



Original Research

Variables associated with active spondylolysis

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ABSTRACT

Study design: Retrospective non-experimental study.**Objective:** To investigate variables associated with active spondylolysis.**Design:** A retrospective study audited clinical data over a two year period from patients with suspected spondylolysis that were referred for a SPECT bone scan. Six exploratory variables were identified and analysed using uni- and multi-variate regression from 82 patient records to determine the association between symptomatic, physical and demographic characteristics, and the presence of an active spondylolysis.**Setting:** Tertiary level multidisciplinary private practice sports medicine clinic.**Participants:** All patients with low back pain that required a SPECT bone scan to confirm suspected spondylolysis. 82 subjects were included in the final sample group.**Main outcome measurements:** The six exploratory variables included Age, Gender, Injury duration, Injury onset, Sports participation and the result of the Single Leg Hyperextension Test.

The dependent outcome variable was the result of the SPECT bone scan (scan-positive or scan-negative).

Results: Adolescent males had a higher incidence of spondylolysis detected by SPECT bone scan compared to other patients and a statistically significant association was demonstrated for both age ($p = 0.01$) and gender ($p = 0.01$). Subjects with an active spondylolysis were nearly five times more likely to be male and aged less than 20 years. Furthermore, the likelihood ratio indicated that adolescent males with suspected spondylolysis were three and a half times more likely to have a positive bone scan result. The Single Leg Hyperextension Test did not demonstrate a statistically significant association with spondylolysis ($p = 0.47$).**Conclusions:** Clinicians assessing for a predisposition to the development of spondylolysis should consider the gender and age of the patient and not rely on the predictive ability of the Single Leg Hyperextension Test.

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1. Introduction

Spondylolysis in the lumbar spine is usually a result of a fatigue fracture of the pars interarticularis that tends to occur at two distinct periods of skeletal development (Micheli & Wood, 1995). In early childhood, as a child attempts to stand and walk, a structurally deficient pars may fracture as it fails to withstand the increase in mechanical loads that occur when first walking. This form of spondylolysis does not normally cause any pain or functional restriction in childhood and there does not seem to be any increase in long term disability or low back pain (LBP) when compared to the general population (Beutler et al., 2003). The second period in

which spondylolysis may develop, is in early adolescence. In this instance the pars of the maturing spine fractures as it fails to withstand the increase in mechanical loads associated with increasing activity and sporting participation. The pathophysiological development of a pars stress fracture is called 'active spondylolysis' and, although the condition often remains asymptomatic, it can be responsible for significant pain and disability (Congeni, McCulloch, & Swanson, 1997).

More recently, spondylolysis has been recognised as a potential source of LBP in athletic adolescents with some authors suggesting it accounts for up to 50% of symptoms in this population (Micheli & Wood, 1995; Wiesel, 2002). Gender would also appear to have a factor in the prevalence of spondylolysis with some studies showing up to a two fold increase in the incidence of spondylolysis in males (Sys, Michielsen, Bracke, Martens, & Verstreken, 2001). Despite advances in the understanding of the development of the

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condition, considerable uncertainty exists in diagnosing the condition (Moeller & Rafit, 2004).

Low back pain is the most common symptom that is attributed to spondylolysis and is typically aggravated by upright postures such as standing and walking as well as active movement involving lumbar spine extension (Standaert & Herring, 2000). The Single Leg Hyperextension Test (SLHT) has been advocated as the most effective clinical test for confirming spondylolysis (Hresko & Micheli, 1989). This test requires the patient to stand on one leg and actively extend their lumbar spine, however the specificity and sensitivity of this test has recently been shown to be poor (Masci et al., 2006). It is recognised that the symptoms that are common in spondylolysis are often present in non specific LBP and there are limitations in making a diagnosis of spondylolysis based on patient characteristics, history and physical examination alone (Wiesel, 2002). The radiological visualisation of a pars lesion is therefore essential to confirm the diagnosis of spondylolysis (Lim, Yoon, & Green, 2004). The combination of Computerised Tomography (CT) and Single Photon Emission Computerised Tomography (SPECT) bone scanning remains the gold standard for diagnosing and classifying an active spondylolysis as there is a higher sensitivity to detect subtle fractures and an improved insight into the metabolic activity of a pars fracture when compared to alternate radiological investigations (Wiesel, 2002).

Clinically, it is often difficult to determine if a patient with LBP is presenting with symptoms that are directly associated with an active spondylolysis and further research is required to improve our understanding of the condition. This study is therefore an initial step in identifying variables that are associated with active spondylolysis. An improved understanding of the demographic, physical and symptomatic variables that are associated with a developing spondylolysis may assist clinicians in diagnosing the condition and initiating treatment more efficiently. Conversely, patients who present with characteristics that are not strongly associated with spondylolysis are less likely to require unnecessary radiological imaging to exclude the diagnosis.

2. Methods

A retrospective, non-experimental study was undertaken to determine if an association existed between specific patient characteristics and the outcome of radiological investigations for spondylolysis. The study was conducted within a large medical facility that included a sports medicine centre and radiology clinic. The study sample consisted of a group of patients with LBP that had been referred, over a two year period, for a SPECT bone scan to confirm an active spondylolysis. Six exploratory variables were recorded relating to the demographic, symptomatic and physical characteristics of the group. The dependent variable was the diagnostic outcome of the SPECT bone scan result to confirm or exclude an active spondylolysis (*scan-positive* or *scan-negative*).

Six binary, exploratory variables were selected on the basis that they had previously been identified to possibly have an association with an active spondylolysis (Micheli & Wood, 1995; Wiesel, 2002):

1. Age at bone scan (Greater or less than 20 years old)
2. Gender (Male or Female)
3. Injured Period (Greater or less than 3 months)
4. Onset of symptoms (Sudden or Gradual)
5. Sports participation (Yes or No)
6. Single Leg Hyperextension Test result (Positive or Negative)

Univariate and multivariate logistic regression analysis were used to model the relationship between the exploratory variables and the dependent variable (bone scan result positive/negative). An a-priori level of significance was set at $p \leq 0.05$.

3. Results

Eighty two subjects were included in the retrospective sample. Twenty six of the subjects had a positive SPECT scan indicating an active spondylolysis. The descriptive data for the six exploratory variables are shown in Table 1.

The results from the univariate regression analysis of the association between individual exploratory variables and the SPECT bone scan are shown in Table 2. There was a statistically significant association between bone scan outcome and *age* ($p = 0.01$) and *gender* ($p = 0.01$). There was no significant association for any other variables. The *SLHT* was the variable with the least association with the bone scan result ($p = 0.47$).

The *SLHT* has previously been advocated as a clinical test to diagnose spondylolysis and therefore additional univariate tests for association were investigated. Only 44 of the 82 patient reports had sufficient detail to determine the outcome of the *SLHT* and therefore the results for this variable should be interpreted with caution. In this study the sensitivity of the *SLHT* was 73% and the specificity was 17.2%.

The multivariate analysis was carried out for the two variables (*age* and *gender*) that had shown a significant association with the outcome of the bone scan in the univariate analysis. The multivariate analysis demonstrated a significant association for the *gender* and *age group* variable and the outcome of the bone scan (Table 3). The addition of further variables did not improve the predictive model.

The classification table for the *gender* and *age group* variables to predict the outcome of a bone scan indicated that these two variables could predict the outcome of a SPECT bone scan on 76.8% of occasions (Table 4). The sensitivity value for *gender* and *age group* to predict a positive bone scan was 61.5% and the variables had a positive likelihood ratio of 3.66. The likelihood ratio indicates that a male patient who is aged less than 20 years has over three and a half times the odds of having a positive bone scan. The specificity value for *age group* and *gender* was 83.9% and the negative likelihood ratio was 0.27. The negative likelihood value indicates that a female, who is over the age of 20, has nearly a quarter of the odds of having a positive scan.

4. Discussion

The results of this study indicate that age and gender has a significant association with the diagnosis of active spondylolysis. The odds ratio (3.6) for gender shows that an individual with spondylolysis is three and a half times more likely to be male. The high proportion of males with active spondylolysis is similar to that found in previous studies and it would appear that males are more susceptible to developing pars stress fracture than females (Beutler

Table 1
Descriptive data for exploratory variables.

Variable	n/(n with data)		
	Scan-positive n = 26	Scan-negative n = 56	All subjects n = 82
Gender (Male)	19/26 (73.1%)	24/56 (42.9%)	43/82 (52.4%)
Age group (< 20 years)	21/26 (81.8%)	31/53 (58.5%)	52/79 (65.8%)
Injury onset (Sudden)	17/24 (70.8%)	27/55 (49.1%)	44/79 (55.7%)
Sports participation (Yes)	22/26 (84.6%)	37/56 (66.1%)	59/82 (72.0%)
Injured period (< 3 months)	17/26 (65.4%)	25/55 (45.5%)	42/81 (51.9%)
SLHT (Positive)	11/15 (73.3%)	24/29 (82.7%)	35/44 (79.5%)

Table 2

Univariate regression for categorical variables (n = 82).

Variable	Beta coefficient (SE)	Odds ratio (95% CI)	p value
Gender (Male)	1.29 (0.52)	3.6 (1.3–10.0)	0.01
Age group (≤ 20 years of age)	1.57 (0.54)	4.8 (1.7–13.8)	0.01
Injury onset (Sudden)	0.85 (0.53)	2.3 (0.8–6.6)	0.11
Sports participation (Yes)	1.10 (0.61)	2.9 (0.9–9.7)	0.08
Injured period (≤ 3 months)	0.82 (0.49)	2.3 (0.9–6.0)	0.10
SLHT (Positive)	−0.56 (0.76)	0.6 (0.1–2.6)	0.47

et al., 2003; Miller, Congeni, & Swanson, 2004; Soler & Calderon, 2000).

The high proportion of active spondylolysis in adolescent males is most likely multi-factorial. Previous studies have demonstrated that a crucial period exists during adolescent development in which the lumbar spine has a reduced level of Lumbar Spine Bone Mineral Density (LSBMD) when compared to the adult spine (Nelson, Simpson, Johnson, Barondess, & Kleerekoper, 1997; Zanchetta, Plotkin, & Alvarez, 1995). This disparity was most prominent in cortical bone, the main component of the pars interarticularis, and the pars would appear to be particularly at risk to mechanical stress throughout puberty. The male adolescent spine may be more vulnerable on account of having a generally lower LSBMD when compared to the female adolescent spine (Zanchetta et al., 1995). Biomechanical characteristics of the spine may also contribute to the high proportion of males with spondylolysis. The male spine is not as flexible as the female spine and the increased rigidity may adversely effect the distribution of torsional loads throughout the spinal column (Kondratek, Krauss, Stiller, & Olson, 2005). This factor may contribute to an increase in stress at the pars interarticularis and eventual structural fatigue. Further research is required to assist in determining the extent to which spine mobility influences spondylolysis development.

Stress fractures develop as a result of sustained and/or repetitive loading on skeletal structures (Wheeler & Batt, 2005). This increase in the rate of spondylolysis in males may also reflect the higher proportion of males in this study that participated in sports activities (males 70%, females 40%). Furthermore, a greater proportion of male subjects participated in sports that involved high velocity, torsional loading of the lumbar spine, such as cricket (14.6%) or soccer (12.2%), which have previously been identified to increase the risk of spondylolytic development (Hardcastle, Annear, & Foster, 1992).

The high incidence of spondylolysis in adolescents may also be due to an increased exposure to a structured regime of sports activities. School and club sports usually commence during early adolescence and participation often involves weekly training and weekend competitions. The increase in training load may be an important risk factor for the development of spondylolysis. School aged children are also more likely to be introduced to physical 'high risk' sports such as cricket, gymnastics and soccer whilst at school and the increased exposure to high velocity activities may heighten the risk of developing a spondylolysis. Further research is required

Table 3

Multivariate logistic regression (Gender and Age group) n = 82.

Variable	Beta coefficient (SE)	Odds ratio (95%CI)	p value
Gender (Male)	1.2 (0.54)	3.5 (1.2 to 10.1)	0.02
Age group (≤ 20 years of age)	1.5 (0.56)	4.6 (1.5 to 13.7)	0.01

Table 4

Classification table for gender and age group.

Observed bone scan result	Predicted positive scan	Predicted negative scan	Percent correct
Positive	16	10	61.5%
Negative	9	47	83.9%
Total	25	57	76.8%

to determine the extent to which biomechanics and training load influence the development of spondylolysis.

The SLHT has been advocated as the only clinical test that specifically assists in diagnosing spondylolysis (Hresko & Micheli, 1989; Moeller & Rafit, 2004). The predictive value of the SLHT can be determined by calculating the sensitivity and specificity of the test. Taking both sensitivity (73.3%) and specificity (17.2%) figures found in this study, it appears that the SLHT provides minimal clinical value in confirming or excluding an active spondylolysis. The results of this study supports the recent findings of Masci et al. (2006), and suggest that the SLHT has limited value in diagnosing or excluding spondylolysis.

The results of this study represent an initial step in determining the variables that are strongly associated with spondylolysis. Both Age and Gender variables appear to be important in determining which patients are more likely to have a pars stress fracture. In order to develop a robust clinical prediction rule for active spondylolysis, further prospective research is needed to identify a wider range of variables that are associated with the development of the condition.

5. Conclusion

Clinicians considering the likelihood of a patient having an active spondylolysis should consider the gender and age of the patient and not rely on the predictive ability of the Single Leg Hyperextension Test.

Conflict of interest statement

The authors of this submitted manuscript declare that there is no conflict of interest related to this research project and academic paper.

Ethical approval

Ethics approval for this study was granted from the Central Regional Ethics committee, a division of the National Ethics committee. The National Ethics Committee is a branch of the Health Research Council of New Zealand, representing the New Zealand Ministry of Health.

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