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Commentary

On the confusion between static load level and static task

Dennis R. Ankrum*

Human Factors Research, Nova Solutions, 421 West Industrial Avenue, Effingham, IL 62401, USA

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Electromyography (EMG) is widely used to evaluate muscle activity. EMG can indicate which muscles are active and the relationship between a level of activity and the worker's capacity. Properly employed, EMG assists in evaluating the relative risks of alternative working conditions. Articles reporting EMG results are often used by ergonomics practitioners as guidance in job design. As such, the ability to interpret EMG research is critical to effectively utilize research as a guide to practice.

In evaluating risk, three levels of muscle loading have been of concern for ergonomists: peak, average, and static. It is generally accepted that jobs should not demand high exertion efforts over long periods. Likewise, the average exertion level should be controlled.

Sustained low-level muscle exertions have also been recognized as a risk factor for musculoskeletal disorders. This is usually referred to as 'static work'. However, there has been some confusion regarding the difference between the terms 'static load level' and 'static work'. The confusion becomes misleading when research-based recommendations for allowable levels of static load level are mistakenly applied to static work.

1. Three levels of muscle activity

Bengt Jonsson is perhaps the most-cited author on specific quantitative thresholds for interpreting stress levels from EMG data. In his 1978 article, 'Kinesiology: With special reference to electromyographic kinesiology' (Jonsson, 1978), he defines three levels of muscle load: static, dynamic and peak, based on the amplitude probability distribution function (APDF). The APDF (Fig. 1) is the distribution of the levels of muscle contraction during the observation period. The graph can be used to identify the percentage of time that muscle activity was less than a given proportion of the person's maximum voluntary ability to use that muscle, also known as the percent of maximum voluntary contraction (% MVC).

Peak load level, the highest level of muscle activity observed during the period of recording, is defined by Jonsson as the 90th percentile of the APDF. He defines the dynamic load level as the 50th percentile. Static load level is defined as the 10th percentile of the APDF, or the level at which the muscle activity will be 10% or below.

Jonsson suggested limits for each load level in cases of continuous work: the 90th percentile (peak) should not exceed 50–70% of MVC. The 50th percentile (dynamic, also referred to by Jonsson as the "mean") should not exceed 10–14% MVC, and the 10th percentile (static) should not exceed 2–5% MVC.

The nature of the work suggests which limit might be more important for a specific analysis: heavy lifting might be more concerned with peak loads and active assembly-line work with average loads. Relatively sedentary work, such as data entry, would be more concerned with static loads. However, according to Jonsson the recommended limits should be respected regardless of work type.

Some confusion has arisen because of the similarity between the terms 'static task' and 'static load level'. 'Static task' is a loosely defined reference to work in which muscles are active without much outward movement, such as when the trapezius stabilizes the scapula when the arm is elevated. 'Static load level' referring to the 10th percentile of the APDF, is not task specific.

A misapplication of Jonsson's recommendations can occur when static and dynamic are thought to be descriptions of work types, rather than components of the APDF. This can lead to incorrectly identifying conditions as exceeding Jonsson's recommended limits when they are actually well below them.

One example of this error can be found in 'The effects of video display terminal height on the operator: a comparison of the 15 and 40° recommendations' (Turville et al., 1998). The study investigated the effects of two VDT positions (center of screen at 15 and 40° below eye level) on muscle activity, in addition to other variables.

* Correspondence address: Human Factors Research, Nova Solutions, Inc., 10007 San Luis Trail, Austin, TX 78733-1253, USA. Tel.: + 1-512-263-5575; fax: + 1-512-263-5585.

E-mail address: ankrum@aol.com (D.R. Ankrum).

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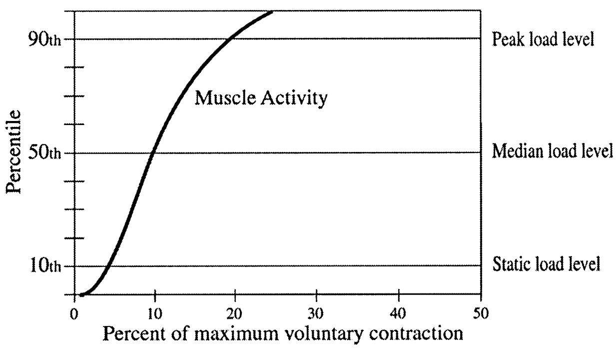

Fig. 1. Amplitude Probability Distribution Curve (adapted from Jonsson, 1978).

In the Discussion section, the authors state:

> The results of the normalized EMG analysis showed significantly higher muscle activity in the 40° monitor condition for the cervical and thoracic erector spinae. The magnitude of EMG activity doubled from 3% maximum voluntary contraction (MVC) in the 15° condition to 6% MVC in the 40° condition (Fig. 4). According to Jonsson (1978), static load level should not exceed 5% MVC for work tasks of long duration... *Although subjects were allowed to move throughout the experiment, operating a VDT is defined as a static task.* [Emphasis added]

The authors have applied recommendations for the 10th percentile to the observed means. The definition of the task as static might be accurate, but the application of Jonsson's static load recommendations to a mean figure is not. A misunderstanding of 'static load level' has led to a conclusion that is quite different from what the data show.

In some published studies, a reference to Jonsson's recommended limits is not explicitly stated, but the misunderstanding of the difference between 'static load level' and 'static task' can be deduced from the context.

For example, Sommerich et al. (1998) compared EMG data for three monitor heights. The median muscle-activity levels ranged between 0.6 and 3.9% MVC (numeric values are estimated from published graphs). One figure showed an increase of 0.7–1.3% MVC for the right sternocleidomastoid when the center of the monitor was lowered from eye level to 35° below eye level. If it were correct to compare those results to Jonsson's static load level limit (2–5% MVC), the increase might be noteworthy. However, when properly compared to the Jonsson's 10–14% MVC recommendation, the observed increase is trivial. The space devoted to this result might have been better used to highlight the much more notable 10% increase in worker performance for the low monitor condition.

A tendency exists to view as more favorable the work condition that results in the lowest level of muscle activity. Effective ergonomic design does not necessarily seek to reduce muscle activity, but to control it. In a relatively sedentary job such as VDT work, higher levels of mean % MVC for normally statically loaded muscles might actually be desirable, provided they do not exceed the recommended limits and the 'static load level' is kept low.

2. Conclusions

Although the 10th percentile data ('static load level') in the above studies might have provided a better indication of risk than the mean (or median) load level, other aspects of muscle activity might be even more important. Åaras (1994) has proposed that the percentage of time below 1% MVC may be critical, while Veiersted et al. (1993) have suggested measuring the number of gaps of at least 0.2 s duration under 0.5% MVC. Hägg (1991) states that, for normally statically loaded muscles, the duration of the load and the pauses are the critical factors. Westgaard (in press) states that three physical dimensions must be considered: amplitude, duration and repetitiveness (i.e. force variation pattern), in addition to the contributions of mental stress and the variable of individual susceptibility.

EMG research can provide valuable insights for ergonomic practitioners. However, without a recognition of the permissible limits one may accept one condition as superior when both may be almost equally risky, or equally lacking in risk.

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