

## **Comparison of Two Methods of Moving A Manual Wheelchair Short Distances on Leveled and Inclined Surfaces**

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### **Abstract**

The aim of this study was to determine, which method is more effective while moving a manual wheelchair short distances on four and rear wheels over two surfaces (leveled and inclined) for the attendant or caregiver. It was an observational study design consisting of normal healthy male [N=30] subjects, aged 20-30 yrs. Subjects used both methods i.e. moving a manual wheelchair first on four and then on rear wheels over leveled and inclined surfaces. Distance of 10 m was used. After completion of both trials, subjects used 10 cm Visual Analog Scale (VAS) to quantify, how they perceived, (i) the ease of use (ii) efficiency and (iii) back discomfort. Paired 't' test for all the variables between four and rear wheels over the two surfaces shows significant difference with p- value <0.05. This concludes moving the wheelchair on four wheels over the two surfaces is faster, easier, efficient and more comfortable for the back than on rear wheels.

**Key Words: Wheelchair, Leveled Surface, Inclined Surface, Four Wheels, Rear wheels**

### **Introduction**

A personal caregiver is an important element for many people with activity restrictions, in the rehabilitation process. Wheelchair users who require assistance most frequently depend on family members. As a result of the burden of providing assistance, some caregivers may neglect themselves and are at a higher risk of physical harm when providing care (*Kirby et al, 2004*). Moving a manual wheelchair is a common task performed by health care workers and caregivers as the wheelchair is among the most common and important of rehabilitation devices (*Woolfrey & Kirby, 1998*). Wheelchairs are an integral component of medical rehabilitation, their use ranges from short-distance propulsion within the home to long-distance marathon racing.

However, wheelchairs can be difficult to manage and there is potential for acute or overuse injuries to the wheelchair user and/or the caregiver.

Lack of wheelchair skill training may also lead to decreased mobility and reduced community access (*Kirby et al, 2004*). If wheelchair users and their caregivers do not know how to overcome obstacles such as rough ground and curbs safely, they may perform this task in poor posture which may lead to back discomfort.

Most commonly, caregivers propel wheelchair from few to several metres per day. The average time spent working with a bent or twisted position of the back like stooped work posture was found to contribute to the prevalence of back pain or discomfort. The other risk factors include heavy physical work, monotonous tasks, sudden maximal physical effort and forceful movements (*Burdorf et al, 1991*). This strongly suggests that job-related rather than personal characteristics are the major predictors of back injury in health care workers and caregivers (*Venning et al, 1987*).

Activities that are usually done on a flat surface can be made more or less resistive by changing the level of the surface. The standard horizontal work surface itself can be raised to make demands on certain muscle groups or to alter the effect of gravity e.g. in wheelchair mobility, activities usually begin on level surfaces (including floors, doorway and elevators) and progress to up a curb or a ramp, over rough and uneven terrain.

Manual wheelchair propulsion in daily life is increasingly being studied. Kirby *et al* (2004) in their study have concluded that the WSTP (wheelchair skill training programme) is a safe, practical and effective method of improving the wheelchair handling skill of untrained caregivers. Such training could play an important role in the rehabilitation process.

In wheelchair mobility methods, two methods are mainly used. They are, moving a wheelchair on four wheels and moving on rear wheels. Propelling wheelchair on rear wheels help to clear objects on the floor, sidewalk or to manage a step. But much attention is not paid to the effect of changes that occur while propulsion of wheelchair on four wheels and rear wheels over leveled and inclined surface. So, the purpose of the study was to determine, which method is more effective while moving a manual wheelchair short distance on four and rear wheels over two surfaces (leveled and inclined) for the attendant or caregiver. To prevent or minimize back injuries, the health care workers and caregivers should be well trained in performing this task. Caregiver training can improve patient handling and moving skills. This could, in turn, reduce caregiver stress and improve

the quality of life for both caregiver and wheelchair user (Kirby *et al*, 2004).

To determine which method is more effective while moving a manual wheelchair short distances on four and rear wheels over two surfaces (leveled and inclined).

## Material and Method

Thirty males participated in the study. All the subjects were healthy with mean age of 21.9 yrs. Out of 30 subjects, half of the subjects were hospital workers and half of them were students. The study was carried out at Civil Hospital, Patti, Amritsar. The subjects were alert, co-operative and understood the purpose of the study. An informed consent was taken from all subjects.

### Inclusion Criteria :

1. Normal healthy subjects.
2. Age 20-30yrs
3. Height 165-175cms
4. Weight 50-70kgs
5. BMI 18.9-24.9

### Exclusion Criteria :

1. Musculoskeletal disorders like problem in the back, upper limb and lower limb.
2. Neurological disorders.
3. Cardiac problems.
4. Respiratory problems.
5. Psychological problems.

### Instrumentation :

Wheelchair: The wheelchair selected for the study was of a type commonly used in hospital & home setting. It was a manually propelled wheelchair.

VAS: 10-cm Visual Analog Scale (VAS) was used to quantify the subject's perception of ease of use, efficiency & back discomfort. It is a reliable and valid

method for measuring subjective feelings (Woolfrey & Kirby, 1998; Price et al., 1983).

Manual Stopwatch was used to measure the time, taken by the subjects to complete the task.

Measuring tape was used to measure 10m distance on the floor and ramp.

#### *Protocol :*

Thirty healthy male subjects were randomly assigned for the study, based on the inclusion and exclusion criteria. Study involves single group of 30 males. All the subjects were instructed to move a manual wheelchair on four and rear wheels over two surfaces (leveled and inclined). 10-cm VAS was used to quantify the subject's perception of ease of use, efficiency and back discomfort. Time taken was measured using manual stopwatch.

Based on the inclusion and exclusion criteria, thirty healthy male subjects were recruited for the study. Before the experiment, all the subjects were explained about the procedure, practice trials were performed. Each subject was instructed to move the wheelchair on leveled (floor) and inclined (ramp up) surfaces with wheelchair on four wheels and then on rear wheels. Instructions were given to propel the wheelchair at normal speed, not considering it a sport. Patient care being must.

The weight of the patient taken for the study was 63 kgs. The distance used was 10m (Wilkinson & Menz, 1997). Measuring tape was used to mark the distance on the floor and ramp. Subjects were indicated with the start and finish of

the move made by chalk. Subjects performed the task at a speed that was normal for them. Rest break of about 45 sec. was given, however if the subjects reported any sustained discomfort, additional rest time was given (Olendorf & Drury, 2001).

Manual stopwatch was used to time the move from start to finish. After completion of both trials, subjects used 10cm Visual Analog Scale (VAS) to quantify, how they perceived,

1. The ease of use.
2. Efficiency and
3. Back discomfort of the two methods.

#### *Data Analysis :*

Data was analyzed using SPSS software 12.0 version. Mean & Standard deviation of the physical characteristics i.e. age, height, weight & BMI was calculated for the single group subjects.

Paired t-test was done to analyze all the four variables (ease of use, efficiency, back discomfort and time taken) between four and rear wheels over the two surfaces (leveled and inclined).

The significant level of 0.05 was taken for the study.

## **Results**

The mean and standard deviation of age, height, weight & BMI of 30 subjects who participated in the study was found to be  $21.9 \pm 2.9$  years,  $169.7 \pm 3.8$  cms,  $60.2 \pm 6.2$  kg and  $20.8 \pm 2.0$  respectively as given in Table 1.

Table 1: Demographic data of the subjects

	Age (Years)	Height (cm)	Weight (kg)	BMI
Mean	21.9	169.7	60.2	20.8
SD	2.9	3.8	6.2	2.0

Table 2–Comparison between four and rear wheels on the two surfaces (leveled and inclined) for ease of use

VARIABLE	Mean	±S.D	t	p-value
Eoulsfw	2.5	1.9		
Eoulsrw	4.7	2.8		
Eoulsfw vs Eoulsrw			5.8	.0001
Eouisfw	4.5	2.0		
Eouisrw	5.7	2.1		
Eouisfw vs Eouisrw			2.8	.009

eou=ease of use, ls=leveled surface, is=inclined surface, fw=four wheels, rw=rear wheels

Table 3-Comparison between four and rear wheels on the two surfaces (leveled and inclined) for efficiency

VARIABLE	Mean	±S.D	t	p-value
Eflsfw	2.4	2.2		
Eflsrw	4.4	2.4		
Eflsfw vs Eflsrw			4.9	.0001
Efisfw	4.2	2.0		
Efisrw	5.4	2.0		
Efisfw vs Efisrw			2.9	.006

Ef= efficiency

Table 4:Comparison between four and rear wheels on the two surfaces (leveled and inclined) for back discomfort

VARIABLE	Mean	±S.D	t	p-value
Bdlsfw	2.5	2.3		
Bdlsrw	4.3	2.8		
Bdlsfw vs Bdlsrw			3.9	.0001
Bdisfw	4.4	2.1		
Bdisrw	5.8	2.2		
Bdisfw vs Bdisrw			3.8	.001

Bd=back discomfort

Paired t-test for all the variables (ease of use, efficiency, back discomfort and time taken) between four and rear wheels over the two surfaces (leveled and inclined) shows significant difference with p-value < 0.05 shown in table 2, 3, 4, 5.

Table 5: Comparison between four and rear wheels on the two surfaces (leveled and inclined) for time taken

VARIABLE	Mean	± S.D	t	p-value
Ttlsfw	11.3	2.3		
Ttlsrw	11.9	3.0		
Ttlsfw vs Ttlsrw			2.5	.018
Ttisfw	9.7	2.2		
Ttisrw	10.9	2.4		
Ttisfw vs Ttisrw			3.6	.001

Tt=Time Taken

This indicates that moving a manual wheelchair on four wheels over the two surfaces (leveled and inclined) is easier, efficient, comfortable and faster method than moving the wheelchair on rear wheels.

## Discussion

Many researches have been done on the manual wheelchair propulsion by the patient. Very few researches were done on the ergonomics of the caregiver while propelling the wheelchair. In this study, the ergonomics of the caregiver was taken into account, to reduce the caregiver stress and to improve the quality of life.

*Woolfrey & Kirby (1998)* in their study used two methods i.e. wheelbarrow method and conventional method. Their results showed that wheelbarrow method was faster, easier, more efficient and more comfortable for the back than the conventional method. The result of present study was somewhat consistent with the study done by *Woolfrey & Kirby (1998)*.

Moving a manual wheelchair over four wheels was easier than moving the wheelchair on rear wheels. In order to move the wheelchair on rear wheels, the caregiver tilts the wheelchair back by

pushing the push handles down and by stepping on the tilt bar raising the casters off the surface. This results in the bending of the back of the caregiver. He then moves the wheelchair while maintaining the above position. The caregiver requires being more careful regarding the balancing of the wheelchair and patient. To the extent that moving a manual wheelchair on four wheels decreases the bending and twisting of the back, its use may also decrease the risk of back injury. This may occur because the forward flexion leads to compression of the intervertebral disc anteriorly and stretching of the soft tissues posteriorly. The disc pressure also increases under the flexion moment. Flexion can lead to disc damage under fatigue loads at the low load levels persisting for a long periods of time. The nuclear material displaces posteriorly. Large tensile strains in disc fibres in flexion lead to the vulnerability of lumbar discs to rupture. The anterior portion of the annulus fibrosus get compressed and bulges anteriorly while the posterior portion gets stretched.

As the caregiver was able to move the wheelchair over four wheels more easily and it caused less bending and back discomfort as compared to moving the wheelchair on rear wheels, so moving the wheelchair on four wheels may result in the efficient performance of the caregiver.

Moving a manual wheelchair over the two surfaces (leveled and inclined) on four wheels was found to be a faster method as compared to moving the wheelchair on the rear wheels.

The reason may be that while moving the wheelchair on four wheels, the weight of the patient as well as wheelchair get distributed on all the four

wheels. So the overall weight on the wheelchair on four wheels is less as compared to the weight while moving the wheelchair on rear wheels. According to the law of rolling friction, the rolling friction force  $F$  is directly proportional to the load  $L$  and inversely proportional to the radius of curvature  $r$  or  $F = \mu_r L/r$ . (Gomber & Gogia, 2009). Due to the decrease in the load and large radius of the rear wheels while moving the wheelchair on four wheels, the rolling friction decreases which results in the increase in the speed and less time taken. Further, there may not be any problem with balancing the wheelchair on four wheels, because the caregiver requires force only for the propulsion rather than to balance the wheelchair.

Rolling friction is maximum while moving the wheelchair on rear wheels. This results because of the increased load and difficulty in balancing the wheelchair.

### *Conclusion*

Moving the wheelchair on four wheels over the two surfaces (leveled and inclined) is faster, easier, efficient and more comfortable for the back than moving the wheelchair on rear wheels. Its use may reduce the risk of back injury. Health care workers should be instructed to use this method while moving the wheelchair.

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