Review Article

J Babol Univ Med Sci
Vol 17, Issu 8; Aug 2015. P:55-62

Evaluation of the Prevalence and Predisposing Factors of Spondylolysis and Spondylolisthesis: A Systematic Review of Previous Studies

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Received: Mar 17th 2015, Revised: May 6th 2015, Accepted: Jun 21th 2015.

ABSTRACT

BACKGROUND AND OBJECTIVE: Instability of the lumbar spine is one of the major causes of back pain and is considered as a subtype of non-specific lower back pain. Spondylolysis and spondylolisthesis due to this instability could lead to back pain. This systematic study aimed to review the published articles on the incidence of spondylolysis and spondylolisthesis.

METHODS: In this study, we searched for English articles in databases of PubMed, Scopus, Elsevier, Ovid, CINAHL and ScienceDirect using key words such as spondylolisthesis, spondylolysis, prevalence, incidence, predisposing factors and epidemiology from 2000 to 2014. In addition, we searched in other databases including SID, IranMedex, Magiran and Medlib for the Iranian articles published during this period.

FINDINGS: In total, 26 articles with dissimilar size and types of samples focusing on different spinal regions and variables were selected for this study. To assess the prevalence of spondylolisthesis and spondylolysis, 17 articles used plain radiography, seven articles used CT-scan and two articles used magnetic resonance imaging (MRI). Moreover, the prevalence of these disorders was investigated among children and athletes in four and five articles, respectively. With the exception of three articles on the incidence of cervical spondylolisthesis, other articles evaluated lumbar spondylolysis and spondylolisthesis. The total prevalence of spondylolysis and spondylolisthesis was estimated between 3-10% and 2-6%, respectively.

CNCLUSION: According to the results of this review, spondylolysis and spondylolisthesis have a high prevalence in different populations. These disorders are more common among athletes and physically active individuals, and the incidence rate is higher among children with osteogenesis imperfecta compared to normal children.

KEY WORDS: Spondylolisthesis, Spondylolysis, Incidence, Predisposing factors, Epidemiology.

Please cite this article as follows:

Shadani A, Rahmani N, Mohseni-Bandpei MA, Bassampour SA. Evaluation of the Prevalence and Predisposing Factors of Spondylolysis and Spondylolisthesis: A Systematic Review of Previous Studies. J Babol Univ Med Sci. 2015;17(8):55-62.

Introduction

Back pain is one of the most common musculoskeletal disorders in different populations (1), and about 60-80% of individuals experience back pain at least once in their lifetime (2). In Iran, the prevalence of back pain has been reported to be 62% among nurses, 84% among pregnant women, 17.4% in

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[DOR: 20.1001.1.15614107.1394.17.8.8.9]
[DOI: 10.22088/jbums.17.8.55]

children, 84.8% among surgeons and 36.5% in primary and high school teachers (3-7). Approximately 85% of the patients with back pain are classified as cases of non-specific lower back pain (8). Instability of the lumbar spine is one of the major causes of lower back pain (9) and is considered as a subtype of non-specific lower back pain accounting for 30-40% of the cases (10). Some of the manifestations of lumbar spine instability are aberrant movement patterns, positive prone instability test and the presence of chronic pains associated with functional disabilities (11). Spondylolysis and spondylolisthesis due to the instability of the lumbar spine could lead to back pain; spondylolysis is an anatomical defect in the pars interarticularis of the lumbar vertebra, which is most commonly detected in the lower spine (12-14). Spondylolisthesis is defined as the slipping of one vertebra on the other one (12,14,15). The prevalence of spondylolysis in the general population is estimated at 3-10% (16), while it has been reported to be 4.4% among children under six years of age. Moreover, the prevalence of spondylolysis in the adult population has increased by 4-6% (17). According to the statistics, the overall prevalence of spondylolisthesis is between 2-6% (18). In this regard, Hatz et al. recently reported the prevalence of low-grade spondylolisthesis to be about 3% among normal children, while the frequency of high-grade spondylolisthesis is between 6-8% among adults. This disorder commonly occurs in children at the age of six and adults (2.6% and 4%, respectively) (17). Spondylolysis is more common among men, while degenerative spondylolysis is more prevalent among women. However, there is no difference between male and female individuals in the prevalence of the isthmic type of this disorder. Spondylolysis most frequently involves the L5 vertebral segment, and L5-S1 and L4-L5 segments are most commonly affected by the isthmic and degenerative types, respectively (14). Due to the availability, low radiation levels and cost-efficiency, plain radiographs of the lumbar spine are widely used in the primary diagnosis of the lower back pain (19). Therefore, the use of lumbosacral plain radiographs seems necessary in case of patients with lower back pains (over two weeks) before the initiation of any treatment procedures (20). To date, several studies have evaluated the prevalence and incidence of spondylolysis and spondylolisthesis using different samples and methods, such as plain radiography, computed tomography (CT) and magnetic resonance imaging (MRI). Despite the high prevalence of these disorders, no published reviews were found in this regard. This study aimed to review and evaluate the prevalence and predisposing factors of spondylolysis and spondylolisthesis systematically.

Methods

For the evaluation of the incidence rate of spondylolysis and spondylolisthesis, we searched for English articles in several databases including PubMed, Scopus, Elsevier, Ovid, CINAHL and ScienceDirect during 2000-2014 using key words such as spondylolisthesis, spondylolysis, prevalence, incidence and epidemiology. In order to find the articles published in Iran, we searched other databases such as SID, IranMedex, Magiran and Medlib. In addition, we used the references available in the literature, which were not indexed in the aforementioned websites. The articles focusing on the prevalence of spondylolysis and spondylolisthesis in human subjects, which were published in English and Persian and were available in full text, were selected for this study.

Results

In total, 308 articles were found using key words such as spondylolysis, spondylolisthesis, incidence, predisposing factors and epidemiology, 26 of which (14,16,17,21-43) were included in this study. However, no articles were found in this regard in the Iranian databases. The exclusion criteria for the articles were as follows: 1) publication in languages other than English; 2) studies conducted on animal subjects; 3) case studies and reviews and 4) abstracts presented in medical conferences. Differences in the collected articles were in terms of size and types of samples, and investigated spinal regions and variables (table 1).

Size and Types of Samples: Most of the reviewed studies were conducted on sample sizes of more than 100 subjects, with the exception of five articles (min: 16, max: 98) (table 1). The majority of these studies were performed on patients of both genders, and only five cases had female-only (23,33) and male-only samples (27,30,41). In all the investigated articles, the subjects were presented with lumbar spondylolysis and spondylolisthesis, and only three studies were performed on patients with cervical spondylolisthesis

[DOR: 20.1001.1.15614107.1394.17.8.8.9]
[DOI: 10.22088/jbums.17.8.55]

(table 1). Furthermore, five articles focused on the prevalence of spondylolysis and spondylolisthesis among athletes, and the disorders were reported to be more common in track and field events, rhythmic gymnastics and sailing (symptomatic athletes: 47.45%, gymnasts: 6.55%,). On the other hand, four studies carried out on children population reported the prevalence of spondylolisthesis and spondylolysis to be 5.3% and 8.2% in children with osteogenesis imperfecta (OI), while in another study the frequency of spondylolisthesis was estimated at 10.9% among children (17, 29). According to the findings of other investigated articles, the prevalence of spondylolisthesis and spondylolysis was not higher among patients with spina bifida occulta (SBO) (39). Most of the reviewed articles evaluated the prevalence of degenerative and isthmic spondylolisthesis, and only one study evaluated the prevalence of traumatic spondylolisthesis in the second cervical vertebra (C2) (table 1).

Studied Variables in the Articles: Out of 26 articles, 17 cases assessed the status of spondylolisthesis and spondylolysis using plain radiography, and the prevalence of spondylolysis among athletes, children with OI and porters (cervical) was reported to be between 5.3-44%. As for spondylolisthesis, the frequency among athletes, children with OI, taxi drivers and middle-aged individuals was reported to be between 3.2-58.3% (table 1). In another article, the prevalence of isthmic spondylolisthesis was estimated at 5%, while the frequency of the degenerative type was reported to be 18%.

In addition, the most commonly involved spots in these two types were L5 and L4 vertebra, respectively (43). In seven articles, the prevalence of spondylolysis and spondylolisthesis was reported to be between 3.5-11.5% and 3.1-20.7%, respectively using CT-scan. In these studies, 8.2% of the subjects had isthmic spondylolisthesis and 13.6% had the degenerative type (14). In two articles, magnetic resonance imaging (MRI) was used to evaluate the prevalence of spondylolisthesis and spondylolysis (34, 37), and the frequency of anterior, angular and posterior instability in patients with spondylolysis or isthmic spondylolisthesis was reported to be 5%, 16% and 13%, respectively.

In addition, the prevalence of degenerative cervical spondylolisthesis was estimated at 20% among symptomatic patients, mostly affecting C4-C5 and C5-C6 vertebra (table 1).

Table 1. Reviewed studies on the prevalence of spondylolysis and spondylolisthesis

Author/Year	Participants	Assessment Criteria	Findings
Soler &Calderon(2000)(21)	3152 Young Athletes	Plain Radiography	Spondylolysis: Athletes: 8.02%, Track and Field (26.67%), Rhythmic Gymnastics (16.96%) Sailing (16.88%)
Rossi (2001) (22)	4243 Male and Female Athletes (Age: 15-27 years)	Plain Radiography	Spondylolysis: 13.90% , Spondylolisthesis: 47.45% (First-grade: 75.5%, second-grade: 23.21%, third-grade 1.43%)
Vogt et al. (2003) (23)	481 Women (Age: >65 years)	Plain Radiography	Anterior Spondylolysis: 58.3%, (Higher prevalence among black women)
Chen et al. (2004) (24)	1242 Subjects (1193 Male and 49 Female) (Mean age: 44.5)	Plain Radiography	Spondylolisthesis: 3.2% (Drivers with ≤5 and 6-15 years of experience or more: 1.1%, 2.4% and 7.1%, respectively)
Belfi et al. (2006) (25)	510 Subjects (222 Male and 288 Female) (Age: 5-97 years)	CT-scan	Spondylolysis: 5.7%, Spondylolisthesis: 3.1%
Horikawa,et al.(2006)(26)	528 Subjects (205 Male and 323 Female) (Age: 65-92 years)	Plain Radiography	Spondylolisthesis: 8.9%, Osteoarthritis: 38.3%, Osteoporosis: 17.8%
Mahbub et al.(2006) (27)	98 Porters (Age: 18-65 years)	Plain Radiography	Cervical Spondylosis: 39.8% , (Significant relationship between age, work experience and spondylolysis incidence)
Jacobsen,etal.(2007) (28)	4151 Subjects (1533 Male and 2618 Female) (Age: 22-93 years)	Plain Radiography	Spondylolysis: 8.4% (women), 2.7% (men), (Significant relationship between degenerative spondylolisthesis, body mass index (BMI), age and lumbar lordotic angle in women), (Significant relationship between degenerative spondylolisthesis and age in men)
Sakai et al. (2009) (16)	2,000 Subjects (991 Male and	CT-scan	Lumbar Spondylolysis: 5.9% in Japan (7.9% in men,

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	1009 Female) (Age: 20-92 years)		3.9% in women)
Kalichman et al.(2009) (14)	188 Subjects (104 Male and 84 Female) (Age: 40-80 years)	CT-scan	Spondylolysis: 11.5%, Spondylolisthesis: 20.7% (8.2% isthmic, 13.6% degenerative)
Verra et al. (2009)(29)	113 Subjects (52 Male and 61 Female) (Age: 6-24 years)	Plain Radiography	Spondylolysis: 5.3% in Patients with OI
Denard et al. (2010) (30)	300 Men (Age: >65 years)	Plain Radiography	Spondylolisthesis: 31%
Brooks et al. (2010) (31)	2555 Subjects	CT-scan	Overall Prevalence: 8%, Range from 7% (30-39 years) to 9.2% (70 years and older) at each Decade Male-to-female ratio: 1.5 to 1
Toueg et al. (2010) (32)	93 Gymnasts (19 Male and 74 Female)	Plain Radiography	Spondylolysis and Spondylolisthesis: 6.5%
Aono et al. (2010) (33)	142 Women without Spondylolisthesis	Plain Radiography	Newly Developed Degenerative Spondylolisthesis: 12.7%, (Excessive lumbar lordosis, higher angle, smaller vertebrae)
Niggemann et al. (2011) (20)	140 Patients with Spondylolysis/Isthmic Spondylolisthesis (age not reported)	MRI	Spondylolysis/Isthmic Spondylolisthesis with anterior, angular and posterior instability: 5%, 16% and 13%, respectively
Ko and Lee (2011) (35)	855 Subjects (551 Male and 304 Female) (Age: 20-86 years)	CT-scan	Spondylolisthesis: 9% of Patients , (men: 65%, women: 35%), (No significant relationship between spondylolisthesis and back pain)
Hatz et al. (2011) (17)	180 Patients with OI (48 Male and 62 Female) (Mean age: 6.1±4.2)	Plain Radiography	Spondylolysis: 8.2%, Spondylolisthesis: 10.9% (Overall Prevalence: 19.2%)
Ferro et al. (2012) (36)	16 Subjects (11 Male and 5 Female) (Age: 19-84 years)	Plain Radiography	Fracture Type I: 31.2%, Fracture Type II: 50% Type II α Fracture: 18%
Suzuki et al. (2013) (37)	468 Subjects (228 Male and 240 Female) (Age: 19-79 years)	MRI	Cervical Spondylolisthesis (at least 2mm): 20% of patients, (more frequent in C4-C5 and C5-C6)
Toueg et al. (2013) (38)	92 Gymnasts (19 Male and 73 Female) (Age: 5-21 years)	Plain Radiography	Spondylolisthesis: 6.5%, (6 subjects)
Urrutia et al. (2014) (39)	288 Subjects (107 Male and 181 Female) (Age: 4-15 years)	CT-scan	Spondylolysis: 3.5% (range: 1.1-5.9%) SBO: 41.2% (higher prevalence among male and younger subjects)
Urrutia et al. (2014) (40)	228 Children (4-15 years) 235 Adults (30-45 years)	CT-scan	Spondylolysis in Children: 3.5%, Spondylolysis in Adults: 3.8%, SBO in Children: 41.2%, SBO in Adults: 7.4%, (No significant difference between men and women), (Higher prevalence among boys)
Donaldson (2014) (41)	25 Male Athletes (Age: 15-18 years)	Plain Radiography	Lumbar Spondylolysis: 44% of subjects
He et al. (2014) (42)	3990 Subjects (1994 Male and 1996 Female)	Plain Radiography	Grade 1 Spondylolisthesis: 19.1% and 25% in men and women, respectively, Grade 2 or above: 11.3% and 13.8% in men and women, respectively (Significant relationship between spondylolisthesis and age, height, BMI and bone density)
Vining et al. (2014) (43)	247 Patients with Chronic Lower Back Pain (111 Female and 136 Male) (Age: 21-65 years)	Plain Radiography	Isthmic Spondylolisthesis: 5%, Degenerative Spondylolisthesis: 18%, (Most involved spots: L5 and L4, respectively), (Degenerative type was twice more prevalent among women)

Discussion

In this systematic review, spondylolysis and spondylolisthesis were observed to have a high prevalence in different individuals and populations. Various techniques such as plain radiography, CT-scan and MRI could be used in order to detect spondylolysis and spondylolisthesis. In this regard, MRI is considered as the most efficient method since it provides a comprehensive assessment of the lumbar spine (22), while CT-scan offers the most accurate imaging modality for the detection of spondylolysis defects, especially in one-sided and double-sided defects without displacement, as well as chronic cases (14). Furthermore, this method could be used in case of the simultaneous incidence

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of spondylolisthesis and spondylolysis (25). In one study, Kalichman et al. reported the prevalence of spondylolysis and spondylolisthesis to be 11.5% and 20.7%, respectively using CT-scan (14), which were higher than the levels detected by plain radiography. Although cervical spondylolisthesis is a common disorder, limited studies have evaluated its prevalence among different populations (27). In another study by Mahbub et al. (2006), the prevalence of cervical spondylolysis was estimated at 39.8%; this amount was higher in patients with working experience of 10-15 years and more. In addition, the individuals who carried heavier loads were observed to be more prone to spondylolysis (27). The majority of the investigated articles evaluated the prevalence of spondylolysis and spondylolisthesis occurring in the lumbar spine, with the results ranging between 3-31% (14, 16, 17, 21-28, 26-35, 38-43).

According to their findings, the occurrence of spondylolisthesis was considerably higher in the back area compared to the neck. In the related studies, the prevalence of spondylolysis ranged from 3.5% to 13.90%, while the frequency of spondylolisthesis was reported to be between 3-31%. Furthermore, spondylolysis was observed to be more common among men, whereas spondylolisthesis was more prevalent among women (14). These differences in the findings could be due to ethnic diversities; for instance, spondylolysis was found to be more prevalent among indigenous populations of Alaska and America, as well as white populations (2 to 3 times). In addition, spondylolisthesis was reported to be more common among black American women compared to white ones (23, 26).

On the other hand, spondylolisthesis has been observed to be more prevalent among physically active individuals (30), taxi drivers (24) extreme sportsmen (21, 22, 24, 30, 32). Moreover, spondylolysis is normally detected among individuals performing exercises with hyperextension and hyperflexion involving strong and repeated rotations of the lumbar spine (22). According to the results of this review, increased durations of exercise, along with higher levels of competition for a long period, could cause more severe tensions in the lumbosacral junction, resulting in the higher incidence rate of spondylolysis and spondylolisthesis among athletes (38). In a study by Rossi et al., the prevalence of spondylolysis was estimated at 13.9%, and the simultaneous occurrence of spondylolisthesis in the studied population was reported to be about 47.45% (22). While the prevalence of spondylolysis and spondylolisthesis is between 3-10% (16) and 2-6% in the general population, respectively (18), the incidence rate of spondylolysis in the general population of adults and children has been estimated at 5-9% and 4.4%, respectively (17). In another study, Verra et al. reported the prevalence of spondylolysis to be 5.3% in a population of children with OI (29), which was indicative of no significant difference with normal children; however, the findings of Hatz et al. revealed a higher incidence rate for spondylolysis and spondylolisthesis (8.2% and 10.9%, respectively) (17). This inconsistency could be due to the differences in the walking patterns between the studied populations. In the study by Hatz et al., the majority of children with OI had a good weight bearing (17); however, the OI children evaluated by Verra et al. had difficulty performing physical activities (29). Therefore, the lower tension applied to the lumbar spine of these could protect them against the risk of spondylolysis. Moreover, subjects under six years of age were excluded from the study by Verra et al., (29) while Hatz et al. showed a prevalence of 62% for spondylolisthesis and 53% for spondylolysis among children ageing six years and above (17).

According to the results of the present review, spondylolysis and spondylolisthesis have a high prevalence in different populations. Moreover, it seems that spondylolysis is relatively more common compared to spondylolisthesis. Furthermore, these disorders have a higher incidence rate among athletes, children with OI and physically active individuals.

In conclusion, the results obtained by the current study were indicative of a higher incidence rate for spondylolysis among men, as well as a higher prevalence of spondylolisthesis among women. Given the considerable incidence rate of these disorders, it is recommended that further studies be conducted on the underlying factors associated with spondylolysis and spondylolisthesis. Moreover, training the individuals who are more likely to be affected by these disorders on the risk factors is of paramount

[DOR: 20.1001.1.15614107.1394.17.8.8.9]
[DOI: 10.22088/jbums.17.8.55]

importance in the prevention of spondylolysis and spondylolisthesis.

Acknowledgments

Hereby, the authors would like to extend their gratitude to the Research Deputy of the University of Social Welfare and Rehabilitation Sciences for the financial support of this research project.

References

1.Jin K, Sorock GS, Courtney TK. Prevalence of low back pain in three occupational groups in Shanghai, People's Republic of China. J Safety Res. 2004;35(1):23-8.

2.Ehrlich GE. Low back pain. Bull World Health Organ. 2003;81(9):671-6.

3.Mohseni-Bandpei MA, Fakhri M, Ahmad-Shirvani M, Bagheri-Nesami M, Khalilian AR. Epidemiological aspects of low back pain in nurses. J Babol Univ Med Sci. 2005;7(2):35-40. [In Persian]

4.Mohseni-Bandpei MA, Fakhri M, Ahmad-Shirvani M, Bagheri-Nessami M, Khalilian AR, Shayesteh-AzarM, et al. Low back pain in 1,100 Iranian pregnant women: prevalence and risk factors. spine j. 2009;9(10):795-801.

5.Mohseni-Bandpei MA, Bagheri-Nesami M, Shayesteh-Azar M. Nonspecific lowback pain in 5000 Iranian school-age children. J Pediatr Orthop. 2007;27(2):126-9.

6.Mohseni-Bandpei MA, Ahmad-Shirvani M, Golbabaei N, Behtash H, Shahinfar Z, Fernandez-de-las-Penas C. Prevalence and risk factors associated with low backpain in Iranian surgeons. J Manipulative Physiol Ther. 2011;34(6):362-70.

7.Mohseni Bandpei MA, Ehsani F, Behtash H, Ghanipour M. Occupational low back pain in primary and high school teachers: prevalence and associated factors. J Manipulative Physiol Ther. 2014;37(9):702-8.

8.Petersen T, Olsen S, Laslett M, Thorsen H, Manniche C, Ekdahl C,et al. Inter-tester reliability of a new diagnostic classification system for patients with non-specific low back pain. Aust J Physiother. 2004;50(2):85-94.

9.Garet M, Reiman MP, Mathers J, Sylvain J. Nonoperative treatment in lumbar spondylolysis and spondylolisthesis: a systematic review. Sports Health. 2013;5(3):225-32.

10.O'Sullivan PB. Lumbar segmental 'instability': clinical presentation and specific stabilizing exercise management. Man Ther. 2000;5(1):2-12.

11.Javadian Y, Behtash H, Akbari M, Taghipour M, Zekavat H. Reliability of clinical examination in patients with chronic lowback pain suspected to lumbar segmental instability. J Babol Univ Med Sci. 2008;10(4):16-23.[In Persian]

12.Haun DW, Kettner NW. Spondylolysis and spondylolisthesis: a narrative review of etiology, diagnosis, and conservative management. J Chiropr Med. 2005;4(4):206-17.

13.Ruiz-Cotorro A, Balius-Matas R, Estruch-Massana AE, Vilaro Angulo J. Spondylolysis in young tennis players. Br J Sports Med. 2006;40(5):441-6.

14.Kalichman L, Kim DH, Li L, Guermazi A, Berkin V, Hunter DJ. Spondylolysis and spondylolisthesis: prevalence and association with low back pain in the adult community-based population. Spine (Phila Pa 1976). 2009;34(2): 199-205.

15.Jeong HY, You JW, Sohn HM, Park SH. Radiologic evaluation of degeneration in isthmic anddegenerative spondylolisthesis. Asian Spine J. 2013;7(1):25-33.

16.Sakai T, Sairyo K, Takao S, Nishitani H, Yasui N. Incidence of lumbar spondylolysis in the general population in Japan based on multidetector computed tomography scans from two thousand subjects. Spine (Phila Pa 1976). 2009;34(21):2346-50.

17.Hatz D, Esposito PW, Schroeder B, Burke B, Lutz R, Hasley BP. The incidence of spondylolysis and spondylolisthesis in children with osteogenesis imperfecta. J Pediatr Orthop. 2011;31(6):655-60.

18.McNeely ML, Torrance G, Magee DJ. A systematic review of physiotherapy for spondylolysis and spondylolisthesis. Man ther. 2003;8(2):80-91.

19.Brant Zawadzki MN, Dennis SC, Gade GF, Weinstein MP. Low back pain. Radiology. 2000;217(2):321-30.

20.Roohi M, Keshani M, Mahboubi A, N Nikzad, Issapour R. Evaluation of radiographic findings in chronic low back pain. J Babol Univ Med Sci. 2004;6(3):50-4.[In Persian]

[DOR: 20.1001.1.15614107.1394.17.8.8.9]
[DOI: 10.22088/jbums.17.8.55]

21.Soler T, Calderon C. The prevalence of spondylolysis in the Spanish elite athlete. Am J Sports Med. 2000;28(1):57-62.
22.Rossi F, Dragoni S. The prevalence of spondylolysis and spondylolisthesis in symptomatic elite athletes: radiographic findings. Radiography. 2001;7(1): 37-42.
23.Vogt MT, Rubin DA, Palermo L, Christianson L, Kang JD, Nevitt MC, et al. Lumbar spine listhesis in older African American women. Spine J. 2003;3(4):255-61.
24.Chen JC, Chan WP, Katz JN, Chang WP, Christiani DC. Occupational and personal factors associated with acquired lumbar spondylolisthesis of urban taxi drivers. Occup EnvironMed. 2004;61(12):992-8.
25.Belfi LM,Ortiz AO, Katz DS. Computed tomography evaluation of spondylolysis and spondylolisthesis in asymptomatic patients. Spine (Phila Pa 1976). 2006;31(24):E907-10.
26.Horikawa K, Kasai Y, Yamakawa T, Sudo A, Uchida A. Prevalence of osteoarthritis, osteoporotic vertebral fractures, and spondylolisthesis among the elderly in a Japanese village. J Orthop Surg (Hong Kong). 2006;14(1):9-12.
27.Mahbub MH, Laskar MS, Seikh FA, Altaf MH, Inoue M, Yokoyama K, et al. Prevalence of cervical spondylosisand musculoskeletal symptoms among coolies in a city of Bangladesh. J Occup Health. 2006;48(1):69-73.
28.Jacobsen S, Sonne-Holm S, Rovsing H, Monrad H, Gebuhr P. Degenerative lumbar spondylolisthesis: an epidemiological perspective: the Copenhagen Osteoarthritis Study. Spine (Phila Pa 1976). 2007;32(1):120-5.
29.Verra WC, Pruijs HJ, Beek EJ, Castelein RM. Prevalence of Vertebral Pars Defects (Spondylolysis) in a Population With Osteogenesis Imperfecta. Spine (Phila Pa 1976). 2009;34(13):1399-401.
30.Denard PJ, Holton KF, Miller J, Fink HA, Kado DM ,Yoo JU, et al. Lumbar spondylolisthesis among elderly men: prevalence, correlates and progression. Spine (Phila Pa 1976). 2010;35(10):1072-8.
31.Brooks BK, Southam SL, Mlady GW, Logan J, Rosett M. Lumbar spine spondylolysis in the adult population: using computed tomography to evaluate the possibility of adult onset lumbar spondylosis as a cause of back pain. Skeletal Radiol. 2010;39(7):669-73.
32.Toueg CW, Mac-Thiong JM, Grimard G, Parent S, Poitras B, Labelle H. Prevalence of spondylolisthesis in a population of gymnasts. Stud Health Technol Inform. 2010;158:132-7.
33.Aono K, Kobayashi T, Jimbo S, Atsuta Y, Matsuno T. Radiographic analysis of newly developed degenerative spondylolisthesis in a mean twelve-year prospective study. Spine (Phila Pa 1976). 2010;35(8):887-91.
34.Niggemann P, Kuchta J, Beyer HK, Grosskurth D, Schulze T, Delank KS. Spondylolysis and spondylolisthesis: prevalence of different forms of instability and clinical implications. Spine (Phila Pa 1976). 2011;36(22):1463-8.
35.Ko SB, Lee SW. Prevalence of spondylolysis andits relationship with low back pain in selected population. Clin Orthop Surg. 2011;3(1):34-8.
36.Ferro FP, Borgo GD, Letaif OB, Cristante AF, Marcon RM, Lutaka AS. Traumatic spondylolisthesis of the axis: epidemiology, management and outcome. Acta Ortop Bras. 2012;20(2):84-7.
37.Suzuki A, Daubs MD, Inoue H, Hayashi T, Aghdasi B, Montgomery SR, et al. Prevalence and motion characteristics of degenerative cervical spondylolisthesis in the symptomatic adult. Spine (Phila Pa 1976). 2013;38(17):E1115-20.
38.Toueg CW, Mac-Thiong JM, Grimard G, Poitras B, Parent S, Labelle H. Spondylolisthesis, Sacro-pelvic Morphology and Orientation in Young Gymnasts. J Spinal Disord Tech. 2015;28(6):E358-64.
39.Urrutia J, Cuellar J, Zamora T. Spondylolysis and spina bifida occulta in pediatric patients: prevalence study using computed tomography as a screening method. Eur Spine J. 2014. [Epub ahead of print]
40.Urrutia J, Zamora T, Cuellar J. Does the Prevalence of Spondylolysis and Spina Bifida Occulta Observed in Pediatric Patients Remain Stable in Adults? J Spinal Disord Tech. 2014. [Epub ahead of print]
41.Donaldson LD. Spondylolysis in elite junior-level ice hockey players. Sports Health. 2014;6(4):356-9.
42.He LC, Wang YX, Gong JS, Griffith JF, Zeng XJ, Kwok AW, et al. Prevalence andrisk factors of

[DOR: 20.1001.1.15614107.1394.17.8.8.9]
[DOI: 10.22088/jbums.17.8.55]

lumbar spondylolisthesis in elderly Chinese men and women. Eur Radiol. 2014;24(2):441-8.
43.Vining RD, Potocki E, McLean I, Seidman M, Morgenthal AP, Boysen J,et al. Prevalence of radiographic findings in individuals with chronic low back pain screened for a randomized controlled trial: secondary analysis and clinical implications. J Manipulative Physiol Ther. 2014;37(9):678-87

[DOR: 20.1001.1.15614107.1394.17.8.8.9]
[DOI: 10.22088/jbums.17.8.55]