Can height loss across a functional spinal unit modified by static rest breaks modify cumulative compression induced injury?

Robert J. Parkinson and Jack P. Callaghan

University of Waterloo, Waterloo, ON, Canada
E-mail: rjparkin@uwaterloo.ca

INTRODUCTION

The results of multiple in vitro studies indicate that it is the central area of the endplate and vertebral body that fractures under cyclical compressive loads (Brinckmann et al. 1988; Parkinson and Callaghan 2007), indicating that this central region plays a large role in load carriage. Interestingly, it has been shown that static creep loading across the disc can force the loads experienced by the endplate towards the periphery (van Dieen et al. 2001), providing a potential mechanism to alter the load transference across the disc and change the resistance of the spinal unit to cyclic compression.

METHODS

218 porcine spinal units (C3/C4 and C5/C6) were randomly assigned to one of 15 loading groups - 3 normalized loading magnitudes (50, 70 and 90% of estimated ultimate compressive strength) and 5 normalized rest durations (0, 50, 100, 200 and 1000% of load application duration (2 seconds)). Specimens were dissected to remove excess soft tissue, mounted into custom aluminum cups via non-exothermic dental plaster and mounted into an Instron materials testing system (8872, Instron Canada, Toronto, ON, Canada). The lower aluminum cup was in contact with a metal bearing covered surface allowing unconstrained translations in the horizontal plane and rotation about the vertical axis. Once mounted, specimens were preloaded at 300N for 15 minutes. When preloading was complete specimens were cyclically loaded using a normalized physiological profile until failure occurred or a 12 hour trial time was reached. Throughout testing load and displacement were sampled at 10 Hz.

RESULTS AND DISCUSSION

Of the 218 specimens tested, 13 survived the 12 hour loading protocol (Table 1). Those specimens who received rest durations equal in length to the loading duration had the lowest occurrence of survival.

Table 1: Number of spinal units tested within each load magnitude/rest duration group. The number of surviving specimens is indicated in parentheses.

		Load Magnitude		
		50%	70%	90%
Rest Duration	0%	14(4)	16	14
	50%	14(2)	14	14
	100%	15(1)	15	14
	200%	15(3)	14	16
	1000%	14(2)	15(1)	14

As shown in our previous work (Parkinson and Callaghan 2007), load magnitude significantly altered the cumulative load tolerated prior to failure, with those loaded to a maximum of 50% tolerating significantly more load than those in the 70 or 90% groups ($p < 0.0001$). In contrast, there was no statistically significant effect of rest duration on the cumulative load tolerated prior to failure (p = 0.1646), although it appears that short periods (50 or 100%) of rest may decrease the tolerance at moderate load magnitudes (figure 1).

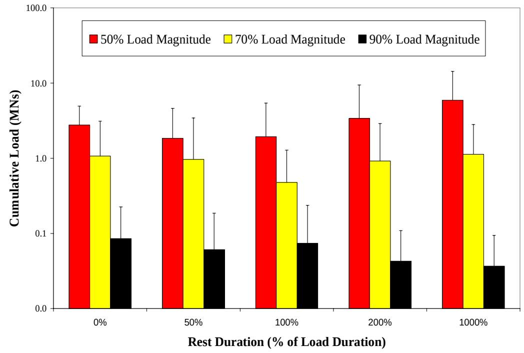

Figure 1: Average cumulative load (MNs) tolerated in each rest group (+ 1 standard deviation) separated by load magnitude.

Height loss was similarly affected by rest, with those specimens receiving short rest periods displaying the least amount of height loss prior to failure (p = 0.0301, figure 2). Load magnitude also significantly affected height loss, with increased load magnitudes leading to decreased height loss (p<0.0001), exhibiting the same pattern as cumulative load.

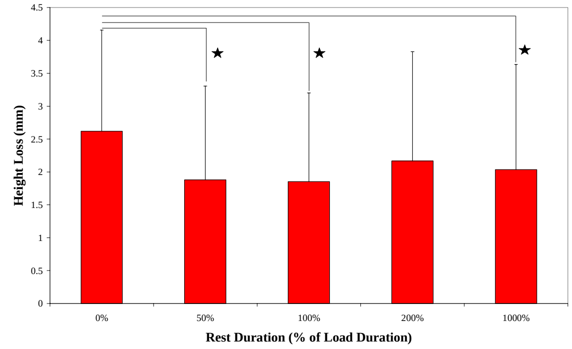

Figure 2: Average height loss (mm) at failure in each rest group (+ 1 standard deviation). Significant between group differences have been indicated with a star.

The similarities in the patterns of height loss and cumulative load tolerance may indicate a protective effect of height loss, as it has been shown that with an increase in height loss there is an increase in the amount of load carried through the annulus (Adams et al. 1996). This load redistribution may provide some relief to the central endplate region, the most common site of failure in cyclic compression. However, this relief may not translate into significantly altered load tolerance as the peripheral endplate bone may be less capable of bearing load (Lin et al. 1997).

SUMMARY/CONCLUSIONS

The results of this study have indicated that inserting periods of static rest into dynamic loading exposures is not an effective method to increase the cumulative compressive tolerance of the osteoligamentous spine, and in fact may be detrimental if the rest period is of equal duration to the loading period. This may be due to an inability to lose height within the joint, which may afford protection through load redistribution.

REFERENCES

ADAMS, M.A., et al. (1996). *Spine*, **21**, 434-438.

BRINCKMANN, P., et al. (1988). *Clin Biomech*, **3**, S1-S23.

LIN, R.M., et al. (1997). *Clin Biomech*, **12**, 331-336.

PARKINSON, R.J. and CALLAGHAN, J.P. (2007). *TIES*, **8**, 171-184.

VAN DIEEN, J.H., et al. (2001). *Clin Biomech*, **16 S1**, S135-S142.

ACKNOWLEDGEMENTS

The authors wish to thank Ms. Erin Harvey for statistical advice and Ms. Laura Malinowski for assistance in data collection.