Silverstein BA, Fine LJ, Armstrong TJ. Occupational Factors and Carpal Tunnel Syndrome. Am J Ind Med 1987;11:343-358. [SPSS Output to Follow]

Design: Cross-sectional study

Population/sample size/setting:

- 652 workers (358 men, 294 women, mean age 39.4) in 39 jobs at 7 industrial sites in southern, Midwestern, and southeastern USA
- Eligibility requirement was at least 1 year seniority on the job; active rheumatoid arthritis was a criterion for exclusion

Main outcome measures:

- Walk-throughs were done at each work site by observers who were not informed about worker health status
- Jobs were classified on two dimensions: force and repetition
- High repetition (HR) was defined as having a cycle time of less than 30 seconds, or having more than 50% of the cycle time performing the same kind of fundamental cycles; if neither of these was present, the job was classified as low repetition (LR)
- Initially, High Force (HF) jobs had estimated average hand force requirements of more than 4 kg; low force (LF) jobs had estimated average hand force less than 1 kg; these definitions were later altered to account for force requirement variability
- Videotapes of the job cycles were used to estimate postural data (wrist flexion, extension, and deviation)
- Hand force requirements were estimated with surface EMG from the forearm flexor muscles; the final definition of force was adjusted to equal the sum of the mean force per cycle plus the variance/mean force; in this way, HF was defined as 6 kg
- The mean adjusted force for the HF jobs was 14.5 kg; the mean adjusted force for the LF jobs was 3.2 kg
- CTS diagnosis was based on history and physical exam by examiners who were not aware of the work of the subjects
- CTS was diagnosed if all of the following were present: median nerve pain, numbness, or tingling; nocturnal exacerbation, symptoms occurring more than 20 times or lasting more than 1 week in the previous year; no history of traumatic onset, no rheumatoid arthritis, onset since beginning current job; Phalen's or Tinel's sign, and absence of cervical nerve root, thoracic outlet, or pronator teres syndromes
- 14 cases of CTS met the criteria; 8 cases were HF/HR, and only 1 case was LF/LR; 2 cases were HF/LR and 3 cases were LF/HR
- The HF/HR group had more than 15 times the risk of CTS as the LF/LR group
- Repetition was more important than force as a risk factor; the adjusted odds ratio for high repetition was 5.5 and statistically significant; the odds ratio for force was 2.9 and not statistically significant
- Postural factors were not statistically significant predictors of CTS

Authors' conclusions:

- CTS was strongly associated with HF/HR jobs compared to LF/LR jobs
- Repetition appeared to be a stronger risk factor than force
- Posture and gender were not confounding factors
- The study was limited to workers with 1 year on the job; this may have excluded workers who left the job because of CTS, and may underestimate the period prevalence of CTS
- Force and repetition appear to have a combined effect which is more than multiplicative, increasing the risk fore than 5 times that of either factor alone

Comments:

- With only 14 cases of CTS confirmed by the case definition of interview and physical examination, the power of the study to determine risk factors is limited, and a logistic regression model can accommodate at most 2 variables
- The statement that HF/HR jobs had more than 15 times the risk of LF/LR jobs does not appear to be accurate; there were 157 workers in each category, with 8 cases of CTS in the HF/HR category and 1 case in the LF/LR category, for a relative risk of 8, not 15
- The "plant-adjusted" odds ratio for HF/HR vs. LF/LR was 14.3; this does approximate the RR of 15 in the text of the article
- There is sufficient data in the tables and Fig. 2 to run some analyses of CTS risk factors of sex, force, and repetition; since age was not associated with CTS, there is an opportunity to approximate some of the logistic regression analyses separately in SPSS
- Sex was not associated with CTS; the odds ratio was .091 and not statistically significant
- Force and repetition were not associated; the odds ratio for this was close to 1
- Sex and repetition were associated; the odds ratio for female sex and repetition was 2.67
- Sex and force were associated; the odds ratio for female sex and force was 0.485
- An SPSS logistic regression model with repetition and sex yields an odds ratio close to that in the article (Table VIII, with sex, age, years on the job, and repetition); the adjusted OR is 4.9 (p=.017), which is close to the crude odds ratio of 4.42
- An SPSS logistic regression model with force and sex yields an odds ratio close to that in the article (Table VIII, with sex, age, years on the job, and force); the adjusted OR is 2.2 (p=.198), which is close to the crude odds ratio of 2.16
- While there does seem to have been an effect of plant location (in Table VII), that table's logistic regression model has too many variables for the 14 CTS cases
- The definition of force (using a formula which accounts for variation over the work cycle) is difficult to try to translate into conveniently measured variables such as tool weight

- The adjusted force cutoff of 6 kg may mean that some jobs classed as LF/HR involved some exertions that might be classified as high force under other classification criteria
- If some jobs in the LF/HR classification actually involved some significant expenditure of force, this would qualify the conclusion that repetitiveness alone is more important than force
- The setting of the jobs, in manufacturing and assembly, makes it likely that most jobs entailed 6 hours or more per day in the tasks analyzed
- The authors report that there were no significant interaction terms between force and repletion; this is confirmed by SPSS
- The conclusion that force and repetition are more than multiplicative is not justified (this would mean that there was an interaction); a no-interaction model is more appropriate, with the effects of force and repetition being approximately multiplicative

Assessment: Adequate for evidence that a combination of force and repetition increases the risk of CTS. Not adequate for evidence that repetition alone increases the risk of CTS (the classification of LF/HR jobs may have included some jobs with appreciable force).

SPSS Output

```
cro/tab=sex by cts/sta=chisq.
```

Crosstabs

Notes

Output Created		30-Apr-2010 07:24:13
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Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
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```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
sex * cts	652	100.0%	0	.0%	652	100.0%

sex * cts Crosstabulation

Count

		cts		Total
		.00	1.00	
sex	male	350	8	358
	female	288	6	294
Total		638	14	652

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.029[a]	1	.865		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.029	1	.865		
Fisher's Exact Test				1.000	.544
Linear-by-Linear Association	.029	1	.865		
N of Valid Cases	652				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.31.

b. Computed only for a 2x2 table

Crosstabs

Notes

Output Created		30-Apr-2010 07:24:24
Comments		
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	N of Rows in Working Data File	14
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax		cro/tab=force by rep/sta=chisq.
Resources	Processor Time	0:00:00.016

	Elapsed Time	0:00:00.015
	Dimensions Requested	2
	Cells Available	174762

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
force * rep	652	100.0%	0	.0%	652	100.0%

force * rep Crosstabulation

Count

		rep		Total
		.00	1.00	
force	.00	157	143	300
	1.00	195	157	352
Total		352	300	652

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.612[a]	1	.434		
Continuity Correction[b]	.495	1	.482		
Likelihood Ratio	.612	1	.434		
Fisher's Exact Test				.478	.241
Linear-by-Linear Association	.611	1	.434		

N of Valid Cases	652				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 138.04.

b. Computed only for a 2x2 table

Crosstabs

Notes

Output Created		30-Apr-2010 07:24:40
Comments		
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	Weight	count
	Split File	<none>
	N of Rows in Working Data File	14
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax		cro/tab=sex by rep/sta=chisq.
Resources	Processor Time	0:00:00.016
	Elapsed Time	0:00:00.017
	Dimensions Requested	2
	Cells Available	174762

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
sex * rep	652	100.0%	0	.0%	652	100.0%

sex * rep Crosstabulation

Count

		rep		Total
		.00	1.00	
sex	male	232	126	358
	female	120	174	294
Total		352	300	652

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	37.394[a]	1	.000		
Continuity Correction[b]	36.435	1	.000		
Likelihood Ratio	37.684	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	37.337	1	.000		
N of Valid Cases	652				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 135.28.

b. Computed only for a 2x2 table

Crosstabs

Notes

Output Created		30-Apr-2010 07:24:48
Comments		
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	Weight	count
	Split File	<none>
	N of Rows in Working Data File	14
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax		cro/tab=force by sex/sta=chisq.
Resources	Processor Time	0:00:00.000
	Elapsed Time	0:00:00.000
	Dimensions Requested	2
	Cells Available	174762

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
force * sex	652	100.0%	0	.0%	652	100.0%

force * sex Crosstabulation

Count

		sex		Total
		male	female	
force	.00	136	164	300
	1.00	222	130	352
Total		358	294	652

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	20.575[a]	1	.000		
Continuity Correction[b]	19.865	1	.000		
Likelihood Ratio	20.652	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	20.543	1	.000		
N of Valid Cases	652				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 135.28.

b. Computed only for a 2x2 table

Logistic Regression

Notes

Output Created		30-Apr-2010 07:25:12
Comments		
Input	Data	J:\personal\upperext\reviews 2009\causation\silverstien CTS force rep.sav
	Active Dataset	DataSet1

	Filter	<none>
	Weight	count
	Split File	<none>
	N of Rows in Working Data File	14
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing
Syntax		logist reg cts/meth=enter sex rep.
Resources	Processor Time	0:00:00.015
	Elapsed Time	0:00:00.016

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	14	100.0
	Missing Cases	0	.0
	Total	14	100.0
Unselected Cases		0	.0
Total		14	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
.00	0
1.00	1

Block 0: Beginning Block

Classification Table[a,b]

Observed			Predicted		
			cts		Percentage Correct
			.00	1.00	
Step 0	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-3.819	.270	199.832	1	.000	.022

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	sex	.029	1	.865
		rep	6.106	1	.013
	Overall Statistics		6.721	2	.035

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

	Chi-square	df	Sig.

Step 1	Step	6.964	2	.031
	Block	6.964	2	.031
	Model	6.964	2	.031

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	128.281[a]	.011	.057

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Classification Table[a]

			Predicted		
			cts		Percentage Correct
	Observed		.00	1.00	
Step 1	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	sex	-.432	.559	.598	1	.439	.649
	rep	1.589	.669	5.651	1	.017	4.901
	Constant	-4.629	.597	60.145	1	.000	.010

a. Variable(s) entered on step 1: sex, rep.

Logistic Regression

Notes

Output Created		30-Apr-2010 07:25:28
Comments		
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	Active Dataset	DataSet1
	Filter	<none>
	Weight	count
	Split File	<none>
	N of Rows in Working Data File	14
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing
Syntax		logist reg cts/meth=enter sex force.
Resources	Processor Time	0:00:00.015
	Elapsed Time	0:00:00.015

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	14	100.0
	Missing Cases	0	.0
	Total	14	100.0
Unselected Cases		0	.0
Total		14	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
.00	0
1.00	1

Block 0: Beginning Block

Classification Table[a,b]

Observed		Predicted		
		cts		Percentage Correct
		.00	1.00	
Step 0	cts .00	638	0	100.0
	1.00	14	0	.0
	Overall Percentage			97.9

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-3.819	.270	199.832	1	.000	.022

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	sex	.029	1	.865

	force	1.752	1	.186
	Overall Statistics	1.756	2	.416

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	1.829	2	.401
	Block	1.829	2	.401
	Model	1.829	2	.401

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	133.416[a]	.003	.015

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Classification Table[a]

			Predicted		
			cts		Percentage Correct
	Observed		.00	1.00	
Step 1	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	sex	.037	.554	.004	1	.947	1.038
	force	.778	.605	1.655	1	.198	2.178
	Constant	-4.324	.590	53.718	1	.000	.013

a. Variable(s) entered on step 1: sex, force.

Logistic Regression

Notes

Output Created		30-Apr-2010 07:26:00
Comments		
Input	Data	J:\personal\upperext\reviews 2009\causation\silverstien CTS force rep.sav
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	Weight	count
	Split File	<none>
	N of Rows in Working Data File	14
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing
Syntax		logist reg cts/meth=enter sex force rep.
Resources	Processor Time	0:00:00.016
	Elapsed Time	0:00:00.015

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	14	100.0
	Missing Cases	0	.0
	Total	14	100.0
Unselected Cases		0	.0
Total		14	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
.00	0
1.00	1

Block 0: Beginning Block

Classification Table[a,b]

Observed			Predicted		
			cts		Percentage Correct
			.00	1.00	
Step 0	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-3.819	.270	199.832	1	.000	.022

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	sex	.029	1	.865
		force	1.752	1	.186
		rep	6.106	1	.013
	Overall Statistics		8.365	3	.039

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	8.653	3	.034
	Block	8.653	3	.034
	Model	8.653	3	.034

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	126.592[a]	.013	.070

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Classification Table[a]

Observed			Predicted		
			cts		Percentage Correct
			.00	1.00	
Step 1	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	sex	-.280	.569	.241	1	.623	.756
	force	.763	.611	1.561	1	.212	2.145
	rep	1.574	.668	5.559	1	.018	4.828
	Constant	-5.165	.764	45.670	1	.000	.006

a. Variable(s) entered on step 1: sex, force, rep.

Logistic Regression

Notes

Output Created		30-Apr-2010 07:26:12
Comments		
Input	Data	J:\personal\upperext\reviews 2009\causation\silverstien CTS force rep.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	count
	Split File	<none>
	N of Rows in Working Data File	14

Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing
Syntax		logist reg cts/meth=enter sex force rep forcerep.
Resources	Processor Time	0:00:00.016
	Elapsed Time	0:00:00.017

```
[DataSet1] J:\personal\upperext\reviews 2009\causation\silverstien CTS
force rep.sav
```

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	14	100.0
	Missing Cases	0	.0
	Total	14	100.0
Unselected Cases		0	.0
Total		14	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
.00	0
1.00	1

Block 0: Beginning Block

Classification Table[a,b]

Observed			Predicted		
			cts		Percentage Correct
			.00	1.00	
Step 0	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-3.819	.270	199.832	1	.000	.022

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	sex	.029	1	.865
		force	1.752	1	.186
		rep	6.106	1	.013
		forcerep	8.555	1	.003
	Overall Statistics		9.603	4	.048

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	8.734	4	.068
	Block	8.734	4	.068

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
	Step	8.734	4	.068
	Block	8.734	4	.068
	Model	8.734	4	.068

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	126.511[a]	.013	.071

a. Estimation terminated at iteration number 8 because parameter estimates changed by less than .001.

Classification Table[a]

			Predicted		
			cts		Percentage Correct
	Observed		.00	1.00	
Step 1	cts	.00	638	0	100.0
		1.00	14	0	.0
	Overall Percentage				97.9

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	sex	-.272	.569	.228	1	.633	.762
	force	.449	1.231	.133	1	.715	1.567
	rep	1.287	1.173	1.204	1	.273	3.622
	forcerep	.407	1.410	.083	1	.773	1.502

	Constant	-4.948	1.022	23.427	1	.000	.007

a. Variable(s) entered on step 1: sex, force, rep, forcerep.