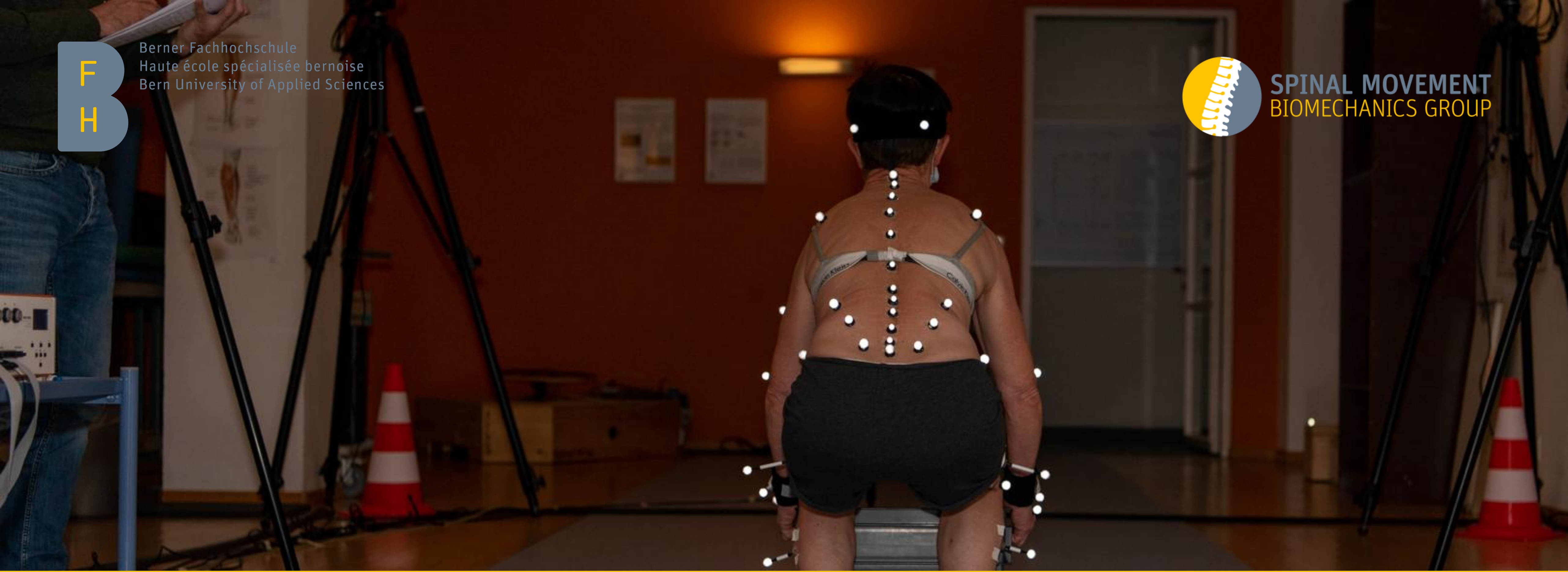

Beugen oder Nicht-Beugen

Aktuelle Evidenzlage zur Wirbelsäulenbelastung beim Lastenheben

Prof. Dr. Stefan Schmid

Swiss Insurance Medicine
Versicherungsmedizin Schweiz
Médecine d'assurance suisse
Medicina assicurativa svizzera

14. Fortbildungskurs 2025

Über mich…

- Ausbildung zum dipl. Physiotherapeuten in Bern
- Studium der Pathomechanik an der New York University, USA
- Doktorat an der ETH Zürich (Biomechanik)
- Research Fellowship an der Harvard Medical School, USA (Wirbelsäulen-Biomechanik)
- Habilitation (venia docendi) an der med. Fak. der Universität Basel (Experimentelle Medizin)

- 3 Jahre klinische Erfahrung als Physiotherapeut in CH und USA

- Leiter der Spinal Movement Biomechanics Group
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- Kontakt: stefan.schmid@bfh.ch, +41 31 848 37 96

DISCLAIMER

Die folgenden Inhalte basieren ausschliesslich auf wissenschaftlicher Evidenz. Sie spiegeln keine persönlichen Meinungen oder kommerziellen Interessen wider.

Wasmuth et al., 2004

Bild 1
Richtige Hebetechnik: Heben der Last mit geradem Rücken.

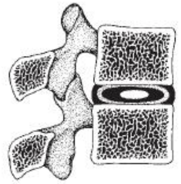


Bild 2
Gleichmässige Belastung der Bandscheiben.

Bild 3
Heben einer Last mit gebeugtem Rücken (falsche Technik).

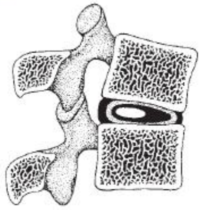
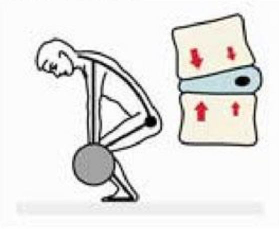


Bild 4
Keilförmige Verformung der Bandscheiben.

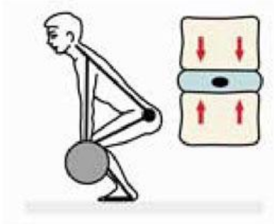
Richtig heben

FALSCH

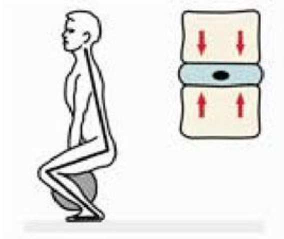


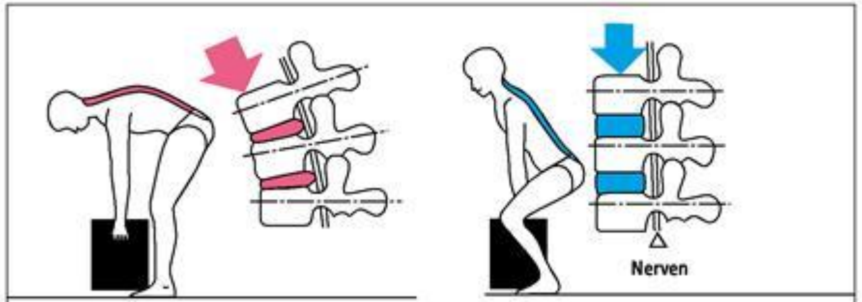
Heben und tragen Sie Lasten nicht mit gebeugtem Rücken, denn dies fördert den vorzeitigen Verschleiß der Bandscheiben.

RICHTIG



Wenn Sie die Lasten mit geradem Rücken heben, sind die Belastungen für Wirbelsäule und Bandscheiben geringer.





Falsch: Die Bandscheiben werden verformt und daher ungleichmäßig und an den Kanten übermäßig belastet.

Richtig: Die Bandscheiben werden gleichmäßig belastet.

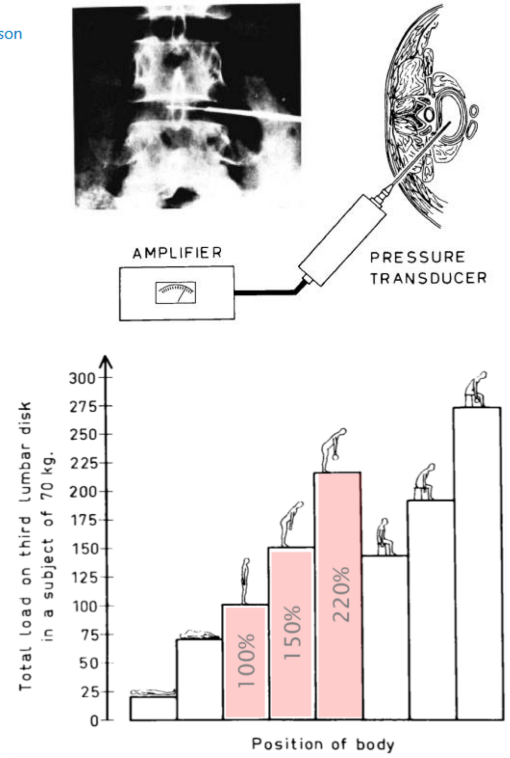
Begründungsansätze?

Intradiskale Druckmessungen

> Clin Orthop Relat Res. Mar-Apr 1966;45:107-22.

The load on lumbar disks in different positions of the body

A Nachemson



Kadaverexperimente

ELSEVIER

Clinical Biomechanics 16 (2001) 28–37

CLINICAL BIOMECHANICS

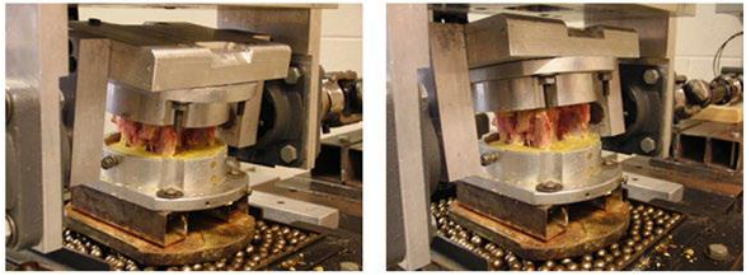
www.elsevier.com/locate/clinbiomech

Intervertebral disc herniation: studies on a porcine model exposed to highly repetitive flexion/extension motion with compressive force

Jack P. Callaghan [1], Stuart M. McGill *

Occupational Biomechanics and Safety Laboratories, Faculty of Applied Health Sciences, Department of Kinesiology, University of Waterloo, Waterloo, Ont., Canada N2L 3G1

Received 5 January 2000; accepted 8 August 2000



«…intervertebral disc herniation may be more linked to repeated flexion extension motions than applied joint compression…»

Kohortenstudien

SPINE Volume 25, Number 23, pp 3087–3092
©2000, Lippincott Williams & Wilkins, Inc.

Flexion and Rotation of the Trunk and Lifting at Work Are Risk Factors for Low Back Pain

Results of a Prospective Cohort Study

Wilhelmina E. Hoogendoorn, MSc,*† Paulien M. Bongers, PhD,* Henrica C.W. de Vet, PhD,† Marjolein Douwes, MSc,* Bart W. Koes, PhD,‡ Mathilde C. Miedema, MSc,* Geertje A.M. Ariëns, MSc,*† and Lex M. Bouter, PhD†

Table 2. Results From Multivariable Analyses for the Relation of Flexion and Rotation of the Trunk and Lifting at Work With Low Back Pain

Risk Factor	Crude RR (95% CI)* (n = 780)	Adjusted RR (95% CI)† (n = 780)
Percentage of the working time trunk flexion ≥ 30°		
≤ 5% working time	1.00	1.00
5–10% working time	0.98 (0.68–1.41)	1.04 (0.70–1.54)
> 10% working time	1.17 (0.86–1.59)	1.19 (0.86–1.65)
Percentage of the working time trunk flexion		
≤ 5% working time ≥ 30°	1.00	1.00
5–10% working time ≥ 30°	0.98 (0.68–1.41)	1.05 (0.71–1.54)
> 10% working time ≥ 30° and ≤ 5% working time ≥ 60°	1.08 (0.77–1.53)	1.09 (0.76–1.58)
> 5% working time ≥ 60°	1.42 (0.88–2.30)	1.48 (0.90–2.42)
Percentage of the working time trunk rotation ≥ 30°		
≤ 5% working time	1.00	1.00
5–10% working time	1.10 (0.81–1.50)	1.08 (0.78–1.50)
> 10% working time	1.26 (0.77–2.06)	1.29 (0.77–2.15)
Number of lifts per 8-hour working day		
Never	1.00	1.00
Never ≥ 10 kg/working day	1.01 (0.66–1.53)	0.92 (0.60–1.42)
Never ≥ 25 kg/working day	0.95 (0.67–1.36)	0.98 (0.67–1.42)
1–15 times ≥ 25 kg/working day	0.87 (0.56–1.35)	0.83 (0.52–1.33)
> 15 times ≥ 25 kg/working day	1.59 (0.98–2.60)	1.57 (0.90–2.75)
Number of lifts ≥ 25 kg per 8-hour working day		
Never	1.00	1.00
1–15 times/working day	0.88 (0.60–1.31)	0.86 (0.57–1.30)
> 15 times/working day	1.62 (1.04–2.53)	1.62 (0.97–2.69)

RR = relative risk; CI = confidence interval.

- Cohort study over 3 years (861 workers in 34 Dutch companies)
- Video analyses (baseline) and questionnaires (follow-up)

«Flexion and rotation of the trunk and lifting at work are moderate risk factors for low back pain…»

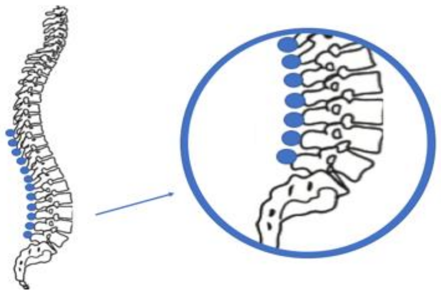
Flexion und Rückenschmerzen

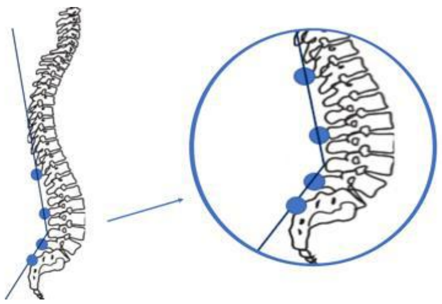
Meta-Analysis > J Orthop Sports Phys Ther. 2020 Mar;50(3):121-130.

doi: 10.2519/jospt.2020.9218. Epub 2019 Nov 28.

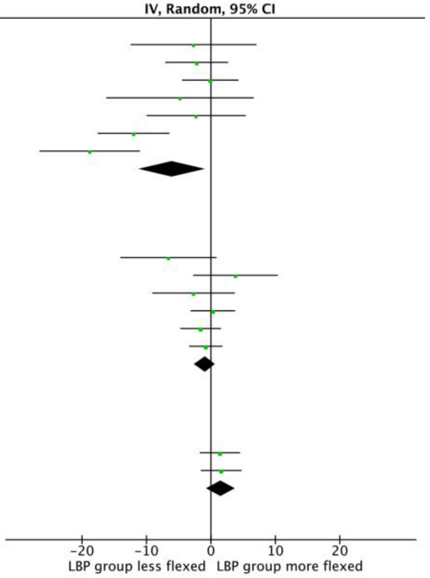
To Flex or Not to Flex? Is There a Relationship Between Lumbar Spine Flexion During Lifting and Low Back Pain? A Systematic Review With Meta-analysis

Nic Saraceni, Peter Kent, Leo Ng, Amity Campbell, Leon Straker, Peter O'Sullivan





Study or Subgroup	LBP Mean	LBP SD	LBP Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
1.1.1 Cross Sectional – Thoraco-pelvic								
Commissaris 2002	78.3	11.3	7	81	7.7	9	3.6%	-2.70 [-12.47, 7.07]
Lariviere 2002	41.5	7.2	15	43.7	7	18	7.3%	-2.20 [-7.07, 2.67]
Marich 2018	18.5	5.8	26	18.6	7.7	16	7.8%	-0.10 [-4.48, 4.28]
Marras 2001	22.5	17.8	22	27.3	20.8	22	2.9%	-4.80 [-16.24, 6.64]
O'Sullivan 2006	189.8	12.2	24	192.1	13.9	21	4.8%	-2.30 [-9.99, 5.39]
Sanchez-Zuriaga 2011	27.3	8.5	39	39.3	10	16	6.6%	-12.00 [-17.58, -6.42]
Shojaei 2017	32.6	11	19	51.4	13.4	19	4.8%	-18.80 [-26.60, -11.00]
Subtotal (95% CI)			**152**			**121**	**37.8%**	**-6.04 [-11.18, -0.89]**
Heterogeneity: $Tau^2 = 34.38$; $Chi^2 = 24.84$, df = 6 (P = 0.0004); $I^2 = 76\%$								
Test for overall effect: Z = 2.30 (P = 0.02)								
1.1.2 Cross Sectional – Intra-lumbar								
Gombatto 2017 (Lower lumbar spine)	32.4	11	18	39	11.5	17	5.0%	-6.60 [-14.06, 0.86]
Gombatto 2017 (Upper lumbar spine)	29.2	8.5	18	25.4	11.1	17	5.7%	3.80 [-2.78, 10.38]
Hemming 2017 (Lower lumbar spine)	0.3	16	50	3	12.5	28	5.8%	-2.70 [-9.11, 3.71]
Hemming 2017 (Upper lumbar spine)	4.9	8.1	50	4.6	7.1	28	8.8%	0.30 [-3.16, 3.76]
Mitchell 08/09 (Lower lumbar spine)	0	8.1	134	1.6	8.7	36	9.1%	-1.60 [-4.76, 1.56]
Mitchell 08/09 (Upper lumbar spine)	5.8	8.1	134	6.6	6.7	36	9.7%	-0.80 [-3.38, 1.78]
Subtotal (95% CI)			**404**			**162**	**44.0%**	**-0.88 [-2.51, 0.74]**
Heterogeneity: $Tau^2 = 0.14$; $Chi^2 = 5.16$, df = 5 (P = 0.40); $I^2 = 3\%$								
Test for overall effect: Z = 1.07 (P = 0.29)								
1.1.3 Longitudinal – Intra-lumbar								
Mitchell 2010 (Lower lumbar spine)	2.3	7.2	31	0.9	8.1	76	9.1%	1.40 [-1.72, 4.52]
Mitchell 2010 (Upper lumbar spine)	7.1	7.55	31	5.5	7.7	76	9.1%	1.60 [-1.57, 4.77]
Subtotal (95% CI)			**62**			**152**	**18.2%**	**1.50 [-0.73, 3.72]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.01$, df = 1 (P = 0.93); $I^2 = 0\%$								
Test for overall effect: Z = 1.32 (P = 0.19)								



«...greater lumbar spine flexion during lifting was **not a risk factor** for LBP onset/persistence, **nor a differentiator** of people with and without LBP...»

Belastung und Rückenschmerzen

› J Orthop Sports Phys Ther. 2024 Mar;54(3):176-189. doi: 10.2519/jospt.2024.11314.

Insufficient Evidence for Load as the Primary Cause of Nonspecific (Chronic) Low Back Pain. A Scoping Review

L J E de Bruin, M Hoegh, C Greve, M F Reneman

TABLE 1 DESCRIPTION OF BRADFORD-HILL CRITERIA AND THEIR CRITERIA FOR SATISFACTION

	Criteria	Description	Criteria for Satisfaction
1.	Strength:	There should be a strong association between loading and NSLBP/CLBP, and low imprecision in effect estimate.	Criteria for satisfaction in **SUPPLEMENTAL APPENDIX 3**.
2.	Consistency:	There should be consistency in strength and direction of associations.	Criteria for satisfaction in **SUPPLEMENTAL APPENDIX 3**, or multiple sources suggesting a strong positive correlation between load and NSLBP/CLBP, respectively.
3.	Temporality:	There should be a temporal relation between the moment of exposure and the moment of result. The causative variable should take place before the outcome. If exposure is removed or reduced, the outcome should also decrease.	Established with consistent evidence that NSLBP or CLBP is found in people who have been exposed to intense load of the spinal structures prior to the incidence of NSLBP or CLBP, or a reduction in NSLBP or CLBP after reduction in load onto spinal structures, or no or low loading of the spine should lead to low NSLBP or CLBP incidence.
4.	Biological gradient:	There should be evidence for a relationship between the dose of exposure and the magnitude of the response.	Criteria for satisfaction in **SUPPLEMENTAL APPENDIX 3**.
5.	Specificity:	There should be evidence that a specific outcome is related to a specific exposure. An adjusted exposure will lead to an adjusted outcome.	Established with evidence of higher incidence or prevalence of NSLBP/CLBP in populations with high load compared to otherwise comparable workers.
6.	Biological plausibility:	The biological mechanism explaining the association between load exposure and the pain response should be plausible.	Established with evidence of a consistent association between (more) structural changes in the spine and (more severe) low back pain.
7.	Coherence:	There should be consistency of the causal relationship between load and NSLBP/CLBP with what is already known about NSLBP/CLBP, dependent on the extent on the amount of knowledge available.	Established by evaluating alternative, biological plausible explanations for the observed association between load and NSLBP/CLBP.
8.	Experiment:	Evidence gathered from experiments to show the consistency of exposure developing into the same outcome at higher prevalence in the experimental group compared to the control group is clear and hard evidence of causation.	Criteria for satisfaction are given in **SUPPLEMENTAL APPENDIX 3**.
9.	Analogy:	There should be evidence that similar causes have similar effects.	Established with similar postures or lifting movements/weight resulting in NSLBP/CLBP in different studies.

Abbreviations: CLBP, chronic low back pain; NSLBP, nonspecific low back pain.

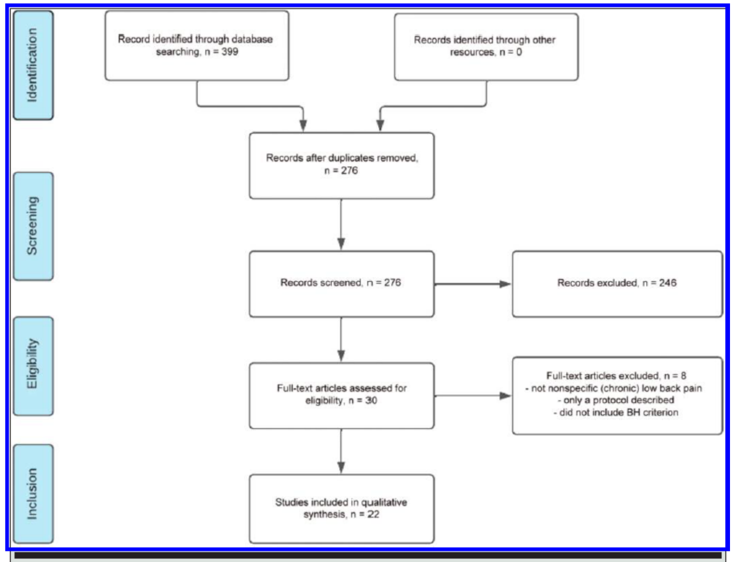


FIGURE. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram describing the literature search and screening process.

«…**insufficient evidence** to support a **causal relationship between loading and the onset and persistence** of NSLBP/CLBP based on the BH criteria.»

Squat vs. Stoop

frontiers
in Bioengineering and Biotechnology

ORIGINAL RESEARCH
published: 04 November 2021
doi: 10.3389/fbioe.2021.769117

**From Stoop to Squat:
A Comprehensive Analysis of Lumbar Loading Among Different Lifting Styles**

*Michael von Arx[1], Melanie Liechti[1], Lukas Connolly[2,3,4], Christian Bangerter[1], Michael L. Meier[2,3] and Stefan Schmid[1,5]**

Journal of Biomechanics 176 (2024) 112352

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech

Intervertebral disc deformation in the lower lumbar spine during object lifting measured in vivo using indwelling bone pins

Stefan Schmid[a,b,*], Inès Kramers-de Quervain[c], Walter Baumgartner[d,1]

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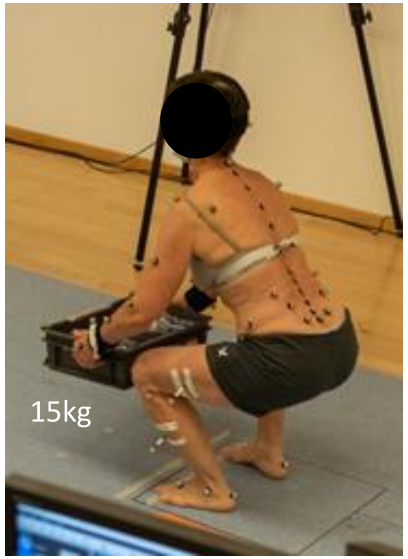
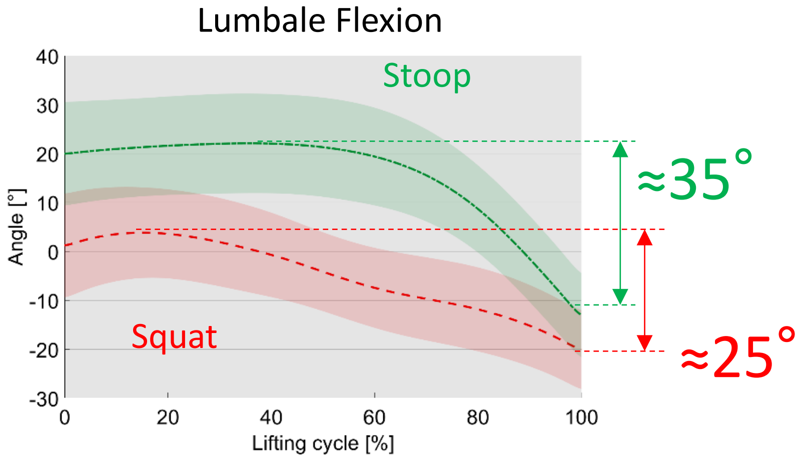
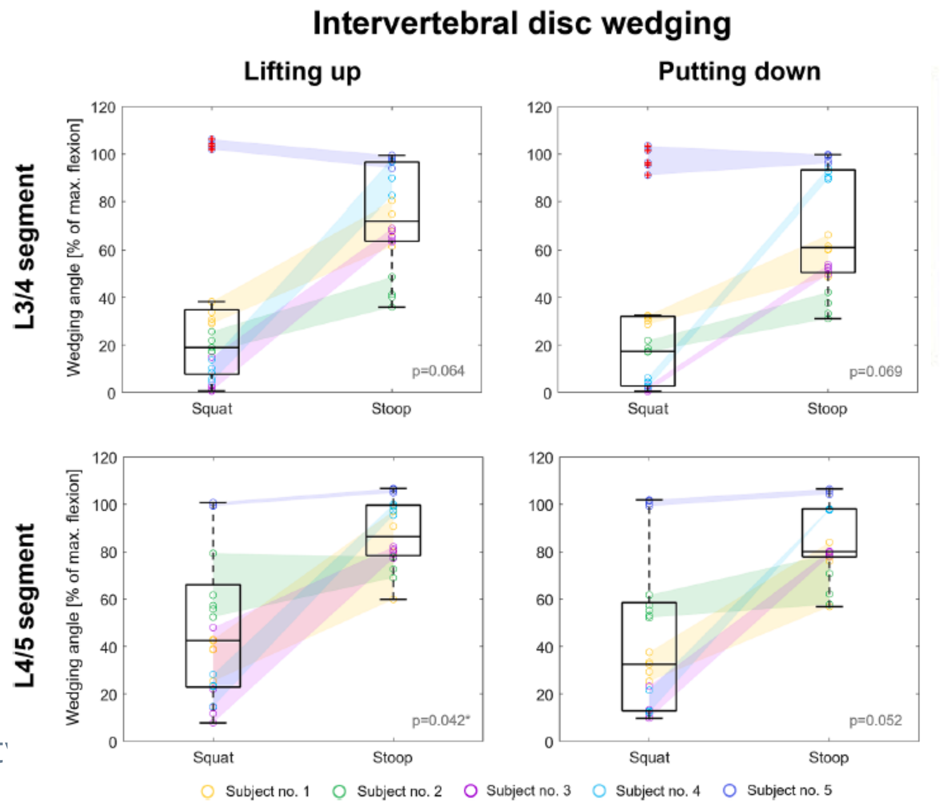
[b] University of Basel, Faculty of Medicine, Basel, Switzerland
[c] Schulthess Klinik, Department of Rheumatology and Rehabilitation, Zurich, Switzerland
[d] ETH Zurich, Laboratory of Biomechanics, Zurich, Switzerland







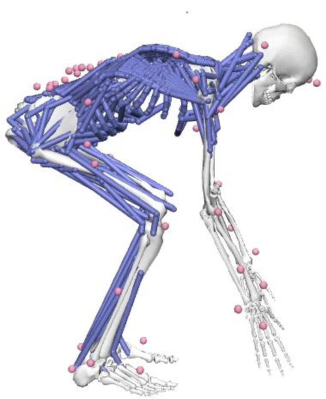
Squat vs. Stoop

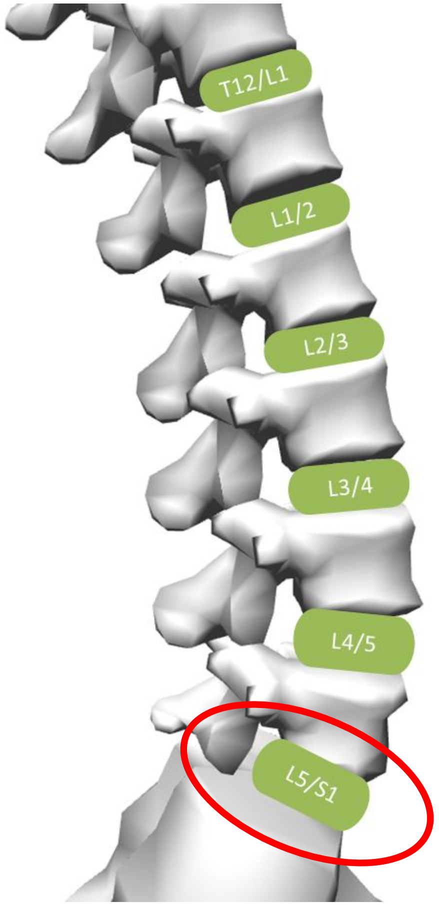
frontiers in Bioengineering and Biotechnology
ORIGINAL RESEARCH
published: 04 November 2021
doi: 10.3389/fbioe.2021.769117

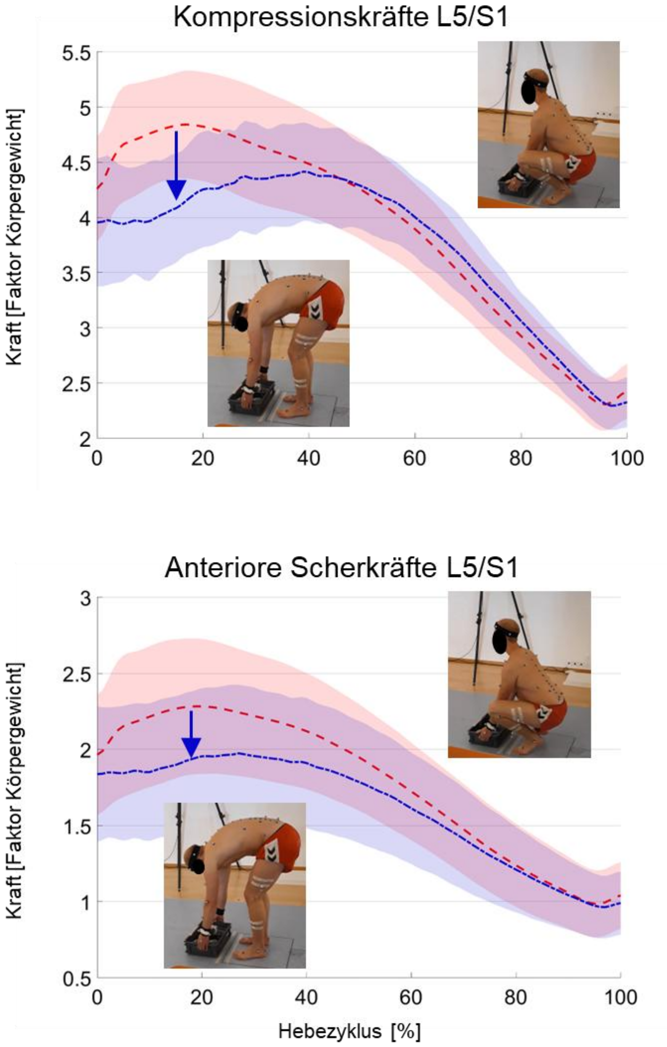
Check for updates

From Stoop to Squat: A Comprehensive Analysis of Lumbar Loading Among Different Lifting Styles

*Michael von Arx[1], Melanie Liechti[1], Lukas Connolly[2,3,4], Christian Bangerter[1], Michael L. Meier[2,3] and Stefan Schmid[1,5]**







Squat vs. Stoop

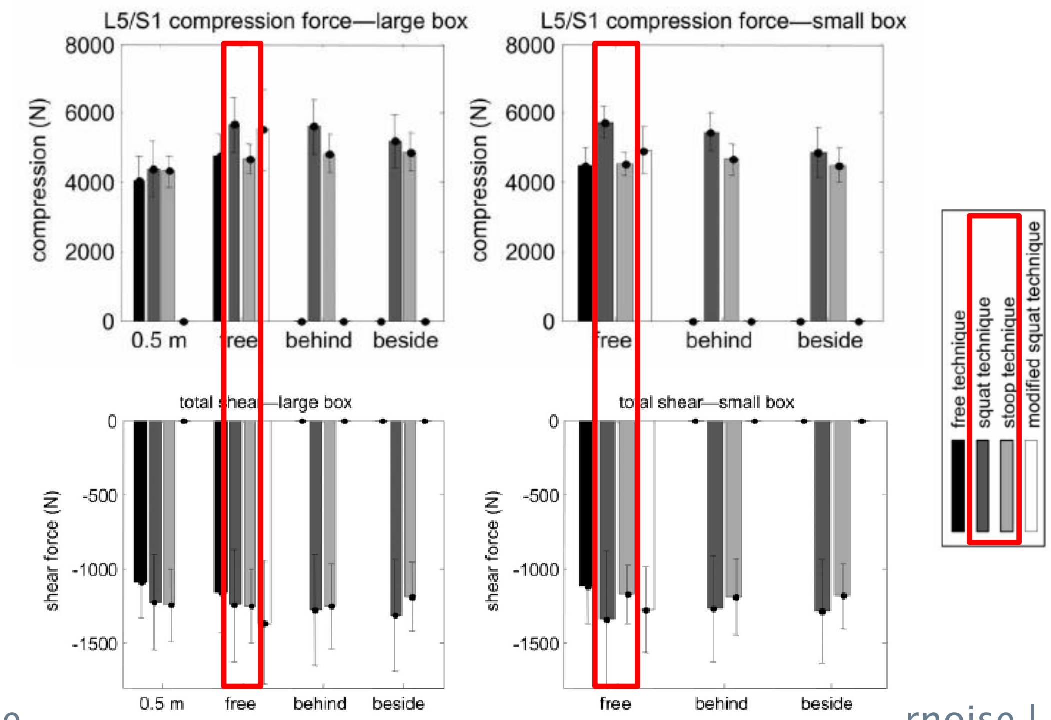
ERGONOMICS, 22 OCTOBER, 2004, VOL. 47, NO. 13, 1365–1385

Taylor & Francis healthsciences

Foot positioning instruction, initial vertical load position and lifting technique: effects on low back loading

IDSART KINGMA*, TIM BOSCH, LOUIS BRUINS and JAAP H. VAN DIEËN

Institute for Fundamental and Clinical Human Movement Sciences, Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam, The Netherlands



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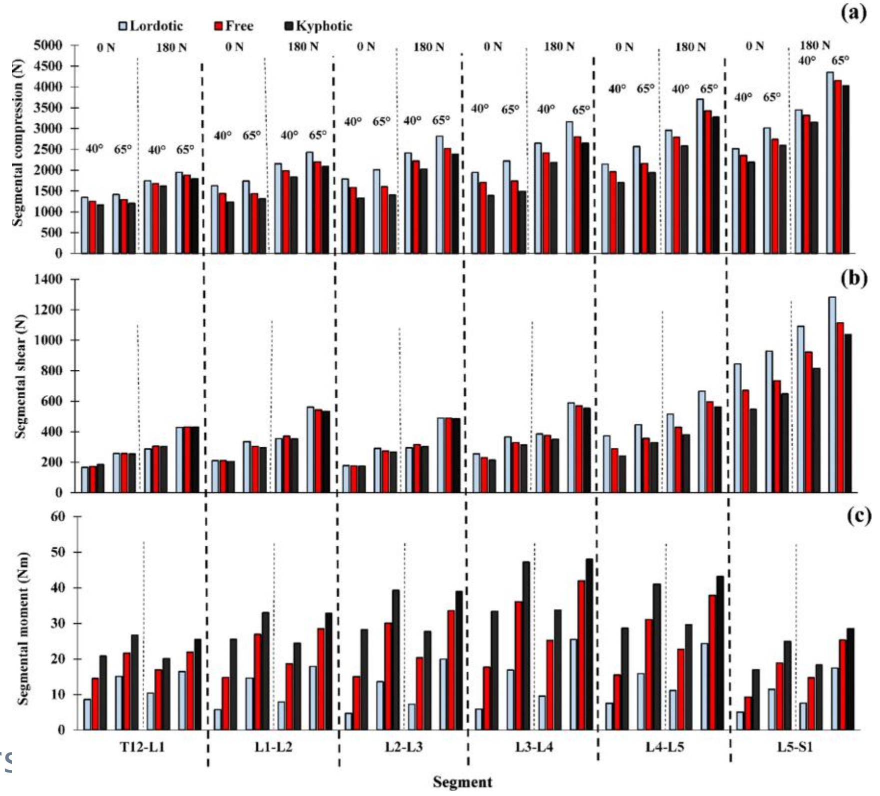
journal homepage: www.elsevier.com/locate/jbiomech
www.JBiomech.com

Effect of changes in the lumbar posture in lifting on trunk muscle and spinal loads: A combined *in vivo*, musculoskeletal, and finite element model study

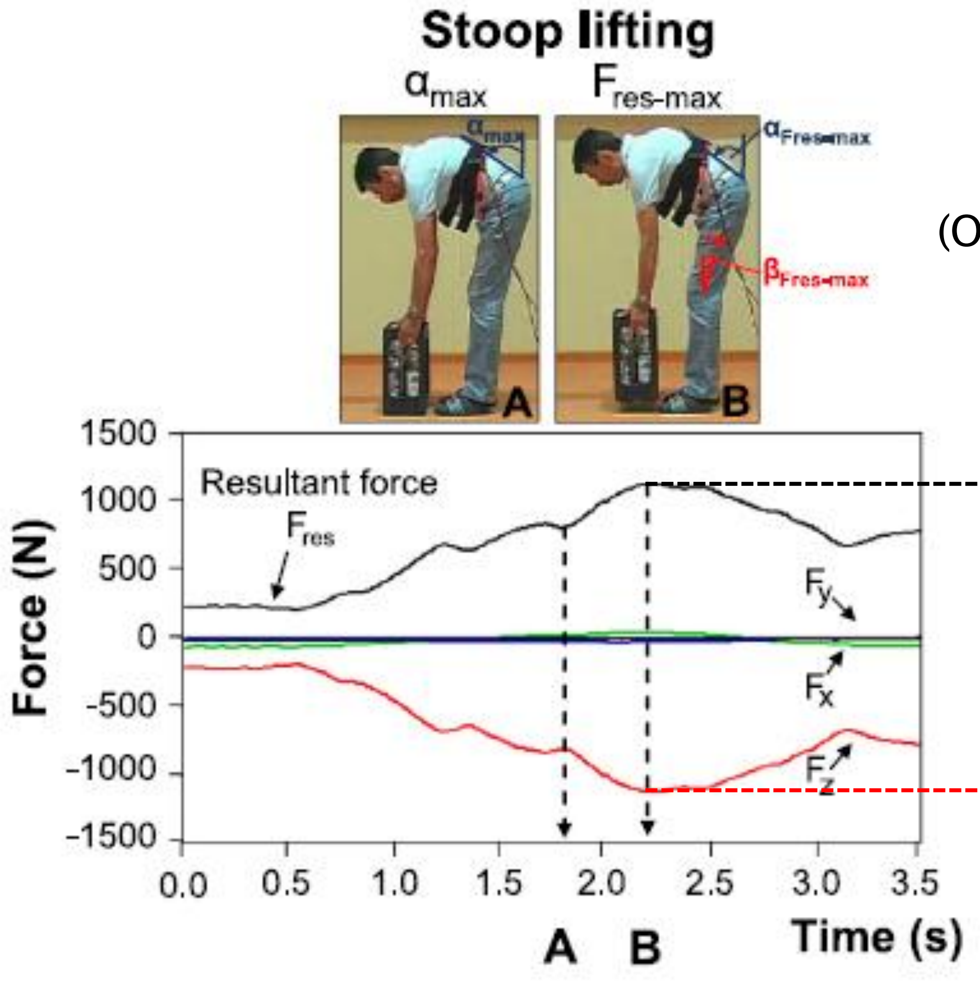
P. Khoddam-Khorasani [a], N. Arjmand [a,*], A. Shirazi-Adl [b]

[a] Department of Mechanical Engineering, Sharif University of Technology, Tehran, Iran
[b] Division of Applied Mechanics, Department of Mechanical Engineering, Polytechnique Montréal, Québec, Canada

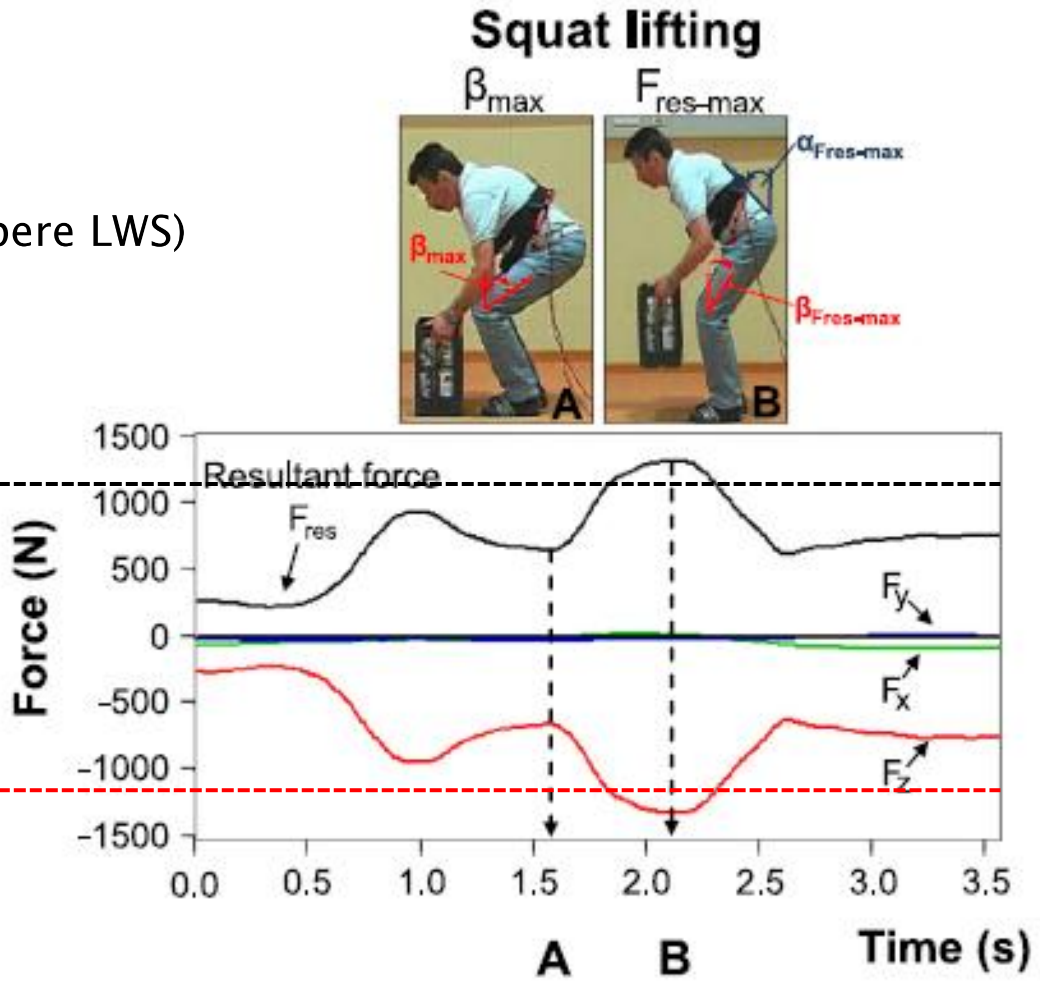


Squat vs. Stoop

Orthoload
Loading of Orthopaedic Implants



(Obere LWS)



Dreischarf et al. J Biomech. 2016;49(6):890-895.

Energie-Effizienz

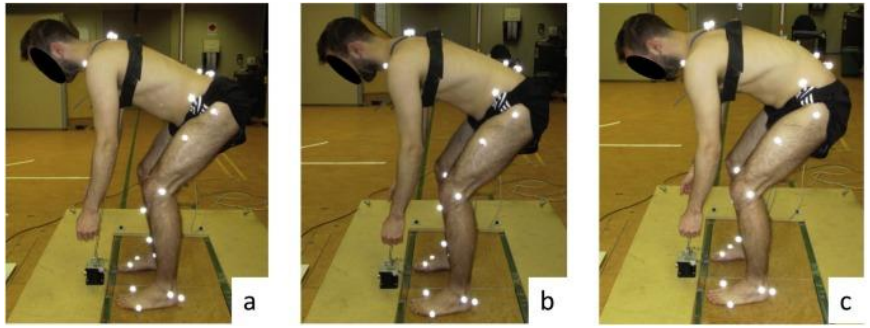
Metabolisch und kardiovaskulär

- Stoop 10-15% weniger als Semi-Squat und 20-30% weniger als Squat in Bezug auf:
  - Sauerstoffverbrauch
  - Herzrate
  - Inspiratorische Ventilation

Neuromuskulär

- Stoop assoziiert mit
  - ↑ lumbales Extensionsmoment
  - ↓ paraspinaler Muskelaktivität

→ Neuromuskuläre Effizienz ↑



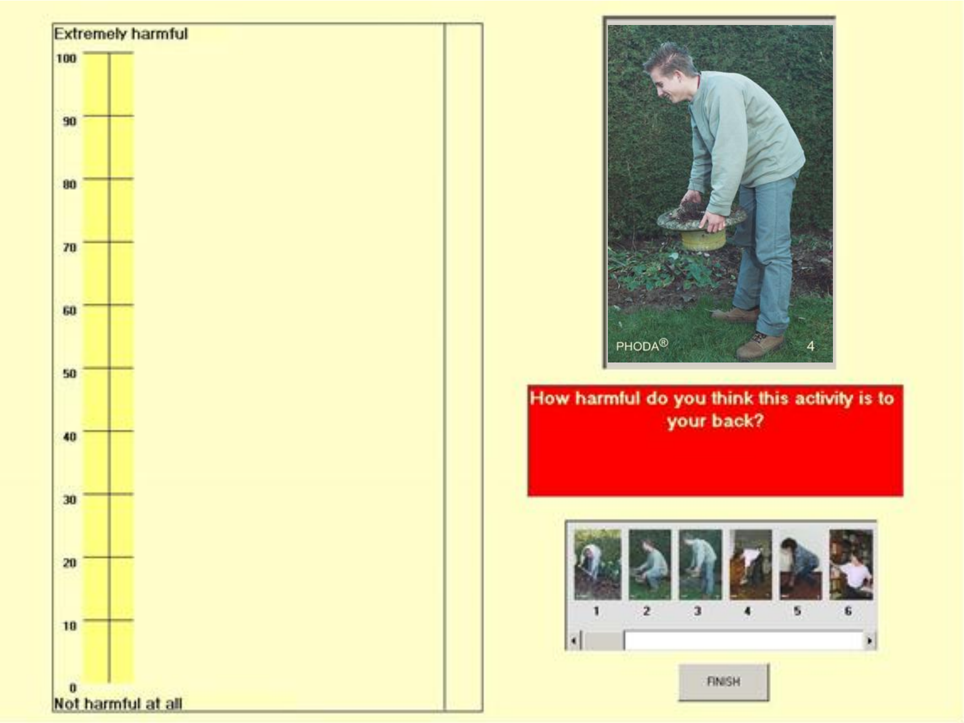
Straker et al. Int J Ind Ergon. 2003:31(3):149-160.
Mawston et al. Gait Posture. 2021:86:245-250.

Warnungen, Angst and Schmerz

Vlaeyen & Linton, Pain. 2000;85(3):317-332.

Schmerzbezogene Angst und Bewegungsverhalten

PHODA-SeV



ORIGINAL ARTICLE

WILEY EJP European Journal of Pain

Lumbar range of motion in chronic low back pain is predicted by task-specific, but not by general measures of pain-related fear

Thomas Matheve[1] | Liesbet De Baets[1] | Katleen Bogaerts[1,2] | Annick Timmermans[1]

Regression model	Variables	Std Beta	*p*-value	R^2	R^2 adj	ΔR^2 adj
Basic model with control variables	Sex [F]	0.34	0.008	0.39	0.31	
	Age	–0.24	0.13			
	Duration LBP	0.02	0.87			
	Current pain	–0.29	0.04			
	RMDQ	–0.24	0.10			
	PCS	0.02	0.86			
Basic model + PHODA-lift	Sex [F]	0.37	0.003	0.49	0.42	0.11
	Age	–0.26	0.07			
	Duration LBP	0.05	0.70			
	Current pain	–0.30	0.02			
	RMDQ	–0.13	0.33			
	PCS	0.06	0.68			
	PHODA-lift	–0.35	0.003			

Notes. LBP: low back pain; PCS: Pain catastrophizing scale; PHODA-lift: score on the task-specific picture of the PHODA-SeV; PHODA-total: total score on the PHODA-SeV; RMDQ: Roland Morris Disability Questionnaire; TSK: Tampa scale for kinesiophobia; TSK-AA: Activity avoidance subscale of the TSK; TSK-SF: Somatic focus subscale of the TSK; ΔR^2 adj: difference in R^2 adj relative to R^2 adj of the model with control variables only.

Due to rounding, ΔR^2 adj might not add up precisely to R^2 adj of the model with control variables only. Sex [F]: a positive Std. Beta indicates that female sex is associated with a larger range of motion.

Schmerzbezogene Angst und Bewegungsverhalten

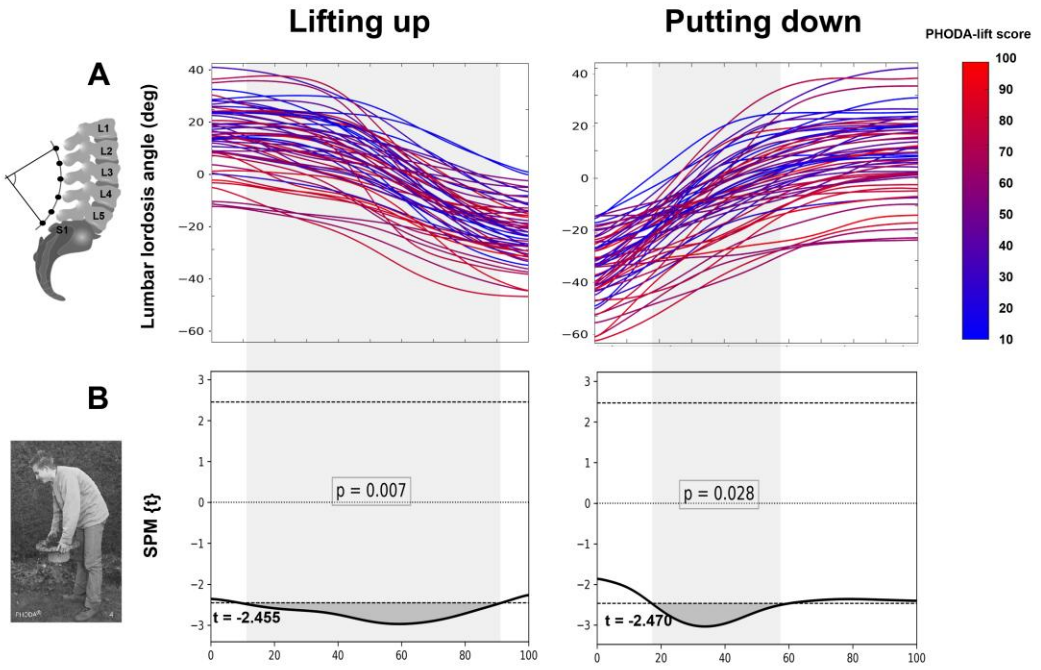
Research Paper

PAIN

OPEN

Fear-avoidance beliefs are associated with reduced lumbar spine flexion during object lifting in pain-free adults

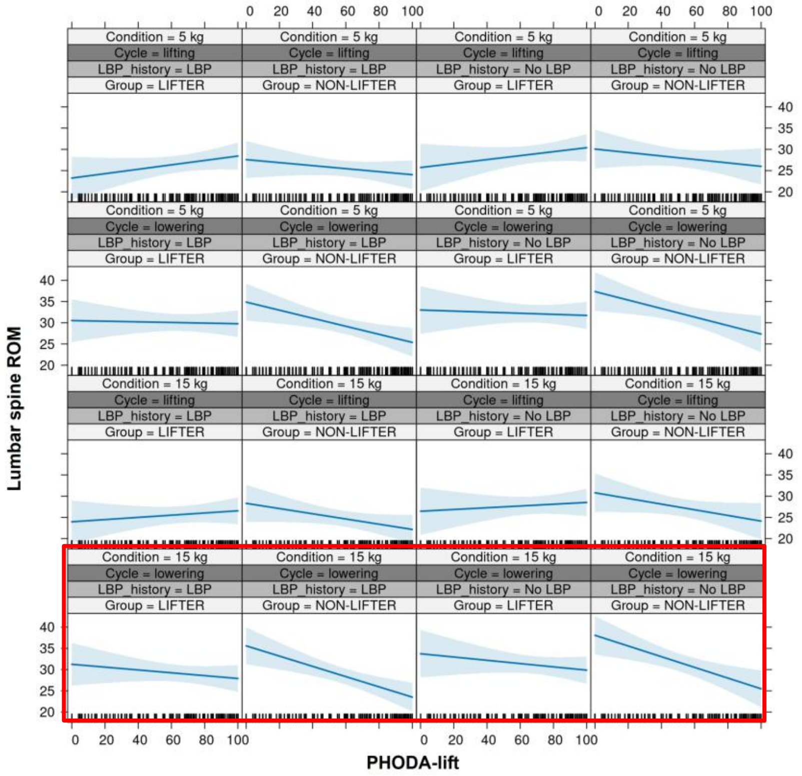
Deborah Knechtle[a,b], Stefan Schmid[c], Magdalena Suter[a,b], Fabienne Riner[a,b], Greta Moschini[d], Marco Senteler[d], Petra Schweinhardt[a,b,e], Michael L. Meier[a,b,*]



Task-specific pain-related fear influences lifting biomechanics differently in individuals with and without occupations involving repetitive lifting tasks

Christian Bangerter[a,b,*], Oliver Faude[b], Denise Weidinger[a], André A. Meichtry[a], Michael L. Meier[c], Carol-Claudius Hasler[d,e], Stefan Schmid[a,e]

Under Review @ Scientific Reports



Protektives Bewegungsverhalten

- Gesunde Personen mit höherer «Angst vor Heben mit rundem Rücken» weisen ähnliches Bewegungsverhalten beim Lastenheben auf wie Grossteil der Rückenschmerz-Patienten

- Protektives Bewegungsverhalten mit erhöhter Ko-Kontraktion der Rumpfmuskeln:
  - Eingeschränkte Bewegung
  - Verminderte Bewegungsvariabilität
  - Potentiell höhere WS-Belastung

- **Kurzfristig Gefühlt von mehr Stabilität / Symptomlinderung (bei Patienten) aber langfristig mit negativen Konsequenzen verbunden**

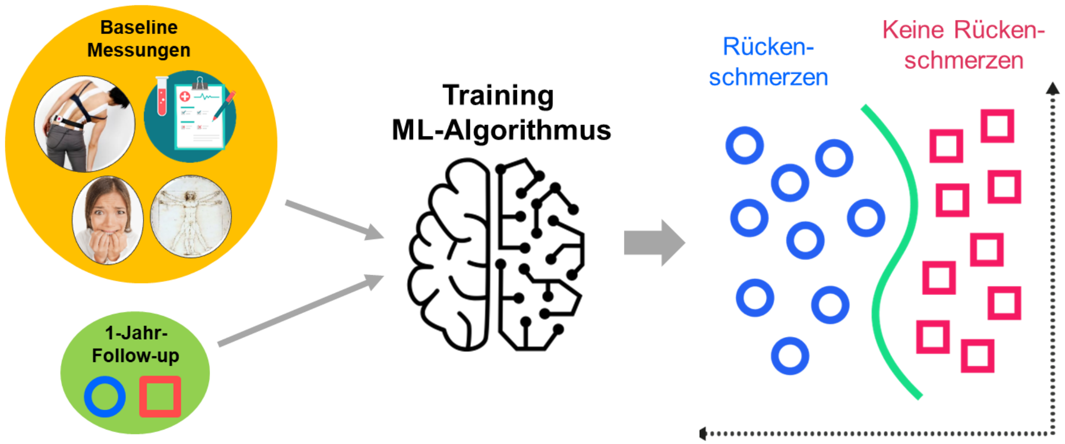
van Dieen et al. JOSPT. 2019;49(6):370-379.

Auswirkungen des protektiven Bewegungsverhaltens

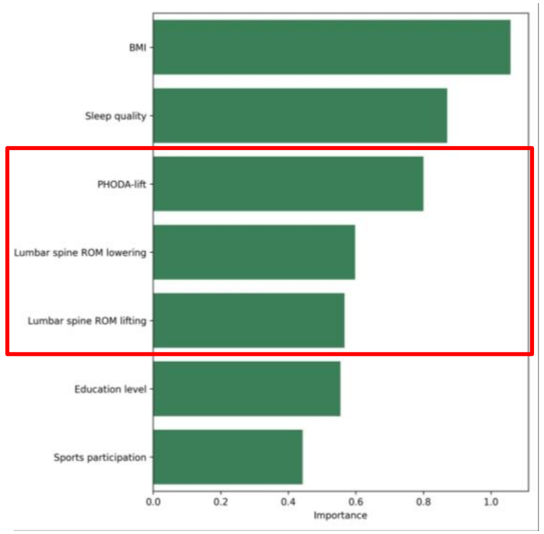
The role of pain-related fear and lifting biomechanics in predicting low back pain incidence: a prospective observational cohort study using supervised machine learning

Christian Bangerter [a,b,*], Oliver Faude [b], Monika Dörig [c], Michael L. Meier [c], Carol-Claudius Hasler [d,e], Stefan Schmid [a,e]

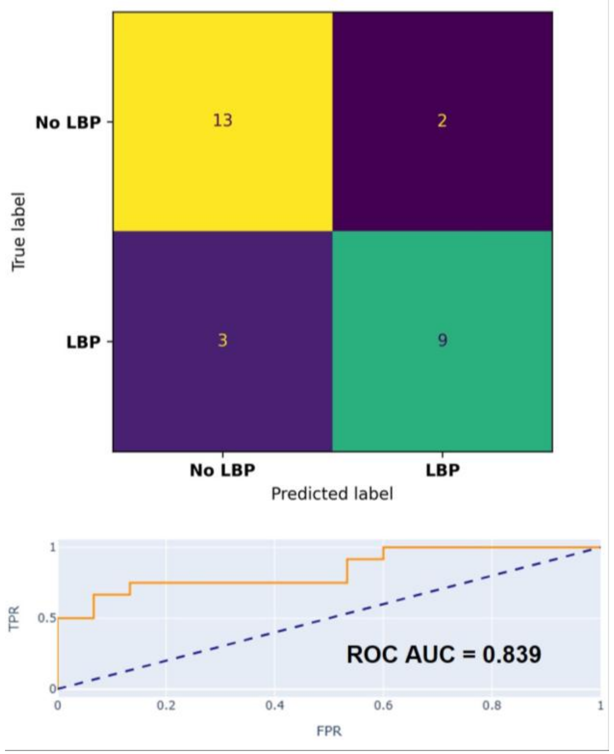
Under Review @ The Journal of Pain



Wichtigste Faktoren



Prädiktion



Zusammenfassung Evidenz

- Rückenschmerzen korrelieren nicht mit WS-Flexion während Lastenheben
- Ungenügende Evidenz für Zusammenhang zwischen WS-Belastung und Rückenschmerzen
- Fast nicht möglich die WS nicht zu flektieren während Heben von Lasten (vom Boden)
- Kompressions- und Scherkräfte vergleichbar zwischen Hebetechniken
- Höhere Ängste vor Rundrücken-Heben korrelieren (bereits bei Gesunden) mit protektivem Verhalten

→ Aktuelle biomechnische Evidenz unterstützt Einteilung in richtiges und falsches Heben nicht!

→ Angst vor Heben mit rundem Rücken könnte sich sogar negativ auswirken!

Heben Sie wie Sie wollen, aber ganz wichtig, …


Vielen Dank für die Aufmerksamkeit!