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A different approach for the ergonomic evaluation of pushing and pulling in practice

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Abstract

Recent epidemiological studies show that pushing and pulling increase the risks of shoulder complaints and not necessarily of low back complaints. Moreover, the magnitude of the exerted hand forces during pushing and pulling is poorly related to the magnitude of the mechanical loading of the low back and the shoulder. In light of that, this paper combines results of several studies to present an approach for evaluating not only the exerted hand forces, but also the low back and shoulder load during pushing and pulling in practice. The approach specifies, based on scientific evidence, that (1) in order to validly obtain exposure (frequency and duration) to pushing and pulling, 10 workers should be observed during eight periods of 30 min; (2) how the exerted hand forces and the load of the low back and shoulder can be estimated in practice based solemnly on the weight of the object, one-handed or two-handed pushing or pulling, and the height of the handle; and finally, (3) how these outcomes can be evaluated in combination with existing guidelines regarding exerted hand forces, compression forces on the low back and the moments at the shoulder. Two cases will be presented here to illustrate the application of the approach.

Relevance to industry

The presented approach is the first to offer practitioners a fairly simple method for the ergonomic evaluation of pushing and pulling carts and four-wheeled containers in practice, especially as regarding the shoulder load.

Keywords: Pushing; Pulling; Low back; Shoulder; Risk assessment; Biomechanical workload

1. Introduction

Imagine your daily job consisted of collecting over 513 two-wheeled waste containers, or pushing a four-wheeled container full speed ahead over 440 times, or moving 621 flower carts. Pushing and pulling (P&P) is a frequent activity for a great segment of the workforce, including waste collectors, warehouse workers and truck drivers. It has been estimated that nearly half of manual material handling consists of P&P (Baril-Gingras and Lortie, 1995). P&P is defined as the exertion of a (hand) force by a person on an object or another person, the resultant force of which is directed horizontally (Hoozemans et al., 1998). Aside from that definition, a distinction can be made between P&P while walking in order to move an object, such as a trolley, and P&P while standing in order to operate an instrument, such as a lever. In the present study, we will focus on P&P in order to move objects over a certain distance while walking.

In terms of the ergonomic evaluation of P&P in practice, the guidelines presented by Mital et al. (1997) and the working draft of ISO document "Ergonomics—manual handling—Part 2: Pushing and pulling" (ISO/TC 159/SC 3 N 241, 1994) probably provide the most useful cut-off points for reducing the risk of fatigue and musculoskeletal complaints. The guideline of Mital et al. (1997) recommends certain initial and sustained, horizontally exerted

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hand forces for different percentiles of male and female industrial workers in one and two-handed P&P. They specify a maximum acceptable force, which depends on the handle height, frequency of P&P, and the P&P distance. The ISO working draft uses a risk assessment model consisting of three steps in total: (1) hazard identification (yes/no); (2) if identified, a risk assessment should follow based on the guidelines of Mital et al. (1997) (acceptable/not acceptable); and (3) if that risk assessment is not addressable, a so-called whole-body P&P force limit should be determined based on muscle strength and compressive lumbar strength (acceptable/conditionally acceptable/not acceptable). Thus, existing guidelines are based on perceived exertion, energetic workload, and partly on lumbar loading. However, epidemiological studies show that P&P appear to be a more significant risk factor for shoulder complaints than for low back complaints (Hoozemans et al., 2002; Harkness et al., 2003; Van Nieuwenhuyse et al., 2004). A 1-year prospective cohort study of several occupational groups found a significant relationship between P&P and shoulder complaints, but not low back complaints (Hoozemans et al., 2002). For the self-reported exposure, the prevalence ratio of reporting shoulder complaints was 2.9 (95% confidence interval (CI) 1.2–7.2) for the medium exposure group and 4.9 (95% CI 1.9–12.8) for the high exposure group as compared to a reference group. For low back complaints, no significant risk was observed. In a 2-year prospective cohort study of newly employed workers, P&P $\geqslant$ 31 kg (70 lbs) was associated with the highest risk estimate (1.9, 95% CI 1.1–3.3) for shoulder complaints, among several other mechanical and psychosocial factors (Harkness et al., 2003). In a cross sectional study on first-ever low back pain among workers in their first job, P&P activities were not associated with low back pain (1.01, 95% CI 0.6–1.8) (Van Nieuwenhuyse et al., 2004).

Although P&P have been found to be related to shoulder complaints, existing guidelines do not account for shoulder load. In addition, the guidelines focus on the maximum acceptable push or pull forces. This may suggest that the magnitude of force exertion is directly related to mechanical loading. However, Hoozemans et al. (2004) could not confirm the assumption that higher magnitudes of initial and sustained exerted forces were related to higher magnitudes of the mechanical loading of the low back and shoulder. One explanation is that the direction of the P&P force has a large effect on the mechanical load (De Looze et al., 2000).

Another consideration that guidelines should take into account as regarding force exertion is that it is often difficult in practice to make valid assessments of these forces. Preferably, forces should be measured in three directions simultaneously (Annex D, working draft of ISO document "Ergonomics—manual handling—Part 2: Pushing and pulling" (ISO/TC 159/SC 3 N 241, 1994). Moreover, contrary to the approach proposed in the working draft, it appears that five repeated force measures are necessary per worker in order to obtain a reliable estimate of exerted P&P forces at the individual level. To make a clear distinction between two groups of workers, at least seven workers must be assessed, as within-worker variance is considerably smaller than between-worker variance (Van der Beek et al., 1999; Hoozemans et al., 2001).

The present paper introduces a different approach for the ergonomic evaluation of P&P that is complementary to the guidelines described above. This approach enables the practitioner to estimate the exerted hand forces based on P&P characteristics: (1) weight of the object; (2) the number of hands used; (3) the handle height; and (4) the specific activity, i.e., pushing or pulling. The biomechanical load of the shoulder and low back are estimated based on the same P&P characteristics. Despite the results of the epidemiological studies, working conditions that pose an increased risk of low back complaints may still be present. The outcomes can be compared to guidelines for exerted hand forces and low back and shoulder load, aimed at reducing the risk of fatigue complaints and musculoskeletal complaints. In addition, this approach specifies how a task analysis should be performed in order to obtain reliable estimates for the duration and frequency of P&P. This paper seeks to introduce a different approach and illustrates its use by presenting two cases.

2. Different approach

As mentioned earlier, the present approach is complementary to the guidelines presented by Mital et al. (1997) and the working draft of ISO document, "Ergonomics—manual handling—Part 2: Pushing and pulling." The first step in this approach consists of specifying how a task analysis should be performed in order to arrive at a relatively precise estimate of the mean frequency and duration of P&P in the workplace. The second step is to estimate the hand forces exerted and the mechanical load of the low back and shoulder. The third step involves comparing the force exertion and mechanical loading of the low back and shoulder with existing guidelines.

2.1. Assessment of frequency and duration of pushing and pulling

Quantification of exposure at the workplace to—say—P&P is time consuming. Ergonomic practice is helped by a data collection strategy that is effective in obtaining estimates for group mean exposure with sufficient accuracy (small bias) and precision (small random error). What is more, this strategy can be employed with a minimal investment of resources (Hoozemans, 2003). Several methods are available for the assessment of activities at the workplace (Van der Beek and Frings-Dresen, 1998). The use of a hand-held computer to record