

# Folding and unfolding manual wheelchairs: an ergonomic evaluation of health-care workers<sup>☆</sup>

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## Abstract

The objective of this study was to test the hypotheses (i) that health-care workers vary greatly in the methods used to fold and unfold selected manual wheelchairs, and (ii) that many of the methods used include bent and twisted back postures that are known to be associated with a high risk of injury. We studied 20 health-care workers in a rehabilitation center. Subjects folded and unfolded two wheelchairs of cross-brace design, one with and one without a sling seat. As outcome measures, we used a questionnaire, time taken, visual analog scales of perceived exertion and back strain, folded width, videotape and Ovako Working Posture Analysis System (OWAS) back scores (1–4). Subjects used up to 14 different combinations of approach, hand placement and back posture to accomplish the tasks. The mean OWAS scores were in the 2.4–3.1 range and 49 (42%) of the 118 scores recorded were class 4 (back simultaneously “bent and twisted”, considered to be associated with the highest risk of injury). We also observed methods that appeared to be safe and effective. Age, gender, profession, experience and seat condition did not generally influence the outcome measures. We conclude that health-care workers use a variety of methods to fold and unfold wheelchairs, many of which include bent and twisted back postures that may carry a risk of injury. Further study is needed to confirm this risk, to identify more ergonomically sound wheelchair designs and to develop better methods of carrying out the common and important task of folding and unfolding wheelchairs.

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## 1. Introduction

Jones and Sanford (1996) projected that there would be 2 million wheelchair users in the United States in 2000. The ability to fold a manual wheelchair into a narrow position for easier transport and storage is a popular design feature (Deitz and Dudgeon, 1995; Kirby, 1997; Cooper, 1998). The cross-brace design (Fig. 1), invented by Herbert Everest and Harry Jennings in 1932 (Cooper, 1998) and now available from most wheelchair manufacturers, is still the most commonly used by community wheelchair users and in the hospital and rehabilitation settings.

Although there is an extensive literature on many aspects of wheelchairs and their use (e.g., acute and overuse injuries of wheelchair users, wheelchair performance), surprisingly little attention has been paid to wheelchair ergonomics. In a search of English-language articles cited by Medline from January 1, 1950 to June 1, 2003, we identified 123 articles in response to the search terms “wheelchair AND ergonomics” and 13 from the search terms “wheelchair AND folding”, but none dealt specifically with the tasks of folding and unfolding manual wheelchairs by people other than wheelchair users or the associated risk of injury. The reported success rates for folding/unfolding manual wheelchairs, as a component of the Wheelchair Skills Test, range from 5% to 88% for groups of wheelchair users, able-bodied subjects, occupational therapy students at different levels of training and untrained caregivers (Kirby et al., 2002, 2003a, b; Coolen et al., 2002). The methods used were not reported.

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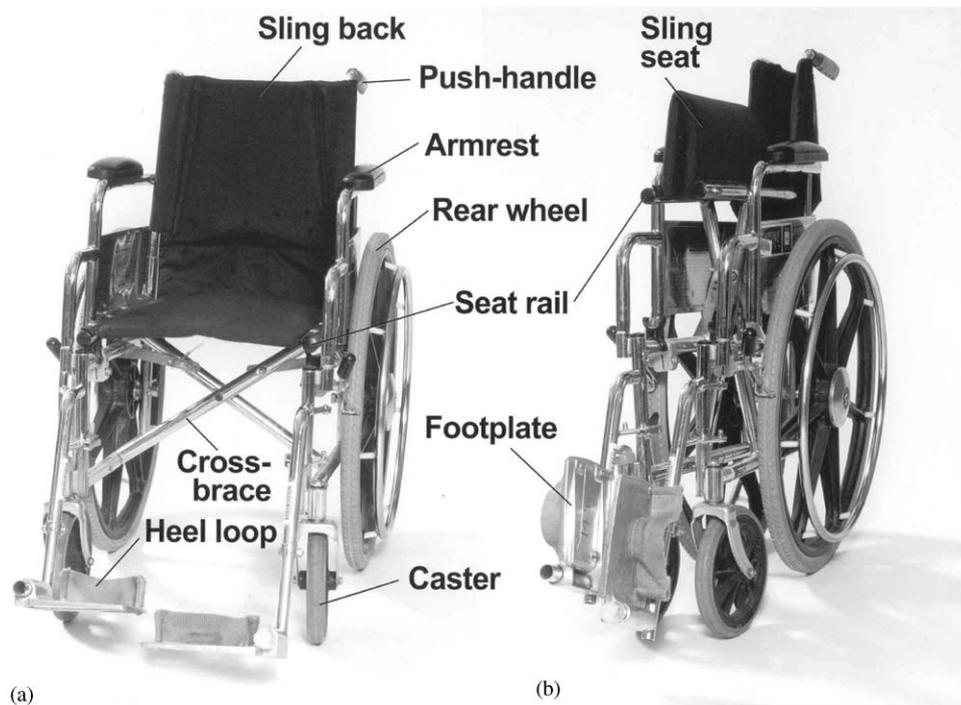


Fig. 1. Cross-braced wheelchair, open (A) and folded (B).

Low back pain (LBP) accounts for 33% of all compensation, 4.6 billion dollars each year in the United States (van Oort et al., 1990). The individual risk factors for the development of LBP that have been explored in the literature include age, gender, anthropometric characteristics, physical fitness, smoking, psychological factors and previous history of LBP (Biering-Sorensen, 1983; Agnew, 1987; Burton and Cassidy, 1992; Garg and Moore, 1992; Khalil et al., 1993). The work-related risk factors reported include heavy work and lifting, static work postures, twisting and bending postures, vibration, perceived exertion and perceived back strain (Stubbs et al., 1983; Videman et al., 1984; Snook, 1985; Harber et al., 1985; Agnew, 1987; Burdorf et al., 1991; McAtamney and Corlett, 1992; Borenstein et al., 1995). Health-care occupations frequently require bending, twisting and lifting postures (Harber et al., 1985; Jensen, 1987; McAtamney and Corlett, 1992; Knibbe and Friele, 1996; Hignett, 1996; Woolfrey and Kirby, 1998; Cromie et al., 2000; Elford et al., 2000; Hui et al., 2001; Daynard et al., 2001). Jensen (1987) reported that health-care occupations constituted 6 of the top 10 ranked occupations for the incidence of LBP. In clinical practice, we have noted that many health-care workers approach the task of folding and unfolding wheelchairs in an awkward and inefficient manner.

Although there is no direct evidence, epidemiologic or otherwise, linking the wheelchair folding/unfolding task to LBP, the circumstantial evidence cited above led us to

believe that this was a topic that warranted investigation. The purpose of this study was to evaluate this task, in a preliminary and predominantly descriptive way, testing the hypotheses (i) that health-care workers vary greatly in the methods used to fold and unfold manual wheelchairs and (ii) that many of the methods used include bent and twisted back postures that are known to be associated with a high risk of injury.

## 2. Methods

### 2.1. Subjects

With their informed consent, we studied 20 health-care workers in a rehabilitation center. Because this was a preliminary descriptive study and the variability of the data was unknown, we chose not to use a power analysis to more formally estimate the sample size. In an effort to achieve a heterogeneous and representative group of health-care workers who routinely deal with wheelchairs, we recruited 5 nurses, 5 health-care aids/porters, 5 occupational therapists and 5 physical therapists. There were 6 men and 14 women and the mean ( $\pm$ SD) age was 32.8 ( $\pm$ 6.6) years (range 22–45). Inclusion criteria included an age range of 18–60 years and previous experience folding a wheelchair (at least once during the month prior to the study). We excluded any subject with current or recent LBP, arm pain or any other contraindications to lifting (e.g., uncontrolled

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