
Minimal Forces to Move Patients

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Objectives. Health care workers who have patient transfer duties are at risk for back injury. Transferring patients between beds and gurneys is a rigorous pulling task that requires back, leg, and arm strength. This study analyzed the efficiency of commercially available transfer devices, namely a patient roller, patient shifter, and draw sheet.

Method. With the use of one or two force scales attached to each transfer device, the amount of force needed to transfer 15 participants, weighing from 101 lb to 240 lb, back and forth between a bed and a gurney was measured. Ten transfers per device per participant were performed.

Results. The patient roller was superior to the patient shifter and draw sheet in reducing transfer forces. Additionally, gurney-to-bed transfers tended to be more demanding for all transfer devices and for heavier participants.

Conclusions. The patient roller was the most efficient transfer device in moving participants compared with the draw sheet and patient shifter. Transfer forces can be estimated with the use of linear equations, with patient weight, direction of transfer, and transfer device as the independent variables. These estimated forces can assist occupational therapists in the returning their injured health care coworkers to patient transfer duties. The results further indicated that high forces are required to transfer patients; therefore, patient-transfer personnel should obtain assistance when moving patients.

Many health care professionals, especially nurses aides, perform or assist in patient transfers. Fuortes, Shi, Zhang, Zwerling, and Schootman (1994) reported that nurses aides have back injury rates 3.3-fold higher than registered nurses and licensed practical nurses and a higher rate than any other occupational group. Owen and Garg (1991) found that nurses rated patient handling tasks, including transfers in and out of bed, as a stressful activity associated with back pain. Moving patients, both a physically and psychologically demanding task, is also well documented in current literature as a source for back injury (Owen & Garg, 1991), but there is a void in the literature about the quantification of forces necessary to transfer patients.

Transferring patients requires strength, stamina, and skill to ensure safety to the patient and transferring personnel. Two components are involved in patient transfers: lifting, the vertical force component, and pulling, the horizontal force component. The patient is not truly lifted, but a vertical force is generated to help reduce friction during the transfer. The results of these two components is the horizontal movement of the patient.

As suggested in their advertisements, commercially available transfer devices reduce the effort in patient transfers and reduce lower back injuries. Among these devices are the patient shifter,¹ the patient roller,² and the draw sheet³. The draw sheet, about the size of the top surface of a hospital bed mattress, is composed of a heavy-duty, high-strength cotton cloth. Patients are placed on this device for transfer within, to, and from the bed. The standard patient shifter is a thin, semirigid plastic board that has four handles cut along each side. A patient is positioned on top of this device, and the patient and shifter are pulled to the desired off-bed position. The patient roller (also called a long roller) is a frame of five rollers with a plasticized cloth covering. This device is rolled under the patient, eliminating friction between the patient and bed as the patient is pulled to the gurney. A search of the literature revealed no quantitative analyses comparing these three devices.

A pilot study was performed in the operating room at our facility as a result of the nurses' comments about the efficiency of the patient shifter and the patient roller. Five transfers from an operating room table to a gurney were performed on a 140-lb participant with the use of the following devices: a standard draw sheet, a patient shifter, and a patient roller. The patient roller required only 18% of the total force when compared with the draw sheet forces. The patient shifter required 56% of the force when compared with the draw sheet forces. Although the patient roller was the most efficient in reducing the force, the patient shifter also substantially reduced the transferring force. Because of these results, a formalized study was performed to evaluate the forces needed to transfer a continuum of different weighted participants with a draw sheet, patient shifter, and patient roller.

Method

Participants

Fifteen hospital and office employees (six women and nine men) participated in this study. Each participant was selected on the basis of body weight to fill each 10-lb range between 100 lb and 240 lb.

¹The patient shifter, model #9-719, standard, white, 22 in., is manufactured by AliMed, Inc., 297 High Street, Dedham, Massachusetts 02026-9135.

²The long roller, model #9-728, is manufactured by AliMed, Inc., 297 High Street, Dedham, Massachusetts 02026-9135.

³The heavy sateen draw sheet is manufactured by John P. King Manufacturing Company, Augusta, Georgia. (Available through MEDLINE, 5675 Bucknell Drive, Atlanta, Georgia 30336)

Materials

The draw sheet was modified to ensure sturdy attachment sites for two force scales. This modification required sleeves to be sewn into both lateral sides of the sheet to hold a 1 1/4-in. dowel. Small slits were cut into the sleeves to attach a short loop of rope around the dowel, and the force scales were attached to these loops (see Figure 1).

The patient shifter measured 72 in. × 22 in. × 3/16 in., weighed 9 lb, and had a weight capacity of 250 lb. A short loop of rope was attached to the handles to secure and balance the pull from either one or two force scales.

The patient roller measured 66 in. × 15 1/2 in. × 1 1/8 in. and weighed 15 lb. The previously described modified draw sheet was used as the pull sheet during transfers with the patient roller because the draw sheet had a secure and stable attachment point for either one or two force scales.

Force was measured with Chantillon⁴ scales, models IN100-MRP (1-lb accuracy) and IN140-MRP (2-lb accuracy). Model IN100-MRP had a maximum reading pointer that locked to mark the maximum applied force. Model IN140-MRP did not have this feature, so the evaluator observed the maximum reading during the transfer. The scales were tested and found to be within their respective accuracies.

Procedure

Each participant was weighed on a hospital scale in street clothing but without shoes before being transferred. Shoes were not worn during the transfers because if they rubbed across the sheets, the increase in friction would have increased the transferring force. The weighing was immediately followed by transfer with the draw sheet, patient shifter, and patient roller.

The participant was approximated in the center of a hospital bed or gurney for each transfer. The bed height was placed about 1 1/2 in. above or below the gurney so that each transfer was downhill. In all transfers, the minimal amount of force was used to initiate and maintain motion. The pulling force was applied to the force scale attachment point on the device, with an upward lift angle of approximately 30° to reduce frictional forces.

Each participant was pulled sequentially from bed to gurney and gurney to bed five times, with force(s) measured at each transfer. There were 10 transfers per device

⁴The Chantillon force scales, models IN100-MRP and IN140-MRP, are manufactured by Chantillon Scales, PO Box 35668, Greensboro, North Carolina 27425-5668.

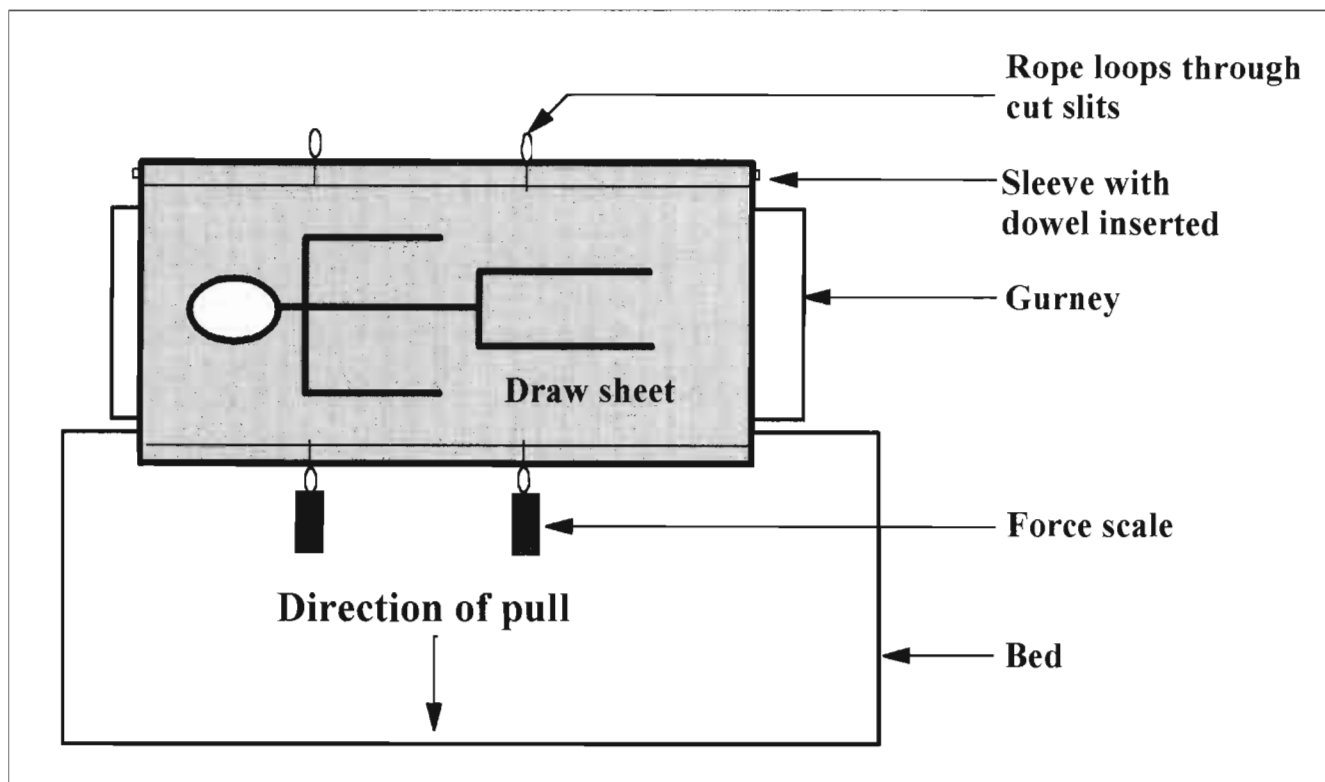


Figure 1. Arrangement of equipment and draw sheet for transferring participant from gurney to bed.

per participant, with a total of 450 planned transfers.

During the draw sheet transfers, the draw sheet was centered under the participant, and both participant and draw sheet were placed in the center of the bed or gurney. During the patient shifter transfers, the participant was positioned on top of the shifter, and the device and participant were pulled together. After each set of 10 transfers, the transfer device was cleaned with an antistatic spray to decrease static electricity. During the patient roller transfers, the draw sheet was placed under the participant. Before beginning the transfer pull, the patient roller was placed halfway under the participant, with the trailing edge of the roller approximated under the participants' spine.

The two evaluators were positioned with their respective scales on the same side of the bed as the device and pulled together. Forces were applied simultaneously at right angles from the midline of the bed-positioned participant with an upward pulling component of approximately 30°. The evaluators observed and recorded the maximum force reading of their scales; the sum of both forces was listed in the database. When only one evaluator and scale were used (following the same pulling procedure for two evaluators), the single maximum force reading was recorded in the database.

Data Analysis

SYSTAT for Windows⁵ was used to analyze data. For the analysis of force, a split-plot factorial design analysis of variance (ANOVA) was used [15(patient weight) × 2(direction of transfer: bed to gurney, gurney to bed) × 3(method of transfer: draw sheet, patient shifter, patient roller)], with the last two factors used as repeated variables. The data for the 121-lb participant were not obtained for the patient roller transfers because she felt back discomfort when moved over this device. To fill these missing cells, a mean was derived from the scores of the 110-lb and 135-lb participants; this mean was computed separately for each direction.

Results

Each direction of transfer (bed to gurney and gurney to bed), transfer device (draw sheet, patient shifter, patient roller), and participant weight variable showed significance at the $p < .001$ level (see F values in Table 1). All these variables had a significant effect on the amount of minimum required force to move each participant. The three-way interaction of the independent variables was

⁵SYSTAT for Windows, version 5, is manufactured by SYSTAT, Inc., 1800 Sherman Avenue, Evanston, Illinois 60201-3793.

significant ($F[28, 120] = 6.94, p < .001$). The linear trends were determined for the three-way interaction and were also significant ($F[14, 60] = 603.05, p < .001$). Given the quantity of collected measurements, a multivariate ANOVA supported the significance of the ANOVA findings ($F[28, 118] = 6.26, p < .001$).

Because of the complexity of this three-way interaction, a linear regression analysis of the averages of each required force to move each participant, each direction, with each method of transfer was completed (see Table 2). This method of analysis was appropriate because of the significant interaction among method, direction, and participant weight. The linear equation formula ($y = mx + b$, where m = coefficient and b = intercept; see Table 2) can be used to approximate the forces to transfer the participants. Figures 2 and 3 show that the patient roller required consistently lower force than the patient shifter or draw sheet, regardless of direction of transfer. Participant weight was directly proportional to the force required for all transfer methods. For direction of transfer, the amount of required force began at essentially the same point for each direction, but increased more rapidly for the gurney-to-bed transfers. For the patient roller, the minimal force required for movement in either direction was not as high as that required for the other two devices.

Significant differences were found between the directions of transfer for the draw sheet and patient shifter (see Figures 4 and 5). For the bed-to-gurney transfers, lighter participants seem to be transferred easier with the patient shifter. As participant weight increased, there was no difference in force required for transfer between devices. For the gurney-to-bed transfers, lighter participants required about the same force for both devices. As participant weight increased, the draw sheet required less force than the patient shifter.

In summary, the patient roller consistently required less force to transfer a participant than either the draw sheet or the patient shifter. The patient roller also showed a slower increase in force required to move participants in both directions.

Discussion

The patient roller was the most efficient transfer device. Additionally, the muscular or heavier participants reported that the use of the roller felt good, like a massage, whereas the thin or bony participants reported that the roller felt uncomfortable when their bony prominences moved over the rollers. Because of these findings, we recommend that the shifter or draw sheet be used to transfer thin or bony patients to reduce their discomfort or chance of possible fracture if they have a brittle bone dis-

Table 1
Summary of Analysis of Variance of Force for Patient Transfer by Patient Weight, Method, and Direction

Source	df	MS	F
Between subjects			
Weight	14	23377.60	603.05*
Error	60	38.77	
Within subjects			
Method	2	35677.12	754.35*
Method × weight	28	370.81	7.84*
Error	120	47.30	
Direction	1	7198.00	170.97*
Direction × weight	14	182.18	4.33*
Error	60	42.10	
Method × direction	2	2040.35	59.63*
Method × direction × weight	28	233.91	6.94*
Error	120	34.22	

Note. df = degrees of freedom, MS = mean square

* $p < .001$

ease or unusually thin or delicate skin conditions. Aside from these limitations, the patient roller seems to be the transfer device of choice to minimize the transfer forces.

In comparing the results of the pilot study with those of the current study, an important factor seems to be the transfer surfaces. The operating room table used in the pilot study was a hard, smooth surface that provided low friction, and, thus, the transfer devices required less force. On the other hand, the bed surface used in the current study was much softer, allowing the participants and transfer devices to sink into the mattress. Additionally, the bed surface had higher friction than the operating room table. The patient roller was exceptional in its ability to reduce forces in transferring from operating room table to gurney. The patient roller reduced the efforts required for the patient shifter by 44% when transferring the 140-lb participant from the operating room table to the gurney. In the current study, the patient roller was also the most efficient in transfers from bed to gurney.

Transfer forces can be estimated with the use of linear equations, with patient weight, direction of transfer, and transfer device as the independent variables. It is important to note that varying firmness of bed or gurney mattresses as well as varying amounts of bed and sheet

Table 2
Summary of Best Fitting Straight Lines for Force Means by Direction and Method of Transfer

Method	Intercept	Coefficient	$F(1,73)^a$
Bed to gurney			
Draw sheet	-5.10	.54	496.11
Patient shifter	-23.69	.62	295.04
Patient roller	-32.90	.56	229.26
Gurney to bed			
Draw sheet	-15.48	.63	459.22
Patient shifter	-26.41	.73	402.69
Patient roller	-15.37	.47	484.73

^aAll F s significant at $p < .001$

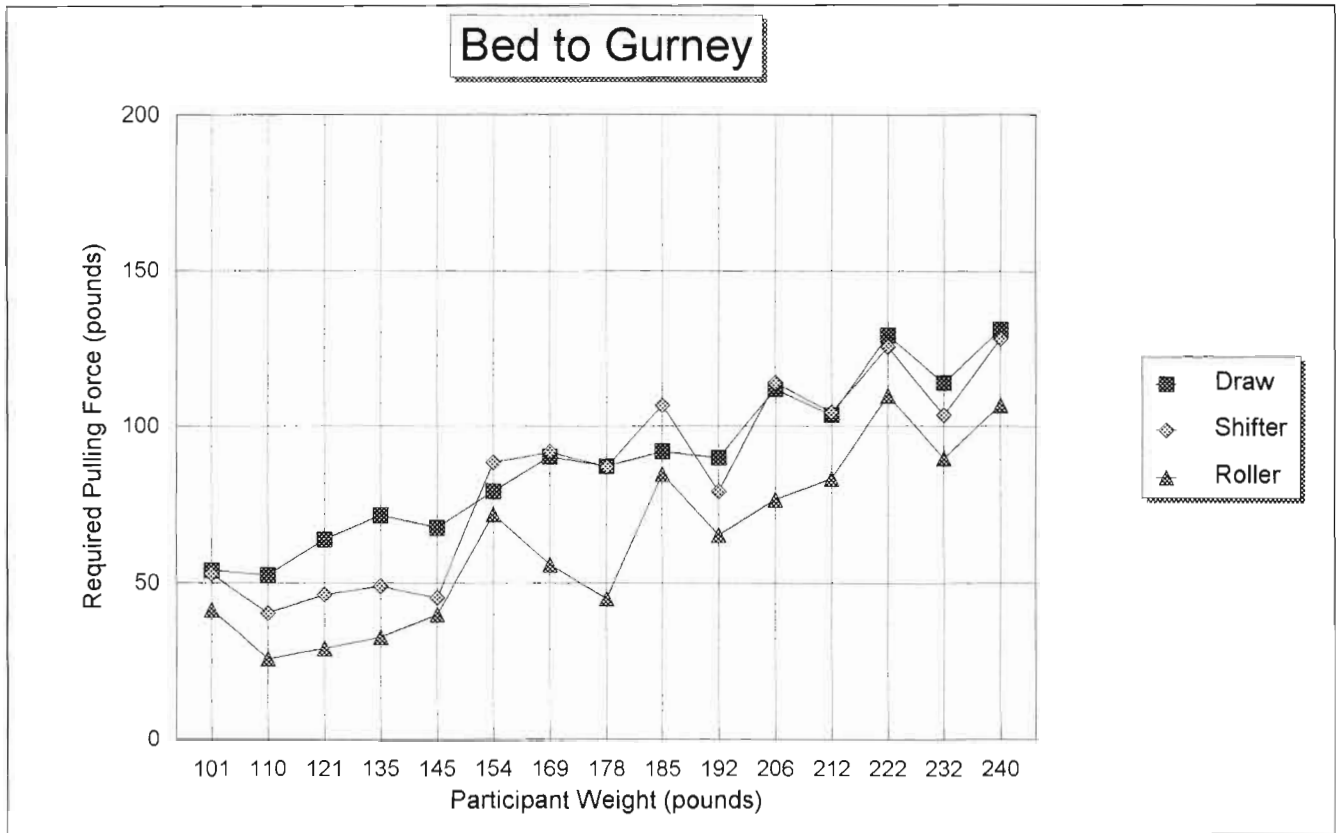


Figure 2. Mean force for bed-to-gurney transfer by participant weight and transfer device.

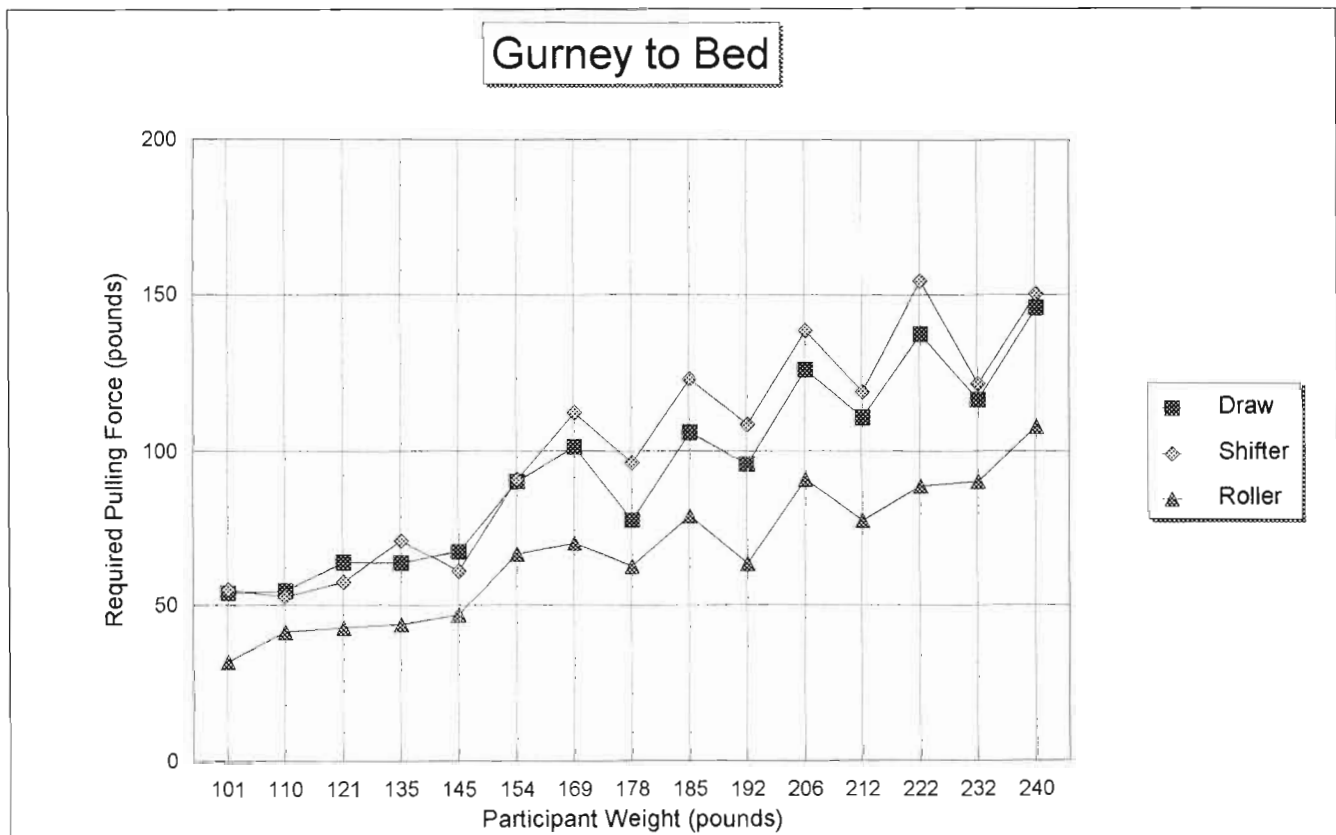


Figure 3. Mean force for gurney-to-bed transfer by participant weight and transfer device.

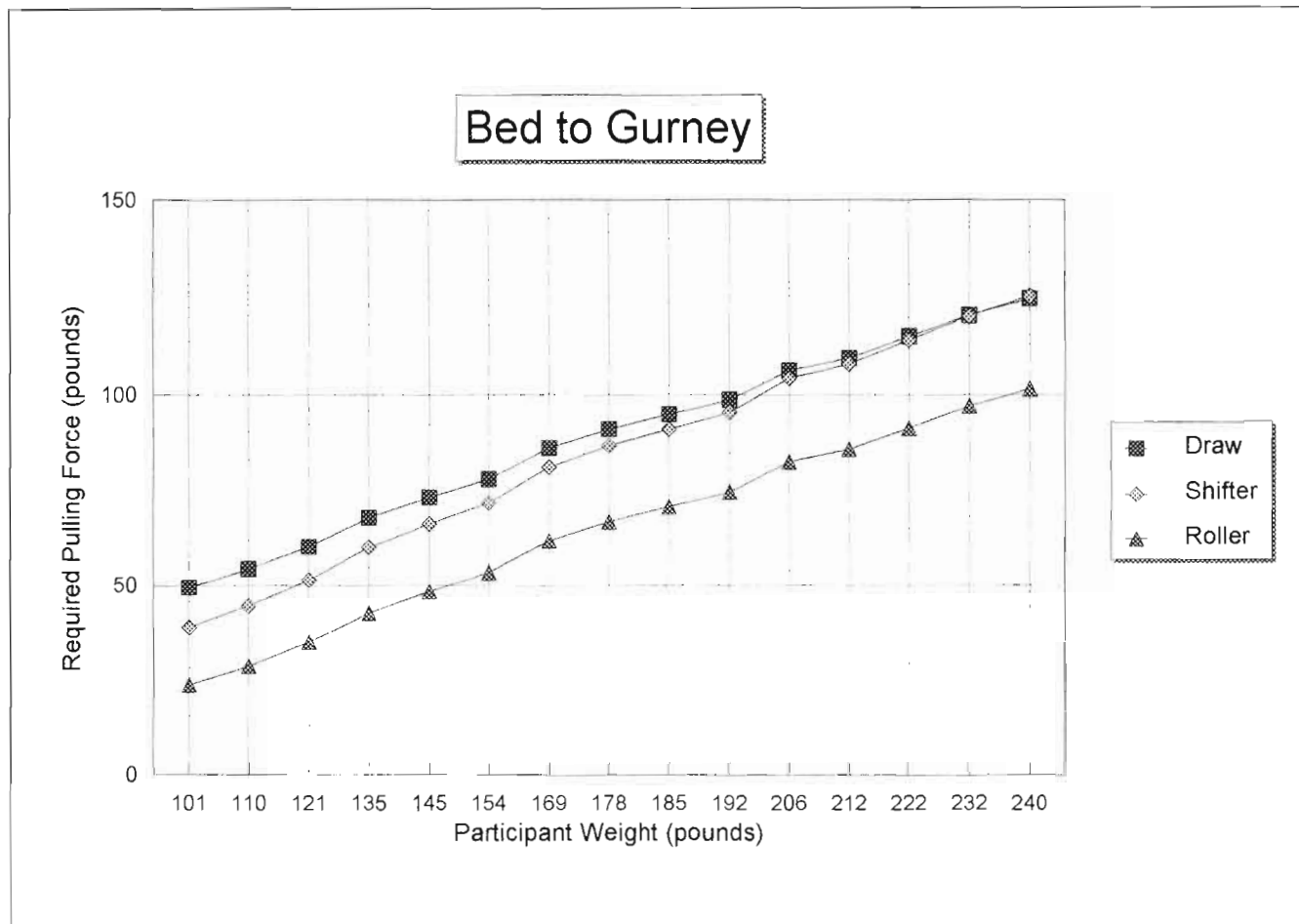


Figure 4. Linear regression lines for bed-to-gurney transfer by participant weight and transfer device.

moistness may also affect the accuracy of these approximation equations. Further cross-validation studies are needed to verify that the proposed theoretical equations are valid for the studied participant weights, transfer devices, and transfer direction for bed and gurney transfers. Further study is also needed to adjust these equations for other transfer surfaces and these and other transfer devices.

These estimated forces can assist occupational therapists in returning injured health care coworkers to patient transfer duties. The use of the minimum force necessary to maintain motion during transfers is the mainstay of safety, work simplification, and energy conservation. During practice pulls outside of this study, higher transfer forces made the transfer process faster but increased the likelihood of back strain. During all transfers, the greatest force was initially exerted when the participant's inert static equilibrium was changed into dynamic equilibrium. This equilibrium change included the force necessary to begin motion plus the force of overcoming static friction. After the motion began and the patient was moved at a constant speed, the force used to maintain movement

was less than the initial force; however, if the transfer speed is increased, as one would do when rushing a transfer, a greater force would be exerted.

During the transfers, the evaluators believed that the patient shifter seemed to require less effort than the draw sheet, but the data did not reflect this perception. The handles along the sides of the patient shifter permitted efficient hand (and force scale) placement, allowing for better hand-shifter coupling and enhancing the perception of a lesser pulling force.

It was assumed that transferring was easier if a slight downward slope was maintained in the direction of the transfer. The difference between surfaces optimized at about 1 1/2 in., allowing the participant to gently slide downward during the transfer. If the distance was greater than 2 in. between the bed and gurney planes, the participant and transfer device tended to sink deeply into the bed, which reduced the transferring momentum and increased the friction. If the two platforms were equal in height, the transfer devices tended to press into the bed or gurney mattress, which also increased the effort in the transfer.

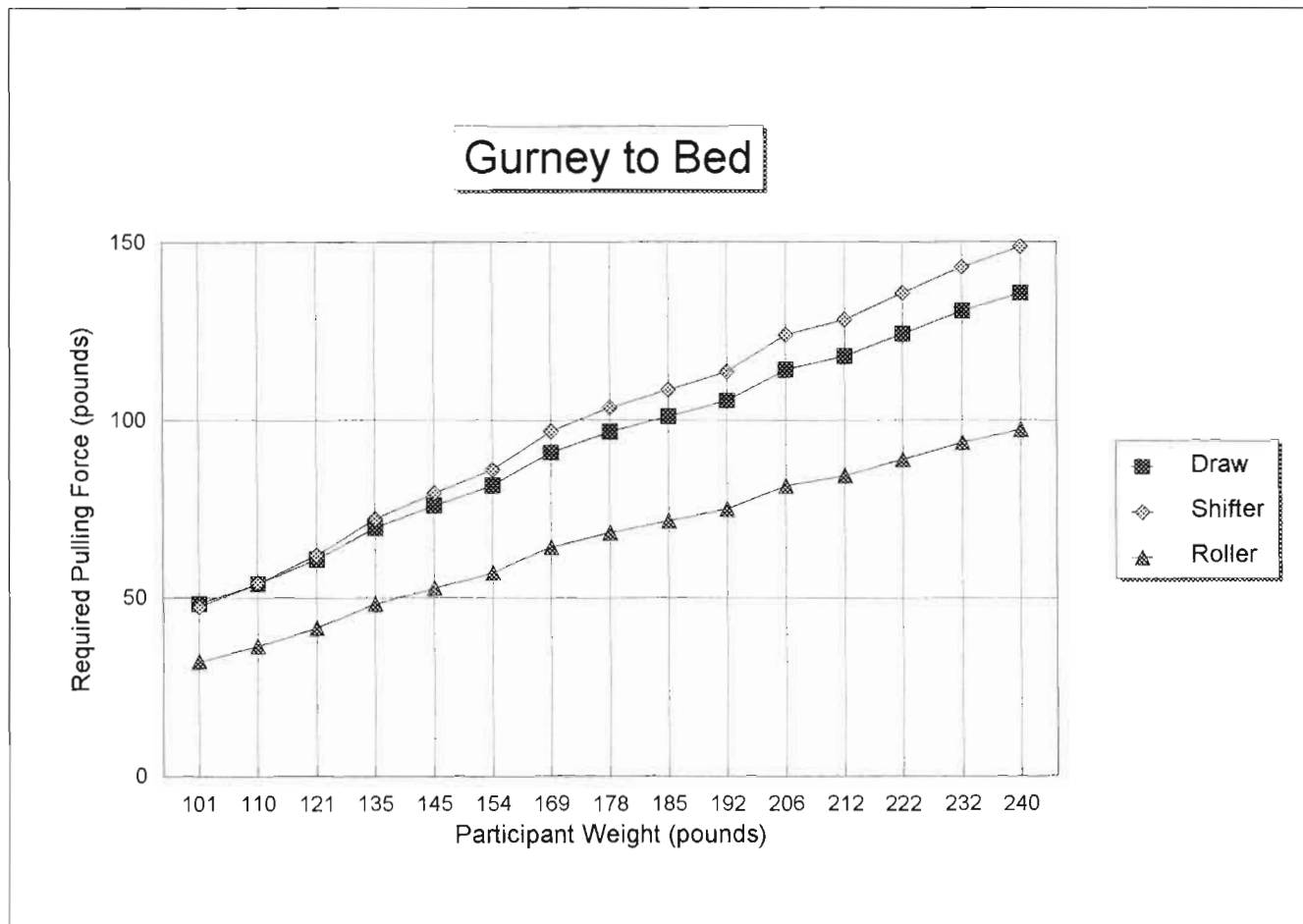


Figure 5. Linear regression lines for gurney-to-bed transfer by participant weight and transfer device.

Conclusion

This study examined the forces required to move patients during bed-to-gurney and gurney-to-bed transfers, which will help occupational therapists and other health care providers insist on obtaining assistance when performing patient transfers. The results can be used to assist health care personnel in returning to work after injury by addressing return-to-work restrictions and the need for suitable transfer devices. The practitioner can also use the results to assign patient transfer duties that match the transfer personnel's abilities.

The results clearly indicate that all health care workers assigned to patient transfer duties should obtain assistance, whether it be mechanical or from fellow workers, when transferring patients. (The evaluators in this study reported back muscle fatigue after some of the transferring sessions.) Occupational therapists should ensure that their coworkers follow this recommendation, complemented with use of correct body mechanics and corresponding strength and skill, to reduce lower back stress and related back disorders. ▲

Acknowledgment

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