In: P. Anderson, D. Hobart and J. Danoff (ed) (1991) Electromyographical Kinesiology. Elsevier Science Publishers, Amsterdam: 141-144

LACK OF RELATION BETWEEN MAXIMAL FORCE CAPACITY AND MUSCLE DISORDERS CAUSED BY LOW LEVEL STATIC LOADS- A NEW EXPLANATION MODEL

Göran M. Hägg

Division of Applied Work Physiology, National Institute of
Occupational Health, S-171 84 Solna, Sweden

INTRODUCTION

Occupational work with static muscle loads has been considered inappropriate since long. There is today strong epidemiological evidence that static workloads cause muscular disorders, at least in the shoulder region (Bjelle, et al., 1979, Kvarnström, 1983, Hagberg and Wegman, 1987). A widespread hypothesis is that these disorders could be avoided by reducing the static load level beneath a safe limit, expressed as a percentage of Maximal Voluntary Contraction (MVC) (Jonsson, 1978). A consequence of this reasoning is that individuals with lower maximal force capacity are expected to run a higher risk of contracting these disorders.

TRADITIONAL MODEL

The hypothesized upper load limit is based on findings and models emerging from laboratory studies of endurance times at different static load levels (Rohmert, 1968). The intramuscular pressure increases with increasing muscle contraction which impedes a sufficient circulation. This deficient circulation leads to hypoxia, anaerobic metabolism and accumulation of metabolites. These conditions are believed to cause muscle disorders (Maeda, 1977, Bjelle, et al., 1981, Henriksson, 1988).

LACK OF RELATION BETWEEN MAXIMAL FORCE CAPACITY AND MUSCLE DISORDERS

Several investigators have failed to show a relation between maximal force capacity and muscular disorders (Jonsson, et al., 1988, Hägg, et al., 1990, Wiker, et al., 1990). In the first two investigations, long time effects of monotonous low intensity assembly work were studied while Wiker et al. studied discomfort in laboratory studies. Contrary to these findings (Kilbom, 1988) reports a relation between disorders and maximal force capacity In this case, however, the loads were heavier, involving peak loads and handling of heavy tools. It is suspected that other tissues like tendons and/or joints also were affected.

ALTERNATIVE MODEL

The proposed disorder model is based on two corner-stones. The first one is the fixed recruitment order of motor units discovered by Henneman and colleagues (Henneman, et al., 1965). This principle is described schematically in figure 1. When motor units are recruited to build up the muscle force, this is done according to a fixed order which implies that low threshold motor units (type I) always are recruited first and remain active until total relaxation of the muscle.

The second corner-stone is findings by K G Henriksson and colleagues when studying muscle biopsies from patients with muscular disorders related to occupational static loads. They found that certain type I muscle fibres seem to be affected selectively ('ragged red fibres') (Larsson, et al., 1988). These fibres seem *not* to be traumatically injured but exhibit a metabolic disturbance with low energy substrate levels.

Considering these two facts, it is reasonable to believe that the fibres belonging to the bottom motor unit of the pyramid ('the Cinderella') in figure 1 is affected first as a result of too long activation and too little rest. If the load conditions are not changed, motor units higher up in the pyramid get affected successively. This process develops slowly over several months or maybe years.

DISCUSSION

The suggested model explains why the maximum force capacity plays no role for the development of these disorders. A stronger person certainly utilize a smaller fraction of the total muscle capacity compared to a weaker person doing the same job. However, according to the Henneman size principle, the low threshold motor units of the two persons are activated to the same degree. The suggested model is also in accordance with findings by (Hägg and Suurküla, 1991) investigating relations between electromyographic signs of fatigue and disorders.

The proposed model implies important consequences for the design of work. Reduction of static load levels becomes irrelevant as a preventive measure as far as these disorders are concerned. Instead the duration of the load and the pauses should be focused. However, our knowledge is still too limited to be able to suggest any recommendations.

REFERENCES

Bjelle, A., Hagberg, A.and Michaelsson, G. (1979). Clinical and ergonomic factors in prolonged shoulder pain among industrial workers. Scandinavian Journal of Work, Environment and Health, 5, 205-210.

Bjelle, A., Hagberg, M.and Michaelsson, G. (1981). Occupational and individual factors in acute shoulder-neck disorders among industrial workers. British Journal of Industrial Medicine, 38, 356-363.

Hagberg, M., and Wegman, D. H. (1987). Prevalence rates and odds ratios of shoulder neck deseases in different occupational groups. British Journal of Industrial Medicine, 44, 602-610.

Henneman, E., Somjen, G.and Carpenter, D. O. (1965). Excitability and inhibitability of motoneurons of different sizes. Journal of Neurophysiology, 28, 599-620.

Henriksson, K. G. (1988). Muscle pain in neuromuscular disorders and primary fibromyalgia. European Journal of Applied Physiology, 57, 348-352.

Hägg, G. M.and Suurküla, J. (1991). Zero crossing rate of EMG during occupational work and endurance test as predictors for work related myalgia in the shoulder/neck region. European Journal of Applied Physiology, In press.

Hägg, G. M., Suurküla, J.and Kilbom, Å. (1990). (In swedish, summary in english) Prediktorer för belastningsbesvär i skuldra/nacke. En longitudinell studie på kvinnliga montörer. Arbete och Hälsa 1990:10, Arbetsmiljöinstitutet, Solna, Sweden.

Jonsson, B. (1978). Quantitative electromyographic evaluation of muscular load during work. Scandinavian Journal of Rehabilitation Medicine, Supplement 6, 69-74.

Jonsson, B. G., Persson, J.and Kilbom, Å. (1988). Disorders of the cervico-brachial region among female workers in the electronics industry-a two year follow up. International Journal of Industrial Ergonomics, 3, 1-12.

Kilbom, Å. (1988). Isometric strength and occupational muscle disorders. European Journal of Applied Physiology, 57, 322-326.

Kvarnström, S. (1983). Occurrence of musculoskeletal disorders in a manufacturing industry, with special attention to occupational shoulder disorders. Scandinavian Journal of Rehabilitation Medicine, Supplement 8,

Larsson, S. E., Bengtsson, A., Bodegård, L., Henriksson, K. G.and Larsson, J. (1988). Muscle changes in work-related chronic myalgia.
Acta Orthopaedica Scandinavia, 59, 552-556.

Maeda, K. (1977). Occupational Cervicobrachial Disorder and its causative factors. Journal of Human Ergology, 6, 193-202.

Rohmert, W. (1968). Die Beziehung zwischen Kraft und Ausdauer bei Statischer Muskelarbeit. Schriftenreihe Arbeitsmedizin, Sozialmedizin, Arbeitshygiene (pp. 118). A. W. Gentner Verlag, Stuttgart.

Wiker, S. F., Chaffin, D. B.and Langolf, G. D. (1990). Shoulder postural fatigue and discomfort. International Journal of Industrial Ergonomics, 5, 133-146.