Evidence scan:

Abdominal wall and groin hernias as the result of a single strenuous event

April 2016

Requested by:	*Expert Advisory Group on ACC cover for abdominal wall and groin hernias*
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Important Note:

- The purpose of this evidence scan is to summarise information on the risk factors for abdominal wall and groin hernias, including their association with a single strenuous event or series of events. This report reflects a brief appraisal and summary of select papers rather than a full systematic review of the literature. The findings should be considered a 'snapshot' of the available evidence.
- Note that sports-related hernia was not considered in this report and any findings and guidance contained within do not necessarily apply to this condition.
- It is not intended to replace clinical judgement, or be used as a clinical protocol.
- The document has been prepared by the staff of the Evidence Based Healthcare Group, ACC. The content does not necessarily represent the official view of ACC or represent ACC policy.
- This report is based upon information up to April 2016.

1 Purpose & background

In collaboration with the Royal Australasian College of Surgeons (RACS) representatives, ACC wish to develop a consensus statement on issues relevant to cover for all traumatic abdominal wall and groin hernias. A second objective is to develop a consensus statement on cover for incisional hernias. The Expert Advisory Group on ACC cover for abdominal wall and groin hernias has asked ACC Research to complete an evidence scan of risk factors for the development of abdominal and groin hernias to support this work.

This report provides a brief outline of the available evidence and highlights the findings of several key studies. It should be read alongside the consensus statement for cover of traumatic abdominal wall and groin hernias.

The purpose of the evidence scan is twofold:

1) Provide a summary of the evidence base investigating risk factors for abdominal wall hernias, focusing particularly on the relationship with traumatic or strenuous events.

2) Provide a summary of the evidence base investigating risk factors for inguinal hernias, focusing particularly on the relationship between inguinal hernias and strenuous events or mechanical exposures.

2 Introduction

Recent research has implicated pathological imbalances in connective tissue (collagen) in the development of abdominal wall hernia, bringing into question theories identifying changes in intra-abdominal pressure (IAP) as a causative factor. If this is the case, it may be less likely that strenuous events or activities are a cause of abdominal wall or inguinal hernia and that ACC criteria for inguinal hernia may need to be reviewed. These criteria were formulated based on the key findings of Smith et al (1996) which determined five factors which must be met before compensation for an injury-related inguinal hernia could be made. The current ACC criteria are as follows:

1) A muscle strain must have been reported to a provider

2) Significant groin pain must have been present at the time of the strain. Preferably this will be noted or mentioned to at least one person at the time of onset.

3) Diagnosis of an inguinal hernia by a medical practitioner must be made within 30 days, but preferably within 10 days of the muscle strain.

4) The diagnosis of traumatic inguinal hernia must be made on the basis of early presentation of the symptoms of hernia with a demonstrable lump or positive cough impulse.

5) There is no previous history of an inguinal hernia. (A recurrence of a previously covered single strenuous event inguinal hernia will be, in most cases, accepted).

3 Methods

ACC Evidence Scans are limited in their scope and the extent of systematic searching of the literature. As such, the following sources were searched for publications between 1996 and 2016:

- Medline and Embase databases
- Google and Google Scholar

The search terms included inguinal, epigastric, umbilical, femoral, ventral, lumbar, Spigelian, and Traumatic Abdominal Wall Hernia (TAWH) hernia.

The search focused on risk factor and aetiology studies, and identified studies of multiple risk factors as well as those aimed at one particular type of contributing factor e.g. mechanical load, obesity, family history, collagen deficiencies. The search was designed to cast the net wide and provide an idea of the scope of the evidence base so no restrictions were made based on study design. Key papers were retrieved and their findings briefly summarized.

The search yielded approximately 2500 publications, from which 68 potentially useful papers were identified after screening the titles and abstracts (see Table 1 below). The majority of these focussed on inguinal hernia (n=45) with a small number focussing on epigastric (n=2), umbilical (n=1), ventral (n=3), and traumatic abdominal wall hernia (n=3). The remaining 14 studies included multiple hernia types.

Table 1: Studies of risk factors for abdominal and groin hernias published 1996 – 2016 divided into hernia type

Inguinal	Epigastric	Umbilical	Ventral	Femoral	Spigelian	TAWH	Multiple types
45	2	1	3	0	0	3	14

Following the initial scan of the evidence base, the Expert Advisory Group asked for a more detailed investigation of risk factors for inguinal hernias. Of the 45 papers investigating the risk factors for inguinal hernia, a subset of 11 papers focused on the role of mechanical exposures (e.g. lifting, standing) or strenuous activities in the development of inguinal hernias. These papers were appraised for quality and the findings summarised in section 4.2 below. The full evidence tables for this subset of papers are presented in Appendix A.

Please note that this is an evidence scan not a full review of the literature. Studies were not critically appraised for quality and the findings are based on a general assessment of the evidence base, rather than a systematic review. The intention of this evidence scan is to provide an overview of what the literature can offer in evaluating the aetiology of abdominal wall and groin hernias.

4 Findings

4.1 Abdominal wall hernias

Twenty-three papers were included in this section which covered a range of risk factors including intra-abdominal pressure, abdominal wall biomechanics, BMI/obesity, smoking, collagen deficiencies, genes/family heritability and the relationship with the occurrence of other hernia.

In terms of key papers, several cohort studies have been published by research groups working with the Danish Hernia Database, the Swedish Hernia Registry and the Swedish Multigenerational Register. Further useful publications have been produced by North American groups, including the Veterans Affairs Cooperative Hernia Study Group.

Key risk factors identified in these studies were:

Heritability/Familial Risk

- One large study which utilized the Swedish Multigeneration Register (Zoller et al 2013), examined familial susceptibility to several types of abdominal wall and groin hernias. Familial sibling risks were increased for inguinal, femoral, incisional, epigastric and umbilical hernia. Familial risks were highest for concordant hernia.
- A recent systematic review (Burcharth et al 2013) concluded that a family history of inguinal hernia was a significant risk factor for the development of a primary hernia, with a tendency towards increased recurrence rate and earlier recurrence.

Body Mass Index

- Being overweight or obese may increase the risk of having a non-inguinal hernia. A large cohort study (Lau et al 2012) reported increased odds of having an umbilical, incisional, ventral, epigastric or Spigelian hernia with increasing BMI, as well as increased risk of incarceration.
- There seems to be an inverse relationship between body mass index and the risk of having an inguinal hernia. A body mass index of greater than 25 has a protective effect, although this may be explained in part by a difficulty in detecting inguinal hernias in overweight and obese people.
- In a large Dutch cohort study (de Goede et al 2015) the hazard ratios for inguinal hernia for overweight and obese people were 0.72 and 0.63 respectively, compared with people with a BMI<25. A large North America cohort study (Ravanbakhsh et al 2015) similarly reported a lower risk of groin hernia in people with a BMI>30 kg/m2, but a higher risk of complications (strangulation/incarceration).

Connective tissue deficiencies

- Several prospective cohort studies have identified an increased prevalence of abdominal aortic aneurysm (AAA) in patients with abdominal wall and inguinal hernias, and an increased risk of hernia development in patients who have been treated for AAA (Antoniou et al 2011).

- A common underlying connective tissue degradation or chronic inflammation disorder have been used to explain these associations but further investigations are needed to understand this relationship.

Occupational factors/mechanical loading

- Almost all the studies investigating the role of mechanical load or work characteristics in the development of hernia focus on inguinal hernias. These studies are discussed in more detail in section 4.2.
- Mixed findings with some studies finding an association between specific occupations or occupational activities and the risk of developing an inguinal hernia.
- No studies were able to report on causality.
- No studies were able to say what proportion of inguinal hernias may be primarily the result of mechanical loading or a single strenuous event.
- A recent systematic review (Svendsen et al 2013) concluded that there was insufficient evidence to draw conclusions about the "existence of causal associations between specific occupational mechanical exposures and the development of inguinal hernia" and "the influence of these exposures on prognosis…with respect to hernia recurrence and persistent pain".

4.2 Inguinal hernias and mechanical exposures or strenuous activities

A small subset of papers (n = 11) was identified which investigated the association between inguinal hernias and mechanical exposures, occupations or strenuous activities. The study designs were comprised of two systematic reviews (Svendsen et al 2013; Hendry et al 2008), three prospective cohort studies (Vad et al 2012; Ruhl and Everhart 2007; De Goede et al 2015), three case-control studies (Lau et al 2012; Ashindoitiang et al 2012; Liem et al 1997) and three case series (Sanjay and Woodward 2007; Pathak and Poston 2006; Williamson et al 2016).

These studies were appraised for quality and are summarised in evidence tables presented in Appendix A. Table 2 (below) summarises their key findings with regards to mechanical exposures and activities.

Table 2. Summary of risk factors for inguinal hernia based on included studies

Risk Factor	Main findings
Standing/walking	• A large prospective cohort study reported a significant association between number of years spent in an occupation which required standing for long periods each day (6 hours +) and the odds of developing lateral (indirect) inguinal hernia (Vad et al 2012) • Adjusted ORs ranged from 1.17 – 1.53 for 4 to 5 standing-years • In general the risk of medial (direct) inguinal hernia was unrelated to exposures
Lifting	• A large prospective cohort study reported a significant association between number of years spent in an occupation which required heavy lifting and the odds of developing lateral (indirect) inguinal hernia (Vad et al 2012). • Frequent heavy lifting-years (objects 20kg or more) associated with increased odds of developing lateral (indirect) hernia (ORs 1.2 – 1.33) but these did not remain significant after controlling for other exposures e.g. standing • Ton-years (lifting 1 ton per day for 1 year) associated with increased odds of lateral hernia, but this did not remain significant after controlling for standing and lifting-years • In general the risk of medial (direct) hernia was unrelated to exposures
Strenuous activity	• One large prospective cohort study (Ruhl and Everhart 2007) reported no significant association between levels of recreational and non-recreational activity and primary inguinal hernia • A large case-control study reported a significant association between total activity index and increased odds of having an inguinal hernia in men (Lau et al 2012). However, absolute differences in activity between cases and controls were small (7.7 v 7.4). • One small case-control study (Liem et al 1997) reported no significant association between present or past work or leisure activity, past sports activity and inguinal hernia in women, but current sports activity had a protective effect. • One case-control study of Nigerian men showed an increased risk for men who reported engaging in strenuous physical activities (mainly as part of their work) (Ashindoitiang et al 2012) • Two case series found that a small percentage of patients (11 – 14%) reported a single strenuous event as the cause of their hernia, and that most of those would not meet Smith criteria for a traumatic hernia (Pathak and Poston, 2006; Williamson et al 2016)
Type of job	• Poor quality evidence overall • A well-conducted systematic review reported that most of the studies used job titles or crude estimates of physical activity to assess occupational exposures. The authors concluded that there was insufficient evidence to make conclusions about any causal associations between occupational exposures and inguinal hernia (Svendsen et al 2013). • One case series reported an increased proportion of people with sudden onset inguinal hernias in jobs which required heavy work and manual labour (Sanjay and Woodward 2007).
Body Mass Index	• Two large prospective studies reported a significant association between increased BMI and reduced risk of primary inguinal hernia (Ruhl and Everhart 2007; de Goede et al 2015) • Risk for obese men was half that of normal weight men (HR(obese) = 0.51, 95% CI 0.36 – 0.71) • One small case-control study (Liem et al 1997) showed a protective effect of overweight and obesity for inguinal hernia in women.
Family history	• Consistent relationship between family history of hernia and odds of having an inguinal hernia in men and women (Lau et al 2012; Ashindoitiang et al 2012) • Odds ratios around 7-8 fold increase
Indirect v Direct hernia	• Some evidence from two studies of a greater likelihood of sudden onset for indirect hernias compared with direct hernias • A large prospective study (Vad et al 2012) investigated the association between mechanical exposures and indirect and direct hernias. • Overall, direct hernias were not related to exposures. Indirect hernias were associated with the number of standing-years (years spent standing/walking for 6 hours or more per day) and frequent-heavy-lifting-years. • The authors estimated that approximately 15% of all indirect inguinal hernia repairs may be preventable by reducing time spent standing/walking per day.

5 Key Points

- Familial susceptibility, body mass index and physical activities or mechanical loading all seem to be contributing risk factors for abdominal and groin hernia, however none of the studies in this evidence scan were able to identify the relative contribution of individual risk factors to the development of abdominal and groin hernia.
- While there have been many investigations of the associations between potential risk factors and the incidence of inguinal hernias, none of the studies identified in this evidence scan were able to make conclusions about causation. The specific mechanisms by which risk factors like occupational activities or familial risk effect the development of hernia remain unclear.
- One well-conducted systematic review of the role of mechanical exposures on the incidence of inguinal hernia (Svendsen et al 2013), concluded that the evidence for a causal association between specific mechanical exposures (e.g. lifting, standing, strenuous activity) and the development of inguinal hernia was low quality and insufficient to make firm conclusions. The studies with the lowest risk of bias suggested no association between the level of physical activity and the likelihood of inguinal hernia.
- Studies of the association between a single strenuous event and the development of a hernia were mostly case series and open to bias. These studies reported that only a small percentage of patients associated their inguinal hernia with a single strenuous event in self-report questionnaires (11 – 14%). Of those patients, a maximum of 5% met published criteria for a hernia caused by a single strenuous event (e.g. Smith criteria).

6 References

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Svendsen S.W., Frost P., Vad M.V., Andersen J.H. (2013). Risk and prognosis of inguinal hernia in relation to occupational mechanical exposures--a systematic review of the epidemiologic evidence. *Scandinavian Journal of Work, Environment & Health*, 39(1): 5-26.

Vad M.V., Frost P., Bay-Nielsen M., Svendsen S.W. (2012). Impact of occupational mechanical exposures on risk of lateral and medial inguinal hernia requiring surgical repair. *Occupational & Environmental Medicine*, 69(11): 802-9.

Williamson J.S., Jones H.G., Radwan R.R., Rasheed R. (2016). Inguinal hernias associated with a single strenuous event. *Hernia*, 20: 687 – 690.

Zoller B.; Ji J.; Sundquist J.; Sundquist K. (2013). Shared and nonshared familial susceptibility to surgically treated inguinal hernia, femoral hernia, incisional hernia, epigastric hernia, and umbilical hernia. *Journal of the American College of Surgeons*, 217(2):289-99.e1.

Appendix A: Evidence tables for studies investigating the relationship between a single or series of strenuous events and inguinal hernia

Systematic Reviews

Study	Methodology	Outcomes & results	Paper Grading		Reviewer comments & evidence level
Svendsen et al 2013 Scandinavian Journal of Work, Environment and Health, 39(1): 5-26 **Study design:** Systematic review **Research Question** To evaluate epidemiologic evidence for a causal effect of mechanical exposures on incidence of inguinal hernia **Funding** Danish Working Environment Research Fund	**Search strategy** Medline, Embase, Web of Science to November 2011 Handsearched references of reviews for additional studies Two authors retrieved and selected references for inclusion **Inclusion criteria** Cohort studies, case control, case series which comprised an analysis of risk or prognosis of inguinal hernia in relation to occupation or mechanical exposures **Exclusion criteria** Single case studies or case reports Reviews or guidance papers that didn't include original research Case series that only considered compensation cases **Quality Assessment** Studies quality assessed using the framework of the Scientific Committee of the Danish Society of Occupational and Environmental	**Risk of inguinal hernia by occupation or occupational mechanical exposures (n=8)** 3 cross-sectional, 4 case-control, 1 prospective cohort 5 studies used self-reported physical effort and work or in activities, 1 used a researcher estimate of activity levels, and 2 compared occupations or job titles 2 studies adjusted for confounders but the remaining studies presented unadjusted analyses None of the studies examined lateral and medial hernias separately **Risk of inguinal hernia as the result of a single strenuous event (n=3)** 3 case series Proportion of hernias with self-reported sudden onset varied substantially from study to study Sanjay and Woodward (2007): 43% of patients reported a sudden onset. Participation rate = 62%. Lateral hernias were more likely to have sudden onset than medial hernias. Nine year recall period. Pathak and Poston (2006): 11% of patients	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded studies listed Characteristics of included studies are provided Scientific quality of included studies assessed and documented Scientific quality of included studies assessed appropriately Appropriate methods used to combine individual study findings Likelihood of publication bias assessed Conflicts of interest declared Are results of study directly applicable to patient group targeted by guideline?	**Y** **Y** **Y** **Y** **N** **Y** **Y** **NR** **Y** **N** **Y** **Y**	**Biases/Weaknesses:** • Well-conducted systematic review • Studies were low quality – self report of physical effort, job titles and occupation groups were used to estimate physical activity. No studies included direct measures of specific activities e.g. loads, lifting, carrying. • Only 2 studies adjusted for confounders in their analyses and these studies reported no significant difference in hazard ratios between those with low and high physical activity. • Hernia occurrence was mostly measured by rate of repair but this may miss asymptomatic hernia and those that were aggravated by physical activity versus those formed as a result of physical activity.

No conflicts of interest declared	Medicine **Included Studies** N=148 studies identified N= 23 studies met inclusion criteria: 11 papers on risk of first-time inguinal hernia 12 papers on prognosis of inguinal hernia repair	reported sudden onset. No check to see if any unusual activity took place before onset. Smith et al (1996):7% of patients reported sudden onset related to lifting strains or a fall. **Authors conclusions** There is insufficient evidence grade 0) to draw meaningful conclusions about a causal association between specific occupational mechanical exposures and the development of medial and lateral inguinal hernia. Contributory evidence with respect to intra-abdominal pressures, a PPV and connective tissue alterations points to mechanisms that may link mechanical exposures to inguinal hernia formation.			

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Hendry et al 2008 Surgeon, 6(6): 361 - 365 **Study design:** Literature review **Research question:** To ascertain relationship of IAP and abdominal wall	**Search strategy** Medline Handsearching of reference lists N=59 studies included All 3 authors identified and selected papers for inclusion **Inclusion criteria** Studies which discussed the connection between raised intra-	**Results:** <u>Direct inguinal hernia</u> • Results from weakness in the fascia of the posterior wall of the inguinal canal • Included evidence suggests connective tissue is defective in those with direct inguinal hernia and is more likely to be related to a congenital or an acquired weakness • Difficult to estimate timeframe	Clearly defined research question Two people selected studies and extract data Comprehensive literature search carried out Authors clearly state how limited review by publication type Included and excluded studies listed Characteristics of included studies are	Y Y N Y N N	**Biases/Weaknesses:** • Limited databases searched so important studies may have been omitted • Meta-analysis or synthesis of study data was not attempted • Quality of included studies not assessed or reported

hernia development, evidence around work-related hernia and risk of early return to work following hernia. **Funding** None stated	abdominal pressure due to single or recurrent strenuous events and hernia formation. **Exclusion criteria** Abstracts, correspondences, unpublished observations Sportsman's Groin Hernia treatment, operative technique or type **Quality Assessment** No appraisal or quality assessment was performed	between development of connective tissue degeneration and development of hernia, or whether a strenuous event has brought forward a hernia which would have developed at some point anyway. <u>Indirect inguinal hernia</u> • Congenital, related to patent processus vaginalis (PPV) • Presentation of hernia may be "brought forward by activities which suddenly or persistently raise IAP" <u>IAP and abdominal hernia</u> • Included studies "shed doubt on the importance of raised IAP as a significant factor in the formation of abdominal wall hernia" <u>Return to work</u> A return to unrestricted activity as soon as possible, governed by the level of pain experienced by the patient, should be encouraged. **Author conclusion:** • No evidence that a single or recurrent strenuous event can cause an abdominal wall hernia which would not have occurred anyway • No clear evidence between single or recurrent strenuous events and subsequent hernia recurrence	provided Scientific quality of included studies assessed and documented Scientific quality of included studies assessed appropriately Appropriate methods used to combine individual study findings Likelihood of publication bias assessed Conflicts of interest declared Are results of study directly applicable to patient group targeted by guideline?	N N N N N Y	**Conclusions** • Immediate pain at the time of an intensive or recurrent strenuous activity followed by diagnosis of a hernia within 3 days of the event supports a link between the activity and the development of a hernia • However, it may be that weakness in the connective tissue is the underlying cause and the activity may have just speeded up a hernia which was going to occur anyway • Early return to work should be encouraged

Prospective Cohort Studies

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Vad et al (2012) Occupational and Environmental Medicine, 69(11):802-9. **Study design:** Prospective cohort **Research question:** To evaluate exposure-response relations between cumulative occupational mechanical exposures and risk of lateral and medial inguinal hernia repair **Funding** Not stated No conflicts of interest declared	**Participants** N=22926 lateral, 15877 medial and 1592 pantaloon or unspecified first-time inguinal hernia repairs **Cohort – Danish Hernia Database** All men born in Denmark between 1938 and 1988, aged 18-65 years with at least 1 year of full-time employment between 1993 and 2007. **Diagnosis** Read codes from the ICD-8 or ICD-10 **Exposure Assessment** Register-based occupational codes for each job held since 1993. Occupations were assessed using a Job Exposure Matrix (validated tool for assessing occupational mechanical exposures). Based on expert assessments of number of hours per day spent standing/walking, total load lifted per day, daily frequency of lifting loads of 20kg or more. Standardised cumulative exposure years were calculated. A priori exposure time set at the 5	**Findings** Looked at link between mechanical exposures in the 5 years up to 1 year before an event 1 standing-year = 6 hours or more per day spent standing/walking for 1 year e.g. standing/walking for 3 hours per day for 1 year = 0.5 standing-years 1 Ton-year = lifting 1 ton per day for 1 year 1 Frequent-heavy-lifting year = lifting heavy objects weighing 20kg or more at least 10 times per day for 1 year e.g. lifting objects weight 20kg or more 80 times per day for 1 year = 8 frequent-heavy-lifting years **Lateral inguinal hernias** <u>Ton-years</u>: Adjusted ORs ranged from 1.05 – 1.35 for 1 – 4+ ton years. These did not remain significant after controlling for standing and lifting-years. <u>Standing-years</u>: Adjusted ORs ranged from 1.17 – 1.43 for 2 up to 6 standing years. Linear increase, remained significant after controlling for other exposures. OR (3-4 years) = 1.47	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Study based on high quality national register databases. • Job classifications based on an independent job exposure matrix so not biased by self-report. • Hernia repair used as a proxy measure of occurrence of hernia so may under-report actual occurrence and represents symptomatic hernias only. • Authors acknowledged that findings may reflect the aggravation of hernia symptoms due to exposures, rather than the formation of hernias, but because of the contrasting findings for lateral and medial hernia, they think this is unlikely. • No information on BMI, smoking or activity
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	Y	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	Y	
			Recognition knowledge of outcome could have affected assessment	NA	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	Y	

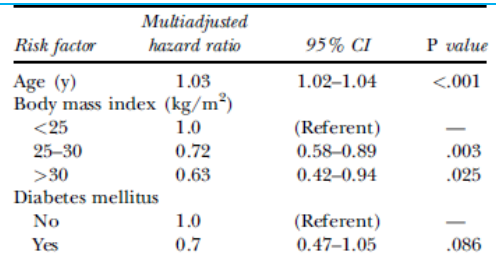
	years prior to 1 year before surgery **Outcome Assessment** First-time inguinal hernia repair between 1998 – 2008. Hernias were divided into medial, lateral and other. **Covariates** SES, age Not able to adjust analyses for BMI, smoking or activity outside work.	OR (4-5 years) = 1.53 OR (5 – 6.1 years) = 1.61 <u>Lifting-years:</u> Adjusted ORs ranged from 1.20 – 1.33 for 10 up to 48 frequent-heavy-lifting-years. Linear increase, did not remain significant after controlling for other exposures. **Medial inguinal hernias** ORs not significant for any of the exposure variables. **Authors conclusions** The odds of lateral inguinal hernia repair was significantly increased with increasing cumulative exposure to daily lifting activities and prolonged standing/walking at work. In general, the risk of medial hernias was unrelated to the exposures. The authors estimated approximately 15% of all lateral inguinal hernia repairs may be preventable by reducing the time spent standing/walking each day.	Main confounders identified and taken into account	N	outside work. • Small but significant increased odds.
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for hernias?	Y	

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Ruhl and Everhart (2007) American Journal of Epidemiology, 165(10): 1154 -	**Participants** N=14407 participants in the National Health and Nutrition Examination Survey (NHANES) Participants were first surveyed	**Findings** Cumulative incidence of hospitalisation with inguinal hernia was 6.3% at 20 years (13.9% among men, 2.1% among women) Adjusted HR = 7.5 for men relative to	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Study based on high quality national survey. • Physical activity measured through subjective self-report.
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	Y	

1161. **Study design:** Prospective cohort **Research question:** To examine risk factors for incident inguinal hernia **Funding** National Institute of Diabetes and Digestive and Kidney Diseases No conflicts of interest declared	between 1971 – 1975 and followed up for a hospital or physician diagnosis of hernia through to 1992 - 1993. **NHANES cohort** Participants aged 25 – 74 years who had been medically examined at the beginning of the survey. 96% of baseline cohort was recontacted and interviewed. Hospital and nursing home records collected at each wave. **Diagnosis** ICD read codes used to identify inguinal hernia cases. **Exposure Assessment** Risk factors assessed by medical examination and interview: Non-recreational activity (low, medium, high) Recreational activity (low, medium, high) Constipation and bowel movements Hiatal hernia diagnosis (ever) Chronic cough, bronchitis or emphysema Alcohol use Menstrual periods Weight, standing height, sitting height	women 20-year cumulative incidence increased with age 7.3% 24 – 39 years 14.8% 40 – 59 years 22.8% 60 -74 years **Risk Factors** All analyses were adjusted for age No significant difference for: Education, height, smoking, alcohol, chronic cough, constipation, chronic bronchitis or emphysema, No significant difference for levels of non-recreational and recreational physical activity Significant difference for: BMI, weight, maximum adult weight **Multivariate analyses** <u>Age</u> HR (40 – 59 years) = 2.2 (95% CI 1.7 – 2.8) <u>BMI</u> HR (60 – 74 years) = 2.8 (95% CI 2.2 – 3.6) HR (overweight) = 0.79 (95% CI 0.66 – 0.95) HR (obese) = 0.51 (95% CI 0.36 – 0.71) <u>Hiatal Hernia</u> HR (Hiatal Hernia) = 1.8 (95% CI 1.2 – 2.7) **Authors conclusions**	Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	Y	
			Recognition knowledge of outcome could have affected assessment	NA	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	Y	
			Main confounders identified and taken into account	N	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for hernias?	Y	

	BMI Smoking Education	For men, a higher incidence of inguinal hernia found with middle and older age. Lower incidence found with overweight and obese participants. No association with moderate to high recreational or non-recreational physical activity, chronic cough, constipation or COPD.			

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
De Goede et al (2015) Surgery, 157(3):540 -546. **Study design:** Prospective cohort **Research question:** To evaluate risk factors for inguinal hernia in middle-aged and elderly men **Funding** Rotterdam Study No conflicts of interest declared	**Participants** N= 5780 men participating in a large longitudinal study in the Netherlands from January 1990 onwards **Cohort – Rotterdam Study** All individuals aged 55 years and over in the Ommoord district, Rotterdam were recruited from January 1990. Two study extensions to include people who had moved to the district and 45 – 54 year olds in 2000 and 2006. **Diagnosis** Hospital discharge and GP records **Exposure Assessment** Baseline extensive face-to-face	**Findings** N= 477 primary inguinal hernias Men cumulative incidence = 7.2% Women cumulative incidence = 0.7% Unadjusted hazard ratios: No significant difference for: Smoking, corticosteroid use, other hernia Significant difference for: Age, BMI, Diabetes Mellitis	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Study based on high quality national register databases.
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	Y	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	Y	

	interviews **Outcome Assessment** Incident inguinal hernia **Covariates** SES, age Not able to adjust analyses for BMI, smoking or activity outside work.	 *Risk factor* / *Multiadjusted hazard ratio* / *95% CI* / *P value* Age (y) 1.03 1.02–1.04 <.001 Body mass index (kg/m²) <25 1.0 (Referent) — 25–30 0.72 0.58–0.89 .003 >30 0.63 0.42–0.94 .025 Diabetes mellitus No 1.0 (Referent) — Yes 0.7 0.47–1.05 .086 **Authors conclusions** Increased risk with age, reduced risk with increasing BMI.	Recognition knowledge of outcome could have affected assessment	NA	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	Y	
			Main confounders identified and taken into account	N	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for hernias?	Y	

Case-Control Studies

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Liem et al (1997) American Journal of Epidemiology, 46(9): 721 - 726. **Study design:** Case-control **Research question:** To examine risk factors for inguinal hernia in women	**Participants** N = 89 cases with inguinal hernia in 6 participating hospitals between Jan 1994 and Nov 1995 N = 176 controls selected from females who visited the outpatient surgical clinic for excision of common benign tumours e.g. sebaceous cysts. Individuals with a previous history of inguinal hernia were excluded.	**Findings** Response rates for questionnaire: 72 cases (81%) and 129 controls (73%) leaving 53 case-control triplets and 19 case-control pairs **Risk Factors** No significant difference between cases and controls for: Any present or past work or leisure activity; past sports activity; smoking;	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Very small absolute difference between cases and controls sports activity index scores, so even though it was statistically significant it doesn't seem to be of great importance clinically. • Recall bias a possibility because information was collected via
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	Y	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	Y	

Funding Department of Epidemiology, University Hospital, Utrecht, Netherlands	Cases and controls were matched for age (+/- 5 years) and time of surgical intervention (in the same month). **Diagnosis** Inguinal hernia diagnosed by two physicians and defined as a clinically detectable swelling in the groin or clearly palpable defect of the abdominal wall in the groin. Included cases with recurrent hernia. **Exposure Assessment** Risk factors assessed by hospital records and questionnaire. Additional phone interview where follow-up information was needed. Age, height, weight, SES Family history for inguinal hernia Lifetime physical activity (work, sports, leisure) Past work activity (sedentary, standing, labour, heavy labour) Past sports and leisure time activity Smoking history History of operations and medical history: Obstipation Obstructive pulmonary and urinary tract disease Trauma of the inguinal region or	children; COPD; trauma; pelvic fracture; abdominal operations Significant difference between cases and controls for: | Risk factor	Adjusted odds ratio*	95% CI† | |---|---|---| | No inguinal hernia in family | 1.0‡ | | | Inguinal hernia in family | 4.3 | 1.9–9.7 | | Present sports activity index score | | | | <1.75 | 1.0‡ | | | 1.75–2.0 | 0.8 | 0.3–1.9 | | 2.0–2.75 | 0.4 | 0.1–1.0 | | >2.75 | 0.2 | 0.1–0.7 | | Quetelet index (kg/m²) | | | | <25 | 1.0‡ | | | ≥25, <30 | 0.7 | 0.3–1.5 | | ≥30 | 0.2 | 0.04–1.0 | | No obstipation | 1.0‡ | | | Obstipation | 2.5 | 1.0–6.7 | **Authors conclusions** For women, the only risk factors found to be independently associated with inguinal hernia were sports activity, defecation pattern, and family history of inguinal hernia.	Comparison made between full participants and those lost to follow-up	N	questionnaire. This may be especially true for past sports, leisure and work activity. No way of cross checking family history. • BMI was a protective factor as was higher sports activity. A family history of inguinal hernia was the strongest risk factor.
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	Y	
			Assessment method reliable	CS	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	Y	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for hernias?	Y	

	lower abdomen Fractures of the pelvis Connective tissue disease				

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Lau et al (2012) Surgery, 141(2): 262 - 266. **Study design:** Case-control **Research question:** To evaluate risk factors for inguinal hernia in adult males **Funding** Faculty of Medicine, University of Hong Kong No conflicts of interest declared	**Participants** N= 709 cases who presented with primary inguinal hernia at a surgical clinic between 2002 -2004 N= 709 controls selected randomly from the general surgical clinic Participants were males aged 18 years and over Cases and controls were matched for age. Controls with a history of hernia repair were excluded. Mean age = 65 +/- 13 years **Diagnosis** Clinical examination **Exposure Assessment** Face-to-face interview by a researcher using a standardised questionnaire: Age, weight, height, BMI Smoking	**Findings** <u>Univariate analyses:</u> No significant difference for: BMI, education level, cirrhosis, renal failure, heart failure, prostatism, connective tissue disorders, smoking, chronic cough, constipation, use of laxatives, sport activity index, leisure time activity index Significant difference for: Body weight, body height, COPD, family history, work activity index, total activity index Family history OR 8.73 (95%C I 4.95 – 15.4) *Activity index* / *Cases* / *Controls* / P Work activity index: 2.8 ± 0.5 / 2.7 ± 0.5 / 0.03 Sport activity index: 2.0 ± 0.7 / 1.9 ± 0.7 / 0.09 Leisure-time activity index: 2.8 ± 0.6 / 2.8 ± 0.6 / 0.58 Total activity index: 7.7 ± 0.6 / 7.4 ± 0.6 / 0.01 <u>Multivariate analyses</u> Family history was the only independent predictor.	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Absolute differences in activity index scores were not great e.g. total activity cases = 7.7 +/- 0.6; controls = 7.4 +/- 0.6
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	Y	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	Y	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	CS	
			Recognition knowledge of outcome could have affected assessment	N	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome	Y	

	Chronic cough, COPD Constipation/straining Use of laxatives Disease-related factors e.g. congestive heart failure History of inguinal hernia in a first degree relative Occupation Level of physical activities – validated measure of physical activity at work, sport and other leisure time	**Authors conclusions** Inguinal hernia in adult males is probably a multifactorial process. Our data indicated that strenuous physical activity, a positive family history of hernia, and the presence of COPD were significant risk factors for primary inguinal hernia. Regression analysis showed that family history was the only independent predictor of inguinal hernia.	assessment is valid and reliable		
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	Y	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for hernias?	Y	

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Ashindoitiang et al (2012) International Journal of Surgery, 10: 364 - 367. **Study design:** Case-control **Research question:** To evaluate risk factors for inguinal hernia in adult male Nigerians	**Participants** N= 202 cases who presented with primary inguinal hernia at a surgical clinic between 2009 and 2011 N= 202 controls selected randomly from the out-patient clinic Participants were males aged 18 years and over Cases and controls were matched for age. Controls with a history of hernia repair were excluded.	**Findings** <u>Univariate analyses:</u> No significant difference for: Chronic cough, constipation, obesity, smoking Significant difference for: Strenuous activities, family history <u>Multivariate analyses:</u> Strenuous activities present OR = 5.8 (95%CI 3.5 – 9.4, p<0.01) Family history OR 7.0 (95% CI 4.1 – 12.0,	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Measure of strenuous activity was based on a validated measure but didn't specify the type of strenuous activity or whether it was work or leisure-based. • Attending physician completed interviews, wasn't clear whether physician was aware who was a case and who a control.
			Two groups sourced from comparable source populations	Y	
			Indicates how many people asked to took part in study	N	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	N	
			Comparison made between full participants and those lost to follow-up	N	

Funding Funded by the authors No conflicts of interest declared	Age range 16 – 80 years **Diagnosis** Clinical examination **Exposure Assessment** Face-to-face interview by attending physician: Age, weight, height, BMI Smoking Chronic cough, COAD Constipation/straining History of inguinal hernia in a first degree relative Occupation Level of physical activities – strenuous/non-strenuous (using a validated measure) used to categorise people into two groups (strenuous activities present/absent)	p<0.01) **Authors conclusions** In the Nigerian workforce the majority engage in farming and trading occupations which involve the carrying of heavy objects. Family history of inguinal hernia and strenuous physical activity were the significant risk factors in the current study.	Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	N	
			Assessment method reliable	Y	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	Y	
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	Y	
			Confidence intervals provided	Y	
			Are results directly applicable to ACC claims for hernias?	Y	

Case Series

<table>
<tr><th>Study</th><th>Methodology</th><th>Outcomes & results</th><th colspan="2">Paper grading</th><th>Reviewer comments & evidence level</th></tr>
<tr>
<td>Sanjay and Woodward et al 2007

Hernia, 11(6), 493-496

Study design:

Case series

Research question: To assess the frequency with which inguinal hernia is attributed to a single muscular strain

Funding

None stated</td>
<td>Total eligible patients = 520 treated by one surgeon over a 9 year period

N = 320 (62% response rate) responded to the questionnaire

Median age = 61.5 years (range 19 – 88 years)

Inclusion criteria

Underwent surgery for inguinal hernia between 1995 – 2004.

Outcome Measures

Postal questionnaire survey:

Patients asked whether the hernia developed gradually or with sudden onset secondary to a strenuous event.

Patients asked to specify the event and whether they experienced severe groin pain at the time

Occupation, employment status at the time of diagnosis of the hernia (retired, sedentary, clerical, manual, heavy labour)

Case notes review for information regarding obesity, smoking, COPD, prostatism</td>
<td>Findings

62% response rate

51% of hernias were described by patients as gradual onset

42.5% described as sudden onset

Sudden onset hernias

91% reported groin pain at the time of the event

No significant difference in demographic risk factors between sudden and gradual onset groups.

Significant differences in some types of employment:

<table>
<tr><th></th><th>Gradual onset (n=164)</th><th>Sudden onset (n=137)</th></tr>
<tr><td>Type of Job</td><td></td><td></td></tr>
<tr><td>Retired</td><td>98 (59.7%)</td><td>44 (32.1%)</td></tr>
<tr><td>Sedentary</td><td>24 (14.6%)</td><td>15 (10.9%)</td></tr>
<tr><td>Clerical</td><td>13 (7.9%)</td><td>15 (10.9%)</td></tr>
<tr><td>Manual</td><td>15 (9.1%)</td><td>21 (15.3%)</td></tr>
<tr><td>Heavy work</td><td>14 (8.5%)</td><td>42 (30.6%)</td></tr>
</table>

Significant differences in type of hernia:

<table>
<tr><td>Indirect</td><td>93 (56.7%)</td><td>101 (73.7%)</td></tr>
<tr><td>Direct</td><td>71 (43.3%)</td><td>36 (26.3%)</td></tr>
</table>
</td>
<td colspan="2">
<table>
<tr><td>Appropriate and focused question?</td><td>Y</td></tr>
<tr><td>Two groups sourced from comparable source populations</td><td>N</td></tr>
<tr><td>Indicates how many people asked to took part in study</td><td>Y</td></tr>
<tr><td>Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis</td><td>N</td></tr>
<tr><td>% of individuals or clusters recruited dropped out</td><td>Y</td></tr>
<tr><td>Comparison made between full participants and those lost to follow-up</td><td>N</td></tr>
<tr><td>Outcomes clearly defined</td><td>N</td></tr>
<tr><td>Assessment of outcome blind to exposure status</td><td>N</td></tr>
<tr><td>Recognition knowledge of outcome could have affected assessment</td><td>N</td></tr>
<tr><td>Assessment method reliable</td><td>N</td></tr>
<tr><td>Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable</td><td>N</td></tr>
<tr><td>Exposure level measured more than once</td><td>N</td></tr>
</table>
</td>
<td>Biases/Weaknesses:

• Patients asked to offer their opinion about whether their hernia was of sudden or gradual onset up to 9 years following their surgery. Question sounds like it may have been open to recall bias and reporting bias.
• Patients beliefs about the causes of hernia may have effected their response when asked about the cause of their specific hernia.
• Analyses were not adjusted for confounders e.g. age</td>
</tr>
</table>

		Author conclusion:	Main confounders identified and taken into account	N	
			Confidence intervals provided	N	
			Are results directly applicable to ACC claims for hernia?	N	

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Pathak and Poston 2006 Annals of the Royal College of Surgeons of England 88(2):168-71. **Study design:** Case series **Research question**: To identify aetiological factors in the development of inguinal hernia **Funding** Not stated	N=133 patients enrolled at one medical centre, of whom n=104 men **Inclusion criteria** Participants with abdominal hernia enrolled over a six month period Participants had abdominal hernia (115 inguinal, 3 femoral, 9 umbilical, 4 incisional, 4 ventral or epigastric) 25 recurrent hernia **Risk factor measures** Self-report questionnaire given to participants on arrival in the surgical clinic Questionnaire asked about possible aetiological factors for hernia development • type of work and labour history • COAD • smoking • pregnancy	**Findings** • 119/133 (89%) reported gradual onset of symptoms • 24% with close relative who suffered from a hernia • 24% smokers or ex-smokers **Single strenuous event responses:** • 14/133 (11%) reported single strenuous event as cause of their hernia (11 inguinal, 2 recurrent inguinal, 1 incisional inguinal) • Of those, 5/14 had no other aetiological risk factors • 1/14 had a prior appendectomy and 2/14 had previous hernia • 1/14 had a job that involved strenuous activity – heavy lifting or straining • 3/14 stated that strenuous stretching or exercising was the cause • 2/14 stated coughing was the	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Relied on patient self-report – may be inaccurate or misreported • Representativeness of sample unclear • Participants were recruited opportunistically and this may have led to a recruiting bias • Relies heavily on patient report for patients who thought their hernia was caused by a strenuous event – occupational health records were scant • GP notes described as 'very brief' and authors acknowledged that the GP may have overlooked or not
			Two groups sourced from comparable source populations	NA	
			Indicates how many people asked to took part in study	Y	
			Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	
			% of individuals or clusters recruited dropped out	CS	
			Comparison made between full participants and those lost to follow-up	CS	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	N	
			Assessment method reliable	N	

	• obesity • chronic bladder flow obstruction • previous sx and hernia repair • family history of hernia Additional question regarding any single strenuous event which participants felt had caused their hernia GP clinic and work-related occupational health records checked for all those who responded 'yes' to single strenuous event	cause • 8/14 could not pinpoint event **Time to report to physician:** The length of time between event and presentation was 5-13 weeks. Thus 0/14 had any medical evidence to qualify them under Smith et al criteria as having hernia caused by a single strenuous event **Author conclusion:** • Little causal evidence that a hernia might develop as a result of a single strenuous or traumatic event. While it is still possible that it can occur, at best, it is an extremely uncommon event. • For a personal injury claim to be supported, there must be contemporaneous medical evidence of a single strenuous event temporally close to development of symptoms	Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	N	noted indications of a traumatic hernia (haematoma, bruising, soft tissue injury) • Overall quality of data collection tools was low Patients' records indicated there was between 5 and 13 weeks delay between the event and presenting to a physician, which would exclude them from coverage under Smith et al (2001) criteria
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	N	
			Confidence intervals provided	N	
			Are results directly applicable to ACC claims for hernia?	Y	

Study	Methodology	Outcomes & results	Paper grading		Reviewer comments & evidence level
Williamson et al 2016 Hernia, 20: 687 – 690	N=335 consecutive patients surgically treated for primary inguinal hernia Retrospective review of case notes for all inguinal hernia repairs in a	**Findings** • 119/133 (89%) reported gradual onset of symptoms • 24% with close relative who suffered from a hernia	Appropriate and focused question?	Y	**Biases/Weaknesses:** • Relied on patient self-report – may be inaccurate or misreported • Representativeness of
			Two groups sourced from comparable source populations	NA	
			Indicates how many people asked to took part in study	Y	

Study design: Case series **Research question**: To identify aetiological factors in the development of inguinal hernia **Funding** Not stated	single year for a single NHS trust **Inclusion criteria** Participants with inguinal hernia enrolled between 2010 – 2011 87% response rate to follow-up questionnaire (n=292) **Risk factor measures** Operative records and case notes checked for features of their presentation attributable to a single strenuous event Self-report questionnaire sent to eligible patients regarding onset of their symptoms and experience of a single strenuous event (SSE) Questionnaire asked about possible aetiological factors for hernia development • Whether the patients perceived their hernia was related to a SSE • Details of this event • When they presented to a GP with their symptoms • Whether it was officially reported at work Also collected information about: • Smoking history • BMI • Age • Gender	• 24% smokers or ex-smokers **Single strenuous event responses:** • 41/292 (14%) reported single strenuous event as cause of their hernia (11 inguinal, 2 recurrent inguinal, 1 incisional inguinal) • Of those 2/41 (5%) met published criteria for association of a hernia with SSE • 3/41 officially reported the onset of their hernia at work **175 patients in employment were divided into lower or higher physical stress at work:** Lower stress: 9/90 (10%) reported workplace-related SSE Higher stress 13/85 (15%) reported workplace-related SSE A further 11/85 reported some other SSE (vomiting, coughing, bowel opening, recreational activity) **Author conclusion:** • Our data fail to support the theory that inguinal hernia may be associated with a single strenuous event	Likelihood that some eligible subjects may have the outcome at the time of enrolment assessed and taken into account in analysis	N	sample unclear • Relies heavily on patient report for patients who thought their hernia was caused by a strenuous event – no occupational health records searched • Overall quality of data collection tools was low
			% of individuals or clusters recruited dropped out	CS	
			Comparison made between full participants and those lost to follow-up	N	
			Outcomes clearly defined	Y	
			Assessment of outcome blind to exposure status	N	
			Recognition knowledge of outcome could have affected assessment	N	
			Assessment method reliable	N	
			Evidence from other sources used to demonstrate method of outcome assessment is valid and reliable	N	
			Exposure level measured more than once	N	
			Main confounders identified and taken into account	N	
			Confidence intervals provided	N	
			Are results directly applicable to ACC claims for hernia?	Y	