

*Rapid communication*

**Shrinkage and psychophysical load ratings in self-paced and force-paced lifting work and during recovery**

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The purpose of this study was to investigate the effects of the load on the human spine during force-paced and self-paced lifting and subsequent rest. Five women and five men worked under self-paced and force-paced (4 lifts/min) conditions on two days lifting a box for 30 min. The weight of the box was determined by the rating of acceptable load (RAL) method. During the work the lift rate was observed, and subjects made rating of perceived exertion (RPE) in 5 min intervals. The stature was measured with a staturimeter before and after the work period and during the following 30 min rest lying. In self-paced work women had a higher lift rate than men ( $p < 0.05$ ). In general, RPEs increased towards the end of the lifting period but RPEs did not differ between women and men or between self-paced and force-paced work. The mean shrinkage during the 30 min work was in self-paced work  $5.1 \pm 2.0$  mm for women and  $5.8 \pm 1.2$  mm for men, and in force-paced work  $5.8 \pm 2.3$  mm and  $6.8 \pm 2.2$  mm, respectively. There were no significant differences in shrinkage at work between women and men nor between the two different pacing methods. During the 30 min rest recumbent the subjects regained almost the same amount of height as they had lost during lifting. The rapid shrinkage and recovery when loading and unloading suggest that a few minutes rest lying after heavy activities would be beneficial for the spine.

### 1. Introduction

Griffin *et al.* (1984) first reported a quickly-applied, psychophysical assessment of acceptable weights for dynamic lifting: the rating of acceptable load (RAL). Subjects were asked to fill a box with weight they judged acceptable for themselves for lifting between table and floor at 5 min intervals over an 8 h working day. The standard RAL test has proven sensitive to load characteristics and to the work tasks assessed (Stålhammar *et al.* 1989, 1991).

When the spine is compressed disc hydration is reduced, and discs lose height (creep) (Köller *et al.* 1984). As a result the stature changes diurnally about 1% (Reilly *et al.* 1984). Shrinkage is related to biomechanical load on the spine (Eklund and Corlett 1984), and to ratings of perceived exertion or discomfort (Troup *et al.* 1985).

Our aim was to study the effects of load on the spine during lifting of loads (weight determined by the RAL method) under force-paced (4 lifts/min) and self-paced conditions, and of the subsequent rest on stature and psychophysical rating of perceived exertion (RPE).

## 2. Materials and methods

The subjects of the study were five women (mean  $\pm$ SD of age  $38 \pm 3$  years, weight  $57 \pm 10$  kg, and stature  $164 \pm 5$  cm) and five men ( $37 \pm 8$  years,  $69 \pm 6$  kg, and  $176 \pm 7$  cm, respectively). The subjects lifted a box ( $30 \times 30 \times 30$  cm) with handles from a 10 cm shelf to knuckle height for 30 min with two pacing methods on separate days: self-paced and force-paced of 4 lifts/min. The subjects selected the weight of the box with the RAL method (Griffin *et al.* 1984). See Leskinen *et al.* (1991) for the details of the procedure. The lifts were counted in 5 min intervals, and at the end of these intervals the subjects were asked to rate their RPE in Borg's (1985) category scale (0–10) with ratio properties.

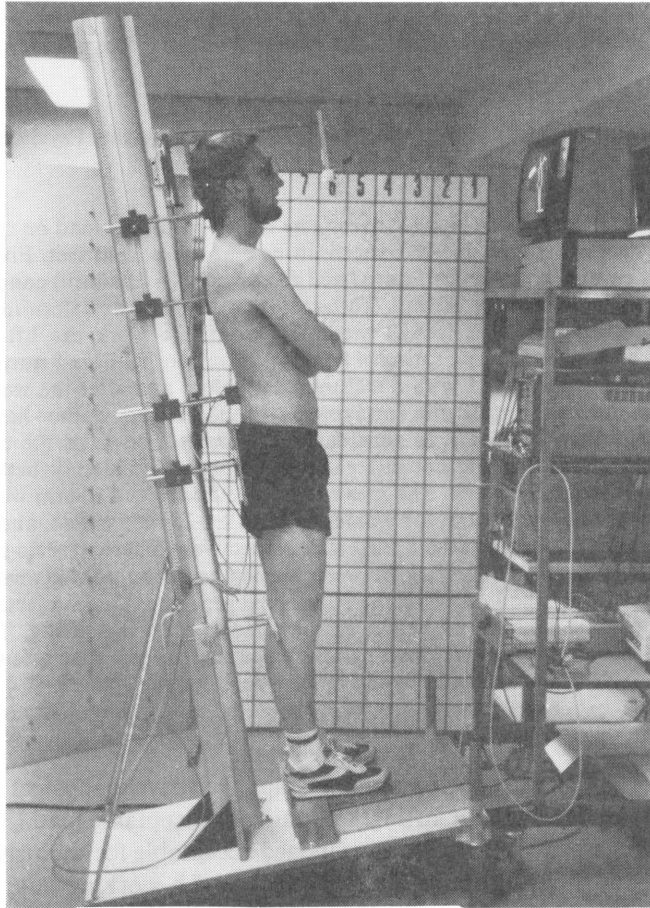


Figure 1. Stature measurement.

The stature recording device (figure 1) was similar to that described by Eklund and Corlett (1984), though some modifications were made. Visual feedback through a graphic computer screen helped the subject to find the same pre-trained posture for each measurement. The stature was recorded automatically with a displacement transducer after the outputs of six posture switches and a force plate under the feet were acceptable for two seconds. The stature was measured six times during an experiment: at arrival into the laboratory; after 15 min rest with the trunk supine and

the legs raised (Fowler's position); after 30 min lifting work; and after 5, 15, and 30 min rest in Fowler's position. Each measurement was repeated three times, and the median of the three values was used for further analysis.

### 3. Results

The isometric strength of the subjects has been reported by Leskinen *et al.* (1991). Women's mean RAL was 7.5 kg (SD 2.0 kg) and men's significantly ( $p < 0.05$ ) higher 11.5 kg (SD 2.8 kg). The mean RAL was  $14 \pm 2\%$  of isometric back muscle strength on men and  $12 \pm 4\%$  on women.

Table 1 shows the lift rates and RPE values for women and men for the two pacing methods. With self pace, women had significantly higher lift rate than men ( $p < 0.05$ ; at 20, 25, 30 min and total  $p < 0.01$ ) but the total weight lifted during 30 min work did not differ because of different RALs.

Table 1. Means and SDs of number of lifts and total mass handled (in kg) in 5 min periods, and rating of perceived exertion (RPE) at the end of the periods for women ( $n=5$ ) and men ( $n=5$ ) during 30 min lifting work with two pacing methods (A=self-paced, B=force-paced, 4 lifts/min). Statistical significance of differences between women and men are shown: NS=not significant, \*= $p < 0.05$ , \*\*= $p < 0.01$ .

A=self-paced						
Period	WOMEN			MEN		
	Lifts	Mass	RPE	Lifts	Mass	RPE
5 min	29 ± 8*	207 ± 31	1.1 ± 0.9	18 ± 4	214 ± 85	0.9 ± 0.2
10 min	27 ± 6*	194 ± 43	1.9 ± 1.1	16 ± 4	195 ± 79	1.1 ± 0.6
15 min	27 ± 8*	196 ± 54	2.1 ± 1.4	15 ± 3	181 ± 76	1.5 ± 1.0
20 min	28 ± 7**	205 ± 57	2.5 ± 1.8	14 ± 4	159 ± 71	1.1 ± 0.6
25 min	29 ± 8**	213 ± 51	2.8 ± 1.5	14 ± 5	170 ± 90	1.8 ± 0.8
30 min	29 ± 6**	214 ± 50	3.4 ± 1.5	16 ± 5	186 ± 92	1.6 ± 0.9
Total	169 ± 40**	1229 ± 258		93 ± 20	1105 ± 472	

B=force-paced						
Period	WOMEN			MEN		
	Lifts	Mass	RPE	Lifts	Mass	RPE
5 min	120	150 ± 40*	0.8 ± 0.5	20	230 ± 55	1.7 ± 1.0
10 min	"	"	1.4 ± 1.1	"	"	1.9 ± 0.9
15 min	"	"	2.1 ± 1.4	"	"	2.2 ± 0.8
20 min	"	"	2.3 ± 1.5	"	"	2.2 ± 0.8
25 min	"	"	2.8 ± 1.5	"	"	2.4 ± 1.1
30 min	"	"	2.8 ± 1.5	"	"	2.6 ± 0.9
Total	120	900 ± 240*		120	1380 ± 331	

Figure 2 shows the changes in stature. The mean shrinkage during 30 min work was in both experiments for both sexes 5–6 mm. The height regain after 30 min rest was equal to the mean shrinkage. The stature changes did not differ statistically significantly between women and men nor between the two pacing methods.

### 4. Discussion

The insignificant differences in women's RPE between self-paced and force-paced

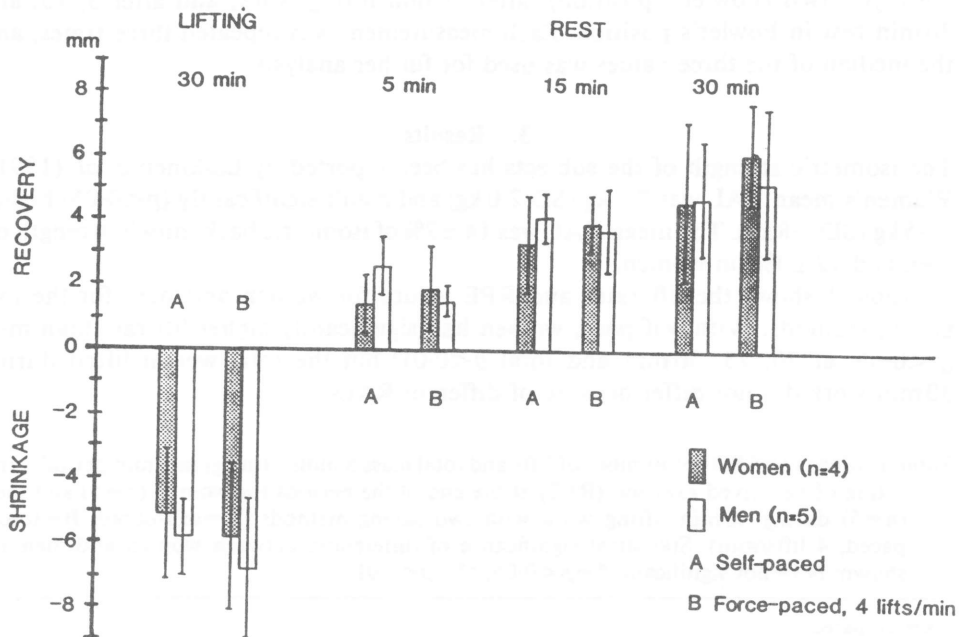


Figure 2. Stature changes (mm) for women ( $n=4$ ) and men ( $n=5$ ) during 30 min lifting work and 5, 15, 30 min rest in Fowler's posture (A=self-paced, B=force-paced 4 lifts/min). The means and SDs of the subjects are shown.

work despite the higher lift rate in self-paced work reflect the preference of self-paced to force-paced work. RPEs were at a moderate level in both experiments but they tended to increase with the duration of lifting (table 1). Lower lift rate for men in self-paced than in force-paced lifting at 15, 20 and 25 min ( $p<0.05$ ) and respectively lower RPEs at 20 and 30 min ( $p<0.05$ ) confirm the relation between lift rate and RPE.

The differences between sexes in the lift rate of self-paced work might indicate that in the RAL test the female subjects underestimated and the male subjects overestimated the load they can handle. Our subjects were unused to lifting and usually unexperienced subjects have assessed higher acceptable weights for the standard RAL test than professional lifting workers (Stålhammar *et al.* 1989, 1991). The results are in line with the earlier finding of Karwowski (1991), that women are more realistic in selecting the acceptable weight of lift than men.

The amount of shrinkage was similar with both sexes and in both pacing methods. The subjects lifted over 900 kg during 30 min and the total shrinkage was over 5 mm. The dynamic loading of this study and the preceding 15 min rest in Fowler's position could have an effect on the overall shrinking. Frequent movements pump fluid in and out of the discs thereby improving their nutritional supply (Urban *et al.* 1982). In our study the stature loss during moderate lifting work for 30 min was virtually regained during 30 min rest after work. Because of fast regain at the very beginning of the rest period short recovery pauses would seem beneficial for the spine metabolism.

The method for measuring changes in stature was proven repeatable and sensitive for assessing both loading and unloading of the spine. More investigation is needed

to get observations of large population to find out reliable relations between musculoskeletal symptoms and shrinkage.

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