Ergonomics

Pushing and Pulling - General

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Who uses pushing and pulling motions at work?

Workers use various pushing and pulling techniques in a wide range of activities, such as:

- using manual carts and trucks
- sliding objects such as cartons on flat surfaces (tables, floors, etc.)
- operating tools and controls
- opening and closing doors
- wrapping or enclosing objects in packaging materials

Are there any statistics to show how common injuries are from pushing and pulling activities?

Because these actions are among the most common work activities, they are also the cause of many injuries. However, there are no comprehensive injury statistics as these types of injuries are not specifically recorded as ‘push or pull’ injuries. Most commonly, the nature of injury is recorded as an overexertion injury (e.g., back strain). Injuries due to slips and falls are also often associated with pushing and pulling. Additionally, injuries to fingers and hands can result when caught in, on, or between objects (e.g., between a cart and the wall) and to lower legs when bumped by carts.

Therefore, existing statistics do not reflect the importance of pushing and pulling as work factors causing injury because the injuries fall into different categories making them difficult to quantify.

Are there any "limits" for the amount of force one should exert?

Because of the complex nature of body motion during pushing and pulling, no numerical standard has yet been developed that can be directly applied in industry.

Many factors affect the amount of force that a worker can develop in a horizontal push and pull:

- body weight and strength
- height of force application
- direction of force application
- distance of force application from the body
- different positions (standing, kneeling, overhead, and seated)
- posture (bending forward or leaning backward)
- friction coefficient (amount of friction or grip between floors and shoes, as well as between the loand and the ground)
- duration and distance of push or pull

Tables 1 and 2 contain the upper force limits for a variety of pushing and pulling tasks. They indicate the amount of force that a worker should exert. It is important to be aware that the forces in the tables are not the same as the weight of objects being pushed and pulled. This difference means that we cannot use these upper force limits as recommendations for weight limits that can be pushed or pulled in the workplace. Only trained personnel using special equipment can measure the forces exerted by a worker.

What are the force limits for horizontal pushing and pulling?

The values in Table 1 show the upper limits of forces for horizontal pushing and pulling. These limits should not be exceeded in work situations. In fact, it is better and safer if pushing and pulling tasks require lower forces, particularly, where the task requires:

- pushing or pulling an object when the hands must be above the shoulder or below the waist level
- exerting a force for longer than 5 seconds

- exerting a force at an angle not directly in front of the body, e.g., not "straight on"

Where a worker can support their body (or feet) against a firm structure higher forces (up to 675N or about 165 lbf or 75 Kgf) can be developed.

Table 1 Recommended Upper Force Limits for Horizontal Pushing and Pulling*		
Condition	**Forces that should not be exceeded, in Newtons (lbf, kgf)****	**Examples of Activities**
A. Standing		
1. Whole body involved	225 N (50 lbf or 23 kgf)	Truck and cart handling. Moving equipment on wheels or casters. Sliding rolls on shafts.
2. Primary arm and shoulder muscles, arms fully extended	110 N (24 lbf or 11 kgf)	Leaning over an obstacle to move an object. Pushing an object at or above shoulder height.
B. Kneeling	188 N (42 lbf or 21 kgf)	Removing or replacing a component from equipment as in maintenance work. Handling in confined work areas such as tunnels or large conduits.
C. Seated	130 N (29 lbf or 13 kgf)	Operating a vertical lever, such as a floor shift on heavy equipment. Moving trays or a product on and off conveyors.

* Adopted from: Ergonomic design for people at work. Vol. 2, by Eastman Kodak Company, Van Nostrand Reinhold, 1986, and Kodak's Ergonomic Design for People at Work 2nd edition by Somadeepti, et al. 2004

** Units of force are: Newton (N), kilogram-force (kgf), pound-force (lbf); 10N is about the same as 1 Kgf or 2 lbf. The values in each unit system - Newtons, kilogram force and pound force, respectively - are provided in the table because all are used in the literature and on instruments, depending on the country of origin.

What are the limits for vertical pushing and pulling?

The values in Table 2 show the upper limits of forces for vertical pushing and pulling. Examples of the use of vertical force are operating controls and hand tools. Such activities tend to be of a repetitive nature and physically more demanding than occasional pushing or pulling. Therefore, these tasks should be designed for considerably lower force requirements than those shown in Table 2.

Table 2
Recommended Upper Force Limits for
Vertical Pushing and Pulling*

Conditions	Upper Limit of Force, in Newtons (lbf, kgf)**	Examples of Activities
Pull down - Above head height	540 N (120 lbf or 55 kgf)	Activating a control, hook grip; such as a safety shower handle or manual control.
Pull down - Shoulder level	200 N (45 lbf or 20 kgf)	Operating a chain hoist, power grips; less than 5 cm (2 in) diameter grip surface.
Pull up - 25 cm above the floor	315 N (70 lbf or 32 kgf)	Stringing cable, threading up a paper machine, activating a control.
Pull up - Elbow height	148 N (33 lbf or 15 kgf)	Raising a lid or access port.
Pull up - Shoulder height	75 N (17 lbf or 7.5 kgf)	Raising a lid, palm up.
Boost up - Shoulder height	200 N (45 lbf or 20 kgf)	Raising a corner or end of an object, like a pipe; boosting an object to a high shelf.
Push down - Elbow height	290 N (64 lbf or 29 kgf)	Wrapping, packing, and sealing cases.

* Adopted from: Ergonomic design for people at work. Vol. 2, by Eastman Kodak Company, Van Nostrand Reinhold, 1986

** Units of force are: Newton (N), kilogram-force (kgf), pound-force (lbf); 10N is about the same as 1 kgf or 2 lbf. The values in each unit system - Newtons, kilogram-force and pound force, respectively - are provided in the table because all are used in the literature and on instruments, depending on the country of origin.

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