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Risk factors associated with piriformis syndrome: A systematic review

Ida Kartini Othman[1, 2], Norazlin Mohamad[1], Sabrilhakim Sidek[3], Raj Naresh Bhaskar[4] and Chua Siew Kuan[1*]

[1]*Centre of Physiotherapy, Faculty of Health Sciences, Universiti Teknologi MARA Selangor Branch, Puncak Alam Campus, Selangor 42300, Malaysia*
[2]*Physiotherapy Unit, Hospital Sultanah Nur Zahirah, Terengganu 20400, Malaysia*
[3]*Department of Radiology, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Jalan Hospital, Selangor 47000, Malaysia*
[4]*School of Rehabilitation Sciences, Faculty of Health Sciences, Universiti Sultan Zainal Abidin, Terengganu 21300, Malaysia*
[*]*Corresponding author: chuasiewkuah@uitm.edu.my*

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ABSTRACT

Information regarding risk factors of piriformis syndrome (PS) among low back pain (LBP) is unclear. This manuscript aimed to determine the risk factors for PS. Searches were conducted in PubMed, Scopus and Google Scholar, as well as English language literatures, published from inception to July 2019. Secondary research, discogenic and spine related sciatica and case study were excluded. Two independent authors assessed the methodological quality used by the National Institutes of Health for observational cohort and cross-sectional studies, and appraisal tool of case series. A total of 28 studies met eligibility criteria, included 14 longitudinal cohort studies, 13 cross sectional studies, and 1 case series. High-quality studies (*n*=10) determined that the risk factor for PS are gender, increase of body mass index (BMI), and occupational related injury to the piriformis (e.g., prolonged sitting, driving, and hazardous manual handling). Moderate-quality studies (*n*=14) indicated age and previous history of LBP, whereas poor-quality studies (*n*=4) determined piriformis abnormality, psychological stress, and unhealthy lifestyle. Gender and strenuous activities were notable risk of PS. Early prevention of LBP may consider the modifiable factors, included increased BMI, occupational-related injury, overused of piriformis muscle, and experienced LBP.

Keywords: low back pain; piriformis syndrome; risk factor; sciatica

1. INTRODUCTION

Piriformis syndrome (PS) is defined as an entrapment neuropathy involving compression or irritation of the sciatic nerve by the piriformis muscle (Shah et al., 2014). Clinical symptoms of PS present as low back pain (LBP) and hip pathologies (Jankovic et al., 2013; Miller et al., 2012) with sciatica (Singh et al., 2013), namely, pain and tenderness at gluteal region and the posterior thigh with or without radiating to leg. Consequences of PS included significant long-term work disability, frequent seeking of health services, long medical leave, and chronic depression (Abásolo et al., 2012; Korovessis et al., 2012).

The incidence of PS ranges between 0.3% to 36% among LBP sufferers (Cass, 2015; Jankovic et al., 2013;

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Papadopoulos and Khan, 2004). In Asia, 5% of the population were estimated to have PS, similar to those in the USA and other places in Europe, Africa, and Australia, as reported in a survey from 1991 to 1994 (Fishman et al., 2002). In a study amongst 2910 Indian patients (aged range = 19-75 years) with LBP, 6.25% were confirmed to have clinically diagnosed PS (Singh et al., 2013). In Malaysia, a study among 93 ambulance drivers with chronic LBP, 17.2% had PS measured by modified flexion, adduction and internal rotation (FAIR) test (Chen and Nizar, 2013). Meanwhile, Mondal et al. (2017) found that 79.5% of healthy sedentary individuals (*N*=200) are diagnosed with PS attributed to PM tightness. The discrimination is mainly due to the heterogeneity of diagnostic management, sample size, and target population in the studies.

From an anatomical view, PS is attributed to excessive contraction of the PM due to its close proximity to the sciatic nerve. Primary PS is due to the abnormality of piriformis, for example, a split piriformis and/or sciatic nerve, or anomalous path of sciatic nerve (Shah et al., 2019). Conversely, secondary PS may be attributed to the ischemic mass effect, microtrauma, and local ischemia at the piriformis muscle (Jankovic et al., 2013; Papadopoulos and Khan, 2004; Shah et al., 2019). Secondary PS is more common than primary PS, which is estimated 90% to be due to piriformis muscle hypertrophy (Dey et al., 2013). Leino-Arjas et al. (2008) found that increased serum lipid level, triglycerides, and low-density lipoproteins cholesterol are associated with increased twofold risk of sciatica in hyperlipidaemia men. In clinical practice, PS is diagnosed in quartet symptoms, i.e., pain in the buttock or gluteal area, tenderness on palpation of piriformis, physical test by increased piriformis muscle tension when subjected to active piriformis test, Beatty test, FAIR test, heel contra lateral knee (HCLK) test, Freiberg test, Pace test, and Seated Piriformis test (Hopayian and Danielyan, 2018). PS includes irritation to the sciatic nerve, imitating sciatica-like symptoms, but yields a negative spine imaging analysis (Shah et al., 2019). Hence, the pain generated by non-spinal or non-lumbar herniation should be considered to distinguish it from differential diagnoses of sciatica, gluteal, buttock, or hip pathologies.

Extensive research has focused on diagnosis, etiology, and management of PS (Boyajian-O'Neill et al., 2008; Jankovic et al., 2013; Papadopoulos and Khan, 2004), prevalence, sociodemographic (Mondal et al., 2017; Singh et al., 2013; Warner et al., 2018) and clinical features (Hopayian and Danielyan, 2018). With regard to the risk factors of PS, a brief discussion is provided solely on the diagnostic criteria of sciatica (Euro et al., 2017; Haugen et al., 2012), rendering unclear the PS source generation. The uncertain risk factors in patient with PS are mainly due to homogeneity of clinical symptoms that may imitate other disorders, such as discogenic sciatica, deep gluteal syndrome, and pelvic outlet syndrome (Jankovic et al., 2013). However, owing to the various factors contributing to LBP with PS, a standardized evidence practice of LBP may be inefficient for prevention and management strategies. Nonetheless, the risk factors of PS are crucial to identify to prevent LBP through early PS prevention. Thus, this review aimed to examine existing evidence of risk factors associated with PS.

2. MATERIALS AND METHODS

2.1 Searching

Comprehensive literature searched in Google Scholar, PubMed, and Scopus utilized the predefined keywords in articles. No restrictions on publication dates with articles published from inception until July 2019 were imposed (Figure 1). Studies published in English language from inception to July 2019, keywords used were: "piriformis syndrome*", or "gluteal* pain*", or "sciatica", or "buttock* pain*", or "posterior hip pain*", and ("risk* factors*" or "cause"). Hand searching was additional attained via reviewing the references of the primary studies and the full text of studies on the associations of risk factor for PS or non-disc sciatica.

2.2 Study selection and data extraction

The retrieved studies were selected by screening the following: i) title, ii) abstracts, and iii) full text. Agreement between a first independent reviewer and second reviewer was obtained through discussion or agreement with a third reviewer, if required. Inclusion criteria were: studies that discussed either primary or secondary PS, evaluated the risk factor of PS or relevant condition, assessed the direct cause of PS or relevant condition, and discussed the prevalence of PS or relevant condition based on demographical and anthropometry parameters. Exclusion criteria were studies involving narrative review and secondary data such as systematic review with or without meta-analysis.

2.3 Assessment of study quality

The methodological quality was assessed using the National Institutes of Health quality assessment tool for observational cohort and cross-sectional (National Heart Lung and Blood Institute, 2017). This tool consists of 14 questionnaires concerning study objectives, patient eligibility, power analysis, timing between exposure and outcome, definition of exposure and outcome measures, and presence of bias. Studies quality was rated as good, fair or poor (Maass et al., 2015). The Joanna Brigg's critical appraisal tool for case-series was employed for the case series (Munn et al., 2019) (Table 1).

3. RESULTS

Table 2 outlines the study design and characteristic of the eligible studies. Results showed that the factors influencing PS can be categorized into non-modifiable ones, such as gender, age, height and genetic relation. Modifiable factors included increased BMI, employment status, trauma, lifestyle, and health problems/ psychology (Table 3).

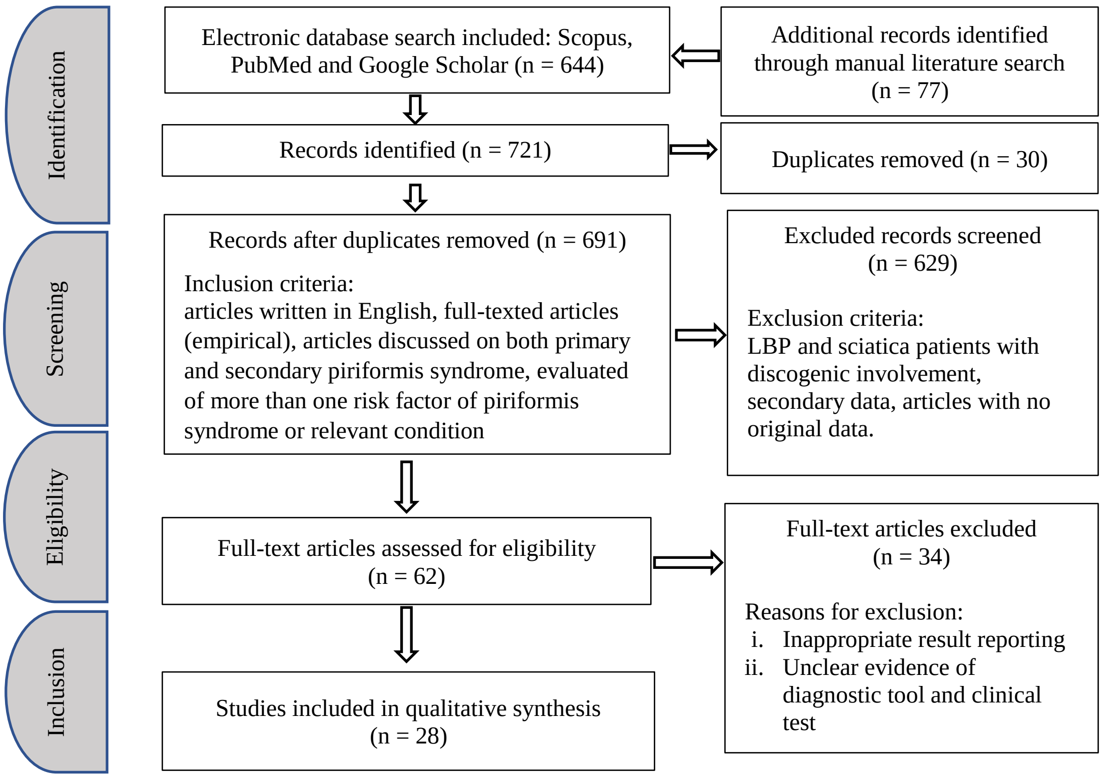

Figure 1 Study selections flow chart

Table 1 Quality assessment and risk of bias (ROB) summary

Study design	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	ROB	Quality rating
[*]Bovenzi et al. (2015)[a]	yes	yes	yes	yes	no	yes	yes	yes	yes	no	yes	no	yes	no	low	good
[*]Euro et al. (2019)[a]	yes	yes	yes	yes	no	yes	yes	yes	no	no	yes	yes	no	yes	low	good
[*]Euro et al. (2017)[a]	yes	yes	yes	yes	no	yes	yes	yes	yes	no	yes	yes	yes	yes	low	good
[*]Kääriä et al. (2011)[a]	yes	yes	yes	no	no	yes	yes	yes	no	yes	yes	yes	yes	yes	low	good
[*]Leclerc et al. (2003)[a]	yes	yes	yes	yes	no	yes	yes	yes	no	no	no	yes	yes	no	moderate	fair
[*]Manninen et al. (1995)[a]	yes	yes	no	yes	no	yes	yes	no	no	yes	no	no	yes	no	moderate	fair
[*]Matsudaira et al. (2013)[a]	yes	yes	yes	yes	no	yes	yes	yes	no	no	no	yes	yes	yes	low	good
[*]Miranda et al. (2002)[a]	yes	yes	yes	yes	no	no	yes	yes	yes	no	no	no	yes	yes	moderate	fair
[*]Pietri-Taleb et al. (1995)[a]	yes	yes	yes	yes	no	no	yes	yes	no	yes	no	no	yes	no	moderate	fair
[*]Riihimaki et al. (1989)[a]	yes	yes	yes	yes	no	no	yes	yes	no	yes	no	no	yes	no	moderate	fair
[*]Riihimaki et al. (1994)[a]	yes	yes	yes	yes	no	no	yes	no	no	yes	no	no	yes	no	moderate	fair
[*]Rivinoja et al. (2011)[a]	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	yes	no	yes	low	good
[*]Shiri et al. (2017)[a]	yes	yes	yes	no	no	no	no	yes	no	no	no	no	yes	yes	moderate	fair
[*]Tubach et al. (2004)[a]	yes	yes	yes	no	no	yes	yes	no	no	yes	no	no	yes	yes	moderate	fair
[*]Benson and Schutzer (1999)[b]	yes	no	no	yes	yes	yes	yes	yes	no	no	-	-	-	-	low	good
[*]Chen and Nizar (2013)[b]	yes	yes	no	yes	no	yes	yes	no	yes	no	yes	no	yes	no	moderate	fair
[*]Heliovaara et al. (1991)[b]	yes	yes	yes	yes	no	no	no	yes	no	no	yes	no	yes	yes	moderate	fair
[*]Kaila-Kangas et al. (2009)[b]	yes	yes	yes	yes	no	yes	no	yes	yes	no	yes	yes	yes	no	low	good
[*]Karjalainen et al. (2013)[b]	yes	yes	no	yes	no	yes	yes	yes	no	N/A	no	yes	N/A	yes	moderate	fair
[*]Kherad et al. (2017)[b]	yes	yes	no	yes	no	yes	yes	no	no	no	yes	no	N/A	yes	high	poor
[*]Korovessis et al. (2012)[b]	yes	yes	yes	no	no	no	N/A	no	no	no	no	yes	N/A	no	high	poor
[*]Mondal et al. (2017)[b]	yes	yes	no	yes	no	no	no	no	no	no	no	no	no	no	low	poor
[*]Nurminen (1997)[b]	yes	yes	no	yes	no	yes	N/A	no	no	no	no	no	N/A	yes	high	poor
[*]Shah et al. (2019)[b]	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	no	yes	no	low	good
[*]Siahaan et al. (2019)[b]	yes	no	yes	yes	no	yes	yes	no	no	N/A	yes	no	yes	no	moderate	fair
[*]Singh et al. (2013)[b]	yes	yes	no	yes	no	yes	no	no	yes	no	yes	no	no	no	moderate	fair
[*]Warner et al. (2018)[b]	yes	yes	yes	yes	no	no	no	N/A	N/A	N/A	yes	no	yes	no	moderate	fair
[**]Siddiq et al. (2017)[c]	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	-	-	-	-	low	good

Note: [*]NIH quality assessment tool for observational cohort and cross-sectional studies. Q1: research question, Q2: study population, Q3: participation rate, Q4: inclusion criteria, Q5: sample size, Q6: exposure prior to outcome, Q7: sufficient timeframe, Q8: different level of exposure, Q9: exposure measure, Q10: multiple exposure measurement, Q11: outcome measure, Q12: blinding of outcome assessor, Q13: loss of follow, Q14: potential confounding

[**]Joanna Brigg's critical appraisal tool for case-series. Q1: inclusion criteria, Q2: reliability measurement of participants, Q3: valid methods for identification, Q4: consecutive inclusion, Q5: complete inclusion of participants, Q6: demographics, Q7: clinical information, Q8: outcomes or follow up results, Q9: presenting site(s)/clinic(s) demographic, Q10: statistical analysis

[a]longitudinal study

[b]cross-sectional study

[c]case series

Table 2 Participants characteristics of longitudinal studies, cross-sectional studies and case series

Authors	Sample size	Study population	Diagnosis	Assessment/ Clinical test
Bovenzi et al. (2015)[a]	537	professional drivers	Sciatica	Self-reported sciatica questionnaire
Euro et al. (2017)[a]	702	general population	Sciatica	ICD-8
Euro et al. (2019)[a]	3891	general population	Sciatica	ICD-8 & ICD-9
Kääriä et al. (2011)[a]	5261	professional & non-professional, manual & non-manual workers	sciatica	Self-reported sciatica questionnaire
Leclerc et al. (2003)[a]	841	electricity and gas industry workers	Sciatica, LBP	Self-reported sciatica, Nordic questionnaire
Manninen et al. (1995)[a]	70	farmers	Sciatica	Self-reported sciatica questionnaire
Matsudaira et al. (2013)[a]	765	office workers, nurses, sales/marketing personnel, manufacturing engineers	Sciatica	Clinical test by orthopedic, sciatica questionnaire
Miranda et al. (2002)[a]	2,077	Employees (large forest industry company)	LBP radiating below the knee	Self-reported sciatica questionnaire
Pietri-Taleb et al. (1995)[a]	1,149	blue collar workers and white-collar worker	Sciatica/ LBP radiating to leg	Self-reported sciatica questionnaire
Riihimaki et al. (1989)[a]	163	concrete reinforcement worker & house painters	Sciatica, LBP radiating to the leg	Self-reported sciatica questionnaire
Riihimaki et al. (1994)[a]	1,149	Machine operators, carpenters, and office workers	Sciatica, LBP radiating to the leg	Self-reported sciatica questionnaire
Rivinoja et al. (2011)[a]	453	adolescents	Sciatica	ICD-9 & ICD-10
Shiri et al. (2017)[a]	34,589	general population	Sciatica	ICD-8, ICD-9 & ICD-10
Tubach et al. (2004)[a]	622	electricity and gas industry workers	Sciatica	Self-reported sciatica, Nordic questionnaire
Benson and Schutzer (1999)[b]	15	computer programmers, marketing manager, officer, psychiatrist, homemaker, lawyer, secretary, airport inspector, supervisor, waitresses, independent sales representative	PS	ICD-9 Palpation: gluteal tenderness Clinical test: SLR Radiography: X-ray, MRI, CT scan, Ultrasonography Electromyography LA injection
Chen and Nizar (2013)[b]	93	general population	PS	Modified FAIR test LA injection

Table 2 Participants characteristics of longitudinal studies, cross-sectional studies and case series (continued)

Authors	Sample size	Study population	Diagnosis	Assessment/ Clinical test
Heliovaara et al. (1991)[b]	5673	general population	sciatica	Clinical test: Lasègue sign, SLR
Kaila-Kangas et al. (2009)[b]	4811	general population	sciatica	Clinical test: SLR
Karjalainen et al. (2013)[b]	1987	general population	sciatica	Self-reported sciatica questionnaire
Kherad et al. (2017)[b]	3014	elderly	sciatica	Self-reported sciatica questionnaire
Korovessis et al. (2012)[b]	674	general population	sciatica	Self-reported sciatica questionnaire
Mondal et al. (2017)[b]	200	students, staff, caregiver	PS	Clinical test HCLK, Seated piriformis stretch
Nurminen, (1997)[b]	217	concrete reinforcement workers	sciatica	Interview on symptoms
Shah et al. (2019)[b]	143	not reported	PS	Radiography: X-ray, MRI LA injection
Siahaan et al. (2019)[b]	65	not reported	PS	Clinical test: FAIR, Freiberg, Beatty, Pace and Hip Abduction LA injection
Singh et al. (2013)[b]	182	general population	sciatica & PS	Palpation PM tenderness Clinical test: FAIR, Freiberg, Pace, Beatty Radiography: X-ray, MRI, CT scan, Ultrasonography LA injection
Warner et al. (2018)[b]	113	students	PS	Clinical test: Lasègue sign, FAIR
Siddiq et al. (2017)[c]	31	housewife businessman farmer day laborer driver	PS	Clinical test: FAIR, Pace Palpation: gluteal tenderness Ultrasonography: Piriformis thickness LA injection

Note: ICD= international classification of disease; LBP= low back pain; BMI= body mass index; PS= piriformis syndrome; SLR= straight leg raise; FAIR= flexion, adduction, internal rotation; HCLK= heel contra lateral knee; MRI= magnetic resonance imaging; CT= computerized tomography; LA= local anaesthesia

[a]longitudinal study

[b]cross-sectional study

[c]case series

Table 3a Nonmodifiable factors associated with piriformis syndrome

Authors (year)/ ROB	**Non-modifiable**		
	Gender	**Age**	**Height /Others**
Euro et al. (2017)/ low	Female	-	-
Kääriä et al. (2011)/ low	Female/Male	-	-
Matsudaira et al. (2013)/ low	-	OR 1.59	-
Rivinoja et al. (2011)/ low	Yes	-	-
Benson and Schutzer (1999)/ low	-	-	-
Kaila-Kangas et al. (2009)/ low	Male (5.3%) > Female (4.2%)	Yes	-
Shah et al. (2019)/ low	Female (71%)	Young female	Tumor (male) (5%)
Siddiq et al. (2017)/ low	Yes	-	-
Heliovaara et al. (1991)/ moderate	-	-	Height (OR 1.2)
Karjalainen et al. (2013)/ moderate	Female OR 1.48 - 3.87	18 years (OR 3.9)	- abnormal Piriformis
Siahaan, et al. (2019)/ moderate	Female	Yes	-
Singh et al. (2013)/ moderate	Yes	40- 50 years (31-33%)	-
Warner et al. (2018)/ moderate	-	-	-
Leclerc et al. (2003)/ moderate	-	-	≥ 180cm (OR 3)
Manninen et al. (1995)/ moderate	-	-	-
Miranda et al. (2002)/ moderate	-	OR 2.4 - 3.5	-
Riihimaki et al. (1989)/ moderate	-	-	Yes
Tubach et al. (2004)/ moderate	Female (OR 1.41)	-	-
Korovessis et al. (2012)/ high	Female (OR 0.6)	65 years ≥ (OR 2.9)	-
Mondal et al. (2017)/ high	-	Yes	-
Nurminen (1997)/ high	-	Yes	-

Note: ROB = risk of bias, OR = odds ratio, HR = hazards ratio, RR = risk ratio

Table 3b Modifiable risk factors associated with piriformis syndrome

Authors (year)/ ROB	Modifiable factors				
	Body mass index	Employment status	Occupational related trauma	Lifestyle	Health problems/ psychology
Bovenzi et al. (2015)/ low	-	-	Previous lumbar trauma and physical workload (OR 1.33-1.83)	-	Psychosocial environment (OR 0.44-1.87)
Euro et al. (2017)/ low	Overweight (HR 1.41)	-	Physically strenuous work (HR 0.38-0.74) Occupation-prolong standing (nurse, sales, industrial worker) (HR 1.46-1.81)	(leisure activity (HR 0.74)	-
Euro et al. (2019)/ low	Overweight (HR 1.94) Obese (HR 3.50)	-	Whole-body vibration (HR 1.61) Lifting and carrying heavy loads (HR 1.57) Sedentary + carry light weight (HR 1.57)	-	-
Kääriä et al. (2011)/ low	Overweight (OR 1.4) Obese (OR 1.6)	-Manual worker (OR 1.2-1.5), -Manual (OR 2.3), semi-professional (OR 1.5)	Prolong sitting Prolong standing	Smoking (OR 1.5) Physical inactivity (OR 1.6: 1.3-2.3)	Previous neck pain and LBP (OR 1.5) Acute LBP (OR 1.5), chronic LBP(OR 2.1)
Matsudaira et al. (2013)/ low	Obesity (OR 1.77)	-	-	-	-
Rivinoja et al. (2011)/ low	Female: Overweight/ obesity (HR 7.1)	-	Driving at least 2 hours/day, Carry heavy loads	Smoking (HR 3.2) (male)	Previous sciatic High level psychosomatic problems
Shiri et al. (2017)/ moderate	Obese (36%),	-	-	Current Smoking (33%)	-
Leclerc et al. (2003)/ moderate	-	-	Prolong sitting Driving ≥ 2 hours daily (OR 2) Driving ≥ 2 hours several days a week (OR 2.7)	-	Poor self-rated health (OR 2.8)
Tubach et al. (2004)/ moderate	-	-	Carrying loads >10 kg daily (1.49) Driving ≥ 2 hours daily (OR 1.01) Driving ⩾ 2 hours > once a week (OR 1.79)	-	-
Manninen et al. (1995)/ moderate	-	Yes	-	Ex-smoker (OR 13.1) Current (OR 9.6)	Mental stress No production factor

Table 3b Modifiable risk factors associated with piriformis syndrome (continued)

Authors (year)/ ROB	**Modifiable factors**				
	Body mass index	**Employment status**	**Occupational related trauma**	**Lifestyle**	**Health problems/ psychology**
Miranda et al. (2002)/ moderate	-	-	Job related trunk forward bending >2 hours daily (OR 2.1), Hand above shoulder level >1 hour daily (OR 1.9) Twisting trunk (OR 1.7-2.6) Kneeling/squatting >1 hour daily (OR 2.6)	Smoking for long duration (OR 1.6-2.5)	Psychological stress (OR 1.5-2.6)
Riihimaki et al. (1989)/ moderate	-	-	Heavy physical work Concrete worker House painting (RR 1.4)	-	History of stress (RR 1.4)
Tubach et al. (2004)/ moderate	-	-	History of sciatica)1 years) Carrying heavy loads/ Driving ≥ 2 hours (OR 2-2.7)	-	Mental stress (OR 2.87)
Riihimaki et al. (1994)/ moderate	-	-	History of LBP/lumbago (RR 2.7-4.5)	Smoking, physical exercises (RR 1.3)	-
Pietri-Taleb et al. (1995)/ moderate	-	-	-	-	Hysteria (OR 1.4)
Benson and Schutzer (1999)/ low	-	-	Blunt trauma to the buttock	-	-
Kaila-Kangas et al. (2009)/ low	Yes	Yes	Long history of handling heavy objects (OR 3.3) (nonworking women)	-	-
Shah et al. (2019)/ low	-	-	Chronic inflammatory changes (25%) post steroid injection	-	-
Siddiq et al. (2017)/ low	Yes	Yes	Blunt trauma over the buttock Prolong sitting/standing, cross leg sitting Use of rear pocket's wallet Intramuscular gluteal injection Prolonged squatting Repetitive stair up-down Repetitive use of lower limbs with swing machine Preceding fall, fibromyalgia, lumbar spinal stenosis	-	-

Table 3b Modifiable risk factors associated with piriformis syndrome (continued)

Authors (year)/ ROB	Modifiable factors				
	Body mass index	Employment status	Occupational related trauma	Lifestyle	Health problems/ psychology
Heliovaara et al. (1991)/ moderate	-	-	Physical stress(men), history of LBP (OR 2.5) kneeling/bending (OR 1.6-2.5)	-	psychological stress (OR 1.1-2.4)
Karjalainen et al. (2013)/ moderate	-	-	Prolong sitting >8 hours (OR 4.2), 5-7 hours (OR 3.6)	-	History of LBP (OR 1.68-5.02)
Siahaan, et al. (2019)/ moderate	normal BMI	-	History of microtrauma, sitting on rigid surfaces (36.9%), walking or running long distances (18.5%), cross-legged sitting (10.8%)	-	-
Singh et al. (2013)/ moderate	-	-	Trauma/ vigorous massage (3.3%) Prolonged sitting (37.91%), overuse (47.25%),	-	-
Warner et al. (2018)/ moderate	-	-	Prolong sitting (75%), long standing (15%)	-	-
Kherad et al. (2017)/ high	-	-	-	Smoker (RR 1.10)	Morbidity (RR 1.23), Poor self-health perceived (RR 1.49)
Korovessis et al. (2012)/ high	-	Working female (OR 2.4)	-	Smoker (OR 2.1)	-
Mondal et al. (2017)/ high	-	-	Prolong sitting & standing	-	-
Nurminen (1997)/ high	-	-	Concrete reinforcement work	-	-

Note: ROB = risk of bias, LBP= low back pain, PM= piriformis muscle, OR = odds ratio, HR = hazards ratio, RR = risk ratio

3.1 Factors influence risk PS

Findings on the influence of gender in risk of PS were inconsistent. Seven studies showed that being female had greater risk (Chen and Nizar, 2013; Karjalainen et al., 2013; Korovessis et al., 2012; Shah et al., 2019; Siahaan et al., 2019; Siddiq et al., 2017; Singh et al., 2013). Five studies agreed employed men with strenous physical workload had higher incidence of sciatic pain than women (Bovenzi et al., 2015; Heliovaara et al., 1991; Kaila-Kangas et al., 2009; Korovessis et al., 2012). Increased age with majority age group between 30 to 50 years (Chen and Nizar, 2013; Kaila-Kangas et al., 2009; Korovessis et al., 2012; Matsudaira et al., 2013; Miranda et al., 2002; Mondal et al., 2017; Shah et al., 2019; Siahaan et al., 2019) and height (more than 180 cm) (Euro et al., 2017; Leclerc et al., 2003; Riihimaki et al., 1989; Tubach et al., 2004) were another non-modifiable risk factors for non-discogenic sciatica. Unusual pathophysiologies or abnormalities of piriformis muscle such as tumor, aberrant anatomy of piriformis muscle, undetermined piriformis atrophy, or sciatic nerve were also observed to be risk factors (Shah et al., 2019).

With regards to modifiable factors, a high incidence of PS among higher BMI and overweight/ obese subjects were reported in eight studies (Euro et al., 2017; Kääriä et al., 2011; Karjalainen et al., 2013; Kherad et al., 2017; Miranda et al., 2002; Pietri-Taleb et al., 1995; Rivinoja et al., 2011; Siddiq et al., 2017). Overweight (OR, 1.94) and obese (OR, 3.50) workers exposed to whole-body vibration had an increased risk of sciatica (Euro et al., 2019).

Occupation-related trauma like carry heavy loads (Euro et al., 2019; Tubach et al., 2004) and work tasks required twisting trunk and bending was weighted to increased risk of PS (Kaila-Kangas et al., 2009). Conversely, sedentary work included handling fairly heavy objects or physically light work predict sciatica (HR, 1.57). Previous spine injury at both neck and low back among workers with heavy workloads (Kääriä et al., 2011; Karjalainen et al., 2013; Nurminen, 1997; Riihimaki et al., 1989; Riihimaki et al., 1994). Moreover, manual workers (OR, 2.0) were considered to have higher risk compared with male managers and professionals groups (OR, 1.5; 95% CI, 1.1-2.1) (Kääriä et al., 2011).

Trauma directly at gluteal region comprised of post intramuscular gluteal injection (Benson and Schutzer, 1999; Siddiq et al., 2017). The majority of studies observed indirect trauma due to prolonged sitting on rigid surfaces ("wallet neuritis") and work-related to prolonged sitting (4-6 hours a day) (Euro et al., 2019; Kääriä et al., 2011; Kaila-Kangas et al., 2009; Karjalainen et al., 2013; Leclerc et al., 2003; Mondal et al., 2017; Siddiq et al., 2017; Singh et al., 2013; Tubach et al., 2004;Warner et al., 2018). Others included rear-wallet pressure (Siddiq et al., 2017; Warner et al., 2018), regular cross-legged sitting (Siahaan et al., 2019; Siddiq et al., 2017), driving (more than 2 hours) (Leclerc et al., 2003; Tubach et al., 2004), preceding fall (Siddiq et al., 2017), and lumbar spinal stenosis and fibromyalgia (Siddiq et al., 2017).

Unhealthy lifestyle particularly physical inactivity (Euro et al., 2017; Kääriä et al., 2011; Kherad et al., 2017; Manninen et al., 1995; Miranda et al., 2002; Riihimaki et al., 1994; Rivinoja et al., 2011; Shiri et al., 2017) and smoking (Korovessis et al., 2012) were recognized as risk for PS. A contradiction of being physically active like jogging was related to incidence of sciatic pain (Euro et al., 2017; Kääriä et al., 2011).

In psychosocial and psychological aspects, poor self-health perception (Euro et al., 2017; Kherad et al., 2017; Leclerc et al., 2003) and psychological stress were determined as risk for PS (Miranda et al., 2002; Pietri-Taleb et al., 1995). Psychological illness in participants who were married (OR, 2.3) compared with unmarried ones (Korovessis et al., 2012), self-employed compared with employees (OR, 2.4) (Korovessis et al., 2012), and hysteria among blue-collar workers (OR, 1.34) (Pietri-Taleb et al., 1995) had greater risk of sciatic pain. Mental stress was an independent risk factors for non-discogenic sciatica (Miranda et al., 2002).

4. DISCUSSION

This study was aimed to identify the consistent risk factors consistently associated with PS. The development of PS to be linked with multiple factors categorized into modifiable and non-modifiable. Overall, primary causes may not be associated with the same risk factors as secondary PS.

4.1 Non modifiable factor: gender, age, height and abnormal in piriformis muscles

Gender differences related to risk of PS were probably due to gender difference in anatomical structure and degenerative or aging changes. Anatomically, female had a wider angle ("Q angle") of quadriceps femoris muscle than male (Boyajian-O'Neill et al., 2008). This fact may be partly explained why female have higher incidence of PS than men (Karjalainen et al., 2013; Korovessis et al., 2012; Siahaan et al., 2019). However, inconsistent findings of risks for PS across studies were likely due to the nature of occupation dealing, particularly the more strenuous occupation of men than women (Bovenzi et al., 2015; Heliovaara et al., 1991; Kaila-Kangas et al., 2019; Korovessis et al., 2012; Leclerc et al., 2003). The fourth decade of life is the decade of highest productivity and peak of physical overload to the body among male workers. This strenuous overload may result in higher tendency of injury and trauma to the spine and lumbopelvic region among workers (Neumann, 2010). Male also have high tendency to have tight piriformis muscle because they work or sit on their open knees, where muscles around thigh especially piriformis muscle show consistent contraction of external hip rotator, leading to tight piriformis (Park and Bae, 2014).

Increased age is another risk factor of PS (Kaila-Kangas et al., 2009; Korovessis et al., 2012; Matsudaira et al., 2013; Miranda et al., 2002; Mondal et al., 2017; Shah et al., 2019; Siahaan et al., 2019), especially in large-population prospective cohort study (Kaila-Kangas et al., 2009; Miranda et al., 2002). The age range of 30 to 50 years was the highest risk group for PS, especially the fourth decade for non-discogenic sciatica. Aging related to progressively declined disc matrix composition resulted in deterioration of collagenous tissues stiffness and strength (Adams and Roughley, 2006). In the fifth decade and above, physiological changes may delay piriformis muscle healing following traumatic and chronic injuries (Andersson, 1999; Maher et al., 2017). The older a person, the slower his piriformis muscle healing, so microtrauma is more remarkable among older females following trauma or injury, rendering them to be high risk for PS.

Height more than 180 cm may increase the whole body muscle volume and muscle length (Leclerc et al., 2003; Riihimaki et al., 1989; Tubach et al., 2004). The interrelation between lower limb muscle volume, body mass, height, and height-body mass creation implied that higher mass demands greater muscle volume (Handsfield et al., 2014). Thus, taller individuals require more exertion in piriformis muscle mass and muscle volume in maintaining torque-balance and control of body, thereby providing stability at the lumbopelvic region.

Abnormal split piriformis muscle was regarded as a genetically related common cause of PS (Boyajian-O'Neill et al., 2008) owing to anatomical variations of piriformis muscle and sciatic nerve (Jawish et al., 2010; Kosukegawa et al, 2006). The association between genetic and risk factors affecting PS has not been firmly discussed in existing evidence. However, in a study among 294 cadavers with PS, Natsis et al. (2014) found that 6.4% were categorized in uncommon type genetically. Further research is necessarily to explore the extent of relationship among them.

4.2 Overweight and obesity

Being overweight/ obesity was associated with high incidence of PS in eight of the reviewed studies, although no direct association was observed between being overweight or obesity and PS. High BMI is estimated to be responsible for 5.5% of years lived with disability (Hurwitz et al., 2018; GBD 2015 Disease and Injury Incidence and Prevalence Collaborators, 2016) and increase the risk of radiating pain in adults with LBP (Frilander et al., 2015). In a case-series study by Siddiq et al. (2017), high BMI was found to be positively associated with piriformis thickness. Increased thickness of piriformis may lead to increased compression forces at the intervertebral disc at the fifth lumbar and first sacral (Singh et al. 2015) and to the compression of the sciatic nerve (Mondal et al., 2017) when lifting a moderate-load. Increased BMI may separate the piriformis muscle and nearby soft tissue (Chen and Nizar, 2013). Conversely, Shiri et al. (2007) proposed that increased BMI may increase systematic inflammatory response, resulting in sciatica (Bejia et al., 2004).

4.3 Unhealthy lifestyle

Physical inactivity created remarkable muscular imbalance over the spine and lower limb (Kääriä et al., 2011; Riihimaki et al., 1994). Sedentary lifestyle like sitting for long hours caused inactivated and weak gluteus (Flack et al., 2012). Moreover, weakness of hip abductors resulting in synergistic activation by the piriformis muscle to stabilize the body posture may cause hypertonicity and tightness of the piriformis muscle, thereby increasing local muscular tension and strain (Mondal et al., 2017). Smoking, already regarded as an unhealthy lifestyle, was identified as another factor. Smokers had 2.1 times higher sciatica intensity than non-smokers (OR, 2.1) (Korovessis et al., 2012). Smoking influenced sciatica by interfering with the healing process of intervertebral discs, leading to malnutrition (Korkiakoski et al., 2009) and increase of inflammatory reactions (Oda et al., 2004). Tobacco smoke is known as a cause of intervertebral disc degeneration (Wang et al., 2012).

4.4 Occupation related strenuous activities

Strong evidence was found for physical exposure related to sciatica or PS among workers in the construction, farm, electricity, and gas industries exposed to load lifting, awkward twisted-and-bending work postures (Miranda et al., 2002), exposure to whole body vibration (Euro et al., 2019). Siddiq et al. (2017) explained that during load lifting with repeated forward movements and lateral movement of the legs, exhibited a compensatory contraction of weak hip abduction and tight adduction were observed, leading to excessive strain to the piriformis muscle, subsequent piriformis muscle shortening. A hypertrophy of piriformis muscles caused by strain is a typical feature of PS, resulting from reduced muscle control, stability in the lumbopelvic, and hip complexity (Leung et al., 2015; Shah et al., 2019). Moreover, excessive physical load subjected to irritation and inflammation of neural and soft tissues was followed by sciatic pain (Cook et al., 2014).

With respect to strenuous physical activities such as jogging, a dual effect on the incidence of sciatica was found. Jogging is a healthy physical activity as it strengthens the core muscles of the back (Belavý et al., 2017) and increases the overall physical and mental health (Sculco et al., 2001), thus, jogging is preventive measures for developing PS or sciatica. Jogging may induce irritation of piriformis or sciatic nerve owing to repetitive compression load in the spine vertebral and hip in joggers with a history of sciatica (Stafford et al., 2007) compared with those lacking sciatica experience (Miranda et al., 2002).

As for cumulative, the trauma-related repetitive awful posture incidence of PS was 38% (n=182) in patients caused by prolonged sitting (Singh et al., 2013). Regular cross-leg sitting (Siahaan et al., 2019) caused piriformis muscle elongation (Snijders et al., 2006). A static position for a long time, such as 15-20 min, or prolonged sitting in a chair for more than 5 hours a day (Kaila-Kangas et al., 2009; Karjalainen et al., 2013; Mondal et al., 2017) can induce excessive pressure on the muscles at the bottom of the pelvic bone and deep gluteal musculatures, leading to hypertrophic piriformis muscle (Neumann, 2010). Tremendous compensatory movements were attributed to the flatten of the low back experience of and altered the load-sharing strategies at the lumbopelvic-hip complexity (Shum et al., 2007). The previous studies have shown that driving for more than 2 hours induced PS in professional drivers (Leclerc et al., 2003; Siddiq et al., 2017). Pain exacerbation by prolonged sitting (4-6 hours) was also found in patients with LBP (Gupta et al., 2015).

4.5 Trauma of gluteal

As for post-traumatic hip fracture or traumatic at the gluteus region, inflammation and muscle spasm can result in the compression of the sciatic nerve (Boyajian-O'Neill et al., 2008). An irritated sciatic nerve modulates inflammatory mediator secretion and elicits the inflammatory cascade, subsequently producing neuropathic pain (Eker et al., 2010; Zhang and An, 2007). Benson and Schutzer (1999) suggested that previous trauma at the buttock region may result in adhesions among the piriformis, sciatic nerve, and soft tissues at the roof of the greater sciatic notch. Moreover, long-term microtrauma can lead to the scarring of the piriformis muscle fibre (Knudsen et al., 2016), resulting in piriformis muscle hypertrophic and eventually PS (Siddiq et al., 2017).

4.6 Psychological factor

Psychological factor were not a single aspect that can influence risk PS, as observed in five studies. For instance, poor self-health perceive (Euro et al., 2017; Kherad et al., 2017; Leclerc et al., 2003) and psychological stress were determined as risk for PS (Miranda et al., 2002; Pietri-Taleb et al., 1995). Hysteria and incidence of sciatica among professional workers (Pietri-Taleb et al., 1995), as well as mental stress and being smoker, were independent risk factors for incidental sciatic pain (Miranda et al., 2002). Self-perceived health and psychological stress were not clearly discussed in previous studies among patients with PS; however, they were related to the increased risk of developing sciatica among employees and people with higher educational background.

5. CONCLUSION

Based on our analysis, female, higher BMI, middle age, previous gluteal injury including overused of piriformis, increased age are the important risk factors of PS. Piriformis anatomical variation, previous LBP, poor lifestyle, and psychological stress also contribute to the disorder. However, most studies included in this review did not fall in the higher evidence-based medicine; hence, longitudinal studies with PS in multicentre addressing modifiable and non-modifiable risk factors are warranted.

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