela S, et al.: Subject characteristics and low back pain in young athletes and nonathletes. *Med Sci Sports Exerc*, 1992, 24: 627–632. [[Medline](#)] [[CrossRef](#)]
- 16) Hershkovich O, Friedlander A, Gordon B, et al.: Associations of body mass index and body height with low back pain in 829,791 adolescents. *Am J Epidemiol*, 2013, 178: 603–609. [[Medline](#)] [[CrossRef](#)]
- 17) Sano A, Hirano T, Watanabe K, et al.: Body mass index is associated with low back pain in childhood and adolescence: a birth cohort study with a 6-year follow-up in Niigata City, Japan. *Eur Spine J*, 2015, 24: 474–481. [[Medline](#)] [[CrossRef](#)]
- 18) Kilic O, Maas M, Verhagen E, et al.: Incidence, aetiology and prevention of musculoskeletal injuries in volleyball: A systematic review of the literature. *Eur J Sport Sci*, 2017, 17: 765–793. [[Medline](#)] [[CrossRef](#)]
- 19) Kelly GA, Blake C, Power CK, et al.: The association between chronic low back pain and sleep: a systematic review. *Clin J Pain*, 2011, 27: 169–181. [[Medline](#)] [[CrossRef](#)]
- 20) Auvinen JP, Tammelin TH, Taimela SP, et al.: Is insufficient quantity and quality of sleep a risk factor for neck, shoulder and low back pain? A longitudinal study among adolescents. *Eur Spine J*, 2010, 19: 641–649. [[Medline](#)] [[CrossRef](#)]
- 21) Augustsson SR, Augustsson J, Thomeé R, et al.: Injuries and preventive actions in elite Swedish volleyball. *Scand J Med Sci Sports*, 2006, 16: 433–440. [[Medline](#)] [[CrossRef](#)]
- 22) Bahr R, Bahr IA: Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports*, 1997, 7: 166–171. [[Medline](#)] [[CrossRef](#)]
- 23) Baugh CM, Weintraub GS, Gregory AJ, et al.: Descriptive epidemiology of injuries sustained in National Collegiate Athletic Association men’s and women’s volleyball, 2013–2014 to 2014–2015. *Sports Health*, 2018, 10: 60–69. [[Medline](#)] [[CrossRef](#)]
- 24) Verhagen EA, Van der Beek AJ, Bouter LM, et al.: A one season prospective cohort study of volleyball injuries. *Br J Sports Med*, 2004, 38: 477–481. [[Medline](#)] [[CrossRef](#)]
- 25) Bahr R: No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med*, 2009, 43: 966–972. [[Medline](#)] [[CrossRef](#)]
- 26) Sundell CG, Jonsson H, Ådin L, et al.: Clinical examination, spondylolysis and adolescent athletes. *Int J Sports Med*, 2013, 34: 263–267. [[Medline](#)]
- 27) Buchanan AS, Docherty CL, Schrader J: Functional performance testing in participants with functional ankle instability and in a healthy control group. *J Athl Train*, 2008, 43: 342–346. [[Medline](#)] [[CrossRef](#)]
- 28) Agel J, Palmieri-Smith RM, Dick R, et al.: Descriptive epidemiology of collegiate women’s volleyball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*, 2007, 42: 295–302. [[Medline](#)]
- 29) Freeman MA: Instability of the foot after injuries to the lateral ligament of the ankle. *J Bone Joint Surg Br*, 1965, 47: 669–677. [[Medline](#)] [[CrossRef](#)]
- 30) O’Leary CB, Cahill CR, Robinson AW, et al.: A systematic review: the effects of podiatric deviations on nonspecific chronic low back pain. *J Back Musculoskeletal Rehabil*, 2013, 26: 117–123. [[Medline](#)] [[CrossRef](#)]