Specialist Medical Review Council

Reasons for Decisions

Section 196W
Veterans' Entitlements Act 1986

Re: Statements of Principles concerning lumbar spondylosis Nos. 37 & 38 of 2005 as amended by Statements of Principles Nos. 78 & 79 of 2008 and 36 & 37 of 2010

Request for Review Declaration No.19

TABLE OF CONTENTS

SUMMATION 3

THE SPECIALIST MEDICAL REVIEW COUNCIL 3

THE LEGISLATION 4

BACKGROUND 6

FIRST APPLICATION FOR REVIEW BY THE COUNCIL 6
THE INFORMATION SENT BY THE RMA TO THE COUNCIL - FIRST APPLICATION 7
AMENDMENTS TO STATEMENTS OF PRINCIPLES 7
SECOND APPLICATION FOR REVIEW BY THE COUNCIL 8
THE INFORMATION SENT BY THE RMA TO THE COUNCIL - SECOND APPLICATION 9
SECOND APPLICANT'S POSITION 9
NOTIFICATION OF PRELIMINARY DECISIONS ON PROPOSED SCOPE OF REVIEW AND PROPOSED POOL OF INFORMATION 9
PROPOSED SCOPE OF REVIEW 10
PROPOSED POOL OF INFORMATION 10

FIRST APPLICANT'S SUBMISSIONS AND COMMENTS ON THE PROPOSED SCOPE OF THE REVIEW AND PROPOSED POOL OF INFORMATION DECISIONS 11

SECOND APPLICANT'S SUBMISSIONS AND COMMENTS ON THE PROPOSED SCOPE OF THE REVIEW AND PROPOSED POOL OF INFORMATION DECISIONS 13

COMMISSIONS' SUBMISSIONS AND COMMENTS ON THE PROPOSED SCOPE OF THE REVIEW AND PROPOSED POOL OF INFORMATION DECISIONS 13

COMMISSIONS' SUBMISSIONS ON 'FLEXION, EXTENSION, TWISTING OF THE SPINE' 14
COMMISSIONS' SUBMISSIONS ON FLIGHT FACTORS 22
REVISED PROPOSED SCOPE OF REVIEW AND REVISED PROPOSED POOL OF INFORMATION 23

FINAL SCOPE OF REVIEW 24
FINAL POOL OF INFORMATION 24
REASONS FOR THE COUNCIL'S DECISION 25
THE COUNCIL'S TASK 25
DOES THE SOUND MEDICAL - SCIENTIFIC EVIDENCE, 'POINT TO' OR 'LEAVE OPEN' THE RELEVANT ASSOCIATION? 26
THE COUNCIL'S ANALYSIS OF THE INFORMATION BEFORE THE RMA 26
PRELIMINARY COMMENT ON LUMBAR SPONDYLOSIS 26
GENERAL OBSERVATIONS 27
THE REVIEW COUNCIL'S ANALYSIS OF THE INFORMATION IT CONSIDERED MOST IMPORTANT AS BEING POTENTIALLY REFERABLE TO THE CONTENDED FACTORS FOR 'REPETITIVE OR PERSISTENT FLEXION, EXTENSION OR TWISTING OF THE LUMBAR SPINE.' 29
SUMMARY OF THE COUNCIL'S CONSIDERATION OF THE SOUND MEDICAL SCIENTIFIC EVIDENCE ON LUMBAR SPONDYLOSIS AND FLEXION, EXTENSION AND TWISTING. 56
THE COUNCIL'S CONCLUSIONS ON THE SOUND MEDICAL-SCIENTIFIC EVIDENCE 58
THE COUNCIL'S CONCLUSIONS ON WHETHER THERE SHOULD BE A FACTOR(S) FOR PERSISTENT (PROLONGED, FORWARD) FLEXION AND REPETITIVE EXTENSION OR TWISTING. 59
NEW INFORMATION SUBMITTED BY THE APPLICANT 59
DECISION 60
EVIDENCE BEFORE THE COUNCIL 60
GLOSSARY OF TERMS: 61
APPENDIX A 65
APPENDIX B 70
APPENDIX C 92

SUMMATION

1. In relation to the Repatriation Medical Authority (the RMA) Statement of Principles concerning lumbar spondylosis No. 37 of 2005, as amended by Statement of Principles No. 78 of 2008 and Statement of Principles No. 36 of 2010, made under subsections 196B(2) and (8) of the *Veterans' Entitlements Act 1986* (the VEA), the Specialist Medical Review Council (the Council) under subsection 196W of the VEA:

> DECLARES that there is sound medical-scientific evidence on which the RMA could have relied to amend the Statement of Principles to include the factor/s set out below;
>
> DIRECTS the RMA to amend Statement of Principles concerning lumbar spondylosis No. 37 of 2005, as amended by Statement of Principles No. 78 of 2008 and Statement of Principles No. 36 of 2010 by including factors:
>
> – for extreme prolonged forward flexion/bending for a cumulative total of at least 1500 hours.
>
> AND DECLARES that the sound medical-scientific evidence available to the RMA is insufficient to justify any amendment to the Statement of Principles to include a factor for repetitive extension or twisting of the lumbar spine.

2. In relation to the RMA Statement of Principles concerning lumbar spondylosis No. 38 of 2005, as amended by Statement of Principles No. 79 of 2008 and Statement of Principles No. 37 of 2010, made under subsections 196B(3) and (8) of the VEA the Council under subsection 196W of the VEA:

> DECLARES that there is sound medical-scientific evidence on which the RMA could have relied to amend the Statement of Principles to include the factor/s set out below;
>
> DIRECTS the RMA to amend Statement of Principles concerning lumbar spondylosis No. 38 of 2005, as amended by Statement of Principles No. 79 of 2008 and Statement of Principles No. 37 of 2010 by including factors:
>
> – for extreme/prolonged forward flexion/bending for a cumulative total of at least 1500 hours.
>
> AND DECLARES that the sound medical-scientific evidence available to the RMA is insufficient to justify any amendment to the Statement of Principles to include a factor for repetitive extension or twisting of the lumbar spine.

THE SPECIALIST MEDICAL REVIEW COUNCIL

3. The Council is a body corporate established under section 196V of the VEA, and consists of such number of members as the Minister for Veterans' Affairs determines from time to time to be necessary for the proper exercise of the function of the Council as set out in the VEA. The Minister must appoint one of the Councillors to be the Convener. When appointing Councillors, the Minister is

required to have regard to the branches of medical science that would be necessary for deciding matters referred to the Council for review.

4. When a review is undertaken the Council is constituted by three to five Councillors selected by the Convener. If the Review Council as constituted for the purposes of a review does not include the Convener, the Convener must appoint one of the Councillors selected for the purposes of the review to preside at all meetings of the Council as so constituted as Presiding Councillor.

5. Dr David Newman was the Presiding Councillor for this review. Dr Newman spent over 12 years in the Royal Australian Air Force as a medical officer and aviation medicine specialist. He is currently Senior Lecturer and Head of Research in the Aviation Discipline in the Faculty of Engineering and Industrial Sciences at Swinburne University in Victoria and head of the Aviation Medicine Unit in the Department of Epidemiology and Preventive Medicine at Monash University.

6. The other members of the Review Council for the purposes of the review were:

Professor Robert Cumming

(1) Professor Cumming is Professor of Epidemiology and Geriatric Medicine, School of Public Health University of Sydney, and researcher at the Centre for Education and Research on Ageing at Concord Hospital.

Associate Professor John Hart

(2) Associate Professor Hart is an orthopaedic surgeon based in Melbourne. He was head of the orthopaedic unit at the Alfred Hospital from 1980 until 2003, and is a clinical associate professor in the Department of Surgery at Monash University.

Associate Professor Geoff Littlejohn

(3) Associate Professor Littlejohn is Professor of Medicine and Director of Rheumatology at Monash Medical Centre, Melbourne, and Adjunct Professor at Edith Cowan University, Perth. He completed a MD thesis in Toronto on Diffuse Idiopathic Skeletal Hyperostosis and has remained an international expert in that field. He has also published widely in other rheumatic disorders including inflammatory joint disease, chronic pain syndromes, and osteoarthritis.

THE LEGISLATION

7. The legislative scheme for the making of Statements of Principles is set out in Parts XIA and XIB of the VEA. Statements of Principles operate as templates, which are ultimately applied by decision-makers in determining individual claims for

benefits under the VEA and the *Military Rehabilitation and Compensation Act 2004* (the MRCA)[1].

8. Fundamental to Statements of Principles is the concept of 'sound medical-scientific evidence', which is defined in section 5AB(2) of the VEA. Information about a particular kind of injury, disease or death is taken to be sound medical-scientific evidence if:

   a) the information

      (i) is consistent with material relating to medical science that has been published in a medical or scientific publication and has been, in the opinion of the RMA, subjected to a peer review process; or

      (ii) in accordance with generally accepted medical practice, would serve as the basis for the diagnosis and management of a medical condition; and

   b) in the case of information about how that injury, disease, or death may be caused - meets the Applicable criteria for assessing causation currently applied in the field of epidemiology.[2]

9. The functions of the Council are set out in section 196W of the VEA. In this case, the Council was asked (under section 196Y of the VEA) first by a person eligible to make a claim for a pension and secondly by an eligible organisation mentioned in s196Y of the VEA, to review the contents of:

      (i) Statement of Principles concerning lumbar spondylosis No. 37 of 2005 as amended by Statements of Principles No. 78 of 2008 and No. 36 of 2010, being a Statement of Principles determined by the RMA under section 196B(2)[3] of the VEA ('the **reasonable hypothesis** test') and

---

1 See sections 120, 120A and 120B of the VEA and sections 335, 338 and 339 of the MRCA.

2 This has been held to mean 'information which epidemiologists would consider appropriate to take into account' see *Repatriation Commissions v Vietnam Veterans' Association of Australia NSW Branch Inc* (2000) 48 NSWLR 548 (the New South Wales Court of Appeal decision) per Spigelman CJ at paragraph 117.

3 196B(2) provides;

If the Authority is of the view that there is sound medical-scientific evidence that indicates that a particular kind of injury, disease or death can be related to:

(a) operational service rendered by veterans; or

(b) peacekeeping service rendered by members of Peacekeeping Forces; or

(c) hazardous service rendered by members of the Forces; or

(caa) British nuclear test defence service rendered by members of the Forces; or

(ca) warlike or non-warlike service rendered by members;

the Authority must determine a Statement of Principles in respect of that kind of injury, disease or death setting out:

(d) the factors that must as a minimum exist; and

(e) which of those factors must be related to service rendered by a person;

(ii) Statement of Principles concerning lumbar spondylosis No. 38 of 2005 as amended by Statements of Principles No. 79 of 2008 and No. 37 of 2010, being a Statement of Principles determined by the RMA under section 196B(3)[4] of the VEA ('the **balance of probabilities** test').

10. Specifically, the first Applicant contended that there was sound medical-scientific evidence on which the RMA could have relied to include repetitive or persistent flexion, extension or twisting of the lumbar spine as a factor or factors in Statements of Principles concerning lumbar spondylosis Nos. 37 & 38 of 2005. The second Applicant contended that there was sound medical-scientific evidence, on which the RMA could have relied to provide a lower exposure threshold for helicopter crews in Statements of Principles concerning lumbar spondylosis Nos. 37 & 38 of 2005 as amended by Statements of Principles Nos. 78 & 79 of 2008 and 36 & 37 of 2010.

11. In conducting its review, the Council must review all the information that was available to (before) the RMA at the time it determined, amended, or last amended the Statements of Principles (the relevant times) and is constrained to conduct its review by reference to that information only.[5]

12. Under section 196W of the VEA, the Council can only reach the view that a Statement of Principles should be amended on the basis of sound medical-scientific evidence.

BACKGROUND

First Application for review by the Council

13. On 8 November 2005, the RMA under subsections 196B(2) and (3) of the VEA revoked Instruments Nos. 46 & 47 of 2002 as amended by Instruments Nos. 77 & 78 of 2002 and determined in their place Statements of Principles concerning

---

before it can be said that a reasonable hypothesis has been raised connecting an injury, disease or death of that kind with the circumstances of that service.

4 196B(3) provides;

If the Authority is of the view that on the sound medical-scientific evidence available it is more probable than not that a particular kind of injury, disease or death can be related to:

(a) eligible war service (other than operational service) rendered by veterans; or

(b) defence service (other than hazardous service and British nuclear test defence service) rendered by members of the Forces; or

(ba) peacetime service rendered by members;

the Authority must determine a Statement of Principles in respect of that kind of injury, disease or death setting out:

(c) the factors that must exist; and

(d) which of those factors must be related to service rendered by a person;

before it can be said that, on the balance of probabilities, an injury, disease or death of that kind is connected with the circumstances of that service.

5 *Vietnam Veterans' Association (NSW Branch) Inc v Specialist Medical Review Council and Anor* (full Federal Court decision) (2002) 72 ALD 378 at paragraph 35 per Branson J.

lumbar spondylosis Nos. 37 & 38 of 2005. The Statements of Principles took effect from 16 November 2005.

14. On 11 November 2005 the Statements of Principles were registered on the Federal Register of Legislative Instruments.

15. On 16 February 2006 in accordance with section 42 of the *Legislative Instruments Act 2003* the Statements of Principles were tabled in the House of Representatives and in the Senate.

16. An Application for Review of Statements of Principles Nos. 37 & 38 of 2005 was received by the Council on 17 January 2006 (the first Application). The Application contended that the Statements of Principles should include a factor or factors concerning repetitive or persistent flexion, extension or twisting of the lumbar spine.

17. Pursuant to section 196ZB of the VEA the Council published, in the Gazette No. 23 of 14 June 2006, a Notice of its Intention to Carry Out a Review under section 196W of the Act of all of the information available to the RMA when it determined, amended or last amended the Statements of Principles concerning lumbar spondylosis and invited eligible persons or organisations authorised so to do to make submissions to the Council. The Council gazetted subsequent notices as to the dates by which written submissions must be received by the Council.[6]

The information sent by the RMA to the Council - First Application

18. By letter dated 27 April 2006 the RMA, under section 196K of the VEA, sent to the Council the information the RMA advised was available to (before) it at the relevant times, as listed in Appendix B.

19. By agreement between the RMA and the Council, information the RMA advised was available to (before) it at the relevant times is posted on a secure website (referred to as FILEForce). It was made accessible by the Council to the Repatriation Commission and the Military Rehabilitation and Compensation Commission (the Commissions), the first Applicant and other participants in the review via confidential password. The information which was available to (before) the RMA at the relevant times was posted on FILEForce on 29 March 2009.

Amendments to Statements of Principles

20. By Notice of Investigation under s196G of the VEA dated 19 June 2008, the RMA gave notice of its intention to carry out an investigation in respect of aircraft flight as a factor in lumbar spondylosis, to be carried out in the context of Statements of Principles concerning lumbar spondylosis Nos 37 and 38 of 2005. The RMA invited eligible persons or organisations authorised so to do to make submissions in writing.

---

[6] Gazette Notices No. GN 4, 31 January 2007; No. GN 32, 15 August 2007; No. GN 30, 5 August 2009.

21. On 22 October 2008, the RMA under subsections 196B (2) and (3) of the VEA determined amending Statements of Principles Nos. 78 & 79 of 2008, concerning lumbar spondylosis. The amending Statements of Principles took effect from 5 November 2008.

22. No Applications were received by the Council in respect of the 2008 amendments.

23. By Notice of investigation under s196G of the VEA dated 17 April 2009, the RMA gave notice of its intention to carry out an investigation in respect of aircraft flight as a factor in lumbar spondylosis in the context of Statements of Principles concerning lumbar spondylosis Nos 37 & 38 of 2005, as amended by Instrument Nos. 78 & 79 of 2008. The RMA invited eligible persons or organisations authorised so to do to make submissions in writing. On 22 April 2010, the RMA under subsections 196B (2) and (3) of the VEA determined amending Statements of Principles concerning lumbar spondylosis Nos. 36 & 37 of 2010. The amending Statements of Principles took effect from 3 May 2010.

24. On 3 May 2010 the Statements of Principles were registered on the Federal Register of Legislative Instruments.

25. On 11 May 2010 in accordance with section 42 of the *Legislative Instruments Act 2003* the Statements of Principles were tabled in the House of Representatives and in the Senate.

Second Application for review by the Council

26. An Application for Review of Statements of Principles concerning lumbar spondylosis Nos. 37 & 38 of 2005 as amended by Statements of Principles Nos. 78 & 79 of 2008, and 36 & 37 of 2010 was received by the Council on 29 June 2010 (the second Application). The second Application contended that the Statements of Principles should be amended to provide lower exposure thresholds for helicopter crews.

27. The second Applicant contended that helicopter crews are subject to greater vibration and less adjustable seating than powered aircraft crews and had more limited opportunity for movement in flight.

28. Pursuant to section 196ZB of the VEA the Council published, in the Gazette No. 2, 20 January 2010, a Notice of its Intention to Carry Out a Review under section 196W of the Act of all the information available to the RMA when it determined, amended or last amended the Statements of Principles concerning lumbar spondylosis and invited eligible persons or organisations authorised so to do to make submissions to the Council.[7] The Council gazetted subsequent notices as to the dates by which written submissions must be received by the Council.[8]

---

7 Gazette Notice No. GN 35, 9 September 2009 p. 2358.

8 Gazette Notice No. GN 43, 3 November 2010 and Gazette Notice No. SG231, 30 December 2010.

The information sent by the RMA to the Council - Second Application

29. By letter dated 13 May 2011 the RMA, under section 196K of the VEA, sent to the Council the information the RMA advised was available to (before) it at the relevant times, as listed in Appendix B.

30. The information which was available to (before) the RMA at the relevant times was posted on FILEForce on 24 May 2011 in accordance with the arrangements detailed in paragraph [19] above and made accessible to the Commissions, the Applicants and other participants in the review via confidential password.

Second Applicant's Position

31. The second Applicant advised the Council by electronic mail of 22 July 2011 that

> … there was concern amongst aviation medicine practitioners and other ADF health personnel that there was a discrepancy between the treatment of fixed wing and helicopter aircrew in the RMA Statements of Principles relating to back problems…
>
> … While initially the above concern was reinforced, I [am] satisfied that no such discrepancy existed, at least in relation to lumbar spondylosis. This would certainly be supported by the evidence base available to the RMA.
>
> … no change is required at this time.
>
> … no submission will be provided.

32. The Council took account of the second Applicant's position in making the preliminary decision on the proposed scope of review.

Notification of Preliminary Decisions on Proposed Scope of Review and Proposed Pool of Information

33. In separate letters, dated 20 October 2011, to each of the first Applicant, the second Applicant and the Commissions, the Council in summary:

- advised of the Council's preliminary decisions on the proposed scope of the review and proposed pool of information;
- invited the Applicants and Commissions to make any written comments as to the Council's preliminary decisions by close of business on 17 November 2011; and
- advised that if any written comments were made, any complementary oral comments could be made at a hearing of oral submissions complementing the written submissions.

34. No comments were received.

35. The Council held a meeting on 20 February 2012 to consider all the written submissions and complementary oral submissions.

Proposed Scope of Review

36. The Council's preliminary decision on the scope of the review, as advised to the Applicants and the Commissions on 25 October 2011, was as follows:

> Without limiting the scope of the Council's review of (some or the whole of) the contents of the Statements of Principles, the Council presently proposes to have particular regard to whether there was sound medical-scientific evidence upon which the RMA could have relied to amend either or both of the Statements of Principles in any or all of the following ways:
>
> a) the possible inclusion of a factor or factors in respect of:
>
> repetitive or persistent flexion, extension or twisting of the lumbar spine.
>
> b) and, the possible excision or amendment of the factors:
>
> (1) referred to at paragraphs (ja) and (sa) of Statement of Principles No. 37 of 2005, as amended by Statements of Principles Nos 78 of 2008 and 36 of 2010:
>
> (ja) flying in a powered aircraft as operational aircrew, for a cumulative total of at least 2500 hours within the ten years before the clinical onset of lumbar spondylosis;
>
> and
>
> (sa) flying in a powered aircraft as operational aircrew for a cumulative total of at least 2500 hours within the ten years before the clinical worsening of lumbar spondylosis;
>
> (2) referred to at paragraphs (ia), (iaa), (ra) and (raa) of Statement of Principles No. 38 of 2005 as amended by Statements of Principles Nos. 79 of 2008 and 37 of 2010:
>
> (ia) flying a powered aircraft for a cumulative total of at least 5000 hours within the ten years before the clinical onset of lumbar spondylosis; or
>
> (iaa) flying in a helicopter as operational aircrew, for a cumulative total of at least 5000 hours within the ten years before the clinical onset of lumbar spondylosis:
>
> (ra) flying a powered aircraft for a cumulative total of at least 5000 hours within the ten years before the clinical worsening of lumbar spondylosis; or
>
> (raa) flying in a helicopter as operational aircrew, for a cumulative total of at least 5000 hours within the ten years before the clinical worsening of lumbar spondylosis:

Proposed Pool of Information

37. As mentioned above, the RMA is obliged under section 196K of the VEA to send to the Council all the information that was available to it (the RMA) at the relevant times. That comprises all the information that was available to the RMA when it determined, in 1995, the original Statements of Principles concerning lumbar spondylosis and all the information subsequently available at all times when the

Statements of Principles were amended, or revoked and replaced, up to and including the information that was available in 2010 when the RMA determined the amending Statements of Principles Nos. 36 & 37 of 2010. In other words, within 28 days after being notified that the Council has been asked to conduct a review, the RMA must send to the Council all the information in respect of lumbar spondylosis which was in the possession of the RMA at the time it (the RMA) made the decision that triggered the Council's review.

38. The chronology of the RMA sending the information to the Council is detailed in [18], [19], [29] and [30] above. As mentioned above, all the information which was available to the RMA at the relevant times was made available to the Applicants and the Commissions for the purposes of the review.

39. In determining its preliminary view on the proposed pool of information the Council applied the methodology it had advised the Applicants and Commissions on 25 October 2011 i.e. that the pool of information should comprise the information:

i) that was available to (before) the RMA at the relevant times;

ii) which was sent by the RMA to the Council under section 196K of the VEA;

iii) which was considered by the Council to be sound medical-scientific evidence as defined in section 5AB(2) of the VEA being information which:

(1) epidemiologists would consider appropriate to take into account; and

(2) in the Council's view 'touches on' (is relevant to) the contended factor/s; and

which has been evaluated by the Council according to epidemiological criteria, including the Bradford Hill criteria.[9]

40. Information which the RMA advised was not available to (not before) the RMA at the relevant times, was not taken into account by the Council for the purposes of the review, as it could only be considered as 'new information'.

41. A copy of the Council's preliminary list of the proposed pool of information was forwarded to the Applicants and the Commissions on 24 October 2011.

FIRST APPLICANT'S SUBMISSIONS AND COMMENTS ON THE PROPOSED SCOPE OF THE REVIEW AND PROPOSED POOL OF INFORMATION DECISIONS

42. The first Applicant made two written submissions to the RMA and to the Council, which were taken into account by the Council.

43. In his Application to the Council of 28 February 2006, the first Applicant stated that his grounds for review were the absence of reasons by the RMA for the deletion of

9 See Bradford Hill, A 1965, 'The Environment and Disease: Association or Causation?', *Proceedings of the Royal Society of Medicine* Section of Occupational Medicine, Meeting January 14, pp. 295 - 300.

factors included in the 2002 Statements of Principles concerning 'twisting and turning' from the 2005 Statements of Principles:

> The removal of this subsection factor, ie. Twisting and Turning for the acceptance of lumbar spondylosis is detrimental to the ….care and welfare of the many injured veterans…. I have not seen any reason for its removal …

44. A further written submission by the first Applicant dated 19 August 2011 was received by the Council on or about 19 August 2011. In it the first Applicant submitted that the processes whereby the RMA had determined a factor in 2002 for repetitive or persistent flexion, extension or twisting of the lumbar spine, and had subsequently removed it in 2005 were doubtful:

> I submit that none of the RMA members have every (sic) served on a ship at sea whether in fine or stormy conditions so they would have supposedly carried out a full investigation of the factor originally when it was first included in 2003, it smacks of Political Cost savings when a factor goes through the initial process to be included then suddenly in two years it is withdrawn with out any consultation.
>
> Does that mean the members of the original RMA board who inserted the original factor … did not carry out their due process properly in the first case.

45. As mentioned above, the first Applicant also made an oral submission complementing his written submission.[10]

46. In his oral submission complementing his written submissions, the first Applicant contended there was no justification for removal in 2005 of the factor that had been included in the Statements of Principles in 2002:

> I'm taking they were doing their job at the time and no one is saying they weren't, so why, after that factor was included into the balance of probabilities and the reasonable hypothesis, why was it three years later, in 2004, suddenly there was another review and that factor was deleted after all the sound medical advice and revision was used to include it in the first place?
>
> …there was no justification to take it out when they had already considered it and said there was enough sound medical and scientific knowledge to have it included in the first place.

47. The first Applicant referred the Council to a paper by Andrea Radebold MD[11] dated 28 February 2010, about which he said:

> …lateral bending with flexion and extension and axial rotation with lateral bending will cause lumbar spondylosis.

---

10 The discussion of the first Applicant's submissions set out in these Reasons is derived from the written submissions and the complementary oral submission here identified.

11 Radebold, A. & Young, C.C 2010, 'Lumbosacral Spine Sprain/Strain Injuries, Medscape Reference © 2011 WebMD, LLC, http://emedicine.medscape.com/article/95444-differential

48. The first Applicant submitted that the literature cited by the Commissions in their written submissions did not address the experiences of military personnel, and that there is:

> …nothing in all the … studies that are quoted in these papers - mining, etcetera, lumberjacks ...that have anything whatsoever to do with a military way of life.

49. The first Applicant claimed that his experiences and those of his colleagues in the Australian Navy are relevant to the question.

> Now, you're on a ship at sea. That ship is twisting; it's rocking in a way that it's going up and down.
>
> We run up and down decks and ladders 24 hours a day, seven days a week and we …. vibrate in our bodies 24/7 the whole time we're on a ship… twisting and turning …running up and down ladders …

50. The first Applicant clarified to the Council in the course of the oral hearing that his contention was that twisting and turning alone, without an association with prolonged bending forward and lifting, should be included as a factor in the Statements of Principles but went on to contend the factor, as it stood in 2002, should be included.

51. The first Applicant made no written submission in respect of flight factors but at the oral hearing he submitted that the flight factors which were contained in the revoked 2002 Statements of Principles concerning lumbar spondylosis should be reinstated. His contention was that the factors in Statements of Principles Nos. 46 and 47 of 2002 were more generous to service personnel than the factors which presently apply and must have had some medical scientific basis which should now prevail. The first Applicant declined to indicate any evidence in support of that contention.

52. The first Applicant made no written or oral comment on proposed scope of the review and proposed pool of information decisions.

SECOND APPLICANT'S SUBMISSIONS AND COMMENTS ON THE PROPOSED SCOPE OF THE REVIEW AND PROPOSED POOL OF INFORMATION DECISIONS

53. Consistently with the position mentioned at [31] above, the second Applicant made no written (and consequentially no complementary oral) submission.

COMMISSIONS' SUBMISSIONS AND COMMENTS ON THE PROPOSED SCOPE OF THE REVIEW AND PROPOSED POOL OF INFORMATION DECISIONS

54. Two submissions were made by the Repatriation Commission to the Council for review. The submissions were also made on behalf of the Military Rehabilitation and Compensation Commission.

55. The first written submission dated March 2010 was made in respect of flexion, extension, twisting of the spine. The Commissions submitted that the available sound medical scientific evidence on heavy physical activity is adequately reflected in the existing factors for carrying and lifting and did not support the inclusion of an additional factor for 'flexion, extension, twisting of the spine'.

56. A second submission in respect to the aircraft flight factors was made in July 2011. The Commissions submitted there is no sound medical scientific evidence that was available to the RMA to depart from the RMA's conclusions as reflected in the current Statements of Principles.

57. A Medical Officer with the Department of Veterans' Affairs, representing the Commissions, made an oral submission complementing the Commissions' written submission at the Council's meeting on 20 February 2012.[12] This officer was the principal author of the two written submissions.

Commissions' submissions on 'flexion, extension, twisting of the spine'

58. In their first written submission the Commissions addressed the reinstatement of the factors that were in Statements of Principles No. 46 and 47 of 2002 and which were omitted from Statements of Principles No. 37 and 38 of 2005, that concerned:

> …repetitive or persistent flexion, extension or twisting of the lumbar spine for at least one hour each day on more days than not for at least 10 years

that the Commissions submitted, without reference to heavy physical activity, could have been met by someone undertaking normal activities of every day living.

59. The Commissions outlined the history of manual activity factors in Statements of Principles concerning lumbar spondylosis and noted that in earlier versions of these instruments, there were factors dealing with twisting of the spine and with lifting and carrying loads, which were later removed or modified.

60. In the Commissions' submission:

> … the evidence that was available to the RMA establishes that it is more probable than not that lumbar spondylosis can be caused by heavy physical activity …

61. The Commissions' stated approach was to address 'flexion, extension, twisting of the lumbar spine', and to look more generally at evidence of the potential association between the role of physical activity and lumbar spondylosis.

62. The Commissions specifically excluded 'areas such as acute injury, vehicle driving and whole body vibration' from their submissions and focussed on the evidence for specific types and quantities of physical activity and how, in the Commissions

[12] The information upon which the Commissions relied, being information which the RMA advised was available to (before) the RMA at the relevant times, is listed in Appendix E.

submissions, the factors for these activities should be constructed to best reflect the sound medical scientific evidence.

63. The Commissions submitted that the quality of available evidence was not high, and that most of the relevant studies were cross-sectional studies of lumbar spine disorders.

64. In his oral submission, the Commissions' representative submitted that given the shortage of medical-scientific evidence before the RMA about lumbar spondylosis, further investigation of the types of activities undertaken by the Applicant could be warranted.

65. The Commissions concurred with the Council's preliminary decision on the proposed pool of information.

66. The Commissions made submissions on 13 occupational studies, four athlete studies and five general population studies from the information that was available to the RMA at the relevant times.

67. Of the occupational studies, the Commissions cited:

67.1. **Seidler et al 2001**[13] in respect of which the Commissions submitted that it is a study:

> …providing the best available evidence. It is the only analytical study. It has the best exposure information, allowing for a dose-response assessment. It has the best information on specific types of activities. However, it is not without shortcomings. There is potential for selection and recall bias. Most notably, odds ratios always overestimate relative risk when the odds ratio is above one. The more prevalent the disease and the higher the odds ratio, the greater the overestimate. For a highly prevalent disease such as lumbar spondylosis, the high reported odds ratios in the Seidler et al study provide a significant overestimate of the risk from heavy physical activity.

The Commissions submitted that the study:

> …investigated the relationship between degenerative change in the lumbar spine and cumulative occupational exposure to lifting and carrying and to working postures with extreme forward bending.

and found:

> …a positive association between cumulative exposure to lifting/carrying and risk of symptomatic lumbar spine degeneration, with a significant dose response trend ($p < 0.0005$)

[13] Seidler A, Bolm-Audorff U, Heiskel H, Henkel N, Roth-Kuver B, et al 2001, 'The role of cumulative physical work load in lumbar spine disease: risk factors for lumbar osteochondrosis and spondylosis associated with chronic complaints', *Occupational & Environmental Medicine*, vol. 58, no. 11, pp. 735-46. (RMA ID 24299)

and a statistically significant odds ratio of 8.5 for the highest exposure category (> 150,000 kg2 x hours). Working for 10 years or more in an occupation with a high physical workload was also a significant risk factor (OR 6.5, 95% CI 2.7 to 16.1 vs. low physical workload).

and that:

> Cumulative hours spent working in a posture involving > 90º of trunk flexion was also associated with an increased risk of symptomatic lumbar spine degeneration….

The Commissions noted further that the study found:

The odds ratio for > 1500 hrs working in that posture was 3.5 (95% CI, 1.5 - 7.9). This odds ratio was adjusted for the effects of lifting and carrying. The majority of cases in the highest category for hours of extreme forward bending were also in the highest category for cumulative lifting and carrying (29 of 34).

67.2. **Brinckmann et al 1998**[14] in respect of which the Commissions submitted the study:

…compared the lateral lumbar spine X-rays of 355 male subjects from five cohorts with long-term heavy occupational loading of the lumbar spine with those from 737 male subjects who had undergone X-ray for pre-employment medicals, minor back complaints or complaints unrelated to the lumbar spine.

The Commissions noted that:

Frequent lifting and handling of objects weighing 50 kg or more and/or the handling of heavy objects in confined spaces or over uneven ground was associated with significant decreases in disc height in the lumbar spine. Disc height changes were most marked in the underground miners but not significantly different from the controls …

67.3. **Lawrence & Aitken-Swan 1953**[15] in which, the Commissions submitted, the authors found:

…a higher prevalence of low back pain and clinically diagnosed disc disorders in underground coal miners than in non-miners.

67.4. **Kellgren & Lawrence 1952**[16] in which the Commissions submitted the authors:

---

14 Brickmann P, Frobin W, Biggemann M, Tillotson M, Burton K 1998, 'Quantification of overload injuries to thoracolumbar vertebrae and discs in persons exposed to heavy physical exertions or vibration at the workplace. Part 11 Occurrence and magnitude of overload injury in exposed cohorts.' *Clinical Biomechanics*, vol. 13, Suppl 2, pp. 1-36.

15 Lawrence, J.S. & Aitken-Swan, J. 1952, 'Rheumatism in Miners: Part I: Rheumatic Complaints', British *Journal of Industrial Medicine*, vol. 9, pp. 1-18.

16 Kellgren, J.H. & Lawrence, J.S. 1952, 'Rheumatism in miners', *British Journal of Industrial Medicine*, vol. 9, pp. 197-207.

…further investigated a subset of the miners from the above survey (Lawrence & Aitken-Swan (1953)), carrying out a more detailed clinical and radiological study in males aged 40 to 50 years. Moderate to severe radiological lumbar disc degeneration was significantly more prevalent and widespread in underground coal miners than in manual (engineering yard) workers or office workers. There was a clear association between degenerative change on X-ray and lumbar-sciatic pain. However, only half the subjects with moderate or severe radiological degenerative changes had such pain.

67.5. **Lawrence 1955**[17] in which the Commissions submitted that the authors:

…sought to explain the findings from the above surveys of miners (Kellgren & Lawrence (1952)), by further investigating risk factors associated with underground mining, including heavy lifting and posture.

An assessment based on headroom at different coalfaces and the need for working in a stooping or kneeling position found that work posture had a possible influence (not reaching statistical significance) but was less important than injury or duration of lifting.

67.6. **Kellgren and Lawrence 1958**[18] which the Commissions submitted found:

…a higher prevalence of moderate or severe lumbar disc degeneration … in coal miners (79%) than in (male) cotton mill workers (65%) or other miscellaneous workers (55%). The same pattern was seen for lumbar apophyseal joint osteoarthritis (41% v 24% v 21%)

67.7. **Lawrence et al 1966**[19]**,** which the Commissions submitted found that:

… radiological lumbar disc degeneration was more prevalent in foundry workers (with at least 10 yrs work) than in an age-matched general population sample. However, apophyseal joint arthritis in the lumbar spine was significantly more prevalent in the controls.

67.8. **Hult 1954**[20]**,** which the Commissions submitted was a large scale survey in Sweden of neck and back problems in selected workers (aged 25 to 59) which demonstrated that:

Radiological degenerative changes in the lumbar spine were more prevalent in the heavy workers…The difference in the extent of pronounced degenerative change between heavy

17 Lawrence, J.S. 1955, 'Rheumatism in coal miners. Part III Occupational factors', *Brit J Industr Med*, vol. 12, pp. 249-261. (RMA ID 5528)

18 Kellgren, J.H. & Lawrence, J.S. 1958, 'Osteoarthrosis and disc degeneration in an urban population', *Ann Rheum Dis*, vol.17, pp.388-397. (RMA ID 13036)

19 Lawrence, J.S. Molyneux, M.K. & Dingwall-Fordyce, I. 1966, 'Rheumatism in foundry workers'. *Brit J Industr Med*, vol. 23, pp. 42-52. (RMA ID 13248)

20 Hult, L. 1954, 'Cervical, dorsal and lumbar spinal syndromes: a field investigation of a non-selected material of 1200 workers in different occupations with special reference to disc degeneration and so-called muscular rheumatism', *Acta Orthopaedica Scandinavica Supplementum*, vol.17, pp. 7-102. (RMA ID 12293)

and light workers was particularly evident in subjects aged 45 and older. More than 90% of all subjects aged 55 to 59 had some radiological signs of lumbar disc degeneration.

67.9. **Caplan et al 1966[21],** that the Commissions submitted:

…assessed radiological degenerative change in the lumbar spines of coal miners aged 40 years and over in Pennsylvania...

and found that:

…duration of heavy work was associated with the presence of osteophytes in older subjects (55 to 64). Prior history of back injury was associated with both disc narrowing and osteophytes (results unadjusted for age).

67.10. **Sairanen et al 1981[22],** which the Commissions submitted found:

…no association … between length of work as a lumberjack and prevalence of lumbar disc degeneration. A history of low back pain was reported by half the subjects with normal radiographic findings and two-thirds of those with degenerative changes.

67.11. **Katevuo et al 1985[23]** that the Commissions submitted:

….compared spine X-rays in 30 to 59 year old Finnish dentists and farmers, finding more lumbar disc and apophyseal joint degeneration in the farmers, particularly those 49 years and under.

67.12. **White et al 1993[24],** that the Commissions submitted:

…found a higher prevalence of radiological degeneration in the lumbar spine in female middle-aged physical education teachers in England than in age- and sex-matched general population controls ($p < 0.001$). However, the control subjects reported more low back pain.

67.13. **Luoma et al 1998[25]** that the Commissions submitted:

---

21 Caplan, P.S. Freedman, L.M. & Connelly, T.P. 1966, 'Degenerative joint disease of the lumbar spine in coal miners - a clinical and x-ray study', *Arthritis and Rheumatism*, vol. 9, no. 5, pp. 693-702. (RMA ID 12293)

22 Sairenen, E. Brushaber, L. & Kaskinen, M. 1981, 'Felling work, low-back pain and osteoarthritis', *Scandinavian Journal of Work, Environment and Health*, vol. 7, pp.18-30. (RMA ID 1537)

23 Kalevi, K. Kalle, A. Risto, L. & Juhani, P. 1985, 'Skeletal changes in dentists and farmers in Finland', *Community Dent Oral Epidemiol*, vol. 13, pp. 23-5. (RMA ID 12958)

24 White, J.A. Wright, V. & Hudson, A.M. 1993, 'Relationships between habitual physical activity and osteoarthrosis in ageing women', *Public Health*, vol. 107, pp. 459-470. (RMA ID 1506)

25 Luoma, K. Riihimaki, H. Raininko, R. Luukkonen, R. Lamminen, A. & Viikari-Juntura, E. 1998, 'Lumbar disc degeneration in relation to occupation', *Scand J Work Environ Health*, vol. 24, pp. 358-366. (RMA ID 23201)

…compared lumbar spine MRI findings in machine drivers, carpenters and office workers aged 40 to 45 years in Finland. Degenerative changes were significantly associated with a history of back injury, but not with heavier occupational physical activity.

67.14. **Evans et al 1989**[26] that the Commissions submitted:

…compared lumbar MRI findings in ambulatory and sedentary workers (meter readers and customer service representatives in Colorado), finding no difference in the prevalence of disc degeneration in the males but a significantly higher prevalence of disc degeneration in the sedentary females.

68. Of the studies in athletes the Commissions cited:

68.1. **Videman et al 1995**[27] about which the Commissions submitted:

The athletes had less recent back pain than the controls. Weight lifters had more lumbar degenerative changes than other athletes. There was no difference in the extent of degenerative change between runners and shooters, but soccer players had greater lower lumbar degeneration. After controlling for age and occupational loading, elite level weight lifting (over more than 20 years) could explain only about 10% of the disc degeneration that was seen in that group.

68.2. **Lundin et al 2001**[28] that the Commissions submitted:

…found that former elite athletes (27-39 yrs) from a range of sports had no more back pain than control subjects. They did not report on the extent of degenerative change by type of activity.

68.3. **Sward et al 1991**[29] that the Commissions submitted:

….found considerably more disc degeneration in the thoracolumbar spines of Swedish male national gymnasts vs non-athletes (75% vs 31%).

68.4. **Healy et al 1996**[30] that the Commissions submitted:

---

26 Evans, W. Jobe, W. & Seibert, C. 1989, 'A cross-sectional prevalence study of lumbar disc degeneration in a working population', *Spine*, vol.14, pp. 60-64. (RMA ID 23489)

27 Videman, T. Sarna, S. Battie, M.C. Koskinen, S. Gill, K. Paananon, H. & Gibbons, L. 1995, 'The long-term effects of physical loading and exercise lifestyles on back-related symptoms, disability and spinal pathology among men', *Spine*, vol. 20, no. 6, pp. 699-709. (RMA ID 23490)

28 Lundin, O. Hellstrom, M. Nilsson, I. & Sward, L. 2001, 'Back pain and radiological changes in the thoraco-lumbar spine of athletes. A long-term follow-up', *Scand J Med Sci Sports*, vol. 11, pp.103-109. (RMA ID 23336)

29 Sward, L. Hellstrom, M. Jacobsson, B. Nyman, R. & Peterson, L. 1991, 'Disc degeneration and associated abnormalities o the spine in elite gymnasts', *Spine*, vol. 16, pp. 437-443. (RMA ID 23488)

30 Healy, J. Healy, B. Wong, W.H. & Olson, E.M. 1996, 'Cervical and lumbar MRI in asymptomatic older male lifelong athletes: frequency of degenerative findings', *Journal of Computer Assisted Tomography* vol. 20, pp. 107-112. (RMA ID 23485)

…observed significant lumbar degenerative changes in MRI findings of 16 of 19 male athletes, none of whom reported symptoms. The study used no control group but reported that the prevalence of degenerative change was 'similar to that seen in other populations'.

69. Of the other studies, the Commissions submitted:

69.1. **Battie et al 1995** [31] as finding:

…heavier lifetime occupational and leisure physical loading was associated with greater disc degeneration in the upper lumbar levels.

69.2. **Biering-Sorensen et al 1985**[32] as being:

A Danish population study of 60 year olds (which) found current heavy physical labour to be associated with X-ray observed lumbar disc degeneration.

69.3. **O'Neill et al 1999**[33] as:

Heavy physical activity was also associated with lumbar osteophytosis but in men only, in a UK population sample, reported by O'Neill et al (1999).

69.4. **Videman et al 1990**[34]:

In an autopsy study **Videman et al (1990)** found an association between vertebral osteophytosis and heavy work; whereas symmetrical disc degeneration was related to sedentary work.

The spinal pathology was seen least in subjects with moderate or mixed physical loading

69.5. **Julkunen et al 1981**[35] as finding:

… that antero-posterior X-rays of a large general population sample demonstrated a positive association of both prevalence and 6-year incidence of thoracic spondylosis with 'arduousness of work' examined in categories.

---

31 Battie, M.C. Videman, T. Gibbons, L.E. Fisher, L.D. Manninen, H. & Gill, K. 1995, 'Determinants of lumbar disc degeneration. A study relating lifetime exposures and magnetic resonance imaging findings in identical twins', *Spine*, Vol. 20, no.24, pp.2601-12. (RMA ID 23491)

32 Biering-Sorensen, F. Hansen, F. Schroll, M. & Runeborg, O. 1985, 'The relation of spinal x-ray to low-back pain and physical activity among 60-year old men and women', *Spine*, vol. 10, no. 5, pp. 445-51. (RMA ID 23487)

33 O'Neill, T. McCloskey, E. Kanis, J. et al 1999, 'The distribution, determinants, and clinical correlates of vertebral osteophytosis: a population based survey', *J Rheumatol*, vol. 26, pp. 842-8. (RMA ID 23209)

34 Videman, T. Nurminen, M. &Troup, J.D.G. 1990. 'Lumbar spine pathology in cadaveric material in relation to history of back pain, occupation, and physical loading', Spine, vol. 15, no. 8, pp.728-40. (RMA ID 13778)

35 Julkunen, H. Knelt, P. & Aromaa, A. 1981, 'Spondylosis deformans and diffuse idiopathic skeletal hyperostosis (DISH) in Finland', *Scand J Rheumatology*, vol.10, pp. 193-203. (RMA ID 12917)

70. The Commissions concluded by submitting that collectively, the studies available to the RMA were methodologically weak and are only able to demonstrate associations, not properly test for causation. Only the **Seidler** case-control study addressed the particular disease as defined by the current Statements of Principles.

71. The Commissions submitted that the cited studies showed only a moderate degree of correlation between the extent of degenerative changes on imaging and the presence and severity of clinical signs. Degenerative changes are strongly associated with age and most of the studies inadequately controlled for the role of age.

72. The Commissions also submitted that there was a lack of control for other potential founders; crude exposure assessment potential biases in selection, classification and recall. Although confounding by discrete injury may be a problem, there is some evidence, particularly from the Lawrence study, that the effect of heavy physical activity is independent from discrete injury.

73. In the Commissions' submission, the Seidler case-control study presented the best available evidence. Its methods of exposure allowed for a dose-response assessment.

74. However, the Commissions also submitted that there were shortcomings in this type of study, which the Commissions contended has the potential for recall and selection bias, with the consequence that the odds ratio in the **Seidler et al** study would be an overestimation of the risk from heavy physical activity, because odds ratios are overestimates when the disease is highly prevalent, resulting in a significant over-estimate of the risk from heavy physical activity.

75. The Commissions submitted that despite the limitations, the cross-sectional studies provided support for the Seidler et al study, and overall it is more probable than not that lumbar spondylosis can be caused by long-term heavy physical activity. Carrying or lifting heavy loads is, in the Commissions' submission, the component of heavy physical activity that is most consistent with the evidence and quantifiable.

76. In regard to the position of the spine, the Commissions contended that the available evidence lends support to the notion that heavy physical work in awkward postures may increase the risk of lumbar spondylosis. The Commissions referred in particular to the Seidler study, which mentions 'extreme forward bending', and the Brinckmann and Lawrence papers concerning working with low head heights and submitted

> …undertaking heavy physical work in awkward posture could over-burden the spine by increasing or redirecting the biomechanical load on the spine.

77. The Commissions submitted that this association appears less strong than that for lifting and carrying.

78. The Commissions opposed a return to earlier versions of the factor, pointing out that the 2002 version of the Instruments (46 and 47) did not distinguish between the

flexion, extension and twisting required in heavy lifting, and that which might occur in normal daily activities.

> In the Commissions' view, the available evidence does not support the contention that flexion, extension or twisting per se adds to the risk of developing lumbar spondylosis. These are normal activities of the spine.

79. The Commissions also expressed doubt about the need for an additional Statement of Principles for heavy physical activity carried out in awkward postures.

80. In an oral submission complementing the Commissions' written submission, the Commissions' representative said that:

> ... in 1999 the … repetitive or persistent flexion/extension [factor] was put into the Statements of Principles in the context of undertaking physical activity.

but that in 2002, the Statements of Principles were amended to include:

> …a stand-alone "lifting and carrying" factor and a separate "repetitive or persistent flexion, extension or twisting" factor ...without any connection to undertaking physical activity.

81. He submitted that in the Commissions' view, the factor in the earlier 1999 Statements of Principles,

> … was more reflective of the evidence than the 2002 version (and)
>
> … there is good evidence for heavy lifting and carrying… not so good evidence (for)… sustained forward bending…

and that while there may be a case for reintroducing an additional factor for sustained forward bending, this would be:

> … another parameter of heavy physical activity, because it is in that context that we've got the evidence.

82. He said that the Commissions did not support a stand alone bending and twisting type factor:

> …without the concomitant heavy physical activity.

Commissions' submissions on flight factors

83. A further written submission by the Commissions was made in relation to the second Application for review and concerning powered aircraft and helicopter flight factors in Statements of Principles No 36 and 37 of 2010. This submission

complemented the Commissions' previous submission[36] which related to flexion, extension and twisting of the spine. The second submission focussed on:

- flying powered aircraft;
- flying in a powered aircraft as operational aircrew; and
- flying in a helicopter as operational aircrew

84. The Commissions concluded their written submission:

> On the information available, the Commissions see no evidence, apart from the Applicant's contention itself, to depart from the RMA's conclusions as reflected in the current Statements of Principles.

Revised proposed Scope of Review and Revised proposed Pool of information

85. After the oral hearing the Council revised its preliminary decision on the scope of the review in respect of flight factors.

86. As noted above [26], the second Applicant sought review of Statements of Principles concerning lumbar spondylosis Nos. 37 & 38 of 2005 as amended by Nos. 78 & 79 of 2008, and Nos. 36 & 37 of 2010. The Amendment Statements of Principles Nos. 78 & 79 of 2008 and Nos. 36 & 37 of 2010 concerned factors (ja), (ia), (iaa), (ra), (raa) and (sa) of Statement of Principles No. 37 of 2005, which all concern flying in aircraft or helicopters (flight factors).

87. The second Application contended that the Statements of Principles should be amended to provide lower exposure thresholds for helicopter crews, however that contention was withdrawn by the second Applicant who subsequently informed the Council that the accuracy of the current Statements of Principles in respect of the flight factors was accepted. The Commissions contended for no change to the flight factors.

88. The first Applicant made no written submission in respect of the flight factors. At the oral hearing however, he did make the submission noted above [51].

89. Section 196ZA (3) of the VEA entitles interested persons to make an oral submission complementing the written submission. The first Applicant made written submissions only in respect of repetitive or persistent flexion, extension or twisting of the lumbar spine and not in respect of the flight factors. The Council has taken the first Applicant's written and oral submissions on repetitive or persistent flexion, extension or twisting of the lumbar spine into account in reaching its decision.

90. The Council tentatively decided that, as neither the second Applicant nor the Commissions contended for any change to the flight factors, it would not include those factors in the scope of the review. The Council tentatively decided that the scope of the review identified on a preliminary basis (see [36]) in respect of repetitive or persistent flexion, extension or twisting of the lumbar spine should comprise the review, that is:

---

[36] p. 3

91. Without limiting the scope of the Council's review of (some or the whole of) the contents of the Statements of Principles, the Council presently proposes to have particular regard to whether there was sound medical-scientific evidence upon which the RMA could have relied to amend either or both of the Statements of Principles in any or all of the following ways:

    a) the possible inclusion of a factor or factors in respect of:

        repetitive or persistent flexion, extension or twisting of the lumbar spine.

92. By letter dated 16 January 2013, the Council informed the first Applicant, the second Applicant and the Commissions of the Council's revised proposed scope of the review and revised proposed pool of information and invited them to make any written comments as to the Council's revised view on scope and pool by close of business on 8 February 2013.

93. The only comments received were from the first Applicant who reminded the Council of his oral comments. The Council noted his comments and, as noted above, that the first Applicant's oral submission on the flight factors did not complement his written submission and most importantly, identified no medical science to support any change to the flight factors in the Statements of Principles.

Final Scope of Review

94. The Council's final view on the scope of the review, having taken account of the first Applicant's comments was that it should comprise only the issue noted at [51& 88] above.

Final Pool of Information

95. The Council's final decision on the pool of information was that it should comprise the sound medical-scientific evidence it had identified on a revised preliminary basis as listed in Appendix A.

96. In reaching this decision, the Council took into account the written submissions and complementary oral submissions and considered whether any of the information, to which it was referred, could or should be in the pool.

97. As mentioned above, the Council noted the first Applicant's references to and submissions concerning information which was not available to (not before) the RMA (see Appendix C). As mentioned above, the Council in its review was unable to (and so did not) consider information which was not available to (not before) the RMA at the relevant times.

REASONS FOR THE COUNCIL'S DECISION

The Council's Task

98. In conducting a review the Council follows a two-step process. As its first step, the Council identified the pool of sound medical scientific information. The Council identified, from all the information that the RMA sent to the Council[37], the sound medical-scientific evidence[38] which in its view is relevant to the issue of whether repetitive or persistent flexion, extension or twisting of the lumbar spine could provide a relevant connection between lumbar spondylosis and service.

99. The second step required the Council to determine whether:

99.1. there is sound medical-scientific evidence in the pool that indicates ('points to' as opposed to merely 'leaves open'[39]) whether exposure to repetitive or persistent flexion, extension or twisting of the lumbar spine (if found to exist in a particular case) could provide a link or element in a reasonable hypothesis connecting lumbar spondylosis to relevant [40] service.[41] The Council had to find that the hypothesis contended for was reasonable and not one which was 'obviously fanciful, impossible, incredible or not tenable or too remote or too tenuous.' [42]

99.2. on the sound medical-scientific evidence in the pool, exposure to repetitive or persistent flexion, extension or twisting of the lumbar spine (if found to exist in a particular case) could provide a relevant connection between lumbar spondylosis and relevant [43] service according to a standard of satisfaction 'on the balance of probabilities', or as being more probable than not.

100. In these Reasons the association for both the reasonable hypothesis test (at 99.1] and the balance of probabilities test at [99.2]) are respectively referred to as the 'relevant association'.

101. It was with these tests firmly at the forefront of its collective mind that the Council considered the sound medical-scientific evidence in the pool of information and the submissions made by the first Applicant and the Commissions referable to the matters within the scope of review.

---

37 See paragraphs [18] [19], [29] [30] above.

38 As that term is defined in section 5AB(2) of the VEA (see [8] above)

39 See full Federal Court decision at [49] per Branson J.

40 Relevant service here refers to operational, peacekeeping and hazardous service, British nuclear test defence service, and warlike or non-warlike service as those terms are defined in the VEA and the MRCA.

41 See *Vietnam Veterans' Association of Australia (NSW Branch) Inc v Specialist Medical Review Council and Anor* (2002) 69 ALD 553 (Moore J decision) per Moore J at [29].

42 See the full Federal Court decision in *Repatriation Commission v Bey* (1997) 79 FCR 364 which cited with approval these comments from Veterans' Review Board in *Stacey* (unreported 26 June 1985), all of which were in turn cited with approval in the Moore J decision at [33].

43 Relevant service here refers to eligible war service (other than operational service), defence service (other than hazardous service and British nuclear test defence service) and peacetime service as those terms are defined in the VEA and the MRCA.

102. In forming its judgement on whether there is sound medical-scientific evidence that indicates (ie 'points to' as opposed to merely 'leaving open') the relevant association, the Council was conscious that the reasonable hypothesis test is ‘a test of possibility’ [44] and ‘an unusually light burden.’[45] If the reasonable hypothesis test was found not to be satisfied, the balance of probabilities test necessarily could not be met.

DOES THE SOUND MEDICAL - SCIENTIFIC EVIDENCE, 'POINT TO' OR 'LEAVE OPEN' THE RELEVANT ASSOCIATION?

103. As mentioned above, having settled the pool of information, the second question for the Council to consider was whether the sound medical-scientific evidence in the pool of information 'points to' a contended factor in the scope of the review as a link or element in a reasonable hypothesis connecting lumbar spondylosis to relevant service (see para [9] and footnotes), and if so, whether the relevant association exists on the balance of probabilities (see para [9] and footnotes).

132. The only basis upon which the Council can review the contents of a Statement of Principles is by reviewing all the information that was available to (before) the RMA at the relevant times, in order to ascertain whether there was sound medical-scientific evidence upon which the RMA could have relied to amend either or both of the Statements of Principles.

133. The Council considered all the articles in the pool. However, the Council in these Reasons focused its discussion upon its analysis of those articles in the pool which it considered most pertinent to the scope of review.

134. Ultimately, matters of weight are questions for the Council in the exercise of its expertise and scientific judgement, noting that the Councillors are appointed to a particular review because of their specialist expertise in the particular condition (in this case lumbar spondylosis) and the matters within the scope of the review.

THE COUNCIL'S ANALYSIS OF THE INFORMATION BEFORE THE RMA

Preliminary comment on lumbar spondylosis

135. Set out below are some general and introductory comments on lumbar spondylosis and the Council's analysis of the information in the pool.

136. Lumbar spondylosis is defined in the current Statements of Principles as:

> …degenerative changes affecting the lumbar vertebrae or intervertebral discs, causing local pain and stiffness or symptoms and signs of lumbar cord, cauda equina or lumbosacral nerve root compression, but excludes diffuse idiopathic skeletal hyperostosis and Scheuermann’s kyphosis.

---

44 See full Federal Court decision at [49] citing with approval Spigelman CJ in the New South Wales Court of Appeal decision at [111].

45 See full Federal Court decision at [55] per Branson J.

Lumbar spondylosis attracts ICD-10-AM codes M47.16, M47.17, M47.26, M47.27, M47.86, M47.87, M47.96, M47.97 or M51.3.

General observations

137. Lumbar spondylosis is a very common condition which typically affects individuals over the age of 60 years.

138. The Review Council for the review of Statements of Principles for Cervical Spondylosis Nos. 33 & 34 of 2005 (SMRC Declaration No. 15) included comments in its decision about the condition that this Council considers to be analogous to lumbar spondylosis:

> The Review Council recognise … spondylosis as a clinical diagnosis. It is a common disorder of poorly understood aetiology. Clinically, patients present with symptoms or signs, the causes of which are often difficult to determine.
>
> The contribution of external factors to the development of … spondylosis is difficult to investigate or verify. Degenerative changes … are common and are often asymptomatic. The correlation between the radiological assessment of degeneration, with changes in structure or function, and signs or symptoms experienced by the patient is generally accepted to be loose, but where investigative imaging reveals a close relationship between them, a diagnosis of … spondylosis can be made.
>
> It is difficult to document the postulated causal pathway … to degenerative change affecting the intervertebral discs or other structures of the spine, by clinical symptoms or signs, or by imaging. These difficulties are reflected in gaps in the evidence that appear in the academic literature.
>
> Scientific research into the pathology of the condition has predominantly focused on the objective evidence of degeneration in the spine (without the symptoms or signs which would meet the description 'cervical spondylosis' provided by the Statements of Principles) in the context of lengthy occupational exposures to various stresses with frequently inadequately documented related clinical findings. The major scientific challenge confronting this Council is to apply their collective expertise to interpret this apparently scant and patchy medical scientific evidence.[46]

139. Similarly to cervical spondylosis, the definition of lumbar spondylosis in the Statements of Principles has two main facets; the symptomatic features, e.g. pain and stiffness in the described lumbar regions, and the degenerative features of the spine, which are usually identified through imaging.

140. There is some discrepancy in the terminology used in the literature, as well as in outcomes measured. Often lumbar spondylosis equates in the literature to degenerative disc disease of the lumbar vertebrae, or specific degenerative features,

[46] Specialist Medical Review Council 2011, Reasons for Decisions, Re: Statements of Principles Nos. 33 & 34 of 2005 In Respect of Cervical Spondylosis, Specialist Medical Review Council, pp. 17-18

and may not always correspond to the diagnosis of lumbar spondylosis as specified by the Statements of Principles, which includes radiologically defined features combined with symptoms such as pain and stiffness.

141. Various terms used in the literature which have been applied to lumbar spondylosis are lumbar disc degeneration, (lumbar) degenerative disc disease, degenerative arthritis affecting the (lumbar) spine, osteoarthritis of the (lumbar) spine osteoarthrosis of the (lumbar) spine, and osteochondrosis.[47]

142. References are also made in the literature to 'rheumatism'. This is a very broad term referring to diseases of the joints and related structures, and involving pain and stiffness. This term is used less commonly now than it was in the past. Certain authors cited in this decision may have included lumbar spondylosis in the category of 'rheumatism', but not all rheumatism refers to lumbar spondylosis. For example rheumatic diseases may include 'rheumatoid arthritis' which is an autoimmune disease that is not related to lumbar spondylosis.

143. The term 'disc degeneration':

> is commonly used for an overall subjective impression of imaging findings, including signal loss, bulging, herniation, end plate irregularities, osteophytes and narrowing of the disc space.[48][49]

144. As noted in paragraph [36] above, the Council's preliminary decision on the scope of this review was: 'the possible inclusion of a factor or factors in respect of:

> Repetitive or persistent flexion, extension or twisting of the lumbar spine.

145. Whilst the first Applicant submitted to the Council in the course of the oral hearing that his contention was that twisting and turning alone, without an association with prolonged bending forward and lifting, should be included as a factor in the Statements of Principles he also went on to contend that the factor as it stood in 2002, should be included.

146. The Council noted he relevant factors in the Statements of Principles, until revocation in 2005, referred to:

> repetitive or persistent flexion, extension or twisting of the lumbar spine[50]

147. The Council noted there are two distinct aspects to the contention:

---

47 See Seidler et al 2001

48 Battie et al 2009, p50

49 Refer to Glossary of terms on pp.62-64 of these Reasons.

50 Clauses 5(k) and 5(x) of Statement of Principles concerning lumbar spondylosis No. 46 of 2002 and Clauses 5(j) and 5(w) of Statement of Principles concerning lumbar spondylosis No. 47 of 2002.

i) persistent (prolonged, forward) flexion (i.e. bending); and

ii) repetitive movement, such as extension or twisting.

148. In its consideration of the sound medical scientific evidence, the Council carefully considered how each study addressed either or both of these two aspects of the contended factor, noting that the terminology used within studies varied. For example, forward flexion was referred to in some studies as prolonged or sustained forward bending, forward bent posture, stooping/stooped posture and extreme stooping posture. Extension or twisting studies also refer to axial rotation or torsion.

149. For consistency and comprehension, within these reasons, the Council has retained the wording used for the two categories as outlined at [147] above.

150. The Council also noted that a number of the cited studies address the issue of heavy work and weight-bearing activities either separately or in conjunction with repetitive or persistent flexion, extension or twisting of the lumbar spine

151. As the current Statements of Principles have factors for 'carrying or lifting loads … while bearing weight through the lumbar spine', the Council has focused its consideration on repetitive or persistent flexion, extension or twisting of the lumbar spine and referred in these reasons to carrying or lifting loads in terms of exclusion or confounding.

THE REVIEW COUNCIL'S ANALYSIS OF THE INFORMATION IT CONSIDERED MOST IMPORTANT AS BEING POTENTIALLY REFERABLE TO THE CONTENDED FACTORS FOR 'REPETITIVE OR PERSISTENT FLEXION, EXTENSION OR TWISTING OF THE LUMBAR SPINE.'

Seidler, A. Bolm-Audorff, U. Heiskel, H. Henkel, N. Roth-Küver, B. Kaiser, U. Bickeböller, R. Willingstorfer, WJ. Beck, W. Elsner, G. 2001, 'The role of cumulative physical work load in lumbar spine disease: risk factors for lumbar osteochondrosis and spondylosis associated with chronic complaints.' *Occupational & Environmental Medicine*, vol. 58, no.11, pp.735-46. (RMA ID 24299)

152. The authors conducted a case-control study

> to investigate the relation between symptomatic osteochondrosis or spondylosis of the lumbar spine and cumulative occupational exposure to lifting or carrying and to working postures with extreme forward bending.[51]

153. Subjects were recruited from six German clinical centres. Cases were 229 males aged between 25 and 65 years with confirmed osteochondrosis[52] or spondylosis of

[51] p. 735

[52] Seidler et al used the terms ''oestochondrosis' and 'lumbar spondylosis' interchangeably and defined four specific categories classified according to criteria based on the number of osteophytes and the level of narrowing of the discs and number of discs affected:

0. Normal: no narrowing of intervertebral disc, no osteophytes

the lumbar spine and chronic low back pain complaints. Of these 135 also had reported acute lumbar disc herniation, and 94 had osteochondrosis or spondylosis, without disc herniation.[53]

154. Controls were 197 eligible males, all without history of back complaints: 107 from a general population sample of age matched males, 90 from a clinical sample of urolithiasis patients.

166. A validated questionnaire was used to document musculoskeletal symptoms.

167. Structured interviews were used to gather detailed occupational exposure data, including descriptions of the objects that had been lifted and carried. A formula for estimating cumulative exposure to lifting or carrying was used to incorporate duration, load weight and trunk flexion and standard coding was used for occupations. [54] This data was also used to construct a job exposure matrix.

168. Reliability testing found that agreement of the self-reported data was good to excellent.[55]

169. Logistic regression was used to adjust for: age, region, nationality, and conditions which might affect lumbar discs: malposition of hip or pelvis, leg length discrepancy, scoliosis. Other potential confounders explored were: smoking, body mass index, sedentary work; various sporting and recreational activities; and psychosocial factors.[56]

170. Low back pain was found to be strongly associated with radiographic signs of osteochondrosis or spondylosis with an odds ratio (OR) [57] of 5.4 and a 95% confidence interval (CI)[58] of 2.2-13.0.

171. Excluding cases with a history of lumbar disc herniation, high physical workload had a strong and significant association with symptomatic osteochondrosis or spondylosis (OR 6.5, 95% CI 2.7-16.1), with a marked dose-response relationship. Cumulated lifting/carrying >150,000kg had a strong association with these outcomes (OR 8.5, 95% CI 3.1-23.2).

172. The category of extreme forward bending (>90 degrees trunk flexion) for up to 1500 accumulated hours was associated with a significantly increased risk of symptomatic

---

1. Minimal osteochondrosis/spondylosis: minimal narrowing of intervertebral disc an/or minor osteophytes (2mm ventral or lateral)
2. Moderate osteochondrosis/spondylosis: moderate narrowing (maximum half of adjacent unaffected discs) and/or moderate osteophytes (3-5 mm ventral or lateral, 1-2mm dorsal)
3. Severe osteochondrosis/spondylosis: severe narrowing (more then half of adjacent unaffected discs) and/or severe osteophytes (>5mm ventral or lateral, >2mm dorsal).

53 p.735

54 p. 738 and table 1 at p. 739; (sum of forces, calculated in Newton hours, p.735)

55 p. 740

56 p. 741

57 The odds ratio – See Glossary

58 A confidence interval – See Glossary

osteochondrosis or spondylosis (OR 2.0, 95% CI 1.2 -3.5). This association increased when there were greater than 1500 accumulated hours (OR 4.3, 95% CI 2.3- 8.0).

173. When cases with disc herniation were excluded, there was a strong and statistically significant association between extreme forward bending >1500 accumulated hours and 'pure osteochondrosis or spondylosis' (OR 3.5, 95% CI 1.5-7.9).[59]

174. These associations showed highly significant trends when the exposure score was analysed as a continuous variable (p<0.00005); when herniation was included (p<0.003); and when herniation was excluded.

175. When lifting or carrying were combined with extreme forward bending, the risk was greatly elevated for 'pure osteochondrosis or spondylosis' (OR 18.2, 95% CI 4.8-68.4).

Council's comments

176. The Council considered this was a persuasive study in which the authors examined extreme flexion as a cause of lumbar disk degeneration and it is therefore directly relevant to that aspect of the proposed factor. Twisting of the lumbar spine was not studied.

177. The Council considered that the key potential problem with this paper is recall bias, i.e. people with lumbar spondylosis might over-estimate their prior exposure to load carrying and extreme flexion. Council noted the Commissions' submission about the potential for recall and selection bias, but noted that recall bias is a problem in all case-control studies, and could only be avoided in a prospective study and such studies do not exist in this field. In relation to the potential for selection bias the Council noted that selection bias can also be a problem in all case-control studies however the authors have done a reasonable job of selecting from a random population sample. The Council does not support the contention that selection bias is a major methodological problem of this study. The Council agreed with the Commissions that this study was the best available evidence.

178. The Council commented on the Commissions' further contention that the odds ratio in this study is an overestimation of the risk from heavy physical activity, because odds ratios are overestimates when the disease is highly prevalent, as this condition is, particularly in more aged populations. The Council agreed that odds ratios can be an overestimate compared to a relative risk, however the Council considered that this does not change the statistical significance of the findings and that it was not a serious flaw in this study.

179. Despite limitations, the Council considered this to be a paper as methodologically sophisticated as any in this area of interest. The authors examined quantified measures of occupational [prolonged] forward bending/flexion in relation to spondylosis and osteochondrosis.

180. The Council noted that Table 3 shows results for extreme flexion, with adjusted odds ratios for >1500 hours of extreme flexion of 4.3 (all subjects) and 3.5 (excluding

[59] p. 743 and Table 3 at p. 742

subjects who had disc prolapse) which the Council considered to be convincing of the relevant association.[60]

181. The Commission submitted that the effect of posture could not be disentangled from the effects of lifting and carrying, and that the majority of cases in the highest category for hours of extreme forward bending were also in the highest category for cumulative lifting and carrying (29 of 34).

182. The Council noted that the next part of the table attempts to disentangle heavy lifting from extreme flexion. It identifies a category of people who lifted ≤150,000 kg hrs[61] and who had extreme flexion ≥1500 hours. The ORs were 4.1 (all subjects) and 2.4 (excluding subjects who had disc prolapse). The OR of 2.4 for lumbar spondylosis was not statistically significant, but the Council considered this is probably due to small numbers. Whilst some of the increased risk was due to heavy lifting and carrying, the Council was of the view that the overall pattern of ORs is consistent with an increased risk associated with extreme flexion and bending.

183. The Council considered that this study:

- points to the relevant association with persistent (prolonged, forward) flexion; but
- does not touch on the relevant association with repetitive extension or twisting.

184. The Council further considered that this paper supports extreme flexion of greater than 1500 hours duration as a factor in a reasonable hypothesis connecting lumbar spondylosis with service.

Lawrence, J. S. Molyneux, M. K. & Dingwall-Fordyce, I .1966, 'Rheumatism in foundry workers'*, British Journal of Industrial Medicine*, vol. 23 pp. 42-52. (RMA ID 13248)

185. This cross-sectional/historical cohort study compared the prevalence of 'rheumatic diseases' and work time lost from these diseases, with population based controls. The authors selected from several foundries, 325 workers aged 35 to 74 years who had worked for at least 10 years on the foundry floor. 299 workers (a 92% completion rate) were examined clinically and radiologically for evidence of rheumatic disease. A comparison was made to series of radiographs from a male age-matched random population sample. Loss of time from work was by self-report in the foundry workers and compared to the expected number calculated from the population controls.

186. Lumbar disc degeneration was more frequent at all ages in the foundry workers (chi-square (X^2) of 4.5, P ≈ 0.04), who also had significantly increased prevalence of more severe degeneration compared with the controls.[62] This difference was even greater when miners were removed from the control group (p=0.001).

---

60 p. 742

61 Kilogram hours is a variable for measuring the physical workload, calculated by multiplying the estimated weight lifted (in kilograms) by the cumulative number of hours worked lifting the weight, eg at the theoretical extremes of the range, 150,000kg hrs would equal 1 kilogram lifted for a cumulated 150,000 hours or 150,000kg for 1 hour.

62 p.44

187. Various trades included in the foundries included moulders, core makers, welders as well as general labourers. Of these foundry workers, the moulders and general labourers showed the greatest frequency of disc degeneration. A higher prevalence of the most severe level of degeneration was found in moulders despite half of them being in the youngest age group.[63]

188. On the other hand, compared to controls, foundry workers had significantly less osteoarthrosis in the apophyseal joints of the lumbar spine as well as hips, knees and fingers. They also had lower levels of symptoms, i.e. those foundry workers who had lumbar degeneration reported less pain and took less time off work than expected, from the non-foundry controls.[64]

189. Overall, rheumatic complaints and prolonged incapacity were less frequent in foundry workers than the controls, but evidence of lumbar disc degeneration was more frequent and more severe, and lumbar disc prolapse was more frequent. The authors investigated the possible influence of radiant heat on these findings.

Council's comments

190. The Council noted that rheumatism is a general term referring to diseases of the joints and related structures, and involving pain and stiffness. Although the term is less commonly used, now than during the 1960's, it is used as an umbrella term in the title of this article. More specific outcomes of radiological evidence of lumbar disc degeneration are discussed within the study.

191. This study addressed both pain and radiological evidence however there were contradictory results in the foundry workers. The foundry workers had more lumbar disc degeneration, but reported less pain than the controls.

192. The Council considered that this study:

– leaves open the relevant association with persistent (prolonged, forward) flexion; but

– does not touch on the relevant association with repetitive extension or twisting.

Kellgren, J.H. & Lawrence, J.S. 1958, 'Osteo-arthrosis and disk degeneration in an urban population', *Ann Rheum Dis*, vol. 17. pp. 388-397. (RMA ID 13036)

193. This study aimed to investigate causative factors for osteoarthritis and disc generation, in particular a polyarticular form described as 'primary generalised osteo-arthritis', which had previously been shown to be very common in women in an urban population studied.

194. Using clinical, radiological, and serological examinations of a random sample of subjects from the town of Leigh[65], the authors looked at the number of affected joints and graded them into five levels of severity. The prevalence of signs of osteo-

63 p.44

64 pp. 49-50

65 Other studies by these authors explain that the town of Leigh had a high proportion of miners.

arthrosis[66] in the 55-64 age group was 87% in women and 83% in men (which the authors noted may have been slightly elevated due to a higher response from symptomatic persons).[67] Whilst women had more arthritis in the fingers and legs, men had a higher proportion of lumbar spine disk degeneration. Osteoarthrosis of the finger joints was associated with lumbar disc degeneration.

195. Both miners and cotton workers had significantly more osteoarthritis and disc degeneration than men in other, unspecified, occupations.

196. The authors noted that the most striking finding in respect of the miners was the excess of lumbar degeneration which was statistically significant ($p<0.003$)[68] and consistent with their earlier study (Kellgren & Lawrence 1952). The authors posited that this was closely related to mechanical stress due to coal mining.[69]

197. There were too few cotton workers to observe statistically significant excess prevalence.[70]

198. The study did not report any specific analysis of exposure to twisting, bending, or lifting.

Council's comments

199. The Council noted that this paper was less relevant in its analysis to the factors of interest than some of the other papers by the same authors. It did not touch upon twisting or bending specifically, although when viewed together with the series of articles by the same authors, it provided some background support for the other articles in the series, due to the consistency of results.

200. The Council noted that there was high prevalence of disc degeneration in the miners indicating that they had more lumbar spondylosis. These findings agreed with the findings of the earlier study discussed in these reasons (below), which suggested that prolonged stooping is one of the factors in mining that tends to increase the severity and frequency of disc changes. This study lacked sufficient statistical analysis for the Council to identify possible contributions of forward flexion (or twisting) to the prevalence of lumbar disc degeneration in minors.

201. The Council considered that the study:

– leaves open the relevant association with persistent (prolonged, forward) flexion; but

– does not touch on the relevant association with repetitive extension or twisting.

---

66 The term 'Osteoarthrosis' in relation to the spine was confined by these authors to disease in the apophyseal joints, whereas osteophytosis of vertebral bodies and narrowing of disk spaces were referred to as disk degeneration, per the classification of Collins (1949); as cited at p388.

67 p.388

68 p.391

69 p.396

70 p.391

Lawrence, J.S. & Aitken-Swan, J. 1952, 'Rheumatism in Miners: Part I: Rheumatic Complaints', *British Journal of Industrial Medicine*, vol. 9, pp. 1-18. (RMA ID 1286)

Kellgren, J.H. & Lawrence, J.S. 1955, 'Rheumatism in miners Part II: X-Ray Study', *British Journal of Industrial Medicine*, vol. 9, pp. 197-207. (RMA ID 13288)

Lawrence, J.S. 1955, 'Rheumatism in coal miners. Part III Occupational factors', *Brit J Industr Med*, vol. 12, pp. 249-261. (RMA ID 5528)

202. Lawrence and colleagues conducted a number of early epidemiological studies, including those mentioned in these Reasons and notably the three-part series titled 'Rheumatism in Miners', Part I: Rheumatic Complaints' (1952), Part II: X-Ray Study (1952) and 'Part III: Occupational Factors' (1955). Whilst published separately, the studies follow sequentially, based initially on a large population sample from the coal-mining town of Bedford. Each subsequent study builds on the findings of the preceding one(s).

203. Part 1 of the series, **Lawrence, J.S. & Aitken-Swan, J. 1952**[71]**,** reported on investigations into the incidence of these conditions during a five year period.

204. The investigators surveyed all men employed at the Bedford colliery at Leigh, (just over 1000) of which 80% worked underground.[72] Additional surveys included families of the miners, workers at an engineering yard, office staff and a random sample of the town of Leigh.

205. In total the survey included 1742 male miners from three mines; 1939 non-miners, and 1935 females from mining families. The survey questioned rheumatic complaints based on the preceding five-year-period and each person's working conditions. The miners were questioned about the duration of work underground and postures used, specifically, kneeling and stooping.[73]

206. A range of diagnostic categories were used. Where the history and physical signs were definite enough for a diagnosis, such as rheumatoid or osteo-arthritis to be made, this was recorded as the cause of pain. A category of 'disc disorders' was used to separate those conditions from 'the mass of painful disorders of undetermined nature'. Disc disorders were defined as 'recurrent low back pain, which would formerly have been classified as osteoarthritis of the spine or spondylosis... (including those few) …considered to have had definite disc prolapse'.[74]

207. The authors stated that there were 'some issues with case ascertainment', especially differentiating between undetermined pain and pain due to disc degeneration.

208. Overall, rheumatic complaints were found to be no more frequent in the miners than in the population as a whole, however the rheumatic conditions had greater impact on their working lives and there was evidence of earlier onset of symptoms, with a steeper

71 Lawrence, J.S. & Aitken-Swan, J. 1952, 'Rheumatism in Miners: Part I: Rheumatic Complaints', British Journal of Industrial Medicine, vol. 9, pp. 1-18. (RMA ID 1286)

72 Lawrence & Aitken-Swan 1952, p. 1

73 Lawrence & Aitken-Swan 1952, p.2 - 3

74 Lawrence & Aitken-Swan 1952, p. 3

rise in the fourth decade.[75] A contrasting pattern in females and non-mining males was found. In all age groups, females (all non-miners) and non-mining males from mining families had less overall rheumatic complaints than females or non-mining males from non-mining families,[76] which the authors noted argued convincingly against hereditary or home environment factors in the 'rheumatism' of miners.[77]

209. There was a higher frequency of complaints in the back and hips in the miners than in the non-miners at all ages, which was 'most marked in the fourth decade'.[78]

210. The authors included all miners, rather than a sample, which they noted reduced the risk of sampling error.[79]

211. The survey relied primarily on subjects' recall of the past five years. A clinical examination was carried out only when a history of rheumatic pain was reported.[80]

212. The study detailed in Part II of the sequence is Kellgren, J.H. & Lawrence, J.S. 1952.[81] For this part of the series, the authors selected a subset of the population studied in Part I with the aim of a detailed investigation of pain in relation to disc degeneration, osteo-arthritis, or rheumatic disorders of uncertain nature.[82] The study was confined to males in the fifth decade of life. Clinical symptoms and radiological features of 84 miners and 87 non-miners (45 manual and 42 office workers) were examined in detail. An additional 24 men who had worked both underground and on the surface were studied for additional comparison. All films were read by four observers, sometimes two or three times. Variation in interpretation of the films did not appear to the authors to be a serious source of error.[83]

213. Few differences were found in characteristics between groups, other than in the exposures and outcomes of investigation.[84] Any congenital abnormalities were documented.

214. Clinical examination revealed the following: 10 of 11 participants with painful disability of the back were miners. Loss of lordosis was observed in 33 miners and only 18 non-miners. Signs of arthritis of the hip were found in three miners and no non-miners.

> Altogether, signs (of disability) in the lumbar spine and knees, hips, and elbows were found predominantly in the miners, but signs in the wrists and shoulders were, if anything, more common in the other groups.[85]

---

75 Lawrence & Aitken-Swan 1952, p. 11

76 Lawrence & Aitken-Swan 1952, p. 5 and Table 1, p. 7

77 Lawrence & Aitken-Swan 1952, p. 11

78 Lawrence & Aitken-Swan 1952, pp. 5 -7

79 Lawrence & Aitken-Swan 1952, p.1 and appendix 2, p.17

80 Lawrence & Aitken-Swan 1952, p.3

81 Kellgren, J.H. & Lawrence, J.S. 1952, 'Rheumatism in miners Part II: X-Ray Study', British Journal of Industrial Medicine, vol. 9, pp. 197-207. (RMA ID 13288)

82 Kellgren & Lawrence 1952, p.197.

83 Kellgren & Lawrence 1952, pp.199-200; also appendix p. 206

84 Kellgren & Lawrence 1952, p.198

215. Radiological signs of disc degeneration in the lumbar spine were clearly more predominant amongst the miners. Comparing workers with no disc degeneration, there was a highly significant difference between miners and manual workers (P<0.001). Such differences between the groups were not found in the cervical spine.[86] There were also significantly more miners with three or more discs affected (P=0.05) and with greater severity (P<0.05), compared to manual workers. [87]

216. Radiological change was also significantly associated with lumbar sciatic pain.

217. In the third part of the sequence, **Lawrence, J.S. 1955[88]** the author explored some of the factors and mechanisms which might potentially explain the findings in Parts I and II, that miners lost more working time from rheumatic complaints and had more frequent and severe changes both of disc degeneration and osteoarthritis of the knees and other joints. Part III of the study investigated the relative effect of work at the coal-face and in the roadways, the effect of damp, posture and of heavy lifting.[89]

218. As detailed in Part I, the Bedford miners had been accustomed to roof heights of between 3ft and 4 ft.[90]

219. Initially it was found that 'rheumatic complaints reached a maximum in two peaks, one at a seam with a roof height of 3ft to 3ft 5ins (mainly faceworkers) and the other with a seam height of 4ft 6 to 4ft 11 ins (mainly roadworkers). The author considered they were not able to determine the effect of posture alone on this information because

    (1) …comparison of face workers and roadway workers introduces other variables, and can not be used to determine the effect of posture.[91]

220. Therefore, in Part III of the study, the investigators compared the face workers to a sample of men from two other collieries (Sandhole and Mosley) who worked in coal seams with roof heights of 4ft 6in to 5ft 6ins.[92] These miners

    … had a similar (dry) climate to the Bedford workers but had to adopt a stooping position and did not kneel.[93]

---

85 Kellgren & Lawrence 1952, p.198

86 Kellgren & Lawrence 1952, p.201 and Table 4, p. 202

87 Kellgren & Lawrence 1952, p.200-201

88 Lawrence, J.S. 1955, 'Rheumatism in coal miners. Part III Occupational factors', Brit J Industr Med, vol. 12, pp. 249-261. (RMA ID 5528)

89 Lawrence 1955, p.250

90 Lawrence 1955, p.249. Part I of the study recorded Bedford Colliery employed just over 1,000 men. Of these some 80% worked underground, 43% at the coal face and the remainder on the roadways or at miscellaneous sites. **Lawrence, J.S. & Aitken-Swan, J. 1952,** 'Rheumatism in Miners: Part I: Rheumatic Complaints', *British Journal of Industrial Medicine*, vol. 9, pp. 1-18. (RMA ID 1286) p.1. At the time of the survey three seams were being worked. Two of these were machine-operated and had a roof-height of 3ft. 3 in. The third was higher, 6 to 8 ft, and worked by hand.

91 Lawrence 1955, p 249

92 Lawrence 1955, p.249

93 Lawrence 1955, p. 252

221. Miners were divided into roadway and face workers and the latter further subdivided according to height of roof and wet or dry conditions. [94]

222. A sample of dockworkers was also studied. Altogether, four occupation groups were compared: miners, dockers, light manual workers and office workers.

223. Routine lumbar spine radiographs were judged independently by two observers blinded to the occupational and symptom status of the subjects.[95]

> They [Sandhole Mosley workers] complained rather more than the Bedford workers of back-hip-sciatic pain, had 50% more incapacity, and nearly three times as much prolonged disability. The radiological changes, however, were no greater and the number of discs affected was also very similar[96]

224. The authors then further analysed the data according to the roof height at which the miner had worked for the greatest time, and by both the number of discs affected and severity. Whilst the miners working at a roof height of up to 3ft 5ins had most frequent radiological changes, severe change was found in both 3ft 5ins and 4ft to 4ft 5 ins.[97] However the distribution of these outcomes was not consistently correlated with roof height.

> The radiological differences were below accepted levels of significance and gave no clear evidence that there is a pathological basis for the increased disability at these roof heights though they certainly do not exclude such a basis.[98]

225. When duration of time spent stooping was analysed, pain, loss of work and prolonged disability were most frequent in men who had worked for 15 to 25 years in a stooped position.

> Those who had stooped less or more than this, less often complained…
>
> … The physical signs … became less with prolonged stooping, but radiological changes became increasingly severe and involvement of multiple discs increasingly more probable. The increase of severity, however, was not marked and was within the limits of chance, but there were significantly more men with five or six discs involved amongst the prolonged stoopers (over 30 years P = 0.02).[99]

226. This overall increase in severity of degeneration was not explained by history of back injury.[100] The authors could not exclude the possibility of a pathological basis for the changes in relation to roof heights.[101] They concluded:

> Prolonged stooping thus appears to have an adverse effect on the intervertebral discs but there is some measure of adaptation with persistence at this type of work...

---

94 Lawrence 1955, p. 250

95 Lawrence 1955, p.250

96 Lawrence 1955, p.252

97 Lawrence 1955, p.252

98 Lawrence 1955, p.255

99 Lawrence 1955, p.255

100 Lawrence 1955, p.255, 258

101 Lawrence 1955, p.252 & Fig. 2 at p. 253

> The alternative that those most susceptible to pain go over to work of a different nature and so do not develop such severe changes must, or course, be considered. In either event it would appear that prolonged stooping is one of the factors in mining which tends to increase the severity and frequency of disc changes.[102]

227. Statistically non-significant increase in symptoms was also shown in those who had carried out heavy lifting for more than 30 years. Incapacity for work increased with the duration of heavy lifting.[103] Prolonged disability was four times as common in those who had worked over 30 years at the coal face, and this difference was statistically significant ($p<0.01$).[104]

228. Marked differences were also found between the miners and light or office workers. Miners and dockers had similar frequencies of complaints and of radiological change but the miners had elevated severity (12% in miners vs 2% in dockers with highest grade of radiological change; 36% vs 18% respectively for involvement of four or more discs).[105]

Council's comments

229. The Council noted that rheumatism is a general term referring to diseases of the joints and related structures, and involving pain and stiffness. Although the term is less commonly used now than during the 1960s, it is used as an umbrella term in this series of papers. More specific outcomes of radiological evidence of lumbar disc degeneration are discussed within the study.

230. The Council noted that this series is a very early but a seminal work in the area of an evaluation of a particular occupational group/s – one of the first epidemiological studies.

231. The Council further noted that the first part of the study provided descriptive statistics on the mining population, and analysed the different rates of spinal disc disorders in miners compared to non-miners. However it did not analyse the specific activities of the miners, an issue which is addressed to some extent in Part III[106] of the study.

232. Part II of the series examined both the clinical signs and radiological evidence of disc degeneration which are features of spondylosis.

233. While Part II of the series did not specifically report on the exposure of persistent (prolonged, forward) flexion, the Council considered it to be useful in identifying the elevated prevalence of lumbar problems in miners. Part III of the study more specifically addressed stooping or persistent (prolonged, forward) flexion.

234. The Council considered Part III to be particularly relevant because of the differences in pain and in the evidence of disc changes in the miners required to work in extreme stooping postures, compared to those required to stoop less.

---

102 Lawrence 1955, p.255

103 Lawrence 1955, p.254

104 Lawrence 1955, p.255

105 Lawrence 1955, p.251

106 Lawrence, 1955, RMA ID 5528

235. The Council noted the Commissions' submission that the assessment in this study, showed only a possible influence (not reaching statistical significance) of stooping on lumbar spondylosis, which was less important than injury or duration of lifting.

236. The Council considered that Part III when read in conjunction with the preceding papers in the series contributed to a combined body of evidence which indicated an association between persistent flexion and lumbar spondylosis. Confidence in the results from this paper was strengthened by the supporting information from the overall series of studies of miners.

237. The Council considered that as a group, the study series:

- points to the relevant association with persistent (prolonged, forward) flexion; but ;
- did not touch on the relevant association with repetitive extension or twisting.

238. The Council further considered that this paper, read in conjunction with the preceding papers in the series:

- provides sufficient evidence for the Council to be satisfied on the **balance of probabilities** of the relevant association between persistent (prolonged forward) flexion and lumbar spondylosis.

Sward, L. Hellstrom, M. Jacobsson, B. Nyman, R. & Peterson, L. 1991, 'Disc degeneration and associated abnormalities of the spine in elite gymnasts. A Magnetic Resonance Imaging Study.' *Spine*, vol. 16, no. 4, pp. 437-43. (RMA ID 23488)

239. This was a Magnetic Resonance Imaging (MRI) comparison study of 24 Swedish male elite gymnasts aged 16-29 and 16 male non athletes aged 23-26 years as referents. Three examiners rated the MRIs blinded to the identity of the individuals.

240. Back pain was reported by 79% of the gymnasts and only 38% of the referents. Back pain was significantly associated with reduced disc signal intensity ($p<0.01$). Signs of disc degeneration (defined as reduced disc signal) in the thoracolumbar spine were found to be significantly more common in the gymnasts (75%), in comparison to non-athletes (31%). Higher frequencies of other abnormalities were also found in the gymnasts (reduced disc height; posterior disc bulging, Schmorl's notes, apophyseal ring abnormalities and abnormal configuration of the vertebral body) although the differences for these were not statistically significant. As the non-athletes were slightly older, the authors suggested that this difference may have been underestimated.[107]

Council's comments

241. The Council acknowledged certain limitations of the study, which include the retrospective recall of other risk factors, use of non-standard survey instruments, and a lack of adjustment for potential confounders; the small sample group and the non-

[107] Sward et al 1991, p. 439

matched aged group. However, its strengths include objective findings using MRI and clear evidence of the athletes' training history.

242. The Council noted that this paper dealt with male gymnasts, who, while exerting flexion and rotation forces are also adding a considerable amount of lifting force through their own body weight in gymnastic manoeuvres. The Council considered that the observed effects could be attributed at least in part to the lifting force and/or that repeated small trauma to the spine [due to years of gymnastic manoeuvres] could be a mechanism involved in the degeneration.

243. The Council noted that whilst the study numbers were small, male elite gymnasts had greater frequency of radiological symptoms as well as pain.

    The Council considered this to be a reasonable study that touched on the factor of interest. The Council could not separate the effects of twisting and bending from those of the force of body weight. The study demonstrated the difficulty in this field of disentangling the different factors involved in the causation of disc degeneration and lumbar spondylosis.

244. The Council considered that the study:

– leaves open the relevant association with persistent (prolonged, forward) flexion; and

– leaves open the relevant association with repetitive extension or twisting.

Lundin, O. Hellström, M. Nilsson, I. & Swärd, L. 2001, 'Back pain and radiological changes in the thoraco-lumbar spine of athletes. A long-term follow-up'. *Scandinavian Journal of Medicine and Science in Sports*, vol. 11, no.2, pp.103-109. (RMA ID 23336)

245. This study follows up an earlier study in which 173 young elite athletes and non-athletes were compared using radiological evidence. It focused on the correlation between back pain and disc degeneration. Selection to the initial study was without prior knowledge of subjects' back injury or pain status, and assessors, blinded to the identity and status of the participants, graded the images by number of abnormalities.[108]

246. This follow-up study, 12-15 years later, radiologically re-examined 134 of the athletes representing four different sports and 28 of the non-athletes (94% of the initial participants).[109] Blinded comparisons were made to the subjects' previous x-ray films and current back pain was analysed in relation to radiological evidence of spinal abnormalities.

247. In the initial study the athletic groups had reported back pain at frequencies of 50-85%. At follow-up, after the gymnasts had retired from competitive sports, this had decreased from 85% to 67% in male gymnasts, whereas the frequency remained the same in the other athletes (50-68%).[110] The authors commented:

[108] pp.103-104

[109] p.104

[110] p. 106

> It is possible to speculate that the reduction in back pain among the male gymnasts depends on the reduction in the traumatic load on the spine. Although no overall difference in back pain between different groups of athletes or between athletes and non-athletes could be demonstrated, it is noteworthy that severe back pain was more common in wrestlers than in the other groups of athletes or non-athletes.[111]

248. None of the gymnasts were still active at top elite level but most were still physically active. There was no difference in the reported back pain between the athletes (60%) and non-athletes (61%). Severe back pain was more common in the group of wrestlers (54%)[112] than in other groups of athletes (29%-37%) or non-athletes (32%), but no statistical analysis or adjustment for other variables was made.

> In the initial study, the authors found a significant increase in the number of radiological abnormalities among athletes (Hellstrom et al., 1990[113]) and a correlation to back pain (Sward et al., 1990[114]). …
>
> In the present follow-up study, there was no longer any significant correlation between the number of radiographic abnormalities and back pain. The only significant correlation was between the interval deterioration in the disc space height and back pain.[115]

249. From the first to the second examination there was significant correlation between disc height reduction and back pain (*P*= 0.005), and also between the number of discs deteriorated and back pain (*P*=0.0003).[116]

> …when the progression of disc height reduction or new disc height reduction between the two examinations was studied in the entire material, a significant relationship between disc height reduction and back pain was found (p=0.005) (Fig.1). A significant correlation between the number of discs that had deteriorated and back pain was also found (p=0.0003) (Table 4).[117]
>
> …
>
> Despite a higher frequency of radiographic abnormalities among the groups of athletes, they did not report significantly more back pain than the non-athletes.[118]

Council's comments

250. The Council noted that this was a follow-up of an earlier study by Sward et al 1990[119] but considered the results at follow-up to be less persuasive than the results reported

---

111 p. 106

112 p. 105

113 Helstrom M, Jacobsson B, Sward L, Peterson L. Radiologic abnormalities of the thoraco-lumbar spine in athletes. Acta Radiol 1990. 31: 127-132. This article was not available to the RMA.

114 Sward L, Hellstrom M, Jacobsson B, Peterson L. Back pain and radiological changes in the thoraco-lumbar spine of athletes. Spine 1990: 15: 124-129. This article was not available to the RMA.

115 p. 107

116 p. 106 and Table 4, p 105

117 p. 106

118 p.107

119 Sward L, Hellstrom M, Jacobsson B, Peterson L. Back pain and radiological changes in the thoraco-lumbar spine of athletes. Spine 1990: 15: 124-129. This article was not available to the RMA.) A related paper also cited by the authors is discussed in these Reasons: Sward, L. Hellstrom, M. Jacobsson, B. Nyman, R. & Peterson, L. 1991, 'Disc degeneration and associated abnormalities o the spine in elite gymnasts', *Spine*, vol. 16, pp. 437-443. (RMA ID 23488).

by the authors in their original study, as the athletes had less pain at the second examination.

251. The Council considered that the study:

– leaves open the relevant association with persistent (prolonged, forward) flexion; and

– leaves open the relevant association with repetitive extension or twisting.

Hardcastle, P. Annear, P. Foster, D.H. Chakera, T.M. McCormick, C. Khangure, M. & Burnett, A. 1992, 'Spinal abnormalities in young fast bowlers', *J Bone Joint Surg [Br],* vol. 74-B, pp. 421-425. (RMA ID 12921)

252. In a small Australian imaging series, the investigators examined a group of 24 (cricketing) fast bowlers, aged16-18 years. The authors noted that:

> The action of fast bowling applies large forces to the spine, taking place as many as 300-500 times per week, and involving extension, lateral flexion and thoracolumbar rotation (Cotta and Neithard 1984). Low back pain is common and many young fast bowlers are lost to the game because of this (Evans, Jobe and Seibert 1989)[120]

253. The fast bowlers were examined and questioned about low back pain and its association with cricket. All had MRI scans, 22 had radiographs, and CT scans. 20 had video and high-speed film biomechanical analyses of their bowling actions. A control group of 13 batsmen from the same age group had clinical assessment and MR scans (but apparently not CT scans or radiographs).

254. Radiographs, CT, and MR images were analysed, revealing that 12/22 had pars interarticularis defects; 14/22 had disc degeneration.

255. Seven of the 13 batsmen also had evidence of disc degeneration. None had spondylolisthesis visible on MR, but 'spondylosis could not be excluded without radiography'.[121]

256. The study found a 19% incidence of spondylolisthesis in the bowlers, much higher than the normal Caucasian population rate of 5%-7%. Spondylolysis was seen in 35% but no figure for normal incidence was available.[122]

257. Degenerative disc disease was found in 63% of the bowlers, and in 53% of the batsmen, evenly distributed throughout the lumbar spine, but more common at the lower levels. The authors considered these rates to be a much higher incidence than shown in previous studies.[123]

---

120 p. 421

121 p. 424

122 p. 424

123 p. 424

258. The bowling actions of the young bowlers were classified according to the rotation and counter-rotation.[124]

259. Eleven of the 13 subjects with pars interarticularis defects had pain when bowling. The only fast bowler who did not experience pain used an unusual bowling action with counter-rotation movement. Only two of the bowlers had completely normal spinal images and neither had any pain.

260. All ten of those who rotated >10 degrees between the line of the shoulders and the back foot had pain and degenerative signs. All but one of the 6 who rotated < 10 degrees also had radiological abnormalities. Two of the four who used lateral flexion had no abnormalities.[125]

261. The study concluded that:
   - Young fast bowlers have a high incidence of disc degeneration and pars interarticularis defects.
   - Pain was always associated with a radiological abnormality.
   - Abnormal rotation and/or hyperextension before delivery of the ball appears to cause a significantly higher incidence of both conditions
   - Rotation seemed to be the main cause of unilateral defects.[126]

Council's comments

262. The Council considered this study to be relevant to the repetitive extension or twisting factor because it indicates that a rotation of more than 10 degrees may induce lower back pain in fast bowlers. However, five of the six bowlers whose technique involved rotation of < 10^{o} had radiologic evidence of disc degeneration whereas six of the 10 whose technique involved > 10^{0} had disc degeneration.

263. The Council noted that the fast bowlers appeared to have very high rates of lumbar disc degeneration (63%) and pain; and the batsmen, who also used extension but to a lesser degree, had a lower but still apparently high frequency (53%) of lumbar disc degeneration.

264. The Council was not persuaded that the findings of this study apply more broadly to the general population because of the specific characteristics of the subjects of the study (cricketers). Fast bowlers are known to develop stress fractures (spondylolysis) resulting from repeated traumas which the Council considered may be the mechanisms for the development of pain and spondylolisthesis in these subjects.[127] The Council further noted the existence of Statements of Principles concerning spondylolisthesis and spondylolysis,[128] and that having spondylolisthesis of the lumbar spine before clinical onset or worsening on lumbar spondylosis is currently a factor in the Statements of Principles concerning lumbar spondylosis.

---

124 p. 424

125 p. 424

126 p.425

127 p.421.

128 Statement of Principles concerning Spondylolisthesis and Spondylolysis Nos. 5 & 6 of 2006 as amended.

265. The Council considered that the study:

– does not touch on the relevant association with persistent (prolonged, forward) flexion; and

– touches on, but leaves open, the relevant association with repetitive extension and twisting.

White, J.A. Wright, V. & Hudson, A.M. 1993, 'Relationships between habitual physical activity and osteoarthrosis in ageing women, *Public Health*, vol. 107, pp.459-470. (RMA ID 1506)

266. The authors investigated the possible contribution of habitual physical activity to osteoarthrosis development in terms of biomechanical factors. They compared the prevalence of osteoarthrosis symptoms in women with a history of regular sporting activity, to that of a general population study of British women published by the Arthritis and Rheumatism Council (ARC).[129]

267. The subjects were a sample group of female physical education teachers aged 48-60 years. Validated questionnaires were completed by 577 (84%) of 844 subjects invited to participate, and x-rays were obtained for 365 of these subjects, and graded by two independent radiologists.

268. Results revealed a significantly higher prevalence of degenerative joint disease in the lumbar spine of the subjects aged 48-60 than in the general population women aged 45-60 ($X^2=52.70$, $p<0.001$). The prevalence of degeneration was highest at L3/L4 followed by L4/L5 and L2/3.[130]

269. The authors did not report any data on specific types of physical loading.

Council's comments

270. The Council considered this to be a reasonable epidemiological study. It compared women in the study to a general population sample, and used x-rays. However, the study did not provided details on the type of physical activity in which the subjects were engaged.

271. The Council considered that the study may point to some type of association between physical activity and the condition of interest, but the type of physical strain and loading cannot be isolated from the available information in the study.

272. The Council considered that the study:

– leaves open the relevant association with persistent (prolonged, forward) flexion; and

– leaves open the relevant association with repetitive extension or twisting.

[129] pp. 459-461

[130] pp. 463 and Figure 1 at p. 464.

Videman, T. Sarna, S. Battié, M.C. Koskinen, S. Gill, K. Paananen, H. & Gibbons, L. 1995, 'The long-term effects of physical loading and exercise lifestyles on back-related symptoms, disability, and spinal pathology among men', *Spine*, vol. 20, no. 6, pp. 699-709. (RMA ID 23490)

273. This historical cohort study of 937 former elite Finnish athletes and 620 control subjects investigated the long term effects of exercise on back pain and degenerative changes; following previous findings that certain athletic activities may accelerate spinal degeneration, some physical loading was associated with spinal pathology or increased reports of symptoms, and some types of loading may protect against spinal degeneration.

274. The former athletes were selected from eight different sports with clearly different physical loading patterns and grouped according to the type of training undertaken; running, soccer players, weight lifters, and shooters. Controls were selected from a Finnish military register[131] of men who were classified as completely healthy at age 20 years and who were matched against each athlete in age and residence.

275. Demographic and health data were obtained from linked hospital, population, and social welfare records. A questionnaire was sent to all respondents under 65 years and a sub-group was examined by MRI.

276. Outcomes examined included long-term pain, spinal pathology, and back-related symptoms. Adjusted cumulative 16-year incidence rates of these outcomes were calculated and compared between the various athlete groups and controls and expressed as odds ratios.[132] Sport participation and a graded occupational physical loading, based on a five-point scale, were used as predictors.

> 1 = mainly sitting; 2 = mainly walking and standing; 3 = a variety of tasks including some bending and twisting, but seldom lifting more than 35kg; 4 = a variety of tasks with bending, twisting and lifting more than 35kg daily; and 5 = very heavy jobs including maximal lifts in bent and twisted positions.[133]

277. The athletes with the highest daily 'twisted or bent' scores were running and weight lifting, but all four sports involved some daily twisting or bending.[134]

278. All the athlete groups had reduced odds of back pain in relation to the control subjects. Differences between the athlete groups and controls in back-related hospitalisation rates and pensions, adjusted for age and occupational loading, were not statistically significant.[135]

279. Heavy occupational load was a covariate found to be associated with back pain (OR 3.1, $p<0.001$) as was forced work pace (OR 1.8, $p<0.05$). Heavy occupational load also significantly increased the risk of back-related pension (OR 4.6, $p<0.01$). A range of

131 A register of men eligible for Military service, p 700

132 p. 701

133 p. 702

134 p. 702, Table 3

135 P. 705, Tables 5 & 7

other covariates was explored cross-sectionally, and significant associations with back pain were found.

280. Three types of former athletes were compared with 'shooters' as referents, as the authors theorised that shooters 'enjoy elite athlete status and lifestyles, but do not experience extreme physical loading'.[136] On this comparison, weightlifters and soccer players had more degenerative findings than did shooters and runners. Weightlifters showed the greatest degree of disc degeneration, as expected from previous research. The authors considered to this to be consistent with their expectations.

> The higher incidence of findings throughout the lumbar spine would be expected, because weight lifting increases axial loading across the entire thoracolumbar spine to maximally tolerated levels, and includes increased loading mainly in flexion and extension. [137]

281. In all athletic groups, but particularly in the weightlifters and soccer players, there was a high incidence of dural sac compression, which the authors suggested may be due to high levels of axial, torsional and flexion movements. On the other hand, end plate irregularities were similar, which the authors considered pointed to irregularities developing before late adolescence or that physical loading is not the primary causal factor.[138]

Council's comments

282. The Council considered this to be an important study because of its epidemiological methods and larger sample size, and because athletes represent a group which may be exposed to torsion and flexion, particularly the weightlifters, who showed the highest degree of disc degeneration when compared with the other athletes.

283. However, the study did not disentangle twisting and bending from the confounding factor of heavy loading, as weightlifters had high overall loading in conjunction with bending.[139]

284. The Council noted that the Commissions submitted that:

> After controlling for age and occupational loading, elite level weight lifting (over more than 20 years) could explain only about 10% of the disc degeneration that was seen in that group.

285. The study also examined pain, and while it did not find increased pain in the athletes compared to the population controls, it did find an association with occupational load in relation to pain.

286. The Council considered that the study is generally supportive of an association between persistent (prolonged, forward) flexion or repetitive extension or twisting, in conjunction with heavy lifting, and lumbar disc degeneration; but

---

136 p. 706

137 p. 707

138 p. 708

139 p. 707

- leaves open the relevant association with persistent (prolonged, forward) flexion; and

- leaves open the relevant association with repetitive extension or twisting.

Battié, M.C. Videman, T. Kaprio, J. Gibbons, L.E. Gill, K. Manninen, H. Saarela, J. & Peltonen, L. 2009, 'The Twin Spine Study: contributions to a changing view of disc degeneration', The Spine Journal, vol. 9, pp. 47-59 (RMA ID 52587)

287. The authors reviewed the methods and findings of the Twin Spine Study, a multidisciplinary and multinational research project which investigated, most relevantly, determinants of disc degeneration including occupational exposures, driving and whole-body vibration exposure, smoking exposure, anthropomorphic factors, heritability, and the identification of genotypes associated with disc degeneration. The study, which began in 1991, included 147 monozygotic and 153 dizygotic male twin pairs, yielding a sample of 600 participants, selected from the large, representative, Finnish Twin Cohort. Participants were selected for the study based on discordance between twin siblings for a specific common behavioural or environmental factor (eg, sedentary or heavy occupational physical demands, routine exercise participation, or occupational driving.[140]

288. Various physical loadings through leisure and occupations, driving and associated whole-body vibration and smoking were the primary risk factors hypothesised.[141] Researchers gathered information on an extensive range of potential risk determinants and co-variables, including clinical and anthropometric measures, and environmental or exposure factors such as diet, exercise, smoking, driving and various occupations. These factors were sub-categorised, for example by types of activity and frequency of lifting. Exposure data were gathered again at one year (interview) and five-year follow-up (interview plus examination). The investigators made considerable attempts to standardise exposure data using statistical methods to test reliability.[142]

289. Case assessment was determined by quantitative measures wherever possible[143]. MRI findings were used to carefully measure specific aspects of degeneration. A decision was made early in the study to examine distinct findings associated with disc degeneration separately, as opposed to using summary scores that aggregate different findings. Additionally, qualitative and quantitative image assessments were made by an expert who was blinded to the subjects' exposures and twin status[144].

290. Results of the study contradicted expectations. Any effects of the primary suspected risk factors (occupational exposures, driving and whole-body vibration exposure and smoking exposure), were 'modest or negligible'.[145] Despite wide discordance between twins in the study (e.g. variations in the occupational exposures between the sibling

140 p. 49

141 p. 51

142 pp. 49-50

143 p. 50

144 p. 50

145 p. 52

twins), few differences were found in the outcomes. Occupational and leisure activities combined may have explained up to 7% of the variance in disc degeneration.[146]

291. The authors commented that:

> During the course of the exposure-discordant twin studies, the striking observation of anyone who had the opportunity to view twin sibling images side-by-side was the strong resemblance in disc degeneration, not just in the degree of degeneration, but also in the types of findings and spinal levels involved.[147]

292. However, multivariate modelling indicated some modest association between 'less routine' physical loading of the spine and increased disc 'desiccation'. Higher body mass, greater lifting strength and heavier work were associated with more disc height narrowing, but less disc desiccation, which suggested some beneficial effects on the disc of greater routine loading.[148]

293. Overall, the Twin Spine Study indicated that the most significant determinant was genetics and familial influences. Focussed studies estimated 61% of the variance in disc degeneration at the T12-L4 region can be explained by familial factors, i.e. genetic and/or early environmental influences.[149] Heritability of disc signal intensity (desiccation) was only 50%. Back pain was less clearly influenced by familial features (estimated as 25%), but did not appear to be influenced by the same environmental factors as disc height narrowing, leaving much unexplained.[150]

294. Neither twisting nor bending were specifically analysed, however the authors noted that a study of twins in occupational driving found that

> …although physical loading, that is handling heavy loads, bending, twisting and static work in awkward postures, appears to influence disc degeneration, the effect size is very modest.[151]

Council's comments

295. The Council considered this an important article in the field, because it summarises recent findings based on the key twin study. Also, it was useful for providing summary information on the influence of genetics. However, it lacks specific analysis of the contended factor in relation to lumbar spondylosis.

296. The Council noted that high heritability of lumbar disc degeneration does not exclude an important role for occupational factors in the causation of lumbar spondylosis.

297. The Council considered that the study:

---

146 p. 52

147 P.53

148 Battié et al 2009, p. 52 reporting on findings of Videman, T. Levalahti, E, Battie M.C. The effects of anthropometrics, lifting strength, and physical activities in disc degeneration Spine 2007;32:1406-13

149 p. 53

150 p. 56

151 p. 52

- leaves open the relevant association with persistent (prolonged, forward) flexion;
- but does not touch on the relevant association with repetitive extension or twisting

Videman, T. Nurminen, M. & Troup, J.D.G. 1990, 'Lumbar spinal pathology in cadaveric material in relation to history of back pain, occupation, and physical loading'*, Spine*. Vol. 15, no. 8, pp. 728-740. (RMA ID 13778)

298. This was a cadaver study to investigate the effects of frequent dynamic loading and in contrast, prolonged static load, on the lumbar spine.

299. The hypothesis tested was that minimal pathological change would be found in those cadavers whose previous exposure to physical loading fell between the extremes of overexertion and inactivity.

> At one extreme, the probability of injury is related to … the rate of accelerative increase, while at the other, resistance to injury is inversely related to the duration of the applied load.[152]

300. The study included 86 cadavers. Each deceased person was male, below 64 years, employed before death, with only a short history of illness, and with information provided by the family about the subjects' work history and history of back pain, injury, or disability.[153] Two occupational health physicians independently classified occupational history using the information from family and death certificates.

301. Severity of vertebral osteophytes was classified by radiological assessment. Facet osteoarthrosis was classified pathologically. The subjects graded with highest overall level of disease were considered to be cases, and compared to the non-cases.[154] Age, physical exercise, disabling accidents, and chemical exposures were examined in statistical models.[155]

302. A test of the progressive dependence between type of work and degree of pathologic changes indicated that the significant changes tended to be located in the lower level vertebrae. Results showed that both sedentary and heavy work seemed to be more clearly associated with severe symmetric disc degeneration than mixed and driving work. Heavy occupation and driving were the two factors found to have greatest incidence proportions for back pain and sciatica and for disability from back pain or injury.

303. Heavy work related markedly to mixed and vertebral osteophytosis (OR 12.1, 95% CI 1.4-107).[156] Heavy physical work for more than three years before the age of 20 years appeared to lead to more facet osteoarthrosis; however, a J-shaped curve relationship was demonstrated, as predicted by the authors.[157]

---

152 p. 728

153 p. 728

154 p. 730

155 p. 731

156 p. 732

157 pp. 731, 732 & 736 and fig 9 on page 735

304. Driving was related to the lowest frequency of degenerative features, ie, symmetric disc degeneration, vertebral osteophytosis, and facet osteoarthrosis, However annular ruptures in the low intervertebral levels were over-represented in driving occupations.

305. Torsion or twisting were not analysed specifically in this paper. However the authors suggested that the elevated frequency of annular ruptures may be due to physical loading stresses involved in driving occupations, in particular torsional and lift injuries or postural stress. Rupture of the anulus was the spinal pathology most clearly associated with back pain and sciatica.

306. Whilst the study provided detailed statistical analyses, the authors considered that the reliance on relatives' memory for exposure information was a limitation of this study.[158]

Council's comments

307. The Council considered this to be a useful study because it allowed for accurate examination of the deceased subjects' spines. However, the exposure information (occupational history) was reviewed from other primary materials (ie families and death certificates). The Council considered that the conclusions of the reviewers, relying on these secondary sources for exposures, were therefore not as reliable as primary sources.

308. The Council also noted that there was insufficient information on twisting, flexion and bending to draw conclusions about the contended associations with lumbar spondylosis.

309. Whilst the Council noted that the review touched on twisting injuries in conjunction with physical loading stress, it considered that the study:

- leaves open the relevant association with persistent (prolonged, forward) flexion; and
- leaves open the relevant association with repetitive extension or twisting

Woolfson, T. & Hughes, S.P.F. 2007, 'Synopsis of Causation' *Ministry of Defence, Service Personnel and Veterans Agency* (RMA ID 47901)

310. Although not an original study, this overview focussed on the potential causes of spondylosis. It also provided a useful glossary.

311. The overview emphasised that normal usage of the term spondylosis, which strictly speaking means 'fusion of the vertebrae' may refer both to inevitable age-based degenerative changes to the spine, and to changes which may come after small tears to the area; lumbar spondylosis usually describes the presence of osteophytes arising from the lumbar vertebrae.[159]

158 p. 734

159 pp.3 & 4

312. They note that some authors distinguish between three types of lumbar disc degeneration:

1. Osteophytes, new bone formations, in the margins of the vertebrae, which arise in response to stresses on the ligaments, and occur in 'more than 80% of people over the age of 50 in the Western world' but are usually not painful in themselves, unless the nerve roots are compressed.

2. Lumbar degenerative disc disease, which occurs as a normal part of the aging process, with varying contributions from other factors.[160] The pain is usually dull but may range to severe and is felt in the low lumbar or buttock areas. Movements that put a load on the disc can precipitate this pain.

3. Lumbar facet arthropathy (a component of Lumbar Spondylosis), which is due to excessive stress on the facet joints between the vertebrae, particularly from rotational and extensional spinal movements.

313. Based on their experience and their review of the literature, the authors considered lumbar degeneration to have a multifactorial aetiology, involving genetics, family history and childhood environment.[161]

314. Their review found that physical loading of the spine, compression torsion and shearing; appear to have an unclear relationship, which varies greatly between individuals. They found however that the relationship between load and disc degeneration were not well established in epidemiological studies and reviews suggested that:

> …other issues, such as psychosocial factors are important in defining the level of resultant illness and disability.[162]

315. The authors also noted that military pilots have an incidence of back pain of 13%, and that it is thought that the forward leaning posture combined with whole body vibration may be responsible for this but there is no good evidence that the pain is directly related to spondylosis.[163]

Council's comments

316. The Council considered this to be a useful contribution regarding definitions and classification of lumbar spondylosis. It was a review paper [by a defence and veterans' agency] which mentions bending and twisting as factors.

317. The Council considered that the study:

– leaves open the relevant association with persistent (prolonged, forward) flexion; and

– leaves open the relevant association with repetitive extension or twisting.

160 p. 4

161 p. 6

162 p. 6

163 pp. 6-7

Brinckmann, P. Frobin, W. Biggemann, M. Tillotson, M. & Burton, K. 1998, **'**Quantification of overload injuries to thoracolumbar vertebrae and discs in persons exposed to heavy physical exertions or vibration at the workplace. Part 11 Occurrence and magnitude of overload injury in exposed cohorts', *Clinical Biomechanics*, vol. 13, suppl. 2, pp.1-36. (RMA ID 23494)

318. This was a cross-sectional study using radiographic imaging collected from a number of archival sources to precisely quantify the lumbar disc condition of 355 subjects exposed to occupational overloads and compare them to a normative database from two populations of healthy British (n=249) and German (n=627) adults, aged 17-57.

319. The exposed cohort consisted of eight individual sub-groups of open cut and underground coal workers; underground potassium salt mine workers; steelworks press operators and offshore riggers, machine operators, and a police force. The groups were exposed to heavy lifting and carrying or whole body vibration. Groups exposed to forward bending were almost all exposed to heavy lifting as well.

320. One sub-group consisted of press operators exposed to a specialised task in a forward bent posture. They were exposed to a mean of 14.4 yrs work that involved lifting and inserting red-hot iron blocks weighing 4-60kg, with a forward posture between 10 and 45 degrees.

321. Workers in at least two of the coal mines had also been exposed to forward bending postures, through either shovelling or working with very low headroom.[164]

322. Another sub-group of 19 Ulster police officers wore heavy body armour (~8kg) plus shoulder loading of rifles, for up to 12 hour shifts, which made movement awkward. They also spent up to 10 hours driving and did intermittent fitness training with this loading, thus were dually exposed to loading and to whole body vibration, for an average of 12 years duration.

323. Quantification of radiological features included methods to correct for variations between images, and correction for posture variations such as angle of lordosis.[165]

324. The authors found that lifting and handling very heavy objects lead to a significant decrease in lumbar disc height.

325. In the cohort of press operators, the height of T12 and L1 vertebrae were found to be significantly increased. The authors inferred that this is caused by the forward bent posture adopted when lifting the heavy instruments.

326. One subgroup of 43 coalmine machine operators had pre-employment data allowing for longitudinal comparison. A significant increase in height of L4, L5 vertebrae and L1/2, L2/3 was demonstrated between the two time periods.[166]

---

164 p. S(2)12 & S(2)13

165 p, s(2)4 &s(2)5

166 p. 5s2(24)

327. A trend towards deviation from the normal in the police officers showed a trend significant only for vertebral height at L2.

328. One group of offshore riggers, mean age 45.7, had apparently unexpected results. Their work was arduous but in broken shifts, and involved pushing, shoving and lifting very heavy and objects, and in awkward postures. However their radiographs showed the reverse of what was expected, ie, they had less degeneration, which the authors attributed possibly to the 'healthy worker effect'.

329. Certain limitations were acknowledged in using the normative database, but the authors conducted a number of statistical exercises to correct for some of these, including without their conclusions being affected.[167]

330. The study design did not allow for adjustment for other potential confounding factors, though racial differences were accounted for by limiting to Caucasian workers in one analysis.

Council's comments

331. The Council considered the paper touched on the contended factors. Council noted that this is one of a number of studies that looked at these issues and thus forms part of the body of evidence. It illustrates that this is a difficult topic to research.

332. Council noted that while the study points to an association with heavy lifting it:

- leaves open the relevant association with persistent (prolonged, forward) flexion; and
- leaves open the relevant association with repetitive extension or twisting.

Luoma, K. Riihimaki, H. Raininko, R. Luukkonen, R. Lamminen, A. & Viikari-Juntura, E. 1998, 'Lumbar disc degeneration in relation to occupation' *Scand J Work Environ Health*, vol. 24, no. 5, pp.358-66. (RMA ID 23201)

333. This was a small cross-sectional MRI study of 164 subjects aged 40-45 years from three occupational groups each of which imposed distinctly different loadings on the back, who comprised a subgroup from a larger study.

> The object of this study was to determine the risk factors of lumbar degeneration demonstrable with MRI, with special emphasis on occupational load and back accidents.[168]

334. A self-administered questionnaire was supplemented by a nurse-conducted structured interview.

335. Fifty-three of the men were exposed to whole body vibration as machine drivers or drivers of other heavy construction trucks (machine drivers) 51 did 'dynamic physical work' as construction carpenters (carpenters) and 60 were 'sedentary' municipal office

167 p. S(2)30, s(2) 19

168 p. 359

workers (Office Workers). The authors estimated occupational load based on job title rather than direct assessment.

336. An experienced radiologist graded the x-rays and reliability of the grading was checked against those of two other radiologists.[169]

337. Occupation, history of back pain, and other possible risk factors were statistically analysed in relation to the signs of disc degeneration. Dependent variables were dark nucleus pulposus, posterior bulge and anterior bulge of lumbar discs. The investigators chose a lumbar disc bulge of ≥ 3.2 mm as a sign of disc degeneration.[170] Potential confounding factors explored were height, history of overweight, smoking, physical exercise and car driving.

338. A history of three or more back accidents was found to be associated with a distinctly increased risk of dark nucleus pulposus[171] in discs L3/L4 and at L4/L5 discs.

339. Carpenters had the highest prevalence of posterior disc bulge at each disc level, but in the overall analysis of the lumbar spine, no significant relation between occupation and posterior disc bulges was found. A history of back accidents was related to an increased risk of posterior disc bulges, but significant only at L3/L4.

340. The prevalence of posterior bulge amongst the carpenters was seen to be related to dynamic physical work in which compressive and shear forces act on the lumbar spine. Additionally, a history of back accidents explained a good part of the association between occupation and posterior bulge in the multivariate model.[173]

341. The machine drivers had the highest frequency of anterior disc bulge. At L5/S1 a strong association remained after adjustment for confounders (OR 4.2, 95% CI 1.2-14.1). At L4/L5, the adjusted odds ratio for anterior bulge was 3.3, being of borderline statistical significance (95% CI 1.0 -10.1). The authors noted that these findings may have been related to the constrained, forward flexed and twisted postures which were common in the machine driving work but accepted that the mechanism by which anterior bulges develop is not clear.

342. In respect of the apparent associations between both machine driving and car driving with lumbar disc degeneration, the authors suggested that whole body vibration causing shocks to the disc and compressive forces to the adjacent vertebrae, may partly explain this. They also suggested that constrained forward flexed and twisted postures of the trunk may be involved, but were unable to identify any clear mechanism.

343. Based on these results the authors concluded that occupational loading was related to the presence of disc degeneration.[174] However, they also stated that if they had

169 p. 359 -360.

170 p. 363

171 Dark nucleus pulposus indicates desiccation of the disc

172 p. 361

173 p. 364

174 p. 362

combined the different features of disc degeneration into a general score, no occupational differences would have been found.[175]

344. The authors noted the limitation that poor imaging quality affected the measurement of small disc bulges.

345. All exposures histories were based on self-report which the authors acknowledged is not very reliable. However, three separate questionnaires were conducted over four to seven years, 'reducing recall error'.

Council's comments

346. The Council noted that the sub-analyses in this study, with no clear pattern of findings amongst the various features of disc degeneration, allow for the possibility that some of the associations are functions of chance. The apparent associations between lumbar disc degeneration and driving had no clear mechanisms but may have been related to repetitive small trauma in the case of the drivers; and may have been confounded by the frequency of accidents in the case of the carpenters.

347. The Council considered that the study:

- leaves open the relevant association with persistent (prolonged, forward) flexion; and

- leaves open the relevant association with repetitive extension or twisting.

SUMMARY OF THE COUNCIL'S CONSIDERATION OF THE SOUND MEDICAL SCIENTIFIC EVIDENCE ON LUMBAR SPONDYLOSIS AND FLEXION, EXTENSION AND TWISTING.

348. The Council was careful to differentiate, in its consideration of the sound medical scientific evidence, whether the outcome of interest was diagnostically confirmed lumbar spondylosis or low back pain alone. If low back pain was the only endpoint discussed in a study, then it was important that the pain was shown to be chronic, in order to draw an inference in respect of lumbar spondylosis which, for the purposes of the statements of principles, requires both radiological signs and clinical symptoms.

349. The Council noted that findings in the literature of a relationship between disc degeneration and lower back pain has been inconsistent. Seidler et al (2001) found low back pain to be strongly associated with radiographic signs of osteochondrosis or spondylosis. Lundin et al (2001) found disc height reduction was significantly associated with low back pain; however, Osti and Cullum (1994)[176] in their review noted that earlier reports of association between low back pain to disc degeneration had been disputed in more recent literature, and Battie et al (2009) noted that determinants of lower back pain did not closely overlap with those for disc degeneration.

---

175 p. 365

176 Osti, O.L & Cullum, D.E 1994, 'Occupational low back pain and intervertebral disc degeneration: epidemiology, imaging, and pathology,' *The Clinical Journal of Pain*, no. 10, vol. 4, pp 331-334, p 333

350. The Council found that very few epidemiological studies directly addressed the contribution of repetitive or persistent flexion, extension or twisting of the lumbar spine to lumbar spondylosis. A number of older studies looked at spondylosis or lumbar disc degeneration in relation to postural loads, but did not analyse the specific exposure to twisting, turning or awkward postures *per se* in any detail.

351. One case-control study by Seidler et al (2001) addressed extreme forward bending (persistent (prolonged, forward) flexion) in relation to spondylosis. It found a dose-dependent association between extreme forward bending and lumbar spondylosis, which was significant for exposures of at least 1500 cumulative hours (OR 3.5).

352. The earlier landmark series studies by the Lawrence research group (1952, 1955, and 1958), found a greater frequency of lumbar spondylosis in miners who worked in conditions requiring stooping, than those who did not need to stoop constantly. Whilst it was not possible for the Council to disentangle the effect of postural load from the stooping, this series of studies indicated that prolonged bending further increased the already existing increased incidence of these conditions in miners.

353. Those studies found positive associations between heavy work loads or postural loads and lumbar spondylosis or other endpoints relating to lumbar disc degeneration or spinal osteoarthritis.

354. Conversely, Battie et al 2009, the (Finnish) Twin Study; Hadjipavlou et al (2008)[177] in a review of pathophysiological mechanisms focussed on the contribution of genetic and early environmental factors.

355. Battie et al (2009) noted that aggregated analysis of the exposure-discordant twin studies found that occupational and leisure-time activities explained no more than 7% of the variance in disc degeneration. They concluded from The Twin Study and from their summary of findings from recent genetic studies, that the occupational contribution was minimal and less important than the genetic and familial factors. Results indicated that the most significant determinants were genetic and familial influences. They reported that a number of gene variants have been directly associated with various aspects of disc degeneration[178] They noted in their conclusion:

> Disc degeneration is now considered a condition that is genetically determined in large part, with environmental factors, although elusive, also playing an important role.[179]

356. The Council noted that Battie et al 2009, reported that recent studies in identical twins suggest that genetic and early environmental factors may be more important and up to 7% of lumbar disease remained attributable to occupational and environmental factors.

357. The Council considered that while the studies of identical twins has opened up new areas of research, those findings do not invalidate or positively outweigh the earlier findings of Seidler et al, and Lawrence et al.

---

177 Hadjipavlou AG, Tzermiadianos MN, Bogduk N, Zindrick MR 2008 The pathophysiology of disc degeneration J Bone Joint Surg, 90-B: 1261-70. RMA ID 52869

178 Battie et al 2009, RMA ID 52587, discussed in these Reasons.

179 Battie et al 2009, RMA ID 52587 p. 56

358. Woofson et al (2007) found that the reviewed evidence suggested a mechanical etiology, but the relationships of torsion, compression and shearing with disc degeneration were unclear.

359. Some studies analysed occupation as a surrogate for physical workload. The most notable of these were the series of studies by Lawrence and colleagues (discussed above in these Reasons). Other studies which examined occupation and lumbar degeneration or spondylosis included those by Brinckmann et al (1998) whose results were inconsistent between population samples, regarding awkward postures, and were confounded by heavy lifting and a possible healthy worker effect[180]; and Luoma et al (1998), who found an association between occupation and disc degeneration in carpenters and drivers appeared to be related to repeated injury and trauma (respectively).

360. The Council noted that whilst occupation is sometimes assumed as a surrogate outcome for various activities, it is not a precise measure of types of activities and therefore other factors such as heavy lifting may confound the results and the apparent effect of bending or twisting.

361. The Council also noted that several studies have examined athletes in relation to the repetitive or persistent flexion, extension or twisting and lumbar spondylosis. Hardcastle et al (1992) found frequent radiological signs of degeneration in a very small study of young Australian cricketers; Sward et al (1991) found a small group of elite male gymnasts had double the frequency of disc abnormalities of a smaller number of referents.

THE COUNCIL'S CONCLUSIONS ON THE SOUND MEDICAL-SCIENTIFIC EVIDENCE

362. In considering, firstly whether there is sound medical-scientific evidence in the pool that indicates ('points to' as opposed to merely 'leaves open') that exposure to repetitive or persistent flexion, extension or twisting of the lumbar spine could provide a link or element in a reasonable hypothesis connecting lumbar spondylosis to relevant service the Council carefully considered each article and the pool of information.

363. The Council had to find that the hypothesis contended for was reasonable and not one which was 'obviously fanciful, impossible, incredible or not tenable or too remote or too tenuous.' [181]

364. The Council noted that there was a paucity of sound medical scientific evidence which was directly pertinent to persistent (prolonged, forward) flexion and repetitive extension or twisting, but considered that the evidence that was available, particularly Seidler et al (2001) and Lawrence et al (1955) was persuasive.

365. The Council considered that there was more relevant sound medical scientific evidence dealing with persistent (prolonged, forward) flexion than there was in respect of

---

180 Brinckman et al 1998), p. s(2)14. RMA ID 23494

181 See the full Federal Court decision in *Repatriation Commission v Bey* (1997) 79 FCR 364 which cited with approval these comments from Veterans' Review Board in *Stacey* (unreported 26 June 1985), all of which were in turn cited with approval in the Moore J decision at [33].

repetitive extension or twisting. The Council noted that repetitive movements, which cause acute injury, may fall within the factor for trauma which presently exists in both Statements of Principles.[182]

THE COUNCIL'S CONCLUSIONS ON WHETHER THERE SHOULD BE A FACTOR(S) FOR PERSISTENT (PROLONGED, FORWARD) FLEXION AND REPETITIVE EXTENSION OR TWISTING.

366. Overall, on the basis of a well-designed case-control study (Seidler et al 2001) and a series of epidemiological mining studies (Lawrence and Kellgren et al, 1952, 1953 and 1955) and some less pertinent sporting studies (Videman et al 1995, Hardcastle et al 1992, Lundin et al 2001 Sward et al 1991) supporting biological plausibility, the Council considered that there is sound medical scientific evidence that points to a reasonable hypothesis that connecting prolonged bending/ forward flexion for a cumulated period of at least 1500 hours and lumbar spondylosis.

367. Carefully weighing all of the evidence in the Pool of Information, the Council was satisfied on balance of probabilities that prolonged bending or forward flexion for a cumulated period of at least 1500 hours can cause lumbar spondylosis.

368. The Council considered that there was insufficient sound medical scientific evidence of a relevant association between repetitive twisting or turning and lumbar spondylosis.

NEW INFORMATION SUBMITTED BY THE APPLICANT

369. The Council considered the 'new information' in **Appendix C** (ie information that was not available to (not before) the RMA at the relevant times) to which it was referred by the first Applicant with respect to the contended factors.

370. The new information was not taken into account for the purposes of the review, but rather was considered to determine whether, in the Council's view, it warranted the Council making any recommendations to the RMA.

371. In the Council's view, any such recommendation should only be made if it were to form the view that the new information:

- comprised sound medical-scientific evidence as defined in section 5AB(2) of the VEA, being information which epidemiologists would consider appropriate to take into account; which
- in the Council's view 'touches on' (is relevant to) the contended factors; and
- has been evaluated by the Council according to epidemiological criteria, including the Bradford Hill criteria.

[182] Factor, 6 (g) having a trauma to the lumbar spine before the clinical onset of lumbar spondylosis, from Statements of Principles No. 37 of 2005 Determinations as amended, by No. 36 of 2010.

372. The Council noted that the website article referred by the Applicant did not refer to spondylosis, and did not make specific reference to the contended factor in relation to lumbar spondylosis.

373. The Council further considered that the website article was not sound medical-scientific evidence in that it was not subject to peer review or, so far as concerning causes of lumbar spondylosis, did not meet the Applicable criteria for assessing causation currently applied in the field of epidemiology.

374. The Council was not sufficiently persuaded of the matters in [381] to make any recommendation to the RMA concerning the undertaking of a fresh investigation specifically on this basis.

DECISION

375. The Council made the declarations summarised in **paragraphs 1 and 2** above.

EVIDENCE BEFORE THE COUNCIL

376. Second preliminary list of the proposed pool of information, as advised to the Applicant and the Commissions by letters dated 16 January 2013 (see [92] and the final pool of information see is at **Appendix A**. This list also identifies the information upon which the Applicant and the Commissions relied (being information which the RMA advised was available to (before) the RMA at the relevant times and which the RMA sent to the Council in accordance with section 196K of the VEA).

377. The information considered by the Council (being the information that the RMA advised was available to (before) the RMA at the relevant times and which the RMA sent to the Council in accordance with section 196K of the VEA) is listed in **Appendix B**.

378. The information to which the Applicant referred (being information which the RMA advised was new information, that is, information which was not available to (not before) the RMA at the relevant times, and so was not considered by the Council in reaching its review decision) is listed in **Appendix C.**

GLOSSARY OF TERMS:

The following glossary[183] has been provided to aid in the following analysis of the literature:

1. *ankylosis*: immobility and consolidation of a joint due to disease, injury or surgical procedure

2. *annulus fibrosis:* the fibrous circumferential ring-like portion of an intervertebral disc (*annular* – adj)

3. *hyperostosis*: hypertrophy of the bone

4. *hypertrophy*: enlargement or overgrowth of an organ or part due to increase in constituent cells

5. *kyphosis*: abnormally increased convexity in the curvature of the (thoracic) spine in the sagittal plane

6. *osteoarthritis* (also know as *osteoarthrosis*): a degenerative joint disease marked by degeneration of the articular cartilage, hypertrophy of bone at the margins and changes in the synovial membrane, that may be accompanied by pain, swelling and stiffness

7. *osteochondrosis:* disease of the growth ossification centres. NB: Seidler et al, a German paper, discussed in these Reasons, used this term with spondylosis, and defined in terms of osteophytes and narrowing of the discs.

8. *osteophytes*: bony excrescence or outgrowth of bone or cartilage

9. *rheumatic:* relating to rheumatism

10. *rheumatism:* any of a variety of disorders marked by inflammation, degeneration or metabolic derangement of the connective tissue structures, especially the joints and related structures, and attended by pain, stiffness or limitation of motion

11. *rheumatoid arthritis*: a multisystem disease persisting for a continuous period of at least six weeks, characterised by inflammatory synovitis, usually involving peripheral joints in a symmetrical distribution, sometimes including cartilage damage and bone erosions and changes in joint integrity, in addition to systemic manifestations.[184].

12. *spondylitis:* inflammation of a vertebra

---

183 Glossary definitions have been adapted from Dorland's pocket Medical dictionary. 28th edition, unless otherwise stated.

184 Statement of Principles, No. 68 of 2008

13. *spondylolisthesis*: displacement of one vertebra over another; [185]

14. *spondylolysis*: a defect or fracture, unilateral or bilateral, involving the pars interarticularis of a vertebra.[186]

General Glossary[187]

15. *case-control study:* A study design which compares a group people with a certain disease/condition (cases) to a group of people without that condition (controls) and estimates the relative proportion of each group were exposed to certain factors.

16. *cohort study:* A study design that compares a group of people exposed to certain factor(s) with a similar group of people not exposed to the same factor(s), to estimate the relative proportion of each group which develops the disease or condition.

17. *CI - confidence interval* : The computed interval with a given probability. e.g. 95%, that the true value of a variable such as a mean, proportion, rate, odds ratio or relative risk, is contained within the interval.

    - (If the confidence interval for a ratio (e.g. odds ratio or relative risk) includes the value of 1, then the estimated effect is not considered to be *statistically significant.)*

18. *cross-sectional study:* A study design whereby all participants are assessed at the same time for both exposures and disease/outcome. It can be descriptive, for measuring prevalence, or analytic, whereby the proportions of each exposure group that has the outcome are compared.

19. *Incidence:* the proportion of the given population at risk of a disease/outcome, who actually developed the disease within a given time period, e.g. one-year incidence is the number of new cases of the disease, that develop during one year, divided by the number of persons in the population who did not have the disease at the beginning of the year.

20. *kilogram hours (kg/h):* a variable for measuring the physical workload, calculated by multiplying the estimated weight lifted (in kilograms) by the cumulative number of hours worked lifting the weight, eg at the theoretical extremes of the range, 150,000kg hrs would equal 1 kilogram lifted for a cumulated 150,000 hours or 150,000kg for 1 hour.

21. *OR - Odds ratio*: the ratio of two odds.

    For example:

185 Statement of Principles, no. 5 of 2006

186 Statement of Principles, no. 5 of 2006

187 Key resource is Porta, M (ed), 2008, *A Dictionary of Epidemiology*, 5th ed, Oxford, OUP. Please refer to this dictionary for more detailed explanation of terms.

- for *exposure* – the odds ratio for a set of case control data – the ratio of the odds in favour of exposure among the cases to the odds in favour of exposure among controls; and
- for *risk* – the ratio of the odds in favour of getting the disease, if exposed, to the odds in favour of getting the disease if not exposed.

It is often used to approximate a *relative risk*.

22. *prevalence:* the proportion of a given population with a given condition/disease at a given time.

23. *RR - relative risk*: the ratio of the risk of disease or death among the exposed to the risk among the unexposed – is synonymous with risk ratio. Alternatively, the ratio of the cumulative incidence rate in the exposed to the cumulative incidence rate in the unexposed – ie, the *rate ratio.*

24. *SMR - Standardized mortality rate*: the ratio of the number of deaths observed in the study population to the number that would be expected if the study population had the same specific rates as the standard population, multiplied by 100. Usually expressed as a percentage.

25. *Statistically significant:* Based on a stated level of probability, the effect/variable estimate is unlikely to have occurred by chance alone [usually demonstrated by the *p* value of less than the stated level, eg. <.05; or by the confidence interval not including a null value].

APPENDICES

Appendix A	Second preliminary list of the proposed pool of information, as advised to the Applicant and the Commissions by letters dated **16 January 2013** (see [92]) This list also identifies the information upon which the Applicant and the Commissions relied (being information which the RMA advised was available to (before) the RMA at the relevant times and which the RMA sent to the Council in accordance with section 196K of the VEA).
Appendix B	Information forwarded to the Council under section 196K of the VEA referable to the Council's review of Statements of Principles Nos. 37 & 38 of 2005 as amended by Statements of Principles Nos.78 & 79 of 2008 & 36 & 37 of 2010
Appendix C	Material that the RMA advised was not available to (not before) the RMA (which the Applicant contended was in existence at the relevant times, and so could have been accessed by the RMA).

APPENDIX A

Second preliminary and final list of the proposed pool of information, as advised to the Applicant and Commissions by letters dated **16 January 2013** (see [92] of the Reasons), including information upon which the Applicant and the Commissions relied (being information which the RMA advised was available to (before) the RMA at the relevant times and which the RMA sent to the Council in accordance with section 196K of the VEA).

This list also identifies the information upon which the Applicant and the Commissions relied (being information which the RMA advised was available to (before) the RMA at the relevant times and which the RMA sent to the Council in accordance with section 196K of the VEA).

RMA ID	Details	Relied on by
12974	Anstadt, G.W, 1991, 'Intervertebral disc degeneration', *Journal of Occupational Medicine,* vol. 33, no. 5, pp. 582-584.	
23491	Battie, M.C. Videman, T. Gibbons, L.E. Fisher, L.D, Manninen, H. Gill, K.1995, 'Determinants of lumbar disc degeneration. A study relating lifetime exposures and magnetic resonance imaging findings in identical twins', *Spine*, vol. 20, no. 24, pp. 2601-12.	Commissions
52587	Battie, M.C. Videman, T. Kaprio, J. Gibbons, L.E. Gill K, Manninen, H. Saarela, J. Peltonen, L. 2009, 'The Twin Spine Study: contributions to a changing view of disc degeneration', *The Spine Journal*, vol. 9, pp. 47-59	
49824	Battie, M.C. Videman, T. Parent, E. 2004, 'Lumbar disc degeneration. Epidemiology and genetic influences', *Spine,* vol. 29, no. 23, pp. 2679-90.	
23487	Biering-Sorensen, F. Hansen, F. Schroll, M. & Runeborg, O. 1985, 'The relation of spinal x-ray to low-back pain and physical activity among 60-year old men and women', *Spine*, vol. 10, no. 5, pp. 445-51.	
29788	Billenkamp, G. 1972, 'Physical stress and spondylosis deformans', *Fortschr Rontgenstr*, vol. 116. pp. 211-215	
29613	Bolm-Audroff, U. 1992, 'Intervetebral disc disorders due to lifting and carrying heavy weights', *Med Orthop Tech*, vol. 112, pp. 293-6	
23216	Boos, N. Semmer, N. Elfering, A. Schade, V. Gal, I. Zanetti, M. Kissling, R. Buchegger, N. Hodler, J. & Main, C.J. 2000, 'Natural history of individuals with asymptomatic disc abnormalities in magnetic resonance imaging. Predictors of Low Back Pain-Related Medical Consultation and Work Incapacity', *Spine*, vol. 25, no. 12, pp.1484-1492.	

RMA ID	Details	Relied on by
24574	Bovenzi, M & Betta, A 1994, 'Low-back disorders in agricultural tractor drivers exposed to whoe-body vibration and postural stress', *Applied Ergonomics*, no. 25, vol. 4, pp. 231-241.	
23494	Brickmann, P. Frobin, W. Biggemann, M. Tillotson & M. Burton, K 1998, 'Quantification of overload injuries to thoracolumbar vertebrae and discs in persons exposed to heavy physical exertions or vibration at the workplace. Part 11 Occurrence and magnitude of overload injury in exposed cohorts', *Clinical Biomechanics,* vol. 13, suppl. 2, pp. 1-36.	Commissions
5532	Caplan, P.S. Freedman, L.M.J & Connelly ,T.P. 1966, 'Degenerative joint disease of the lumbar spine in coal miners - A clinical and X-ray study', *Arthritis and Rheumatism*, no. 9, vol. 5, pp. 693-702	Commissions
23645	Egger, P. Frith, S. Duggleby, S. Fall, C. Coggon, D & Cooper, C. 1995, 'Obesity, occupational activity and osteoarthritis of the spine', *British Journal of Rheumatology,* vol. 34, p. S35	
23489	Evans, W. Jobe, W & Seibert, C 1989, 'A cross-sectional prevalence study of lumbar disc degeneration in a working population', *Spine*, no. 14, vol. 1, pp. 60-64.	Commissions
5530	Felson, D.T 1994, 'Do occupation-related physical factors contribute to arthritis?', *Bailliere's Clinical Rheumatology*, no. 8, vol. 1, chap 6 pp 63-77.	
12425	Fiorini, G.T 1976, 'Forces on lumbo-vertebral facets', *Annals of Biomedical Engineering*, vol. 4, pp. 183-187	
23343	Hadjipavlou, A.G. Simmons, J.W., Pope, M.H. Necessary, J.T. & Goel, V.K. 1999, 'Pathomechanics and clinical relevance of disc degeneration and annular tear: a point-of-view review'*, Am J Orthopedics*, no. 28, vol. 10, pp. 561-71.	
52869	Hadjipavlou, A.G. Tzermiadianos, M.N. Bogduk, N & Zindrick, M.R. 2008, 'The pathophysiology of disc degeneration', *J Bone Joint Surg,* vol. 90-B, pp. 1261-70.	
12921	Hardcastle, P. Annear, P. Foster, D.H. Chakera, T.M. McCormick, C. Khangure, M & Burnett, A 1992, ' Spinal abnormalities in young fast bowlers', *J Bone Joint Surg [Br*], vol. 74-B, pp. 421-425.	
23485	Healy JF, Healy BB, Wong WHM, & Olson EM 1996 Cervical and lumbar MRI in asymptomatic older male lifelong athletes: frequency of degenerative findings Journal of Computer Assisted Tomography, Vol 20(1) pp 107-112	
12293	Hult, L. 1954, 'Cervical, Dorsal and Lumbar Spinal Syndromes: A field investigation of a non-selected material of 1200 workers in different occupations with special reference to disc degeneration and so-called muscular rheumatism', *Acta Orthopaedica Scandinavica,* Supplementum no. 17, pp. 7-102	Commissions

RMA ID	Details	Relied on by
12917	Julkunen, H. Knekt, P. & Aromaa, A. 1981,' Spondylosis deformans and diffuse idiopathic skeletal hyperostosis (DISH)', *Finland Scand J Rheumatology*, vol. 10, pp. 193-203	Commissions
12958	Katevuo, K. Aitasalo, K. Lehtinen, R. Pietila, J. 1985, 'Skeletal changes in dentists and farmers', *Finland Community Dentistry Oral Epidemiology*, vol. 13, no. 1, pp. 23-5.	Commissions
13036	Kellgren, J.H & Lawrence, J.S 1958, 'Osteo-arthrosis and disk degeneration in an urban population', *Ann Reheu Dis*, vol. 17, pp. 388-397.	Commissions
13288	Kellgren, J.H & Lawrence, J.S 1952, 'Rheumatism in miners', *British Journal of Industrial Medicine,* vol. 9, pp. 197-207.	Commissions
5528	Lawrence, J.S. 1955, 'Rheumatism in coal miners. Part III Occupational factors', *Brit J Industr Med,* vol. 12, pp. 249-261.	Commissions
1286	Lawrence, J.S & Aitken-Swan, J 1952, 'Rheumatism in Miners: Part I: Rheumatic Complaints', *British Journal of Industrial Medicine*, vol. 9 pp. 1-18.	Commissions
13248	Lawrence, J.S. Molyneux, M.K & Dingwall-Fordyce, I 1966, ' Rheumatism in foundry workers', *British Journal of Industrial Medicine,* vol. 23, pp. 42-52.	Commissions
49825	Lis, A.M. Black, K.M. Korn, H & Nordin, M 2007, 'Association between sitting and occupational LBP', *Eur Spine J*, vol.16, pp. 283-98	
23336	Lundin, O. Hellstrom, M. Nilsson, I & Sward, L 2001, 'Back pain and radiological changes in the thoraco-lumbar spine of athletes. A long-term follow-up', *Scandinavian Journal of Medicine and Science in Sports*, no. 11, vol. 2, pp. 103-109.	Commissions
23201	Luoma, K. Riihimaki, H. Raininko, R. Luukkonen, R, Lamminen, A & Viikari-Juntura, E, 1998. 'Lumbar disc degeneration in relation to occupation', *Scand J Work Environ Health*, no. 24, vol. 5, pp. 358-66.	Commissions
49830	The National Institute for Occupational Safety and Health (NIOSH), 1997, Chapter 6, 'Low-Back Musculoskeletal Disorders: Evidence for Work-Relatedness', from, *Evidence for Work-Relatedness 'A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity and low back*. Publication no. 97-141. http://www.cdc.gov.niosh/docs/97-141/ergotxt6.htm1/bending	
48993	Panel on Musculoskeletal Disorders and the Workplace, Commission on Behavioral and Social Sciences and Education, National Research Council 2001, *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities'*, National Research Council, Washington, DC National Academy Press, pp 29, 118-24, 184-94.	

RMA ID	Details	Relied on by
23209	O'Neill, T.W. McCloskey, E.V. Kanis, J.A. Bhalla, A.K et al 1999, 'The distribution, determinants, and clinical correlates of vertebral osteophytosis: a population based survey', *Journal of Rheumatology*, vol. 26, pp. 842-8.	Commissions
12920	Osti, O.L & Cullum, D.E 1994, 'Occupational low back pain and intervertebral disc degeneration: epidemiology, imaging, and pathology', *The Clinical Journal of Pain*, no.10, vol.4, pp. 331-334.	
5517	Pope, M.H. Bevins, T. Wilder, D.G. Frymoyer, J.W. 1985, 'The relationship between anthropometric, postural, muscular and mobility characteristics of males ages 18-55', *Spine,* no. 10, vol. 7, pp. 644-8.	
1537	Sairanen, E. Brushaber, L. Kaskinen, M. 1981, 'Felling work, low-back pain and osteoarthritis', *Scandinavian Journal of Work, Environment, and Health*, vol. 7, pp. 18-30.	Commissions
24299	Seidler, A. Bolm-Audorff, U. Heiskel, H. Henkel, N. Roth-Kuver, B et al 2001, 'The role of cumulative physical work load in lumbar spine disease: risk factors for lumbar osteochondrosis and spondylosis assiciated withe chronic complaints', *Occupational & Environmental Medicine*, no. 58, vol.11, pp. 735-46.	
33236	Seidler, A. Bolm-Audorff, U. Siol, T. Henkel, N. Fuchs, C. Schug, H et al 2003, 'Occupational risk factors for symptomatic lumbar disc herniation; a case-control study', *Int J Occup Med Environ Health,* vol. 60, pp. 821-30	
23488	Sward, L. Hellstrom, M. Jacobsson, B. Nyman, R. Peterson, L 1991, 'Disc degeneration and associated abnormalities of the spine in elite gymnasts. A magnetic resonance imaging study', *Spine*, vol. 16, no. 4, pp. 437-43.	
23220	Videman, T. & Battie, M.C. 1999, 'Spine Update. The influence of occupation on lumbar degeneration', *Spine*, no. 24, vol.11, pp. 1164-8.	
23490	Videman, T. Sarna, S. Battie, M.C. Koskinen, S et al 1995, 'The long-term effects of physical loading and exercise lifestyles on back-related symptoms, disability, and spinal pathology among men', *Spine*, no. 20, vol. 6, pp. 699-709.	Commissions
13778	Videman, T. Nurminen, M. Troup, J.D.G 1990, 'Lumbar Spinal Pathology in Cadaveric Material in Relation to History of Back pain, occupation, and physical loading', *Spine*. no.15, vol. 8, pp. 728-740.	Commissions
48091	Waddell, G 1998, 'Risk factors for low back pain. The Back Pain Revolution', *Edinburgh, Churchill, Livingstone (Eds):* pp.85-101	
1506	White , J.A. Wright, V. Hudson, A.M 1993, 'Relationships between habitual physical activity and osteoarthrosis in ageing women', *Public Health*, vol. 107, pp. 459-470.	Commissions

RMA ID	Details	Relied on by
47901	Woolfson, T. Hughes, S.P.F 2007, 'Synopsis of Causation: Spondylosis', *Ministry of Defence, Service Personnel and Veterans Agency, UK.*	

APPENDIX B

Information forwarded to the Council by the RMA under section 196K of the VEA referable to the Council's review of Statements of Principles Nos. 37 & 38 of 2005 as amended by Statements of Principles Nos.78 & 79 of 2008 & 36 & 37 of 2010.

Australian Government
Repatriation Medical Authority

LUMBAR SPONDYLOSIS

RMA ID Number	Reference List for Investigation # 97-7 as at 14 April 2010
24344	Abbrecht PH (2001). The relationship between intervertebral disc degeneration and disc prolapse. Adams and Hutton revisited. Spine, 26(21) pp 2400-3.
18576	Acceleration and Vibration. Chapter 2 of United States Naval Flight Surgeon's Manual: Third Edition 1991. Virtual Naval Hospital - http://www.vnh.org/FSManual.02/02sustainedAcceleration.htm
23224	Adams MA, Freeman BJC, Morrison HP, Nelson IW, Dolan P (2000). Mechanical initiation of intervertebral disc degeneration. Spine, 25(13) pp 1625-36.
11497	Advisory Group for Aerospace Research & Development. Physiopathology and Pathology of Spinal Injuries in Aerospace Medicine (Second Edition) pp 1-12, 15-26
54816	Advisory Group for Aerospace Research and Development (AGARD) (1994). The musculoskeletal and vestibular effects of long term repeated exposure to sustained high-G. AGARD Advisory Report 317: 4.
54817	Advisory Group for Aerospace Research and Development (AGARD) (1994). The musculoskeletal and vestibular effects of long term repeated exposure to sustained high-G. AGARD Advisory Report 317: 15-7.
21786	Agency for Toxic Substances and Disease Registry (ATSDR) (1999). Toxicological profile for ionizing radiation. US Department of Health and Human Services, Public Health Service, Atlanta, GA.
13078	Albright JP, Moses JM, Feldick HG, Dolan KD, Burmeister LF (1976). Nonfatal cervical spine injuries in interscholastic football. JAMA, Vol 236 (11) pp 1243-5.
10408	Allan DB, Waddell G (1989). Understanding and management of low back pain. Acta Orthop Scand, 60(Suppl 234) pp 1-23.
12918	Anderson JJ and Felson DT (1988). Factors associated with osteoarthritis of the knee in the first national health and nutrition examination survey (Hanes I): evidence for an association with overweight, race, and physical demands of work. American Journal of Epidemiology, 128(1): 179-89.
10426	Anderson PC, Phillips M (1997). [Letter] The musculoskeletal sequelae of participation in the Vietnam War. MJA, 167(2) pp 112.

54591	Anonymous (2001). Review of methods for evaluating human exposure to whole - body vibration. Retrieved 27 October 2009, from http://www.humanvibration.com/EU/VINET/pdf_files/Appendix_W4A.pdf
54589	Anonymous (2005). Controlling vibration risks. Retrieved 27 October 2009, from http://www.hse.gov.uk/vibration/wbv/risks.htm#employees
54585	Anonymous (2005). Statutory Instrument 2005 No. 1093. The control of vibration at work regulations 2005. Retrieved 27 October 2009, from http://www.opsi.gov.uk/si/si2005/20051093.htm
54588	Anonymous (2005). The control of vibration at work regulations 2005. Retrieved 27 October 2009, from http://www.hse.gov.uk/vibration/wbv/risks.htm
54579	Anonymous (2008). Vibration - health effects. Retrieved 27 October 2009, from http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_effects.html
54580	Anonymous (2008). Vibration - introduction. Retrieved 27 October 2009, from http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_intro.html
54581	Anonymous (2008). Vibration - measurement, control and standards. Retrieved 27 October 2009, from http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_measure.html
12974	Anstadt GW (1991). Intervertebral disc degeneration. Journal of Occupational Medicine, Vol 33 (5) pp 582-583.
12185	Anton DJ (1990). Neck injury in advanced military aircraft environments. NATO Advisory Group for Aerospace Research and Development (AGARD) Conference Proceedings No 471 pp K1-7.
12257	Armstrong JR (1967). Lumbar Disc Lesions: Pathogenesis and Treatment of Low Back Pain and Sciatica. E & S Livingstone, Edinburgh, pp 48-131, 159-161.
5515	Aro S, Leino P (1985). Overweight and musculoskeletal morbidity: A ten-year follow-up. International Journal of Obesity, Vol 9 pp 267-275.
34151	Axelsson P, Karlsson BS (2004). Intervertebral mobility in the progressive degenerative process. A radiostereometric analysis. Eur Spine J, 13: 567-72.
33237	Bar-Dayan Y, Weisbort M, Bar-Dayan Y, Velan GJ, Ravid M, Hendel D, Shemer J. Degenerative disease in lumbar spine of military parachuting instructors. J R Army Med Corps, Vol 149 pp 260-64.
23348	Barozzi L, Olivieri I, De matteis M, Padula A, Pavlica P (1998). Seronegative spondylarthropathies: imaging of spondylitis, enthesitis and dactylitis. European Journal of Radiology, Vol 27 pp S12-S17.
23194	Bashir K, Cai CY, Moore TA 11, Whitaker JN, Hadley MN (2000). Surgery for cervical spinal cord compression in patients with multiple sclerosis. Neurosurgery Vol 47 pp 637-643.
23491	Battie MC, Videman T, Gibbons LE, Fisher LD, et al (1995). Determinants of lumbar disc degeneration. A study relating lifetime exposures and magnetic resonance imaging findings in identical twins. Spine, Vol 20(24) pp 2601-12.
7987	Battie MC, Videman T, Gill K, Moneta GB, et al (1991) 1991 Volvo Award in clinical sciences. Smoking and lumbar intervertebral disc degeneration: an MRI study of identical twins. Spine, 16(9) pp 1015-1021.
52587	Battie MC, Videman T, Kaprio J, Gibbons LE, et al (2009). The Twin Spine Study: contributions to a changing view of disc degeneration. The Spine Journal, 9: 47-59.

49824	Battie MC, Videman T, Parent E (2004). Lumbar disc degeneration. Epidemiology and genetic influences. Spine, 29(23): 2679-90.
23335	Belanger T and Rowe DE (2001). Diffuse idiopathic skeletal hyperostosis: musculoskeletal manifestations. Journal of the American Academy of Orthopaedic Surgeons, 9(4) pp 258-267.
9447	Berg SW, Richlin M (1977). Injuries and illnesses of Vietnam War POWs. I. Navy POWs. Military Medicine, July, pp 514-518.
23370	Berge J, Marque B, Vital J-M, Senegas J, & Caille J-M (1999). Age-related changes in the cervical spines of front-line rugby players. The American Journal of Sports Medicine, Vol 27(4) pp 422-9.
23487	Biering-Sorensen F, Hansen FR, Schroll M, & Runeborg O (1985). The relation of spinal x-ray to low-back pain and physical activity among 60-year-old men and women. Spine, Vol 10(5) pp 445-51.
29788	Billenkamp G (1972). Physical stress and spondylosis deformans. Fortschr Rontgenstr, Vol 116 pp 211-215.
12231	Bindi P, Lavaud S, Bernieh B, Toupance O, & Chanard J (1990). Early and late occurrence of destructive spondyloarthropathy in haemodialysed patients. Nephrology Dialysis Transplantation, Vol 5, pp 199-203.
13090	Bjelle A, & Allander E (1981). Regional distribution of rheumatic complaints in Sweden. Scand J Rheumatology, Vol 10, pp 9-15.
13089	Bjelle A, Allander E, & Lundquist B (1981). Geographic distribution of rheumatic disorders and working conditions in Sweden. Scand J Soc Med., Vol 9, pp 119-126.
8144	Bongers PM, Boshuizen HC, Hulshof CTJ, Koemeester AP (1988). Back disorders in crane operators exposed to whole-body vibration. Int Arch Occup Environ Health, Vol 60 pp 129-137.
49918	Bongers PM, Hulshof CTJ, Dijkstra L, Boshuizen HC (1990). Back pain and exposure to whole body vibration in helicopter pilots. Ergonomics, 33(8): 1007-1025.
23216	Boos N, Semmer N, Elfering A, Schade V, Gal I, Zanetti M, Kissling R, Buchegger N, Hodler J, & Main CJ (2000). Natural history of individuals with asymptomatic disc abnormalities in magnetic resonance imaging. Predictors of low back pain - related medical consultation and work capacity. Spine, Vol 25(12) pp 1484-92.
8112	Boshuizen HC, Hulshof CTJ, Bongers PM (1990). Long-term sick leave and disability pensioning due to back disorders of tractor drivers exposed to whole-body vibration. Int Arch Occup Environ Health, Vol 62 pp 117-122.
24574	Bovenzi M, Betta A (1994). Low-back disorders in agricultural tractor drivers exposed to whole-body vibration and postural stress. Applied Ergonomics, 25(4): 231-41.
13151	Bowden T (1987). Back pain in helicopter aircrew: a literature review. Aviation, Space & Environmental Medicine, Vol 58 pp 461-7.
1927	Boyle CA, Decoufle P, Flanders WD, Holmgreen P, et al (1989). Health status of Vietnam veterans: telephone interview. Vietnam Experience Study (CDC), Vol II. US Dept of Health and Human Services, Atlanta.
34677	Brandt KD (2001). Osteoarthritis. Harrison's Principles of Internal Medicine, Vol 2 15 edition pp 1987 - 1994.
12910	Braunstein EM, Hunter LY & Bailey RW (1980). Long term radiographic changes following anterior cervical fusion. Clinical Radiology, Vol 31 pp 201-3.

23494	Brickmann P, Frobin W, Biggemann M, Tillotson M, Burton K (1998). Quantification of overload injuries to thoracolumbar vertebrae and discs in persons exposed to heavy physical exertions or vibration at the workplace. Part 11 Occurrence and magnitude of overload injury in exposed cohorts. Clinical Biomechanics, Vol 13 (Suppl 2) pp 1-36.
37729	Bridger RS, Groom MR, Jones H, Pethybridge RJ, Pullinger N (2002). Task and Postural Factors are Related to Back Pain in Helicopter Pilots. Aviation, Space and Environmental Medicine, 73(8) pp 805-811.
12195	Brown JR (1973). Lifting as an industrial hazard. American Industrial Hygiene Association Journal, July, pp 292-297.
23647	Burger H, van Daele PLA, Odding E, Valkenburg HA, Birkenhager JC, Pols HAP (1996). Association of radiographically evident osteoarthritis with higher bone mineral density and increased bone loss with age. The Rotterdam Study. Arthritis & Rheumatism, 39(1): 81-6.
23623	Burns JW, Loecker TH, Fischer Jr, Bauer DH (1996). Prevalence and significance of spinal disc abnormalities in an asymptomatic acceleration subject panel. Aviation Space & Environmental Medicine, Vol 67 pp 849-53.
23191	Cammisa M, De serio A, Guglielmi G (1998). Diffuse idiopathic skeletal hyperostosis. European Journal of Radiology, Vol 27 pp S7-S11.
5532	Caplan PS, Freedman LMJ, Connelly TP (1966). Degenerative joint disease of the lumbar spine in coal miners - A clinical and X-ray study. Arthritis and Rheumatism, 9(5) pp 693-702.
13411	Centers for Disease Control (1997)[Second Printing]. Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. National Institute for Occupational Safety and Health, US Department of Health and Human Services.
23207	Chiles BW 111, Leonard MA, Choudhri HF, Cooper PR (1999). Cervical spondylotic myelopathy: patterns of neurological deficit and recovery after anterior cervical decompression. Neurosurgery, Vol 44 pp 762-770.
23342	Coaccioli S, Fatati G, Di Cato L, Marioli D, Patucchi E, Pizzuti C, Ponteggia M and Puxeddu A (2000). Diffuse idiopathic skeletal hyperostosis in diabetes mellitus, impaired glucose tolerance and obesity. Panminerva Medica, 42(4) pp 247-251.
20453	Coggan D, Kellingray S, Inskip H, Croft P, Campbell L, & Cooper C (1998). Osteoarthritis of the hip and occupational lifting. American Journal of Epidemiology Vol 147 pp 523-8.
20585	Coggon D, Croft P, Kellingray S, Barrett D McLaren M & Cooper C (2000). Occupational physical activities and osteoarthritis of the knee. Arthritis & Rheumatism Vol 43 pp 1443-1449.
49802	Colak S, Jovelic S, Manojlovic J (1992). Back ache in helicopter pilots. Vojnosanit Pregl, 49(6): 529-32. [Abstract]
49840	Collier C, Bernstein S, Olins E, Barber D (2007). Backache & Osteoarthritis of the spine. Revised: 13 Jul 2007 (ICD9 724.2 / 721.90) https://aamaweb.usaama.rucker.amedd.army.mil/AAMAWeb/policy1trs/Orthopedics_FINAL.pdf.
13793	Commonwealth Department of Veterans' Affairs. Morbidity Vietnam Veterans: A Study of the Health of Australia's Vietnam Veteran Community. Volume 1 Male Vietnam Veterans Survey and Community Comparison Outcomes.
13249	Congeni J, McCulloch J, & Swanson K (1997). Lumbar spondylolysis. A study of natural progression in athletes. American Journal of Sports Medicine, Vol 25 (2) pp 248-53.

24345	Cowling JM (2001). Cervical spondylosis. Obtained from www.medhelp.org/perl6/FamilyPractice/messages/38a.html
23447	Cvijetic S, McCloskey E, & Korsic M (2000). Vertebral osteophytosis and vertebral deformities in an elderly population sample. Wiener Klinische Wochenschrift, Vol 112(9) pgs 407-12.
23341	Danesh FR, Klinkmann J, Yokoo H and Ivanovich P (1999). Fatal cervical spondyloarthropathy in a hemodialysis patient with systemic deposition of beta2-microglobulin amyloid. American Journal of Kidney Diseases, 33(3) pp 563-566.
48599	De Oliveira CG, Nadal J (2004). Back muscle EMG of helicopter pilots in flight: effects of fatigue, vibration, and posture. Aviation, Space, and Environmental Medicine, 75(4): 317-22.
48598	De Oliveira CG, Nadal J (2005). Transmissibility of helicopter vibration in the spines of pilots in flight. Aviation, Space, and Environmental Medicine, 76(6): 576-80.
49827	de Oliveira CG, Simpson DM, Nadal J (2001). Lumbar back muscle activity of helicopter pilots and whole-body vibration. J Biomech, 34(10): 1309-15. [Abstract]
13038	Delahaye RP, Auffret R (1982). Physiopathology & Pathology of Spinal Injuries in Aerospace Medicine. Backache in helicopter pilots. AGARD-AG, Chapter 6.1, 250: 226-61.
49829	Department of Aerospace Engineering, Indian Institute of Science, Bangalore (2008). Helicopter vibration reduction using single crystal and soft piezoceramic shear induced active blade twist. www.aero.iisc.ernet.in/dipali/synopsis.htm.
24515	di Girolamo C, Pappone N, Rengo C, Miniero E, Crisci C, Olivieri I (2001). Intervertebral disc lesions in diffuse idipathic skeletal hyperostosis (DISH). Clinical & Experimental Rheumatology, Vol 19(3) pp 310-2.
12245	Donisch EW & Basmajian JV (1972). Electromyography of deep back muscles in man. American Journal of Anatomy, Vol 133, pp 25-36.
36996	Duke University Medical Center's Division of Orthopaedic Surgery in conjunction with Data Trace Internet Publishing Company (2005) Wheeless' Textbook of Orthopaedics, http://www.wheelessonline.com/ortho/scheuermanns_kyphosis accessed 21 June 2005.
35447	Echarri JJ, Forriol F (2005). Influence of the type of load on the cervical spine: a study on Congolese bearers. The Spine Journal, 5: 291-6.
23645	Egger P, Frith S, Duggleby S, Fall C, Coggon D, Cooper C (1995). Obesity, occupational activity and osteoarthritis of the spine. British Journal of Rheumatology, Vol 34 p S35.
23338	El Miedany YM, Wassif G and El Baddin M (2000). Diffuse idiopathic skeletal hyperostosis (DISH): is it of vascular aetiology? Clinical & Experimental Rheumatology, 18(2) pp 193-200.
13128	Ende LS, Wickstrom J (1982). Ballet injuries. The Physician and Sportsmedicine, 10(7) pp101-118.
12976	Epstein JA, Epstein BS & Jones MD (1979). Symptomatic lumbar scoliosis with degenerative changes in the elderly. Spine, Vol 4 (6) pp 542-7.
23190	Epstein NE (1999). Circumferential cervical surgery for spondylostenosis with kyphosis in two patients with athetoid cerebral palsy. Surgical Neurology, Vol 52 pp 339-44.

1274	Ernst E (1993). Smoking, a cause of back trouble? Br J Rheumatol, 32(3): 239-42.
12193	Evans FG, Lissner HR (1959). Biomechanical studies on the lumbar spine and pelvis. Journal of Bone and Joint Surgery. 41A(2) pp 278-290.
23489	Evans W, Jobe W, & Seibert C (1989). A cross-sectional prevalence study of lumbar disc degeneration in a working population. Spine, Vol 14(1) pp 60-4.
5530	Felson DT (1994). Do occupation-related physical factors contribute to arthritis? Bailliere's Clinical Rheumatology, 8(1) chap 5 pp 63-77.
34964	Felson DT, Anderson JJ, Naimark A, Hannan MT, Kannel WB, Meenan RF (1989). Does Smoking Protect Against Osteoarthritis? Arthritis and Rheumatism, 32(2): 166-72.
13061	Ferguson RJ, McMaster JH, & Stanitski CL (1974). Low back pain in college football linemen. Journal of Sports Medicine, Vol 2 (2) pp 63-69.
12975	Feuerstein M, Berkowitz SM, Peck CA (1997). Musculoskeletal-related disability in US army personnel: prevalence, gender, and military occupational specialties. Journal Occupational and Environment Medicine, Vol 39 pp 68-78.
12425	Fiorini GT (1976). Forces on lumbo-vertebral facets. Annals of Biomedical Engineering, Vol 4 pp 354-363.
49893	Fischer V, Witt A, Troger N, Beck A (1980). Vibrationsbedingte wirbelsaulenschaden bei hubschrauberpiloten. Arbeidsmedizin Sozialmedizin Praventivmedizin, 15: 161-163.
13068	Fitzgerald B, & McLatchie GR (1980). Degenerative joint disease in weight-lifters. Fact or fiction? British Journal of Sports & Medicine, Vol 14 (2 & 3) pp 97-101.
23208	Fogelholm RR, Alho AV (deceased) (2001). Smoking and intervertebral disc degeneration. Medical Hypotheses, Vol 56(4) pp 537-9.
55065	Froom P, Barzilay J, Caine Y, Margaliot S, et al (1986). Low back pain in pilots. Aviat Space Environ Med, 57: 694-5.
11495	Froom P, Froom J, Van Dyk D, Caine Y, Ribak J, et al (1984) Lytic Spondylolisthesis in Helicopter Pilots. Aviation, Space and Environmental Medicine 55 pp 556-557.
55327	Froom P, Hanegbi R, Ribak J, Gross M (1987). Low back pain in the AH-1 Cobra helicopter. Aviat Space Environ Med, 58: 315-8.
11494	Froom P, Ribak J, Tendler Y, Cyjon A, Kriwisky M, et al (1987) Spondylolithesis in Pilots: a follow-up study. Aviation, Space and Environmental Medicine 58 pp 588-589.
23211	Garfin SR (2000). Cervical degenerative disorders: etiology, presentation, and imaging studies. Instructional Course Lectures, Vol 49 pp 335-8.
23196	Gerszten PC, Derszten E, Allison MJ (2001). Diseases of the spine in South American mummies. Neurosurgery, Vol 48 pp 208-213.
12189	Gillen MH (Major), Raymond D (1990). Progressive cervical osteoarthritis in high performance aircraft pilots. NATO Advisory Group for Aerospace Research and Development (AGARD) Conference Proceedings No.471 pp 6-1 to 6-6.
1277	Goldenberg DL, Reed JL (1985). Bacterial Arthritis. NEJM, 312(12): 764-71.
23493	Goldstein JD, Berger PE, Windler GE & Jackson DW (1991). Spine injuries in gymnasts and swimmers. An epidemiologic investigation. The American Journal of Sports Medicine, Vol 19(5) pp 463-8.
22057	Goldwein JW, Meadows AT (1993). Influence of radiation on growth in pediatric patients. Clinics in Plastic Surgery, Vol 20 (3) pp 455-64.

55328	Grant KA (2002). Ergonomic assessment of a helicopter crew seat: the HH-60G flight engineer position. Aviat Space Environ Med, 73(9): 913-8.
48486	Green BN, Sims J, Allen R (2006). Use of conventional and alternative treatment strategies for a case of low back pain in a F/A-18 aviator. Chiropractic & Osteopathy, 14: 11.
54590	Griffin MJ (2004). Minimum health and safety requirements for workers exposed to hand-transmitted vibration and whole-body vibration in the European Union; a review. Occup Environ Med, 61: 387-97.
23446	Grogan J, Nowicki BH, Schmidt TA, & Haughton VM (1997). Lumbar facet joint tropism does not accelerate degeneration of the facet joints. American Journal of Neuroradiology, Vol 18 (7) pp 1325-9.
25389	Guides to the Evaluation of Permanent Impairment (????). Description of Clinical Studies - Chap 15.1b. The American Medical Association Guides to the Evaluation of Permanent Impairment, Extract from Chapter 15.1b pp 378-379.
23199	Guiot BH, Fessler RG (2000). Molecular biology of degenerative disc disease. Neurosurgery, Vol 47 pp 1034-1040.
54592	Gunaselvam J, van Niekerk JL (2005). Seat selection guidelines to reduce whole-body vibration exposure levels in the SA mining industry. The Journal of the South African Institute of Mining and Metallurgy, 105: 675-86.
34752	Haara MM, Manninen P, Kroger H, Arokoski JPA, Karkkainen A, et al (2003). Osteoarthritis of finger joints in Finns aged 30 or over: prevalence, determinants, and association with mortality. Ann Rheum Dis, 62: 151-8.
23343	Hadjipavlou AG, Simmons JW, Pope MH, Necessary JT, Goel VK (1999). Pathomechanics and clinical relevance of disc degeneration and annular tear: a point-of-view review. Am J Orthopedics, 28(10): 561-71.
52869	Hadjipavlou AG, Tzermiadianos MN, Bogduk N, Zindrick MR (2008). The pathophysiology of disc degeneration. J Bone Joint Surg, 90-B: 1261-70.
6433	Hagberg M, Wegman DH (1987). Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. British J Industrial Med, Vol 44 pp 602-610.
23188	Hagenah JM, Vieregge A, Vieregge P (2001). Radiculopathy and myelopathy in patients with primary cervical dystonia. European Neurology, 45: 236-40.
47309	Hahn SM, Glastein E (2001). Radiation Injury. Harrison's 15th Edition, Principles of Internal Medicine, Part 15, Section 1, pp 2585-90.
11496	Hamalainen O (1993) Flight Helmet weight, +Gz Forces, and neck muscle strain. Aviation, Space and Environmental Medicine 64 pp 55-57.
23337	Hamalainen O, Toivakka-Hamalainen SA and Kuronen P (1999). +Gz associated stenosis of the cervical spinal canal in fighter pilots. Aviation Space and Environmental Medicine, 70(4) pp 330-334.
18951	Hamalainen O, Vanharanta H, Hupli M, et al (1996). Spinal Shrinkage Due to +Gz Forces. Aviation, Space and Environmental Medicine 67 (7) pp 659-661.
8170	Hamalainen O, Vanharanta H, Kuusela T (1993). Degeneration of cervical intervertebral disks in fighter pilots frequently exposed to high +Gz forces. Aviation, Space, and Environmental Medicine, Vol 64 pp 692-696.
23646	Hannan MT, Anderson JJ, Zhang Y, Levy D, Felson DT (1993). Bone mineral density and knee osteoarthritis in elderly men and women. The Framingham Study. Arthritis & Rheumatism, Vol 36(12) pp 1671-80.
50048	Hansen B, Wagstaff AS (2001). Low back pain in Norwegian helicopter aircrew. Aviat Space Environ Med, 72(3): 161-4.

13005	Hansson T & Holm S (1991). Clinical implications of vibration-induced changes in the lumbar spine. Ortho.Clin. North America, Vol 22 (2) pp 247-253.
23206	Harada A, Okuizumi H, Miyagi N, & Genda E (1998). Correlation between bone mineral density and intervertebral disc degeneration. Spine, Vol 23(8) pp 857-862.
12921	Hardcastle P, Annear P, Foster DH, Chakera TM, McCormick C, Khangure M and Burnett A (1992). Spinal abnormalities in young fast bowlers. J Bone Joint Surg [Br], Vol 74-B pp 421-425.
23193	Harrison DE, Harrison DD, Janik TJ, Jones EW, Cailliet R, Normand M (2001). Comparison of axial and flexural stresses in lordosis and three buckled configurations of the cervical spine. Clinical Biomechanics Vol 16 pp 276-84.
34789	Hart DJ, Spector TD (1993). Cigarette smoking and risk of osteoarthritis in women in the general population: the Chingford study. Annals of the Rheumatic Diseases, 52: 93-6.
1279	Hart DJ, Spector TD (1993). Cigarette smoking and the risk of osteoarthritis in women in the general population: the Chingford study. Annals Rheum Dis, 52(2): 93-6.
5524	Hartz AJ, Fischer ME, Bril G, Kelber S, et al (1986). The association of obesity with joint pain and osteoarthritis in the Hanes data. J Chron Dis, 39(4) pp 311-319.
23485	Healy JF, Healy BB, Wong WHM, & Olson EM (1996). Cervical and lumbar MRI in asymptomatic older male lifelong athletes: frequency of degenerative findings. Journal of Computer Assisted Tomography, Vol 20(1) pp 107-112.
22059	Heaston DK, Libshitz HI, Chan RC (1979). Skeletal effects of megavoltage irradiation in survivors if Wilm's Tumor. American Journal of Roentgenology, Vol 133 pp 389-395.
23340	Hendriksen IJM and Holewijn M (1999). Degenerative changes of the spine of fighter pilots of the Royal Netherlands Air Force (RNLAF). Aviation, Space, and Environmental Medicine, 70(11) pp 1057-1063.
12979	Hettinger T (1985). Occupational hazards associated with diseases of the skeletal system. Ergonomics, Vol 28 (1) pp 69-75, 383,387,390,391,395,401.
23197	Hilibrand AS, Carlson GD, Palumbo MA, Jones PK, & Bohlman HH (1999). Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. The Journal of Bone & Joint Surgery, Vol 81-A (4) pp 519-28.
48485	Holopainen K, Nevala N, Kuronen P, Arokoski JPA (2004). Effects of vocationally oriented medical rehabilitation for aircraft maintenance personnel - a preliminary study of long-term effects with 5-year follow-up. J Occup Rehab, 14(4): 233-42.
36997	http://www.hopkins-arthritis.com.jhmi.edu/radrds/radiology_4/4_radrds_diagnosis.html
12293	Hult L (1954). Cervical, Dorsal and Lumbar Spinal Syndromes: A field investigation of a non-selected material of 1200 workers in different occupations with special reference to disc degeneration and so-called muscular rheumatism. Acta Orthopaedica Scandinavica, Supplementum no. 17: 7-102.
21776	IARC (2000). IARC Monographs on the evaluation of carcinogenic risks to humans: Ionizing Radiation Part 1: X - and Gamma - radiation, and neutrons, Vol 75.

34150	Iguchi T, Kanemura A, Kasahara K, Sato K, et al (2004). Lumbar Instability and Clinical Symptoms: Which Is the more Critical Factor for Symptoms: Sagittal Translation or Segment Angulation? J Spinal Disord Tech, 17(4): 284-290.
49828	Irvine T (2003). Vibrationdata May Newsletter. www.vibrationdata.com/Newsletters/May2003_NL.pdf.
23200	Ishida Y, Ohmori K, Inoue H, Suzuki K (1999). Delayed vertebral slip and adjacent disc degeneration with an isthmic defect of the fifth lumbar vertebra. Journal of Bone & Joint Surgery (Br) Vol 81 B pp 240-4.
23347	Jaovisidha S, Apiyasawat P, Poramathikul M, Techatipakorn S, Laohacharoensombat W, Siriwongpairat P (2000). Degenerative disk disease at lumbosacral junction: plain film findings and related MRI abnormalities. Journal of the Medical Association of Thailand, 83(8): 865-71.
34786	Jones G, Cooley HM, Stankovich JM (2002). A Cross Sectional Study of the Association Between Sex, Smoking, and Other lifestyle Factors and Osteoarthritis of the Hand. J Rheumatol, 29: 1719-24.
12230	Jones G, White C, Nguyen T, Sambrook PN, Kelly PJ & Eisman JA (1996). Prevalent vertebral deformities: relationship to bone mineral density and spinal osteophytosis in elderly men and women. Osteoporosis International, Vol 6, pp 233-239.
23365	Jones G, White C, Sambrook P, Eisman J (1998). Allelic variation in the vitamin D receptor, lifestyle factors and lumbar spinal degenerative disease. Ann Rheum Dis, Vol 57 pp 94-9.
12917	Julkunen H, Knekt P & Aromaa A (1981). Spondylosis deformans and diffuse idiopathic skeletal hyperostosis (DISH) in Finland. Scand J Rheumatology, Vol 10 pp 193-203.
5535	Jumah KB, Nyame PK (1994). [Correspondence] Relationship between load carrying on the head and cervical spondylosis in Ghanaians. West African Journal of Med, 13(3) pp 181-182.
7163	Kambin P, Cohen LF, Brooks M, Schaffer JL (1995). Development of degenerative spondylosis of the lumbar spine after partial disectomy: comparison of laminotomy, disectomy, and posterolateral disectomy. Spine, 20(5) pp 599-607.
23345	Kao MC, Huang SC, Chiu CT, Yao YT (2000). Thoracic cord compression due to gout: a case report and literature review. Journal of the Formosan Medical Association, 99(7) pp 572-575.
34751	Karlson EW, Mandl LA, Aweh GN, Sangha O, Liang MH, Grodstein F (2003). Total Hip replacement Due to Osteoarthritis: The Importance of Age, Obesity, and Other Modifiable Risk Factors. Am J Med, 114: 93-8.
12958	Katevuo K, Aitasalo K, Lehtinen R, Pietila J (1985). Skeletal changes in dentists and farmers in Finland. Community Dentistry Oral Epidemiology, 13(1): 23-5.
24372	Katsuura A, Hukuda S, Saruhashi Y, Mori K (2001). Kyphotic malalignment after anterior cervical fusion is one of the factors promoting the degenerative process in adjacent intervertebral levels. European Spine Journal, Vol 10(4) pp 320-324.
13036	Kellgren JH & Lawrence JS (1958). Osteo-arthrosis and disk degeneration in an urban population. Ann.Rheum. Dis, Vol 17 pp 388-397.
13288	Kellgren JH, Lawrence JS (1952). Rheumatism in miners. British Journal of Industrial Medicine, Vol 9 pp 197-207.
1281	Kellgren JH, Lawrence JS (1952). Rheumatism in miners. II. X-ray study. Br J Ind Med, 9(3): 197-207.

23223	Kerttula LI, Serlo WS, Tervonen OA, Paakko EL, & Vanharanta HV (2000). Post-traumatic findings of the spine after earlier vertebral fracture in young patients. Clinical and MRI study. Spine, Vol 25(9) pp 1104-8.
23344	Kinoshita H, Tamaki T, Hashimoto T, Kasagi F (1998). Factors influencing lumbar spine bone mineral density assessment by dual-energy X-ray absorptiometry: comparison with lumbar spinal radiogram. Journal of Orthopaedic Science, 3(1) pp 3-9.
54583	Kittusamy NK, Buchholz B (2004). Whole-body vibration and postural stress among operators of contruction equipment: a literature review. J Safety Res, 35(3): 255-61.
10400	Knapik J, Ang Philip, Reynolds K, Jones B (1993). Physical fitness, age, and injury incidence in infanry soldiers. Journal of Occupational Medicine, 35(6) pp 598-603.
12896	Knapik J, Harman e & Reynolds K (1996). Load carriage using packs: A review of physiological, biomechanical and medical aspects. Elsevier 27 (3) pp 207-216.
24347	Kriss TC (2000). Neck pain: primary care work-up of acute and chronic symptoms. Geriatrics, Vol 55 (Jan) pp 47-57.
49826	Kuisma M, Karppinen J, Haapea M, Niinimaki J, et al (2008). Are the determinants of vertebral endplate changes and severe disc degeneration in the lumbar spine the same? A magnetic resonance imaging study in middle-aged male workers. BMC Muscuoskeletal Disorders, 9: 51.
48176	Landau DA, Chapnick L, Yoffe N, Azaria B, Goldstein L, Atar E (2006). Cervical and lumbar MRI findings in aviators as a function of aircraft type. Aviat Space Environ Med, 77(11): 1158-61.
1486	Lane NE, Beat M, Bjorkengren A, Oehlert J, et al (1993). The risk of osteoarthritis with running and aging: A 5-year longitudinal study. J Rheumatol, 20(3): 461-8.
1285	Lane NE, Bloch DA, Jones HH, et al (1986). Long-distance running, bone density and osteoarthritis. JAMA, 255(9): 1147.
23210	Lane NE, Oehlert JW, Bloch DA, & Fries JF (1998). The relationship of running to osteoarthritis of the knee and hip and bone mineral density of the lumbar spine: a 9 year longitudinal study. Journal of Rheumatology, Vol 25 pp 334-41.
22060	Larson DL, Kroll S, Jaffe S, Serure A, Goepfert H (1991). Long-term effects of radiotherapy in childhood and adolescence. The American Journal of Surgery, Vol 160 pp 348-351.
34761	Lau EC, Cooper C, Lam D, Chan VNH, Tsang KK, Sham A (2000). Factors associated with osteoarthritis of the hip and knee in Hong Kong Chinese: Obesity, joint injury, and occupational activites. Am J Epidemiol, 152(6): 855-62.
5528	Lawrence JS (1955). Rheumatism in coal miners. Part III. Occupational factors. Brit J Industr Med, Vol 12 pp 249-261.
12965	Lawrence JS (1975). Hypertension in relation to musculoskeletal disorders. Ann Rheum Dis, Vol 34 pp 451-6.
1286	Lawrence JS, Aitken-Swan J (1952). Rheumatism in Miners: Part I: Rheumatic Complaints. Br J Ind Med, 9(1): 1-18.
13248	Lawrence JS, Molyneux MK, & Dingwall-Fordyce I (1966). Rheumatism in foundry workers. British Journal of Industrial Medicine, Vol 23 pp 42-52.
23212	Lee S-W, Mathie AG, Jackson JE, Hughes SPF (2001). Investigation of vertebral "end plate sclerosis". Skeletal Radiology, Vol 30 pp 454-9.

23286	Leidig-Bruckner G, Limberg B, Felsenberg D, et al (2000). Sex Difference in the Validity of Vertebral Deformities as and Index of Prevalent Vertebral Osteoporotic Fractures: A Population Survey of Older Men and Women. Osteoporosis International, 11(2): 102-19.
23213	Leone A, Sundaram M, Cerase A, Magnavita N, Tazza L, Marano P (2001). Destructive spondyloarthropathy of the cervical spine in long-term hemodialyzed patients: a five-year clinical radiological prospective study. Skeletal Radiology, Vol 30 pp 431-41.
12912	Levine RA, Rosenbaum AE, Waltz JM & Scheinberg LC (1970). Cervical spondylosis and dyskinesias. Neurology, Vol 20 pp 1194-9.
23225	Liang H-W, Wang Y-H, Lin Y-N, Wang J-D, & Jang Y (2001). Impact of age on the injury pattern and survival of people with cervical cord injuries. Spinal Cord, Vol 39 pp 375-80.
49825	Lis AM, Black KM, Korn H, Nordin M (2007). Association between sitting and occupational LBP. Eur Spine J, 16: 283-98.
5525	Lovell NC (1994). Spinal arthritis and physical stress at Bronze Age Harappa. Am Journal of Physical Anthropology, Vol 93 pp 149-164.
23336	Lundin O, Hellstrom M, Nilsson I and Sward L (2001). Back pain and radiological changes in the thoraco-lumbar spine of atheles. A long-term follow-up. Scandinavian Journal of Medicine and Science in Sports, 11(2) pp 103-109.
23201	Luoma K, Riihimaki H, Raininko R, Luukkonen R, Lamminen A, Viikari-Juntura E. (1998). Lumbar disc degeneration in relation to occupation. Scand J Work Environ Health, Vol 24(5) pp 358-66.
48758	Lyras DN, Tilkeridis K, Stavrakis T (2008). Progression of spondylosis to isthmic spondylolisthesis in an adult without accompanying disc generation: a case report. Acta Orthop Belg, 74: 141-4.
35319	Manninen P, Heliovaara M, Riihimaki H, Suoma-lainen O (2002). Physical workload and the risk of severe knee osteoarthritis. Scand J Work Environ Health, 28(1): 25-32.
23204	Marchiori DM, & Henderson CNR. (1996). A cross-sectional study correlating cervical radiographic degenerative findings to pain and disability. Spine, Vol 21(23) pp 2747-52.
23226	Mata S, Chhem RK, Fortin PR, Joseph L, Esdaile JM (1998). Comprehensive radiographic evaluation of diffuse idiopathic skeletal hyperostosis: development and interrater reliability of a scoring system. Seminars in Arthritis & Rheumatism, Vol 28 pp 88-96.
55661	Matilla VM, Sillanpaa P, Visuri T, Pihlajamaki H (2009). Incidence and trends of low back pain hospitalisation during military service - an analysis of 387,070 Finnish young males. BMC Musculoskeletal Disorders, 10: 10.
23346	Mazieres B, Rovensky J (2000). Non-inflammatory enthesopathies of the spine: a diagnostic approach. Bailliere's Clinical Rheumatology, 14(2): 201-17.
23214	McClure P. (2000). The degenerative cervical spine: pathogenesis and rehabilitation concepts. Journal of Hand Therapy, Vol 13(2) pp 163-74.
5527	McDermott M and Freyne P (1983). Osteoarthrosis in runners with knee pain. Brit J Sports Med, 17(2) pp 84-87.
35448	Mettler FA & Upton AC (Eds)(1995). Medical Effects of Ionizing Radiation. Second Edition. WB Saunders Co, USA. [ISBN 0 7216 6646 9]
54582	Middleton K, Fish DE (2009). Lumbar spondylosis: clinical presentation and treatment approaches. Curr Rev Musculoskelet Med, 2: 94-104.

23368	Mihara H, Ohnari K, Hachiya M, Kondo S, & Yamada K. (2000). Cervical myelopathy caused by C3-C4 spondylosis in elderly patients. A radiographic analysis of pathogenesis. Spine, Vol 25(7) pp 796-800.
47311	Milby TH, Spear RC (1974). Relationship between whole body vibration and morbidity patterrns among heavy equipment operators. US Department of Health, Education, and Welfare, National Institute for Occupational Safety and Health.
34749	Miranda H, Vikari-Juntura E, Martikainen R, Riihimaki H (2002). A prospective study on kneww pain and its risk factors. Osteoarthritis and Cartilage, Vol 10 pp 623-630.
23221	Miyakoshi N, Abe E, Shimada Y, Hongo M, Chiba M, & Sato K. (1999). Anterior decompression with single segmental spinal interbody fusion for lumbar burst fracture. Spine, Vol 24(1) pp 67-73.
23222	Miyakoshi N, Abe E, Shimada Y, Okuyama K, Suzuki T, Sato K (2000). Outcome of one-level posterior lumbar interbody fusion for spondylolisthesis and postoperative intervertebral disc degeneration adjacent to the fusion. Spine, 25(14): 1837-42.
23334	Modic MT (1999). Degenerative disc disease and back pain. Magnetic Resonance Imaging Clinics of North America, 7(3) pp 481-491.
12194	Morris JM, Lucas DB, Bresler B (1961). Role of the trunk in stability of the spine. The Journal of Bone and Joint Surgery, 43A(3) pp 327-351.
12923	Moskowitz A, Moe JH, Winter RB and Binner H (1980). Long-term follow-up of scoliosis fusion. The Journal of Bone and Joint Surgery, 62-A(3) pp 364-376.
5531	Murray-Leslie CF, Lintott DJ, Wright V (1977). The spine in sport and veteran military parachutists. Annals of the Rheumatic Diseases, Vol 36 pp 332-342.
13039	Mustajoki P, Nummi J, & Meurman K. (1978). Permanent changes in the spines of military parachutists. Aviation, Space, and Environmental Medicine, Vol 49 (6) pp 823-6.
23366	Nakai S, Yoshizawa H, Kobayashi S (1999). Long-term follow-up study of posterior lumbar interbody fusion. Journal of Spinal Disorders, 12(4): 293-9.
49830	National Institute for Occupational Safety and Health (1997). A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity and low back. Low-back musculoskeletal disorders: evidence for work-relatedness. Chapter 6, Publication No. 97-141. http://www.cdc.gov.niosh/docs/97-141/ergotxt6.htm1#bending.
48993	National Research Council and the Institute of Medicine (2001). Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Panel on musculoskeletal disorders and the workplace. Commission of behavioral and social sciences and eduction. Washington, DC. National Academy Press. Pp 29, 118-24, 184-94.
55326	Nelson R (2009). Thousands of new cancers predicted due to increased use of CT. Retrieved 20 January 2010, from http://www.medscape.com/viewarticle/714025_print
9442	Nice DS, Garland CF, Hilton SM, Baggett JC, Mitchell RE. (1996). Long-term health outcomes and medical effects of torture among US Navy prisoners of war in Vietnam. JAMA, 276(5) pp 375-381.
34630	Niosi CA, Oxland TR (2004). Degenerative mechanics of the lumbar spine. The Spine Journal, 4: 202S - 208S.
12909	Nishihara N, Tanabe G, Nakahara S, Imai T, Murakawa H. (1984). Surgical treatment of cervical spondylotic myelopathy complicating athetoid cerebral palsy. The Journal of Bone and Joint Surgery, Vol 66-B (4) pp 504-8.

20404	NRC (National Research Council) (1990). Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V Washington, DC: National Academy Press.
33239	Obisesan KA, Obajimi MO (1999). Radiological ageing process in the cervical spine of Nigerian women. Afr J Med Med Sci, 28(3-4): 189-91.
12964	O'Connor FG & Marlowe SS. (1993). Low back pain in military basic trainees. A pilot study. Spine, Vol 18 (10) pp 1351-4.
12246	O'Keefe B, & Smith FB. (1994). Medicine at War: Medical aspects of Australia's involvement in Southeast Asia 1950-1972. Allen & Unwin, St Leonards.
23215	Olivieri I, Salvarani C, Cantini F, Ciancio G, Padula A (2001). Ankylosing spondylitis and undifferentiated spondyloarthropathies: a clinical review and description of a disease subset with older age at onset. Current Opinion in Rheumatology, Vol 13 pp 280-4.
23209	O'Neill TW, McCloskey EV, Kanis JA, Bhalla AK, et al (1999). The distribution, determinants, and clinical correlates of vertebral osteophytosis: a population based survey. Journal of Rheumatology, Vol 26 pp 842-8.
12920	Osti OL and Cullum DE (1994). Occupational low back pain and intervertebral disc degeneration: epidemiology, imaging, and pathology. The Clinical Journal of Pain, 10(4) pp 331-334.
10424	Osti OL, Vernon-Roberts B, Fraser RD (1990). Anulus tears and intervertebral disc degeneration: an experimental study using an animal model. Spine,15: 762-7.
3038	O'Toole BI, Marshall RP, Grayson DA, Schureck RJ, et al (1996). The Australian Vietnam Veterans Health Study: II.Self-reported health of veterans compared with the Australian population. Int J Epidemiol, 25(2): 319-30.
23202	Paavo Z, Rantakallio P, & Vanharanta H. (1998). Cumulative incidence of lumbar disc diseases leading to hospitalization up to the age of 28 years. Spine Vol 23(21)pp 2337-2344.
47310	Page WF (1991). Epidemiology in Military and Veteran Populations. Proceedings of the Second Biennial Conference March 7 1990. National Academy Press, Washington.
1288	Panush RS, Brown DG (1987). Exercise and arthritis. Sports Med, 4(1): 54-64.
5529	Panush RS, Lane NE (1994). Exercise and the musculoskeletal system. Bailliere's Clinical Rheumatology, 8(1) chap 6 pp 79-101.
23486	Parkkola R & Kormano M. (1992). Lumbar disc and back muscle degeneration on MRI: correlation to age and body mass. Journal of Spinal Disorders, Vol 5(1) pp 86-92.
48484	Pelham TW, White H, Holt LE, Lee SW (2005). The etiology of low back pain in military helicopter aviators: Prevention and treatment. Work, 24: 101-10.
20576	Petren-Mallmin M, Linder J (1999). MRI cervical spine findings in aymptomatic fighter pilots. Aviation, Space, and Environmental Medicine, 70(12): 1183-8.
23339	Petren-Mallmin M, Linder J (1999). MRI cervical spine findings in aymptomatic fighter pilots. Aviation, Space, and Environmental Medicine, 70(12): 1183-8.
23492	Petren-Mallmin M, Linder J. (1994). Magnetic resonance findings in the cervical spine of experienced fighter pilots and controls. Aviation, Space, & Environmental Medicine, Vol 66 p 470.

23195	Pfirrmann CWA, Resnick D. (2001). Schmorl nodes of the thoracic and lumbar spine: radiographic-pathologic study of prevalence, characterization, and correlation with degeneerative changes of 1,650 spinal levels in 100 cadavers. Radiology, Vol 219 pp 368-74.
12149	Phillips PB, Zarriello JJ (1959). Central nervous system injury from high radial G Force. Aerospace Medicine, Vol 30 pp 847-851.
23218	Pollak L, Schiffer J, Klein C, Mirovsky Y, Copeliovich L, & Rabey JM. (1998). Neurosurgical intervention for cervical disk disease in dystonic cerebral palsy. Movement Disorders, Vol 13(4) pp 713-17.
5517	Pope MH, Bevins T, Wilder DG, Frymoyer JW (1985). The relationship between anthropometric, postural, muscular and mobility characteristics of males ages 18-55. Spine, 10(7): 644-8.
23284	Porter Se and Hanley EN (2001). The Musculoskeletal Effects of Smoking. J of the American Academy of Orthopaedic Surgeons 9 (1) pp 9-17.
5520	Radin EL, Paul IL, Rose RM (1972). Role of mechanical factors in pathogenesis of primary osteoarthritis. The Lancet, 1(7749): 519-21.
5523	Radin EL, Rose RM (1986). Role of subchondral bone in the initiation and progression of cartilage damage. Clinical Orthopaedics and Related Research, Vol 213 pp 34-40.
5522	Radin EL, Swann DA, Paul IL, McGrath PJ (1982). Factors influencing articular cartilage wear in vitro. Arthritis and Rheumatism, 25(8) pp 974-980.
22061	Rate WR, Butler MS, Robertson WW, D'Angio GJ. (1991). Late orthopedic effects in children with Wilm's tumor treated with abdominal arradiation. Medical and Pediatric Oncology, Vol 19 pp 265-268.
23219	Reddy DR, Prasad VSSV (1998). Alkaptonuria presenting as lumbar disc prolapse: case report and review of literature. Spinal Cord, Vol 36 pp 523-524.
12922	Richter DE, Nash CL, Moskowitz RW, Goldberg VM and Rosner IA (1985). Idiopathic adolescent scoliosis - a prototype of degenerative joint disease: the relation of biomechanic factors to osteophyte formation. Clinical Orthopaedics and Related Research, Number 193 pp 221-229.
13833	Riihimaki H, Wickstrom G, Hanninen K and Luopajarvi T (1989). Predictors of sciatic pain among concrete reinforcement workers and house painters - a five-year follow-up. Scand J Work Environ Health. Vol 15(6) pp 415-423.
13834	Riihimaki H, Wickstrom G, Hanninen K, Mattsson T, Waris P and Zitting A (1989). Radiographically detectable lumbar degenerative changes as risk indicators of back pain. Scand J Work Environ Health. Vol 15 pp 280-285.
23205	Robinson D, Mirovsky Y, Halperin N, Evron Z, Nevo Z (1998). Changes in proteoglcans of intervertebral disc in diabetic patients. Spine, 23(8): 849-56.
24373	Rohlmann A, Neller S, Bergmann G, Graichen F, Claes L, Wilke H-J (2001). Effect of an internal fixator and a bone graft on intersegmental spinal motion and intradiscal pressure in the adjacent regions. European Spine Journal, Vol 10(4) pp 301-308.
49721	Rollin Stott JR (1999). Vibration. Aviation Medicine, Chapter 13. Eds. Ernsting J, Nicholson AN, Rainford DJ: 177-91.
33719	Rom WN (ed)(1998). Environmental and Occupational Medicine, Third Edition, Lippincott-Raven, Philadelphia. [ISBN 0-316-75578-8]
23217	Rosenfeld M, Friedman JH. (1999). Cervical stenosis and dystonic cerebral palsy. Movement Disorders, Vol 14(1) pp 194-5.

5526	Rossi F, Dragoni S (1990). Lumbar spondylolysis: occurrence in competitive athletes. Updated achievements in a series of 390 cases. The Journal of Sports, Medicine and Physical Fitness, 30(4) pp 450-452.
12931	Rowe KW, Brooks CJ (1984). Head and neck injuries in Canadian forces ejections. Aviation, Space and Environmental Medicine, 55(4): 313-5.
12298	Rowe ML (1969). Low back pain in industry: a position paper. Journal of Occupational Medicine, 11(4) pp 161-169.
47673	Ryan J, Sutton K, Baigent M (1996). Australiasian Radiology, A History. McGraw-Hill: Australia, pp 304, 487-93.
1537	Sairanen E, Brushaber L, Kaskinen M (1981). Felling work, low-back pain and osteoarthritis. Scand J Work Environ Health, 7(1): 18-30.
1289	Samanta A, Jones A, Regan M, Wilson S, Doherty M (1993). Is osteoarthritis in women affected by hormonal changes or smoking? Br J Rheumatol, 32(5): 366-70.
23227	Sambrook PN, MacGregor AJ, & Spector TD. (1999). Genetic influences on cervical and lumbar disc degeneration. A magnetic resonance imaging study in twins. Arthritis & Rheumatism, Vol 42(2) pp 366-372.
5521	Sapolsky AI, Altman RD, Woessner JF, Howell DS (1973). The action of cathepsin D in human articular cartilage on proteoglycans. The Journal of Clinical Investigation, Vol 52 pp 624-633.
34345	Sarzi-Puttini P, Atzeni F (2004). New developments in our understanding of DISH (diffuse idiopathic skeletal hyperostosis). Curr Opin Rheumatol, Vol 16 pp 287-292.
12916	Sato H & Kikuchi S. (1993) The natural history of radiographic instability of the lumbar spine. Spine, Vol 18 (4) pp 2075-9.
47313	Sausville E, Longo D (2001). Principles of radiation therapy. Harrison's 15th Edition, Principles of Internal Medicine, Part 6, Section 1, pp 532-3.
22187	Scheibel-Jost P, Pfeil J, Niethard FU, Fromm B, Willich E, & Kuttig H. (1991). Spinal growth after irradiation for Wilm's tumour. International Orthopaedics, Vol 15 pp 387-391.
12209	Scherak O, Shohoumi M, Stanek D, Kolarz G (1990). [Letter] Diffuse Idiopathic Skeletal Hypertosis (DISH) of the spine: a risk factor after hip joint replacement. British Journal of Rheumatology, 29: 75.
13007	Schulte-Wintrop HC & Knoche H. (1978). Backache in UH-ID helicopter crews. AGARD Conference Proceedings pp 19-1 t0 19-12.
23367	Seichi A, Takeshita K, Ohishi I, Kawaguchi H, Akune T, Anamizu Y, Kitagawa T, Nakamura K (2001). Long-term results of double-door laminoplasty for cervical stenotic myelopathy. Spine, Vol 26(5) pp 479-487.
24299	Seidler A, Bolm-Audorff U, Heiskel H, Henkel N, Roth-Kuver B, et al (2001). The role of cumulative physical work load in lumbar spine disease: risk factors for lumbar osteochondrosis and spondylosis associated with chronic complaints. Occupational & Environmental Medicine, 58(11): 735-46.
33236	Seidler A, Bolm-Audorff U, Siol T, Henkel N, Fuchs C, et al (2003). Occupational risk factors for symptomatic lumbar disc herniation; a case-control study. Int J Occup Med Environ Health, 60: 821-30.
55061	Shanahan DF, Reading TE (1984). Helicopter pilot back pain: a preliminary study. Aviat Space Environ Med, 55(2): 117-21.
48597	Sharma L (2007). Lifestyles, flying and associated health problems in flight attendants. JRSH, 127(6): 268-75.
49832	Sheard SC, Pethybridge RJ, Wright JM, McMillan GH (1996). Back pain in aircrew - an initial sruvey. Aviat Space Environ Med, 67(5): 474-7.

55064	Simon-Arndt CM, Yuan H, Hourani LL (1997). Aircraft type and diagnosed back disorders in U.S. navy pilots and aircrew. Aviat Space Environ Med, 68(11): 1012-8.
12196	Sims JA, Moorman SJ (1996). The role of the iliolumbar ligament in low back pain. Medical Hypotheses, Vol 46, pp 511-515.
22058	Smith R, Davidson JK, Flatman GE (1982). Skeletal effects of orthovoltage and megavoltage therapy following treatment of nephroblastoma. Clinical Radiology, Vol 33 pp 601-613.
48596	Smith SD (2006). Seat vibration in military propeller aircraft: characterization, exposure assessment, and mitigation. Aviation, Space, and Environmental Medicine, 77(1): 32-40.
12299	Soini J, Antti-Poika I, Tallroth K, Konttinen YT, et al (1991). Disc degeneration and angular movement of the lumbar spine: comparative study using plain and flexion-extension radiography and discography. Journal of Spinal Disorders, 4(2): 183-187.
13069	Sortland O, Tysvaer AT, Storli OV (1982). Changes in the cervical spine in association football players. British Journal of Sports & Medicine, Vol 16 (2) pp 80-84.
21787	Sources and effects of ionizing radiation. UN scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 Report to the General Assembly, with Scientific Annex. VOL I
52896	Sovelius R, Salonen O, Lamminen A, Huhtala H, Hamalainen O (2008). Spinal MRI in fighter pilots and controls: A 13 - year longitudinal study. Aviation, Space and Environmental Medicine, 79(7): 685-8.
47312	Spear RC, Keller C, Behrens V, Hudes M, Tarter D (1976). Morbidity patterns among heavy equipment. Operators exposed to whole-body vibration - 1975. Followup to a 1974 study. US Department of Health, Education, and Welfare.
13170	Spear RC, Keller CA, Milby TM (1976). Morbidity studies of workers expopsed to whole body vibration. Archives of Environmental Helath, 31(3) pp 141-145.
12977	Stellman SD, Stellman JM, Sommer JF Jr (1988). Health and reproductive outcomes among American legionnaires in relation to combat and herbicide exposure in Vietnam. Environmental Research, Vol 47 pp 150-174.
12924	Stoddard A and Osborn JF (1979). Scheuermann's Disease or spinal osteochondrosis: its frequency and relationship with spondylosis. The Journal of Bone and Joint Surgery, 61-B(1): 56-58.
23488	Sward L, Hellstrom M, Jacobsson B, Nyman R, Peterson L (1991). Disc degeneration and associated abnormalities of the spine in elite gymnasts. A magnetic resonance imaging study. Spine, Vol 16(4) pp 437-43.
23622	Symmons DPM, van Hermert AM, Vandenbroucke JP, Valkenburg HA (1991). A longitudinal study of back pain and radiological changes in the lumbar spines of middle aged women, 11: radiographic findings. Ann Rheum Dis, 50: 162-6.
52586	Taneja N (2008). Spinal disabilities in military and civil aviators. Spine, 33(25): 2749-53.
52897	Taneja N, Pinto LJ (2005). Diagnostic categories among 232 military aircrew with musculoskeletal disabilities. Aviation, Space and Environmental Medicine, 76(6): 581-5.

24478	Teschke K, Nicol AM, Davies H, Ju S (1999). Whole body vibration and back disorders among motor vehicle drivers and heavy equipment operators: a review of the scientific evidence. Report to the Appeal Commissioner, Workers' Compensation Board of British Columbia, Vancouver, British Columbia.
54584	The European Parliament and the Council of the European Union (2002). Minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration). Official Journal of the European Communities, 6.7.2002: L177/13-9.
55062	Thomae MK, Porteous JE, Brock JR, Allen GD, Heller RF (1998). Back pain in Australian military helicopter pilots: a preliminary study. Aviat Space Environ Med, 69(5): 468-73.
12258	Tichauer ER (1978). The Biomechanical Basis of Ergonomics: Anatomy Applied to the Design of Work Situations. John Wiley & Sons, New York, pp 16-31.
13006	Tkach S. (1970). Gouty arthritis of the spine. Clinical Orthopaedics & Related Research, Vol 71 pp 81-6.
12197	Toma S, Shiozawa Z (1995). Amyotrophic cervical myelopathy in adolescence. Journal of Neurology, Neurosurgery, and Psychiatry, 58: 56-64.
12919	Tomlinson JP, Lednar WM and Jackson JD (1987). Risk of injury in soldiers. Military Medicine, 152(2) pp 60-64.
23484	Troup JDG (1965). Relation of lumbar spine disorders to heavy manual work and lifting. The Lancet, Vol 1 pp 857 & 860-61.
21788	United Nations Scientific Committee on the Effects of Atomic Radiation (2000). Sources and effects of ionizing radiation. Vol 11: Effects. United Nations. New York
49831	Valenti M, Prosperini V, Falzano P, Hendel M, Raimondi P (2004). Vibration, back pain and physical exercise in high-risk professionals: a cross-sectional study. G Ital Med Lav Ergon, 26(3): 180-82. [Abstract]
23777	Van Horn Jr, Bohnen LMLJ (1992). The development of discopathy in lumbar discs adjacent to a lumbar anterior interbody spondylodesis. A retrospective matched pair study with a post-operative follow up of 16 years. Acta Orthop Belg, Vol 58 pp 280-6.
23648	van Saase JLCM, Vandenbroucke JP, van Romunde LJJ, Valkenburg HA (1988). Osteoarthritis and obesity in the general population. A relationship calling for an explanation. Journal of Rheumatology, Vol 15 pp 1152-8.
1292	Venn AJ, Guest CS (1991). Chronic Morbidity of Former Prisoners of War and other Australian Veterans. MJA, 155: 705-7, 710-2.
23220	Videman T, & Battie MC. (1999). Spine Update. The influence of occupation on lumbar degeneration. Spine, Vol 24(11) pp 1164-8.
23187	Videman T, Battie MC, Gibbons LE, Kaprio J, Koskenvuo M, et al (2000). Disc degeneration and bone density in monzygotic twins discordant for insulin-dependent diabetes mellitus. Journal of Orthopaedic Research, Vol 18 pp 768-772.
23203	Videman T, Leppavuori J, Kaprio J, Battie MC, Gibbons LE, Peltonen L, Koskenvuo M. (1998). 1998 Volvo award winner in basic science studies. Spine, 23(23) pp 2477-2485.
13778	Videman T, Nurminen M and Troup JDG (1990). Lumbar Spinal Pathology in Cadaveric Matrial in Relation to History of Back Pain, Occupation, and Physical Loading. Spine. Vol 15(8) pp 728-740.

23490	Videman T, Sarna S, Battie MC, Koskinen S, et al (1995). The long-term effects of physical loading and exercise lifestyles on back-related symptoms, disability, and spinal pathology among men. Spine, 20(6): 699-709.
23189	Videman T, Simonen R, Usenius J.-P, Osterman K, Battie MC. (2000). The long-term effects of rally driving on spinal pathology. Clinical Biomechanics, Vol 15 pp 83-6.
20461	Videman T, Simonen R, Usenius J-P, Osterman K, & Battie MC. (2000). The long-term effects of rally driving on spinal pathology. Clinical Biomechanics Vol 15 pp 83-6.
23192	Vijaikumar M, Thappa DM, Srikanth S, Sethuraman G & Nadarajan S. (2000). Clinical & Experimental Dermatology, Vol 25 pp 305-7.
48091	Waddell G (1998). Risk factors for low back pain. The Back Pain Revolution. Edinburgh, Churchill, Livingstone (Eds): 85-101.
23198	Wang P-N, Chen S-S, Liu H-C, Fuh J-L, Kuo B I-T, Wang S-J (1999). Ossification of the posterior longitudinal ligament of the spine. Spine, Vol 24(2) pp 142-145.
48449	Ward MW (1999). Orthopaedics. Aviation Medicine, 3rd Edition. Chapter 26: 358-63. Ernsting J, Nicholson AN, Rainford DJ (Eds.) Oxford: Butterworth Heinemann
55087	Ward MW (1999). Orthopaedics. J Ernsting, AN Nicholson, DJ Rainford (Eds). Aviation Medicine, 3rd Edition,: 358-63. Butterworth Heinemann, Oxford.
13067	Washington EL. (1978). Musculoskeletal injuries in theatrical dancers: site, frequency, and severity. The American Journal of Sports Medicine, Vol 6 (2) pp 75-98.
5516	Weber H (1983). Lumbar Disc Herniation - A controlled, prospective study with ten years of observation. Spine, 8(2) pp 131-140.
5519	Weissmann G (1972). Lysosomal mechanisms of tissue injury in Arthritis. NEJM, 286(3) pp 141-146.
5518	Weissmann G, Smolen JE, Korchak HM (1980). Release of inflammatory mediators from stimulated neutrophils. NEJM, 303(1) pp 27-34.
1506	White JA, Wright V, Hudson AM (1993). Relationships between habitual physical activity and osteoarthrosis in ageing women. Public Health, 107: 459-70.
34753	Wilder FV, Hall BJ, Barrett JP (2003). Smoking and osteoarthritis: Is there an association? The Clearwater Osteoarthritis Study. Osteoarthritis and Cartilage, 11: 29-35.
55063	Winfield DA (1999). Aircrew lumbar supports: an update. Aviat Space Environ Med, 70(4): 321-4.
47314	Wise C (1999). Osteoarthritis. In: Scientific American Medicine, Vol 3, Section 15, Chapter 10, pp 1-9.
47901	Woolfson T (2007). Synopsis of causation. Spondylosis. Service Personnel & Veterans Agency. Obtained from: http://www.veterans-uk.info/pdfs/synopsis/spondylosis.pdf
23229	Yamada Y, Okuizumi H, Miyauchi A, Takagi Y, Ikeda K, & Harada A. (2000). Association of transforming growth factor alfa1 genotype with spinal osteophytosis in Japanese women. Arthritis & Rheumatism, Vol 43(2) pp 452-60.

23228	Yoshimura N, Dennison E, Wilman C, Hashimoto T, Cooper C (2000). Epidemiology of chronic disc degeneration and osteoarthritis of the lumbar spine in Britain and Japan: a comparative study. J of Rheumatology, Vol 27 pp 429-33.
20609	Yoshimura N, Sasako S, Iwasaki K, Danjoh S, Kinoshita H, et al (2000). Occupational lifting is associated with hip osteoarthritis: a Japanese case-control study. Journal of Rheumatology, Vol 27 pp 434-40.
24346	Young WF (2000). Cervical spondylotic myelopathy: a common cause of spinal cord dysfunction in older persons. American Family Pyhsician, Vol 62 pp 1064-70, 1073.
23285	Young WF, Weaver M and Mishra B (1999). Surgical outcome in patients with coexisting multiple sclerosis and spondylosis. Acta Neurologica Acandinavica, 100 (2) pp 84-7.
23369	Zaveri GR & Ford M. (2001). Cervical spondylosis: the role of anterior instrumentation after decompression and fusion. Journal of Spinal Disorders, Vol 14 (1) pp 10-16.
33238	Zejda JE, Stasiow B (2003).Cervical spine degenerative changes (narrowed intervertebral disc spaces and osteophytes) in coal miners. Int J Occup Med Environ Health, 16(1): 49-53.
13323	Zerlett G, fur Arbeitsmedizin A, Medizin I (1986). Relationship between whole-body vibration and disorders of the backbone diagnosed on operators of earth-moving machinery. AGARD Conference proceedings No:378 Backache & back discomfort pp 2-1 to 2.5
52952	Zhang Y, Sun Z, Liu J, Guo X (2008). Advances in susceptibility genetics of intervertebral degenerative disc disease. International Journal of Biological Sciences, 4(5): 283-90.

SUBMISSIONS TO THE REPATRIATION MEDICAL AUTHORITY

Information received in relation to investigation 97-7 concerning lumbar spondylosis as at 14 April 2010

[Investigation restricted to factors and associated definitions connecting 'aircraft flight' with lumbar spondylosis in accordance with ss196B(7A) of the *Veterans' Entitlements Act 1986*.]

RMA ID	Authors	Date	Details
1.1	Repatriation Commission	17/02/95	Submission
1.2	Name Provided (and removed under s196I of the VEA)	23/02/95	Submission
1.3	Name Provided (and removed under s196I of the VEA)	17/03/95	Submission
1.4	Name Provided (and removed under s196I of the VEA)	20/03/95	Submission
1.5	Name Provided (and removed under s196I of the VEA)	20/03/95	Submission
1.6	Name Provided (and removed under s196I of the VEA)	28/03/95	Submission
1.7	Name Provided (and removed under s196I of the VEA)	10/04/95	Submission
1.8	Name Provided (and removed under s196I of the VEA)	20/04/95	Submission
1.9	Name Provided (and removed under s196I of the	29/08/95	Submission

RMA ID	Authors	Date	Details
	VEA)		
1.10	Name Provided (and removed under s196I of the VEA)	25/09/95	Submission
1.11	Name Provided (and removed under s196I of the VEA)	16/10/95	Submission
1.12	Name Provided (and removed under s196I of the VEA)	21/11/95	Submission
1.13	Repatriation Commission	26/06/96	Submission
1.14	Name Provided (and removed under s196I of the VEA)	26/08/97	Submission
1.15	Name Provided (and removed under s196I of the VEA)	03/09/97	Submission
1.16	Name Provided (and removed under s196I of the VEA)	06/10/97	Submission
1.17	Name Provided (and removed under s196I of the VEA)	14/10/97	Submission
1.18	Name Provided (and removed under s196I of the VEA)	25/11/97	Submission
1.19	Name Provided (and removed under s196I of the VEA)	04/12/97	Submission
1.20	Name Provided (and removed under s196I of the VEA)	16/01/98	Submission
1.21	Department of Veterans' Affairs	12/02/98	Submission
1.22	Name Provided (and removed under s196I of the VEA)	18/03/98	Submission
1.23	Name Provided (and removed under s196I of the VEA)	18/06/98	Submission
1.24	Name Provided (and removed under s196I of the VEA)	26/06/98	Submission
1.25	RMA Researcher	10/07/98	Briefing Paper
1.26	RMA Researcher	14/08/98	Summary of Studies
1.27	Name Provided (and removed under s196I of the VEA)	22/09/98	Submission
1.28	Name Provided (and removed under s196I of the VEA)	09/05/00	Submission
1.29	Name Provided (and removed under s196I of the VEA)	05/09/02	Submission
1.30	Name Provided (and removed under s196I of the VEA)	17/11/98	Submission
1.31	Name Provided (and removed under s196I of the VEA)	28/02/99	Submission
1.32	Name Provided (and removed under s196I of the VEA)	26/07/99	Submission
1.33	Name Provided (and removed under s196I of the VEA)	04/04/00	Submission
1.34	Name Provided (and removed under s196I of the VEA)	09/05/00	Submission
1.35	Name Provided (and removed under s196I of the VEA)	25/07/00	Submission
1.36	Name Provided (and removed under s196I of the VEA)	26/09/00	Submission
1.37	Name Provided (and removed under s196I of the	18/10/00	Submission

RMA ID	Authors	Date	Details
	VEA)		
1.38	Name Provided (and removed under s196I of the VEA)	23/11/00	Submission
1.39	Name Provided (and removed under s196I of the VEA)	12/02/01	Submission
1.40	Name Provided (and removed under s196I of the VEA)	13/07/01	Submission
1.41	Name Provided (and removed under s196I of the VEA)	29/07/01	Submission
1.42	Name Provided (and removed under s196I of the VEA)	20/11/01	Submission
1.43	Name Provided (and removed under s196I of the VEA)	14/01/02	Submission
1.44	RMA Researcher	15/03/02	Briefing Paper
1.45	RMA Researcher	01/03/02	Summary of Studies
1.46	RMA Researcher	28/05/02	Briefing Paper
1.47	Name Provided (and removed under s196I of the VEA)	12/06/02	Submission
1.48	Name Provided (and removed under s196I of the VEA)	20/06/02	Submission
1.49	Name Provided (and removed under s196I of the VEA)	26/06/02	Submission
1.50	Name Provided (and removed under s196I of the VEA)	12/09/02	Submission
1.51	Name Provided (and removed under s196I of the VEA)	09/12/02	Submission
1.52	Name Provided (and removed under s196I of the VEA)	28/05/03	Submission
1.53	Name Provided (and removed under s196I of the VEA)	16/07/03	Submission
1.54	Name Provided (and removed under s196I of the VEA)	29/07/03	Submission
1.55	Name Provided (and removed under s196I of the VEA)	28/08/03	Submission
1.56	Name Provided (and removed under s196I of the VEA)	29/09/03	Submission
1.57	Name Provided (and removed under s196I of the VEA)	06/11/03	Submission
1.58	Name Provided (and removed under s196I of the VEA)	12/01/04	Submission
1.59	Name Provided (and removed under s196I of the VEA)	01/02/04	Submission
1.60	Name Provided (and removed under s196I of the VEA)	24/02/04	Submission
1.61	Name Provided (and removed under s196I of the VEA)	09/03/04	Submission
1.62	Name Provided (and removed under s196I of the VEA)	07/04/04	Submission
1.63	Name Provided (and removed under s196I of the VEA)	28/07/04	Submission
1.64	Name Provided (and removed under s196I of the	02/11/04	Submission

RMA ID	Authors	Date	Details
	VEA)		
1.65	Name Provided (and removed under s196I of the VEA)	08/02/05	Submission
1.66	Name Provided (and removed under s196I of the VEA)	17/05/05	Submission
1.67	Name Provided (and removed under s196I of the VEA)	29/06/05	Submission
1.68	Name Provided (and removed under s196I of the VEA)	22/09/05	Submission
1.69	Name Provided (and removed under s196I of the VEA)	22/09/05	Submission
1.70	Name Provided (and removed under s196I of the VEA)	17/10/05	Submission
1.71	Name Provided (and removed under s196I of the VEA)	01/06/05	Submission
1.72	RMA Researcher	01/08/05	Briefing Paper
1.73	Name Provided (and removed under s196I of the VEA)	09/04/08	Submission
1.74	Name Provided (and removed under s196I of the VEA)	01/10/08	Submission
1.75	Name Provided (and removed under s196I of the VEA)	01/10/08	Submission
1.76	Name Provided (and removed under s196I of the VEA)	06/03/09	Submission
1.77	Name Provided (and removed under s196I of the VEA)	20/03/09	Submission
1.78	Name Provided (and removed under s196I of the VEA)	16/07/09	Submission
1.79	Name Provided (and removed under s196I of the VEA)	18/07/09	Submission
1.80	Name Provided (and removed under s196I of the VEA)	28/09/09	Submission
1.81	RMA Researcher	18/06/09	Minute
1.82	RMA Researcher	11/08/09	Minute
1.83	Name Provided (and removed under s196I of the VEA)	14/08/09	Submission
1.84	Name Provided (and removed under s196I of the VEA)	17/09/09	Submission
1.85	Department of Veterans' Affairs	01/10/09	Submission
1.86	RMA Researcher	08/10/09	Submission
1.87	Name Provided (and removed under s196I of the VEA)	11/01/10	Submission

APPENDIX C

List of the information upon which the Applicant relies, which the RMA has advised the Council is new information because it was not available to (not before) the RMA.

Radebold, A. & Young, C.C 2010, 'Lumbosacral Spine Sprain/Strain Injuries', Medscape Reference © 2011 WebMD, LLC, http://emedicine.medscape.com/article/95444-differential