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DOES GOOD TRUNK EXTENSOR PERFORMANCE PROTECT AGAINST BACK-RELATED WORK DISABILITY?

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In this cohort study, dynamic trunk extensor performance was studied as a predictor of permanent work disability due to back disorders. As part of the comprehensive Mini-Finland Health Survey in 1978–80, the back muscle performance of 535 persons (267 men, 268 women) was measured using standardized repetitive arch-up and sit-up tests. At baseline, the participants were between 30 and 64 years of age. Retirements were followed for 12 years on average. During the follow-up, 56 subjects developed permanent work disability; 15 of these cases were back-related. Good dynamic trunk extensor performance was predictive of a decreased incidence of work disability due to chronic back disorders but not work disability due to other diseases. The risk of back-related work disability in the three highest quartiles in relation to the lowest quartile of dynamic trunk extension capacity was 0.28 (95% confidence interval, 0.09–0.94). Our study suggests that good dynamic trunk extension performance may protect against back-related permanent work disability.

Key words: back pain, back muscles, disability, retirement.

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INTRODUCTION

Chronic low back pain (LBP) can lead to permanent work disability. The several strategies to reduce the risk of LBP include trunk muscle conditioning (1). The existence of a relationship between weak back muscle performance and low back disorders is controversial, however (2). Previous studies have shown that especially the back extensor muscles are weak in patients with chronic LBP (3). Inadequate trunk muscle performance could be a causal factor. Biering-Sørensen (4) found that poor static endurance of back muscles was predictive of first-time experience of LBP in men. Similar findings were reported by Leino et al. (5) and Luoto et al. (6). Poor static endurance capacity of back muscles is at least a weak predictor of future LBP (4–6). Good isometric extension strength does not seem to protect from future LBP or back injury (7, 8). Battié et al. (9), on the other hand, found that industrial workers with greater isometric lifting strength even had a slightly higher risk of future LBP. We must bear in mind the difference between static endurance, dynamic endurance and maximal strength tests, however.

In the study of Parnianpour et al. (10), the co-ordination of trunk motion was lost during a fatiguing dynamic sagittal loading. Taimela et al. (11) found that lumbar fatigue after dynamic loading disturbs the ability to sense lumbar position and its changes. Thus, poor dynamic trunk extension capacity may predispose to spine injury, cumulative microtrauma, subsequent LBP and disability. Population studies of the relationship between dynamic trunk extension performance and the risk of LBP or LBP-related disability have not been reported previously, however. The aim of the present study was to investigate dynamic trunk extension performance as a predictor of permanent work disability due to back disorders in a random subsample of the nationally representative cohort of the Mini-Finland Health Survey.

MATERIAL AND METHODS

Population

The present study is based on the comprehensive Mini-Finland Health Survey (12) carried out between 1978 and 1980 to assess the health of adult Finns. The population of the survey was a two-stage cluster sample drawn from the population register and stratified to represent Finns aged 30 years or older. Of the total sample, 6102 persons were between 30 and 64 years of age, and 5673 (93%) of them participated. A random subsample ($n = 1117$) of the participants was chosen for measurement of dynamic trunk muscle performance in the present study; 995 of these individuals were capable of work at baseline. The trunk muscle performance of 215 persons could not be measured because of cardiovascular risks, other illnesses, or current back pain, and 245 refused for other or unknown causes or their test result was rejected. Altogether 535 persons (267 men and 268 women, 54% of the subsample) remained in the study population.

Baseline examination

Dynamic trunk extension performance was measured at baseline using a standardized repetitive arch-up test. Participants were asked to do the test movement as fast as possible. The results of those who could not do the test in an acceptable way were rejected. The test was done with the trunk in a forward-leaning position. The legs and thighs of the person were fastened to a standardized testing bench at 50 degrees from horizontal, with the hands held behind the neck. The test movement started from the flexed position (upper trunk at horizontal level), with the trunk extended repetitively at 50 degrees. The range of the test movement was standardized. The result of the test was the number of repetitions in 30 sec. A reproducibility study of the test has yielded a Pearson's correlation coefficient of 0.83 between two measurement sessions at a 12-month interval (13).

Dynamic trunk flexion performance was measured using a standardized repetitive sit-up test, with the person carrying out the movement as

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Table I. *Covariates for trunk extension performance (repetitive extensions in 30 sec)*

Covariate	Subjects (*n*)	Univariate correlation ratio	Unadjusted (mean)	Multiple partial correlation ratio*	Adjusted (mean*)
Age†	535	−0.37		−0.37	
P for trend		<0.0001		<0.0001	
Sex‡		0.30		0.30	
Male	267		15.2		15.1
Female	268		11.8		12.0
P for heterogeneity		<0.0001		<0.0001	
Body height	535	−0.24		−0.09	
P for trend		<0.0001		0.03	
Body mass index	535	−0.23		−0.20	
P for trend		<0.0001		<0.0001	
Trunk flexion performance	535	0.55		0.44	
P for trend		<0.0001		<0.0001	
Education		0.23		0.18	
Low	298		12.4		12.7
Intermediate	154		14.8		14.4
High	83		15.2		14.8
P for heterogeneity		0.01		0.14	
Physical labour at work		0.12		0.09	
Light	146		14.4		14.3
Moderate	259		12.8		13.3
Heavy	130		14.0		13.2
P for heterogeneity		0.01		0.14	
Mental stress at work	535	−0.01		−0.04	
P for trend		0.79		0.28	
Physical activity at leisure		0.21		0.21	
Light	141		12.4		12.5
Moderate	288		13.3		13.3
Heavy	106		15.8		15.5
P for heterogeneity		<0.0001		<0.0001	
History of smoking		0.11		0.08	
Never smoked	289		13.0		13.8
Stopped smoking	113		14.5		13.8
Current smoker	133		13.9		12.7
P for heterogeneity		0.03		0.13	
History of low back pain		0.14		0.10	
Never	148		14.0		14.0
1–5 episodes	123		14.6		14.0
>5 episodes	264		12.8		13.1
P for heterogeneity		0.005		0.11	
Chronic disabling diseases		0.26		0.20	
None	473		14.0		13.8
Low back disorder	21		7.8		9.1
Other chronic disease	41		10.7		12.2
P for heterogeneity		<0.0001		<0.0001	

* Partial correlation coefficients and means adjusted for age and sex.
† Adjusted for sex only.
‡ Adjusted for age only.

fast as possible. The knees were bent at 90 degrees and the feet were fastened to the testing bench. He held his hands behind the neck. A single repetition of the test movement started with the head and shoulders touching the bench and ended with the elbows touching the knees. The result was the number of repetitions in 30 sec. Pearson's correlation coefficient between two measurement sessions at a 12-month interval was 0.92 (13).

The methods used in the Mini-Finland Health Survey have been reported in detail elsewhere (14, 15). In the present study, particular attention was paid to the factors that may be associated with dynamic trunk extension performance and with risk of disabling back disorders, such as body height, body mass index, physical stress at work, mental stress at work, physical activity at leisure, smoking, history of back pain and chronic diseases (14, 16, 17).

Follow-up

The mortality of the cohort was calculated from data obtained from the Central Statistical Office of Finland. Data on new disability pensions granted to the participants were collected from the Social Insurance Institution's pension register. This was done using the unique personal identification number to link the records. The primary diagnosis appearing in the medical statement used in granting a permanent disability pension was taken as the cause of work disability. All disability pensions granted up to the end of 1994 were included in the present study. The follow-up period extended from the time of the baseline health examination until retirement due to work disability or until death or until the end of the observation period. The mean follow-up period was 12 years, corresponding to 6559 person-years.

Table II. *Factors predicting permanent work disability due to back disorders, other causes and any cause**

		Back disorder			Other causes			Any cause		
Predictor	Subjects (*n*)	Incident cases (*n*)	Relative risk	95% confidence interval	Incident cases (*n*)	Relative risk	95% confidence interval	Incident cases (*n*)	Relative risk	95% confidence interval
Age† (43.0 ± 8.9 yr)	535	15	2.77	1.46–5.26	41	2.17	1.50–3.14	56	2.31	1.68–3.18
P for trend			0.0001			<0.0001			<0.0001	
Sex‡										
Male	267	10	1.00		19	1.00		29	1.00	
Female	268	5	0.40	0.14–1.20	22	0.99	0.53–1.85	27	0.79	0.46–1.34
P for heterogeneity			0.09			0.98			0.38	
Body height (167.8 ± 9.3 cm)	535	15	1.11	0.51–2.43	41	0.64	0.39–1.06	56	0.76	0,50–1.15
P for trend			0.79			0.08			0.19	
Body mass index (25.4 ± 3.7 kg/m^2)	535	15	1.23	0.74–2.06	41	1.09	0.80–1.48	56	1.12	0.86–1.46
P for trend			0.43			0.58			0.39	
Trunk flexion performance (10.2 ± 8.2 repetitions)	535	15	0.93	0.43–2.00	41	0.54	0.32–0.91	56	0.63	0.40–0.98
P for trend			0.84			0.02			0.03	
Trunk extension performance (13.5 ± 5.6 repetitions)	535	15	0.43	0.26–0.70	41	0.90	0.64–1.26	56	0.72	0.55–0.95
P for trend			0.001			0.55			0.02	
Education										
Low	298	12	The model did not converge		29	1.00		41	1.00	
Intermediate	154	3			11	0.84	0.42–1.70	14	0.76	0.41–1.41
High	83	0			1	0.14	0.02–1.06	1	0.10	0.01–0.75
P for heterogeneity			(P for trend = 0.04)			0.03			0.003	
Physical labour at work										
Light	146	3	1.00		5	1.00		8	1.00	
Moderate	259	6	1.18	0.29–4.77	23	2.51	0.95–6.62	29	2.02	0.92–4.43
Heavy	130	6	1.84	0.44–7.57	13	3.07	1.07–8.80	19	2.61	1.12–6.08
P for heterogeneity			0.65			0.06			0.05	
Mental stress at work (1.1 ± 1.1)	535	15	1.40	0.90–2.19	41	1.32	1.00–1.73	56	1.33	1.06–1.69
P for trend			0.16			0.06			0.02	
Physical activity at leisure										
Light	141	5	1.00		12	1.00		17	1.00	
Moderate	288	9	0.71	0.24–2.12	19	0.70	0.34–1.45	28	0.71	0.39–1.30
Heavy	106	1	0.22	0.03–1.87	10	1.08	0.46–2.50	11	0.80	0.37–1.71
P for heterogeneity			0.27			0.47			0.55	
History of smoking										
Never smoked	289	6	1.00		17	1.00		23	1.00	
Stopped smoking	113	2	0.64	0.11–3.57	7	1.38	0.54–3.55	9	1.15	0.50–2.64
Current smoker	133	7	2.49	0.69–8.98	17	3.51	1.61–7.64	24	3.25	1.67–6.35
P for heterogeneity			0.14			0.006			0.001	
History of low back pain										
Never	148	0	The model did not converge		7	1.00		7	1.00	
2–5 episodes	123	1			9	1.73	0.64–4.65	10	1.91	0.73–5.03
>5 episodes	264	14			25	1.99	0.86–4.61	39	3.09	1.39–6.92
P for heterogeneity			(P for trend = 0.0002)			0.23			0.007	
Chronic disabling diseases										
None	473	11	1.00		29	1.00		40	1.00	
Low back disorder	21	3	5.63	1.52–20.88	2	1.32	0.31–5.62	5	2.42	0.94–6.24
Other chronic disease	41	1	1.37	0.17–10.84	10	5.13	2.44–10.79	11	4.13	2.08–8.20
P for heterogeneity			0.09			0.0008			0.0008	

* Relative risk with 95% confidence interval adjusted for age and sex. Relative risks for the continuous variables have been expressed per a standard deviation of each variable. Values in parentheses are mean ± standard deviation.

† Adjusted for sex only.

‡ Adjusted for age only.

Table III. *Adjusted relative risks and 95% confidence intervals of permanent work disability due to back disorders for quartiles of trunk extension performance*

Quartile* of trunk extension performance	Subjects (n)	Incident cases (n)	Model 1†		Model 2‡	
			Relative risk	95% confidence interval	Relative risk	95% confidence interval
I (lowest)	106	9	1.00		1.00	
II–IV§	429	6	0.18	0.06–0.55	0.28	0.09–0.94
P for heterogeneity			0.002		0.04	

* The cut-off points for men and women were 12, 16, 19 and 30; and 9, 12, 16 and 24 repetitions of trunk extension in 30 sec, respectively.

† Adjusted for age and sex.

‡ Adjusted for age, sex, body height, body mass index, education, physical labour at work, mental stress at work, physical activity at leisure, smoking, history of low back pain, chronic disabling diseases and trunk flexion performance.

§ 1, 4 and 1 incident cases in quartiles II, III and IV, respectively.

Statistical analyses

Adjusted means and multiple partial correlation coefficients were estimated using the general linear model (18). Cox's life-table regression model (19) was used to estimate the association between dynamic trunk extension performance and the incidence of work disability. Both confounding and effect-modifying factors were entered into the model. Adjusted relative risks with 95% confidence intervals and likelihood ratio tests (expressed as exact p-values) were based on this model.

RESULTS

The covariates of dynamic trunk extension performance were studied in the cross-sectional setting of the baseline health examination. A number of factors independent of the two most powerful covariates, age and sex, were significantly associated with dynamic trunk extension performance and were thus potential confounders of the association between trunk extension performance and risk of disability (Table I).

The overall incidence of work disability was 8.5 per 1000 person-years. Of the 56 incident cases of work disability, 15 were due to back disorders. As adjusted for age and sex, dynamic trunk extension performance at baseline was strongly predictive of work disability due to chronic back disorders, but not disability due to other diseases (Table II). In contrast, dynamic trunk flexion performance was found to be predictive of work disability due to causes other than back disorders. Low education, previous episodes of LBP, and the presence of a chronic low back disorder at baseline were significant predictors of work disability due to back disorders. Body mass index, heavy labour, smoking, and lack of leisure-time physical activity also appeared to carry predictive value, but the associations with back-related work disability did not reach statistical significance after adjustment for age and sex (Table II).

As entering the quadratic term of dynamic trunk extension performance into Cox's model suggested a non-linear association with the risk of permanent work disability due to back disorders (for departure from linearity, $p = 0.12$), the dynamic trunk extension performance data were divided into quartiles. The relative risk was significantly reduced from second quartile up, but all the quartile-specific risk estimates were unstable, perhaps due to a small number of incident cases in each quartile. The relative risk of back-related work disability between the lowest quartile and higher quartiles of dynamic trunk extension performance remained statistically significant when the work disability risk was adjusted for all the potential confounders (Table III).

DISCUSSION

Dynamic trunk extensor performance was inversely proportional to the risk of permanent retirement due to low back disorders. This association remained significant after adjustment for potential confounding and effect-modifying factors. Dynamic trunk extensor performance showed no association with the risk of retirement due to other diseases. To our knowledge, this is an original finding not reported elsewhere.

In studies utilizing measurements of maximal performance capacity, a good trunk performance capacity has not been protective against future LBP (7, 8, 9, 20, 21), but good trunk extension endurance does offer at least some protection (4–6). Sustained fatiguing contractions or peak strength of the back muscles, as measured in previous studies, are needed in some professions. However, usual daily movements are mostly dynamic (isoinertial), and the loads are light (10). The arch-up test used in this study measured dynamic trunk extension endurance. Parnianpour et al. (10) have demonstrated a loss of coordination of the trunk during fatiguing dynamic sagittal loading. In a study by Taimela et al. (11), both patients with LBP and healthy subjects showed an impaired ability to sense changes in lumbar position after a fatiguing dynamic task. These studies suggest increased vulnerability of the spine during dynamic fatiguing exercise, which may result in injuries, LBP and subsequent disability.

Permanent disability retirement due to low back disorders is of course a complicated issue involving not only medical factors or physical performance but also psychological, social, economic and vocational aspects (22, 23). It should be kept in mind that the incidence of work disability in our study was followed for 12 years on average, which is an exceptionally long period compared with LBP studies in general. It may be that poor dynamic trunk extension performance has predisposed our subjects to chronic LBP, and the role of psychosocial and vocational factors, as potentially important for retirement, is not revealed in our study because of the long interval between the initial measurement and the moment of granting a permanent disability pension.

Motivation, fear and pain are important factors in all performance tests. Motivational factors may have affected the trunk performance test and the final outcome of work disability. In the present study, motivational factors were not measured at baseline, but persons who were afraid to do the tests, or did the tests in an inappropriate way, were excluded. This exclusion probably diminished to some extent the confounding effect of motivation. The final sample was 54% of the original subsample with no current work disability at baseline. Based on our experience gained during the measurements, the participants included in our study were on average in better physical condition than those who were excluded. Thus, the tests of trunk performance have limited applicability in population studies. This was not a critical disadvantage in the present study, since the study provided a conservative estimate of the association between trunk extension capacity and risk of back disability.

When considering the results of this and other studies of trunk extension performance, two facts have to be borne in mind. Firstly, trunk performance tests differ from study to study, e.g. with regard to the movements or positions of the trunk in the tests. Secondly, it is difficult to measure LBP or low back disability accurately. The disability levels of subjects in different studies are likely to vary in a wide range, and the incidence of LBP episodes alone does not measure work disability. The LBP symptoms of the 15 persons who retired during the present study were probably worse and more prolonged than those reported in previous studies, on average, because in our study the back disorder constituted the primary justification for a permanent disability pension.

Although the results of the present study suggest that poor dynamic trunk extension performance significantly predicted work disability, the small number of incident cases of work disability due to back disorders weakens the power of these results. Also several confounding and effect-modifying factors entered into Cox's life-table regression model further weaken the power of the model. However, the present study supports the hypothesis that good dynamic trunk extension performance may protect against work disability due to chronic back disorders.

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