Resistive straight leg raise test, resistive forward bend test and heel compression test: novel techniques in identifying secondary gain motives in low back pain cases

Naresh Kumar · Sujith Indeewara Wijerathne ·
Wen Wei Julian Lim · Tan Wei Loong Barry ·
Chinmay Nath · Shen Liang

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Abstract

Purpose ‘Low back pain’ (LBP) is a prevalent condition with a majority showing no specific organic pathology. Distinguishing ‘secondary gain motives (SGM)’ from organic causes is imperative in clinical practice. We describe here, three new tests—resistive straight leg raise test (*rSLRT*), resistive forward bend test (*rFBT*) and heel compression test (HCT) to help differentiate patients with ‘SGM’ from those without. We conducted a prospective study to validate the above tests in predicting non-organic causes as a reason for LBP.

Methods 200 patients presenting with low back pain at the senior author’s outpatient orthopaedic clinic from Jan 2009 to Nov 2010 were studied. Patients were separated into two groups—‘SGM group’ ($n = 100$) and ‘non-SGM group’ ($n = 100$). ‘SGM group’ patients had a history of work-related accidents, road traffic accidents or assault, with a background of ongoing litigation issues or compensation benefits. *rSLRT*, *rFBT*, HCT, Schober’s test and

Waddell’s five signs were performed on them. Statistical analysis was done to identify correlations between test results, MRI findings and ‘SGM’ status.

Results Statistically significant differences were observed between the SGM and non-SGM group ($p < 0.0005$) for all tests studied. In predicting SGM status, *rSLRT* showed highest specificity (0.94) and highest positive predictive value (0.925) while HCT showed the highest negative predictive value (0.859). Positive *rSLRT* was found to be strongly correlated with ≥ 3 positive Waddell’s signs. SGM patients with positive *rSLRT* tended to show resistance $\leq 45^\circ$.

Conclusions *rSLRT*, *rFBT* and HCT (NK triad) are highly practical tests which strongly predict SGM status in patients.

Keywords Low back pain · Secondary gain motives · Resistive straight leg raise test (*rSLRT*) · Resistive forward bend test (*rFBT*) · Heel compression test (HCT)

N. Kumar · S. I. Wijerathne · W. W. J. Lim · T. W. L. Barry
University Spine Centre, National University Hospital,
5 Lower Kent Ridge Road, Singapore 119074, Singapore

N. Kumar (✉)
University Spine Centre, University Orthopaedics,
Hand and Reconstructive Microsurgery Cluster,
1E Kent Ridge Road, NUHS Tower Block, Level 11,
Singapore 119228, Singapore
e-mail: naresh@doctors.org.uk; dosksn@nus.edu.sg

C. Nath
Apollo Gleneagles Hospital, Kolkata, India

S. Liang
Biostatistics Unit, Yong Loo Lin School of Medicine,
National University of Singapore, Singapore, Singapore

Introduction

Approximately 70 % of the adult population experiences low back pain (LBP) at least once during their lifetime [1, 2]. Worldwide, 37 % of LBP was deemed attributable to occupational risk factors [3]. Work-related LBP was estimated to cause 818,000 disability-adjusted life years loss annually [3], with significant costs to industry [4]. However, up to 85 % of patients with LBP show no identifiable specific organic pathology [1, 2].

Non-organic causes of LBP include stress, personality issues and various ‘secondary gain motives’ (SGM) which could range from a desire to obtain exemption from work duties to seeking financial reimbursement through the legal

system, e.g., those undergoing litigation, seeking compensation or involved in medico-legal cases [5–9]. Distinguishing SGM from organic disease is imperative in improving clinical practice and pertinent in the modern medico-legal climate [5–9]. However, it is often difficult to [10] distinguish patients who have a genuine organic component to their LBP from those who do not [6, 8, 9].

It is desirable to have clinical tests, which are efficient and predictable in identifying patients with SGM. In 1979, Waddell in his classic paper [11] defined 5 categories of non-organic physical signs—tenderness, simulation, distraction, regional and overreaction—which have been found to be strong predictors of SGM [12]. Correlations were also found between his signs and indications of general psychopathology on the Minnesota Multi-phasic Personality Inventory [11, 13]. However, Waddell's signs are time-consuming to elicit and are sometimes equivocal [14]. This led various authors to describe novel tests for non-organic causes of LBP, with varied results [15]. Examples include the heel-tap test [14], production of LBP by active cervical motion of the erect individual [16] and limitation of motion in one or both shoulders distinctly accompanied by LBP [16].

Recently, Moradi et al. [17] have used three physical performance tests (Villiger test, Oesch test, Biering–Sorensen test) to differentiate between patients with somatic parameters of LBP and control group. They found these tests to display good discriminative ability and high reliability, but could not predict treatment outcome. However, these novel tests described above have to be conducted separately from standard clinical examination for the lumbar spine. Here, we describe three simple

clinical tests, which can be incorporated into the routine spinal examination, which have demonstrated different results in patients with SGM. The differences observed were a 'Straight Leg Raise Test' (SLRT) with a downward resistive force in the first 30° of elevation; resistance to 'Forward Bend Test' (FBT); and exacerbation of back pain while conducting a 'Heel compression test' (HCT).

We performed a study to evaluate whether the above-mentioned tests were effective in identifying patients with secondary gain objectives.

Materials and methods

This prospective study consists of patients who presented with LBP to the senior author's outpatient Orthopaedic clinic from January 2009 till November 2010. A study protocol was followed for clinical assessment, patient follow-up and data collection. Please refer to the methodology flow chart (Fig. 1) for details of the study design.

The history taking and physical examination of a selected patient were carried out on the first day of clinic assessment. These two processes were not performed by the same author. One author documented the history and the presence of any possible SGM while the physical examination was carried out by another author who was not informed of the history. SLRT, FBT/Schober's test, HCT, and the five categories of Waddell's signs were performed on these patients. The authors documented their findings on the study protocol separately and independently.

The patients were then divided into two groups—patients with SGM, i.e., LBP following a work-related

Fig. 1 Illustration of methodology

accident, road traffic accident or assault, with a background of ongoing litigation issues or compensation benefits (SGM group) and those without (non-SGM group). All the selected patients were then followed up with an MRI scan of the lumbar spine.

The *resistive* SLRT (*rSLRT*), *resistive* FBT (*rFBT*) and HCT are described in detail below.

Resistive straight leg raise test (*rSLRT*)

Historically, the SLRT was described by Lasègue's pupil Forst in 1881 [18] and subsequently reported in further detail by Lazarevic [19]. The SLRT is traditionally performed with the patient in the supine position. The examiner flexes the patient's hip while maintaining the knee in extension. With lumbar-spine pathology, this may lead to pain radiating down the leg in the appropriate nerve root distribution. This is classified as a 'positive SLRT'. If no pain is reproduced by 90°, it is considered a 'negative SLRT' [20].

We performed the SLRT in a similar manner in our patients. If a patient actively exerts a downward resistive force on the examiner's hand when the examiner tries to lift the leg (Fig. 2), the test would be classed as a 'positive *resistive* SLRT (*rSLRT*)'. A non-SGM patient would be expected to allow the examiner to raise his leg without a downward resistive force until 90° or until the angle at which pain elicited is reached, assuming an organic pathology.

Resistive forward bend test (*rFBT*)

The standard Schober's test (ST) is conducted by placing one mark approximately 5 cm below the posterior superior iliac spine (PSIS) and another mark about 10 cm above the PSIS. The patient is then asked to touch his/her toes. This maneuver increases the distance between the two marks, the amount of increment is measured and documented.

Fig. 2 Demonstration of resistive straight leg raise test (*rSLRT*)

Normal increment is 5 cm or more and there is no difficulty in bending [21].

A 'positive *resistive* forward bend test (*rFBT*)' occurs if a patient expresses complete inability or great difficulty in bending on his or her own due to pain during the bending phase of the Schober's test. They actively exert a resistive force on the examiner's hand when guided to bend forwards (Fig. 3). A patient with an underlying organic pathology would be able to bend with minimal resistive force until the angle at which pain prevents him/her from bending further.

Heel compression test (HCT)

The HCT is a novel test described by the principal author. The patient lies supine on the examination couch. After suggesting that the test may or may not cause or exacerbate LBP, the examiner applies a force on the patient's heel along the axis of the lower limb, with hip and knee in complete extension (Fig. 4). This action will not result in any movement of the spinal column and hence should not cause any LBP or leg pain. If the patient complains of onset or exacerbation of LBP, the test is considered a 'positive heel compression test'. A patient with an underlying organic pathology would not complain of onset or exacerbation of LBP.

Fig. 3 Demonstration of resistive forward bend test (*rFBT*)

Statistical methods

Patients' demographic data and baseline clinical data were analyzed descriptively. The comparison of clinical assessments and findings in the MRI scans between the SGM and non-SGM groups was performed by using either a Chi-square test or Fisher's exact test, where applicable. Analyses were carried out using Statistical Package for the Social Sciences (SPSS) version 18.0.

Results

A total of 200 patients were studied, of which the majority were males ($n = 145$). Mean age of the population was

Fig. 4 Demonstration of heel compression test (HCT)

41.91 years (range 21–60). Mean age and standard deviation in the SGM group was 41.06 (± 11.705) and in the non-SGM group it was 42.76 (± 13.689). In the SGM group there was slight male preponderance (males = 79 %, females = 21 %) as compared to the non-SGM group (males = 66 %, females = 34 %) ($p = 0.04$). Results of the *r*SLRT, *r*FBT, HCT, ST and the five categories of the Waddell's signs showed statistically significant differences between the SGM and non-SGM groups ($p < 0.0005$ for each test) (Table 1).

The most common finding in the MRI scans of the patients was degenerative disc disease at L4–L5, L5–S1 or both levels (27.5 % of all patients). A statistically significant number of abnormal MRI scans were observed in the non-SGM group compared to the SGM group ($p < 0.0001$) (Table 2). There was no statistically significant difference in the MRI scan findings between the patients who had positive or negative *r*SLRT within the SGM group ($p = 0.6440$) (Table 2).

Positive *r*SLRT was observed in 74 % of SGM group patients. In these patients, downward resistance was first felt at a mean of 37.5° (± 20.6). However, in non-SGM group patients, positive *r*SLRT was observed in only 6 % and downward resistance was first felt in these patients at a mean of 69.5° (± 16.2). In patients with positive *r*SLRT, resistance felt at an angle $\leq 45^\circ$ was highly predictive of SGM ($p < 0.0001$). In the SGM group, the ST showed a mean of 2.73 cm (± 1.34) but in the non-SGM group the mean was 5.18 cm (± 1.40). In patients with positive *r*FBT, resistance felt at a length ≤ 4 cm during the ST was highly predictive of SGM ($p < 0.0001$). Out of 74 patients with a

Table 1 Comparative analysis of *r*SLRT, *r*FBT, HCT, Waddell's signs and Schober's test between the SGM and non-SGM groups

Test and results		SGM group	Non-SGM group	Pearson Chi-square value
<i>r</i> SLRT	Positive	74	6	96.333 ($p < 0.0005$)
	Negative	26	94	
<i>r</i> FBT	Positive	82	39	38.686 ($p < 0.0005$)
	Negative	18	61	
HCT	Positive	87	21	87.681 ($p < 0.0005$)
	Negative	13	79	
Tenderness	Positive	83	17	87.120 ($p < 0.0005$)
	Negative	17	83	
Simulation	Positive	52	6	51.384 ($p < 0.0005$)
	Negative	48	94	
Distraction 90°	Positive	92	67	19.175 ($p < 0.0005$)
	Negative	8	33	
Regional	Positive	53	10	42.846 ($p < 0.0005$)
	Negative	47	90	
Overreaction	Positive	82	9	107.450 ($p < 0.0005$)
	Negative	18	91	
Schober's test < 5 cm	Positive	88	43	44.806 ($p < 0.0005$)
	Negative	12	57	

Table 2 Comparative analysis of MRI findings between the SGM and non-SGM groups

SGM/Non-SGM		Normal MRI	Abnormal MRI	<i>p</i> value
SGM	Positive <i>r</i> SLRT	(45) 60.8 %	(29) 39.2 %	<i>p</i> = 0.6440
	Negative <i>r</i> SLRT	(14) 53.9 %	(12) 46.1 %	
	Total	(59) 59 %	(41) 41 %	
Non-SGM	Total	(11) 11 %	(89) 89 %	<i>p</i> < 0.0001

Table 3 Comparative analysis of Waddell's signs, *r*FBT, HCT and Schober's test with *r*SLRT in patients in the SGM group

Test and results		Negative <i>r</i> SLRT	Positive <i>r</i> SLRT	Pearson Chi-square value
Tenderness	Negative	10 (58.8 %)	7 (41.2 %)	11.469 (<i>p</i> = 0.001)
	Positive	16 (19.3 %)	67 (80.7 %)	
Simulation	Negative	19 (39.6 %)	29 (60.4 %)	8.852 (<i>p</i> = 0.003)
	Positive	7 (13.5 %)	45 (86.5 %)	
Distraction (90°)	Negative	4 (50 %)	4 (50 %)	2.603 (<i>p</i> = 0.107)
	Positive	22 (23.9 %)	70 (76.1 %)	
Regional	Negative	16 (34 %)	31 (66 %)	2.981 (<i>p</i> = 0.084)
	Positive	10 (18.9 %)	43 (81.1 %)	
Overreaction	Negative	10 (55.6 %)	8 (44.4 %)	9.966 (<i>p</i> = 0.002)
	Positive	16 (19.5 %)	66 (80.5 %)	
<i>r</i> FBT	Negative	8 (44.4 %)	10 (55.6 %)	3.881 (<i>p</i> = 0.049)
	Positive	18 (22.0 %)	64 (78.0 %)	
HCT	Negative	5 (38.5 %)	8 (61.5 %)	1.206 (<i>p</i> = 0.272)
	Positive	21 (24.1 %)	66 (75.9 %)	
Schober's test (≤4 cm)	Negative	9 (56.3 %)	7 (43.8 %)	9.059 (<i>p</i> = 0.003)
	Positive	17 (20.2 %)	74 (74.0 %)	

positive *r*SLRT in the SGM group, 70 patients (94.6 %) had ≥3 positive Waddell's signs. In the same SGM group, patients with a negative *r*SLRT (*n* = 26) only 15 patients (57.7 %) had ≥3 positive Waddell's signs; this was statistically significant (*p* < 0.0001).

Table 3 shows the correlation of *r*FBT, HCT, Waddell's signs and Schober's test with *r*SLRT results in patients in the SGM group. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the studied variables in predicting SGM are mentioned in Table 4. For individual tests, *r*SLRT and simulation showed the highest specificity (0.94) while distraction showed the highest sensitivity (0.92) followed by ST (0.88) and HCT (0.87). If any two tests out of *r*SLRT, *r*FBT and HCT were positive, then the sensitivity was 0.91 and NPV was 0.898. The highest specificity (0.97) and PPV (0.951) were seen when all three tests (*r*SLRT, *r*FBT and HCT) were positive.

Discussion

The concept of 'secondary gain motives' (SGM) in patients seeking medical treatment is not new and has been described in detail since the early twentieth century [22]. As

patients' self-reporting forms a significant portion of clinical assessment, clinicians have always been particularly vulnerable to patients who feign, magnify or minimize problems due to ulterior motives. In a bid to aid the clinician in this aspect, Waddell in 1979 [11] created physical tests to identify non-organic causes of LBP and various authors have shown his tests to be reliable [10, 13, 23]. New 'non-organic tests' have been developed since [14, 16], but these have not been assessed in terms of sensitivity and specificity. Hence, such tests would be less valuable in clinical practice in exploring non-organic causes for LBP. Despite the reliability of Waddell's signs, we have found them to be more useful for research purposes, with debatable practical functionality in a real clinic setting.

Our present study, which aims to describe and evaluate three new tests for possible non-organic causes of LBP, was done with intimate knowledge of the various pressures and heavy burdens that clinicians face in the modern medico-legal climate. Making the correct clinical decision in medico-legal cases and in treating patients with SGM often involves a fine balance of clinical acumen, empathy towards the patient and dire need for equality to all parties involved.

The three tests described in this study—*r*FBT, *r*SLRT and HCT (NK triad)—stand out from other previously

Table 4 Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of *r*SLRT, *r*FBT, HCT, Waddell's signs and Schober's test in predicting secondary gain motives

Test and results	Sensitivity	Specificity	PPV	NPV
<i>r</i> SLRT	0.74	0.94	0.925	0.783
<i>r</i> FBT	0.82	0.61	0.678	0.772
HCT	0.87	0.79	0.806	0.859
Tenderness	0.83	0.83	0.83	0.83
Simulation	0.52	0.94	0.897	0.662
Distraction 90°	0.92	0.33	0.579	0.805
Regional	0.53	0.9	0.841	0.657
Overreaction	0.82	0.91	0.901	0.835
Schober's test <5 cm	0.88	0.57	0.672	0.826
<i>r</i> SLRT/ <i>r</i> FBT/HCT (at least two positive)	0.91	0.79	0.812	0.898
<i>r</i> SLRT/ <i>r</i> FBT/HCT (all three positive)	0.57	0.97	0.951	0.693

described tests in terms of *convenience* and *ease of performance*. This is illustrated in two ways. Firstly, the nature of the tests themselves—FBT and SLRT are amongst the most frequently used ‘physical impairment tests’ [24] and hence will be familiar to many clinicians who already use them in their practice regularly. Secondly, the smooth transitions in which the tests can be performed—we recommend starting with *r*FBT (done standing up), followed by *r*SLRT and then HCT (patient supine). It can be seen that the order described above minimizes unnecessary patient movement and flows seamlessly from one test to another. We hope that these tests and the order described above will aid the time-pressed clinician in making difficult medico-legal decisions in a busy clinical setting.

Our results show that *r*FBT, *r*SLRT and HCT are strong individual and combined predictors of the presence of SGM in patients (Table 4). In addition, positive *r*SLRT in SGM group patients was found to be strongly correlating with 3 or more positive Waddell's signs. The single best predictor of the SGM status was overreaction followed by *r*SLRT and HCT, respectively. However, we feel that overreaction (e.g., facial expressions, disproportionate verbalizations) is highly subjective and can vary greatly between observers but the three new tests described are more objective tests, which will show greater reproducibility between observers compared to overreaction. In addition, we have provided quantifiable values for *r*SLRT ($\leq 45^\circ$) and *r*FBT (≤ 4 cm) to further enhance the objectivity of the tests to predict SGM.

Our results support the use of the three new tests—*r*FBT, *r*SLRT and HCT (NK triad)—in a clinical setting to aid clinicians in identifying the presence of SGM in patients. However, we would caution against over-interpretation of the results of this study. The resistance to forward bending or straight leg raising may arise from fear of avoidance of pain or further injury [25]. This is pertinent in patients with chronic LBP—persistent pain may have led to the development of specific ‘fear-mediated responses’, i.e., avoidance of

certain movements or activities [25] which could affect their physical examination findings. The ‘SGM’ status does not exclude the presence of a genuine medical condition causing LBP. Despite the higher percentage (89 %) of abnormal MRIs in the non-SGM group, 41 % of patients in the SGM group still had abnormal MRIs.

We would like to alert the reader that the assessment of behavioral signs is not a complete psychological assessment and that the signs may be used to decide type of treatment and not used as a tool to offer or not to offer treatment [25]. All patients in our study, regardless of whether they produced positive test findings, were offered appropriate investigational modalities and treatment options for their conditions. SGM group patients with positive findings were not simply dismissed as malingerers. Studies involving psychological and psychometric testing would be useful in assessing the effectiveness of these tests (NK triad) in predicting psychological components to LBP, particularly when SGM may be involved. The tests, therefore, should only serve to alert clinicians to possible SGM in their patients, so as to act with due caution.

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Conflict of interest None.

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