

# Occupational biomechanical risk factors for ulnar nerve entrapment in a prospective study of male construction workers

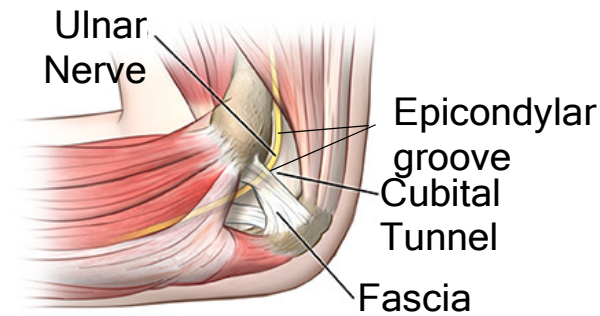
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# Ulnar nerve entrapment (UNE)

- Typically occurs at or near the elbow
- Symptoms
  - paresthesia and change in sensation
  - loss of power grip
  - permanent atrophy and weakness of the ulnar muscles
  - affect quality of life & work ability
- Treatment
  - Rest, splinting &/or rehabilitation → surgery



*Image adapted from: UPMC – University of Rochester*



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# How common is UNE?

- Studies are scarce
- 2<sup>nd</sup> most common upper extremity nerve entrapment (after carpal tunnel)
- Physician diagnosed UNE estimates:
  - 26-33 cases per 100,000 person years (males)
  - 17-20 cases per 100,000 person years (females)
- Surgically treated UNE
  - 7.5 cases per 100,000 person years (males)
  - 5.6 cases per 100,000 person years (females)



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# Who gets UNE?

- UNE described in
  - floor cleaners, coal miners
  - occupations requiring heavy manual labour/forceful work (cyclic) work
  - computer keyboard operators, desk-based work involving handwriting, drawing and computing



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# Occupational risk factors for UNE

- *‘routine use of a hand tool required to be held in position’<sup>1</sup>*
- *‘forceful work of the hand and arm’<sup>2</sup>*

Some evidence for

- Vibration (tool)<sup>1</sup>, leaning on elbows<sup>1</sup>, non-neutral postures<sup>2</sup>, repetitive work<sup>2</sup>

<sup>1</sup> Descatha et al., SJWEH (2004); 30(3):234-40.

<sup>2</sup> Svendsen et al., OEM (2012); 69(11):733-80.



# Aim

To determine the association between occupational biomechanical exposures and occurrence of UNE in a large cohort of construction workers.



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# METHODS



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# Prospective study of construction workers

1971

1992

2001

2013

Construction worker cohort (1971-92)

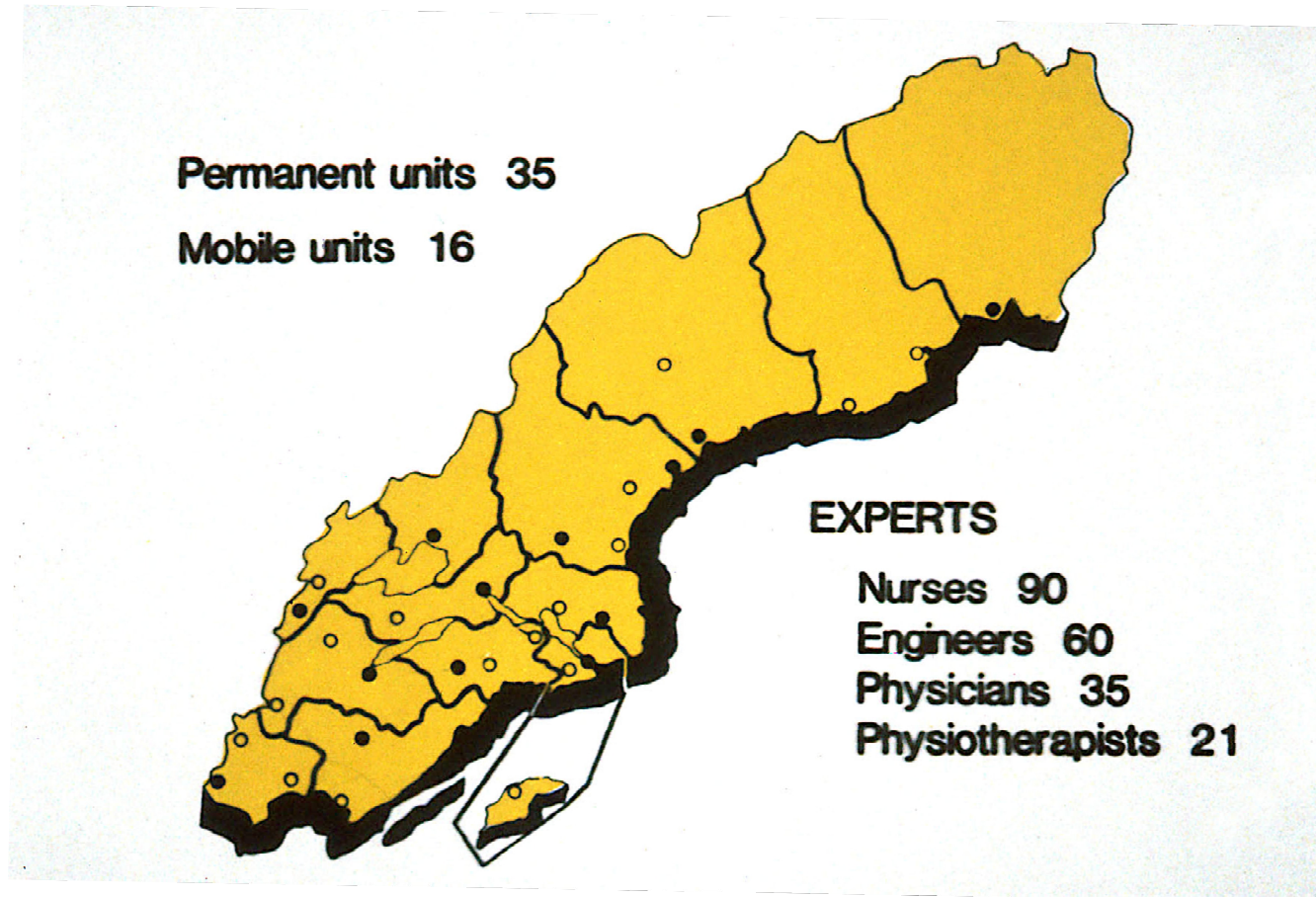
- Bygghälsokohorten
- Cooperation between employers, employee union and employees, and occupational health care within the industry
  - i.e. branschspecifik företagshälsovård
- Beginning of the 1960's through to early 1993
  - Digital data register from 1971 onwards
- Employees offered free health screenings
  - Questionnaire
- Over 80% employee participation



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# Project facilities & teams



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# Mobile Unit



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# Prospective study of construction workers

1971

1992

2001

2013

Construction worker cohort (1971-92)

- Age, height, weight, smoking status
- Job title



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# Combined workers with similar job exposures

## *21 occupational groups*

Asphalt workers	Foremen	White collar workers
Brick layers	Glass workers	Refrigerator technicians
Concrete workers	Heavy machinery operators	Repairers
Crane operators	Insulators	Rock workers
Drivers	Painters	Roofers
Electricians	Plumbers	Sheet-metal workers
Floor layers	Preparatory workers	Wood workers

- Otherwise assigned to 'other' group
- Grouping performed by industry experts



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# Developed Job Exposure Matrix

Exposure	Rating
<b><i>Ergonomic factors</i></b>	
Intensity of hand grip force	1 – 3 <sup>a</sup>
Intensity of upper extremity load	1 – 3 <sup>a</sup>
Frequency of hand-held tool use	1 – 3 <sup>a</sup>
Frequency of using a hand held tool in a fixed position	1 – 3 <sup>a</sup>
Frequency of leaning on the elbow	1 or 3 <sup>b</sup>
Frequency of upper extremity static work	1 – 3 <sup>a</sup>
Frequency of full wrist extension	1 – 3 <sup>a</sup>
Frequency of full elbow extension	1 – 3 <sup>a</sup>
Frequency of repetitive elbow flexion and extension	1 – 3 <sup>a</sup>
Frequency of repetitive wrist flexion and extension	1 – 3 <sup>a</sup>
<b><i>Vibration factors</i></b>	
Magnitude of hand-arm vibration	1 – 3 <sup>c</sup>
Frequency of impact shocks during HAV	1 or 3 <sup>d</sup>

<sup>a.</sup> 1 = low, 2 = moderate, 3 = high

<sup>b.</sup> 1 = none, 2 = acceptable, 3 = high

<sup>c.</sup> 1 = no, 3 = yes

<sup>d.</sup> 1 = rare, 3 = often



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# Determined JEM rating for each *occupational group*

- Assisted by ergonomic assessments
  - performed at the time of the construction worker cohort data collection
  - For each *job title*



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## Job title: Rockblaster

Job tools: platforms of different designs, ladders, drilling machines and scraping tools

Job description: Scraping loose pieces of rock off tunnel walls and ceiling. Work performed from the ground, platforms, and ladders.



Ergonomic assessment of occupational factors	Score				
01 Overall workload (pulse) .....	1	2	3	4	5
02 Upper extremity loading .....	1	2	3	4	5
03 Back loading .....	1	2	3	4	5
03 Lower extremity loading .....	1	2	3	4	5
04 Stone dust exposure .....	1	2	3	4	5
05 Noise .....	1	2	3	4	5
06 Vibration .....	1	2	3	4	5
07 Fall risk .....	1	2	3	4	5
08 Risk for slips or trips .....	1	2	3	4	5
09 Risk for falling objects .....	1	2	3	4	5
10 Risk for being crushed .....	1	2	3	4	5
11 Risk for being struck/rolled on by objects .....	1	2	3	4	5
12 Risk for shrapnel or being splashed .....	1	2	3	4	5



Additional comments:

*Static muscle loading of the upper and lower extremities and back  
Risk of explosive gase and/or diesel exhaust during underground work*



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# Assigned group mean exposure score

Occupational Group	Grip Force	Upper arm load	Elbow Flex/Ext
Asphalt workers	1	2	2
Rock workers	3	3	1
Concrete workers	3	3	2
Wood workers	3	3	3
Brick layers	2	2	3
Floor layers	2	2	1
Heavy Machinery operators	1	1	1
Crane operators	1	1	1
Drivers	1	1	1
Glass workers	3	3	1
Insulators	2	2	1
Refrigerator technicians	2	2	1
Plumbers	3	2	2
Painters	2	2	3
Sheet-metal workers	3	3	1
Electricians	2	2	1
Foremen	1	1	1
White Collar workers	1	1	1
Repairers	2	2	1
Preparatory workers	2	2	1
Roofers	2	2	2



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# Prospective study of construction workers

1971 1992 2001 2013

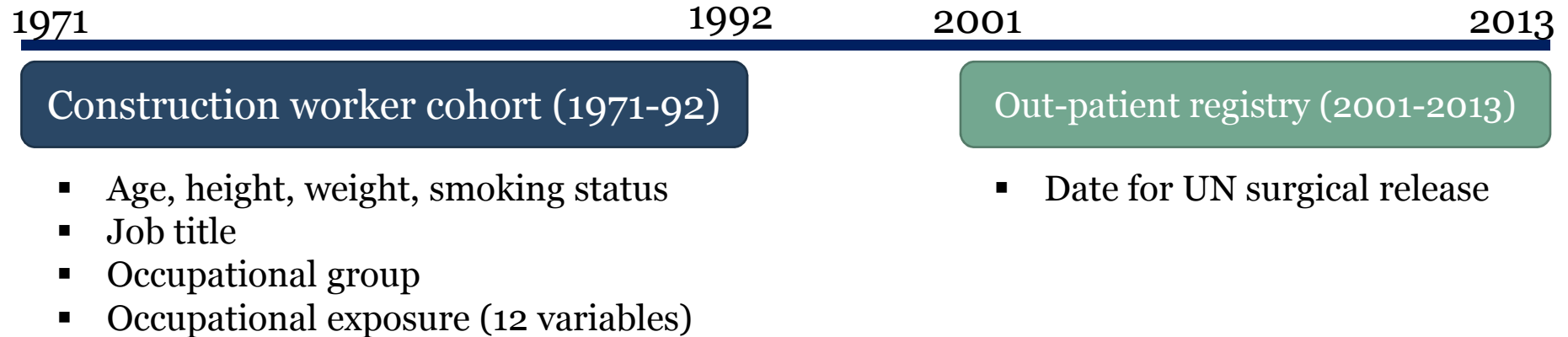
## Construction worker cohort (1971-92)

- Age, height, weight, smoking status
- Job title
- Occupational group
- Occupational exposure (12 variables)



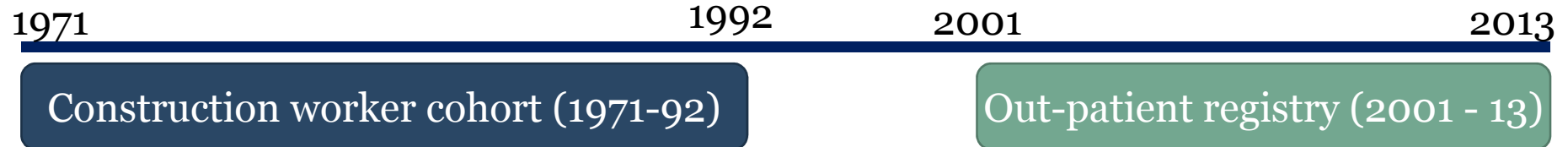
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# Prospective study with 13 year follow up period



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# Exclusion Criterion



**N=389 132, incl. 695 cases**

Exclusion criterion:

- Female
- < 16 or > 65 years old
- < 150 cm or > 200 cm tall
- Documented UNE surgery < 2001
- Occupational group 'other'

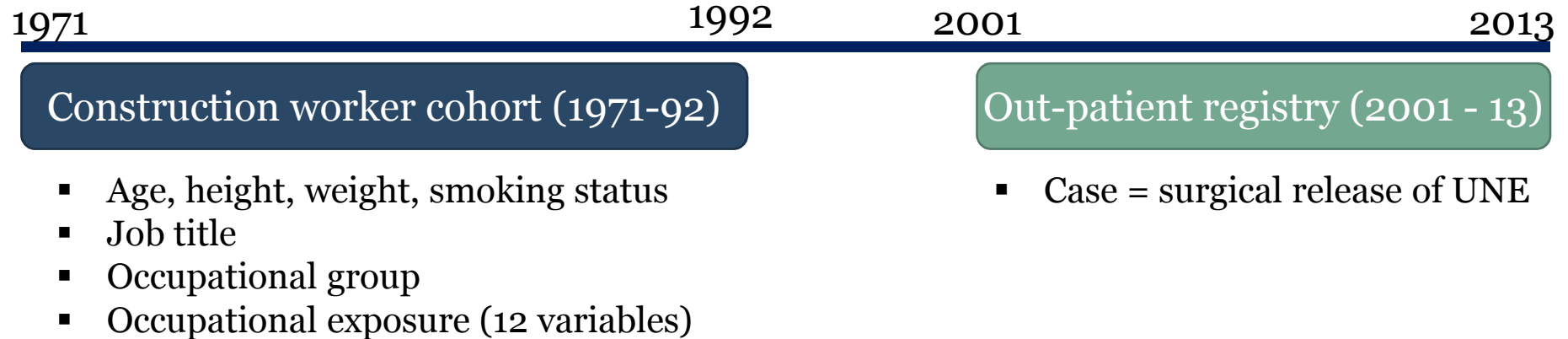
Censoring:

- death, immigration or retirement < 2001



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# Study population



**Study cohort: N = 229 689**



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# Analysis

- Negative binomial models with a log-link were used to estimate relative risks



# RESULTS



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# Incidence rate of UNE surgery

- 555 UN release surgical cases (N=229 689)
- Construction worker cohort: 19.2 cases / 100,000 person years



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# Individual risk factors for UNE

		<i>N</i>	<i>cases</i>	<i>RR</i>	<i>95% CI</i>
BMI	healthy	167873	379	1	--
	overweight	61816	176	1.28	1.07-1.54
Smoking	Never	103509	194	1	--
	Ever	115025	335	1.60	1.34-1.91
	Unknown	11155	26	1.28	0.85-1.93
Age (2001)	25-34	32486	67	1	--
	35-44	64123	158	1.20	0.90-1.60
	45-54	73298	198	1.34	1.01-1.76
	55-64	59782	132	1.14	0.85-1.52



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## Biomechanical factors with ↑ risk of UNE

Factor	rating	<i>N</i>	<i>cases</i>	<i>RR</i>	<i>95% CI</i>
Grip Force	low	52605	100	1	--
	moderate	71875	152	1.15	0.90-1.47
	high	105209	303	1.54	1.24-1.92
Upper Extremity Load	low	48743	89	1	--
	moderate	92802	209	1.27	1.00-1.61
	high	88144	257	1.63	1.30-2.06
Frequency of hand tool use	low	54747	104	1	--
	moderate	17282	52	1.58	1.13-2.22
	high	157660	399	1.37	1.09-1.71
HAV	none	104465	233	1	--
	acceptable	98322	240	1.13	0.95-1.33
	high	26902	82	1.35	1.07-1.71



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# Created exposure scores

- Summed groups of highly correlated factors
  - Spearman correlation coefficients  $> 0.7$



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# Exposure Scores

	Exposure	Rating
	<b><i>Ergonomic factors</i></b>	
Grip Score	Intensity of hand grip force	1 – 3 <sup>a</sup>
	Intensity of upper extremity load	1 – 3 <sup>a</sup>
	Frequency of hand-held tool use	1 – 3 <sup>a</sup>
	Frequency of using a hand held tool in a fixed position	1 – 3 <sup>a</sup>
Static/Lean Score	Frequency of leaning on the elbow	1 or 3 <sup>b</sup>
	Frequency of upper extremity static work	1 – 3 <sup>a</sup>
	Frequency of full wrist extension	1 – 3 <sup>a</sup>
Repetitive FE Score	Frequency of full elbow extension	1 – 3 <sup>a</sup>
	Frequency of repetitive elbow flexion and extension	1 – 3 <sup>a</sup>
	Frequency of repetitive wrist flexion and extension	1 – 3 <sup>a</sup>
	<b><i>Vibration factors</i></b>	
Vibration Score	Magnitude of hand-arm vibration	1 – 3 <sup>c</sup>
	Frequency of impact shocks during HAV	1 or 3 <sup>d</sup>



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## Grip force and HAV associated with UNE

	Factor	N	cases	RR	95% CI
<i>Grip Score<sup>a</sup></i>	Low	48743	89	1.00	--
	Medium	48214	123	1.40	1.08-1.86
	High	132732	343	1.41	1.15-1.85
<i>Vibration Score<sup>b</sup></i>	Unexposed	104465	233	1.00	--
	Exposed	125224	322	1.18	1.00-1.38

<sup>a</sup>Grip Score = Intensity of hand grip force + upper extremity load + frequency of using a hand tool in a fixed posture + hand tool use

<sup>b</sup> Vibration Score = HAV + frequency of impact shocks during HAV

## Occupational groups with ↑ risk of UNE

Occupational Group	N	cases	RR	95% CI
Foremen	26898	37	1	--
Electricians	29665	44	1.11	0.69-1.78
Painters	17446	33	1.37	0.83-2.3
White collar workers	9581	20	1.45	0.81-2.60
Heavy machinery operators	7476	19	1.70	0.95-3.04
Brick layers	6248	16	1.83	0.99-3.38
Plumbers	17065	46	1.91	1.20-3.05
Woodworkers	51463	139	1.99	1.33-2.97
Asphalt workers	3862	11	2.01	1.01-4.03
Concrete workers	19663	61	2.20	1.41-3.42
Floor layers	4388	14	2.28	1.20-4.33
Ground preparatory workers	7725	27	2.48	1.47-4.19
Rock blasters	5224	18	2.50	1.38-4.52
Sheet-metal workers	9652	35	2.55	1.55-4.18

# DISCUSSION



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# Discussion

- All analyses point to ↑ *grip force* as a risk factor for UNE
  - Grip F exposure score
  - Biomechanical exposure factors (JEM)
    - Grip F, UA load, Hand tool use & HAV
  - Occupational groups with high grip force exposure
- Unable to say whether HAV is a risk factor on its own
  - vibrating power tools requires hand power grip



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# Discussion

- Possible mechanisms for UNE
  - increased pressure on the nerve - from forceful or prolonged muscular contractions
  - friction on the nerve - from repetitive elbow flexion and extension
  - increased nerve tension - from elbow flexion
  - direct compression of the nerve - leaning on the exposed nerve





# Discussion

- Association may reflect both risk factors for UNE onset as well as prognostic factors for symptomatic workers
- Decreasing forceful hand grip exposure paramount for primary as well as secondary and tertiary prevention of UNE
  - In line with the broader ergonomic literature on preventing work-related upper extremity disorders



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# Want to know more?

## *Original article*

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*Scand J Work Environ Health – online first. doi:10.5271/sjweh.3757*

### **Occupational biomechanical risk factors for surgically treated ulnar nerve entrapment in a prospective study of male construction workers**

*by Jennie A Jackson, PhD,<sup>1</sup> David Olsson, PhD,<sup>1</sup> Laura Punnett, ScD,<sup>2</sup> Alex Burdorf, PhD,<sup>3</sup> Bengt Järvholm, PhD,<sup>1</sup> Jens Wahlström, PhD<sup>1</sup>*



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