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Electrical Power-Assisted Seat Lift: Is It Helpful? An Appraisal of Its Function

J. B. REDFORD, M.D.[1]
W. S. BROKY, M.D.[2]
S. ZILBER, Ph.D.[3]

This study was carried out to determine the desirability of power-assisted chairs for medical purposes. There seems to be wide public interest in such devices, especially among the geriatric population. Because these chairs are expensive, they could be a significant economic consideration in the provision of health care.

A survey of medical literature reveals that power-assisted chairs to aid individuals with various disabilities in rising from seated positions have been manufactured since 1939. Early models were experimental and designed for individuals with specific disabilities who had difficulty in rising from a standard chair. Young, in 1949, described an early model of a power-assisted chair that was activated by springs (1). Another model had been used by a patient with muscular dystrophy ten years prior to Young's 1949 report. At that time, there was no commercial manufacturer of power-assisted chairs. However, in recent years, there has been an increasing number of manufacturers of motor driven, power-assisted chairs. At least three companies have advertised in the United States medical and lay literature: Burke, Inc., American Stair-Glide, and Ortho-Kinetics, Inc. Whether the system is named power-assisted chair, elevating system, electrically-activated seat, and whether the specific lifting mechanism is a pneumatic bladder or a linkage system, the goal is the same: to assist the disabled individual to rise by use of mechanically elevating seats.

Automatic chairs are becoming increasingly popular among the public. Manufacturers and physicians claim that certain patients, such as those afflicted with arthritis, Parkinsonism, stroke, and other paralytic conditions, are benefited by the power-assisted chair seat. Our study was undertaken to verify, by experimental techniques, the claims of the manufacturer and reasons for acceptance by the public.

Description of Chairs

The chair, originally described by Young (1), resembled a dining room chair with a spring mechanism concealed in the arm rests. The seat tilted forward through a hinge located several inches in front of the chair at the seat level. In the lowered position, the seat gave an initial upward boost of about forty pounds, sufficient to allow the patient to arise with ease and the number of springs and tension were varied to suit requirements of the individual patient. The present day electric models of elevating chairs vary in their lifting mechanisms and degree of angulation of lift in the elevated position, and have the same assisting lift concept as the mechanical chair described by Young. Some chairs simply tilt the seat cushion forward as the hinge is located at the lower front edge of the seat (Burke). Others, by means of a linkage system, raise the seat vertically a few inches before significant tilting begins (Ortho-Kinetics and American Stair-Glide). The Burke chair seat is elevated by a pneumatic cushion. When activated, an electric motor compressor combination fills an air bladder which gently lifts the cushion upward and forward. Control is provided by a constant-pressure switch which, when released, stops the chair seat at any angle between horizontal and about 60 deg of angulation. A valve is used to control escape of the air from the bladder allowing the seat to return slowly to a lowered position.

Ortho-Kinetic and American Stair-Glide chairs have an electric motor and linkage system to elevate the seat. The linkage system can be adjusted to provide several degrees of angulation of the elevating seat to permit the user to select the most useful angle. A constant-pressure switch can stop the raising or lowering of the seat in any position and the angle of the seat back can be adjusted by a crank screw. These chairs rise slightly more rapidly than the Burke chair and do not have the slow cushion descent of the Burke seat. All three of the chairs are made of various materials and different colors. They can be adjusted to fit persons with long or short legs by changing height.

Methods

Four methods of evaluation were used.

1) *Electromyography.* Electromyography of selected thigh muscles was used to determine activity during rising and sitting. The electromyograph used was the TECA 4 with high speed paper recording. Muscles studies were made of the rectus femoris and vastus medialis, using surface electrodes. The rationale for this study was that reduction in muscle contraction during the lifting phase of the chair should reduce stresses on the knee joint.

2) *Angular Displacement of the Knee During Power-Assist.* A goniometer similar to the one described by McLeod and Kettlekamp (2) was used at the knee. It consisted of an elastic knee support with medial and lateral hinged metal staves. A potentiometer measured movements of the knee joint in the sagittal plane, which were recorded on electrocardiographic paper. The rationale for this was that angular displacement of the knee should be increased by the seat lift without muscle assistance.

3) *Percentage Body Weight Shift Using an Electronic Scale.* With a subject in the seated position, a recording of weight upon the feet is obtained as the subject is power-lifted and assumes the standing position. The weight upon the feet of a properly seated subject is approximately 12 percent of body weight. As the subject rises, the weight on the scale increases to 100 percent of body weight. The rationale for this study was that the greater the percentage of body weight shift by the chair, the less energy was needed by the patient to rise. The electronic scale to measure weight shift consisted of four force transducers and associated electronic circuitry to convert electrical energy into weight. Body weight shift upon the feet was calibrated in terms of percentage weight transfer of the subject during rising. Recordings were made on electrocardiographic paper.

4) *Survey of Patients Using the Chairs.* This was a questionnaire and telephone survey of patients who had owned the

chairs for at least two years, asking questions regarding effectiveness in helping the disorder, mechanical problems encountered, subjective opinion regarding appearance, controls, etc. Five hundred questionnaires were sent to randomly selected owners who bought the chair in 1975, and thirty telephone calls were made on a random basis to purchasers living near Kansas City.

Test subjects for the measurement methods were seven healthy adult male and female volunteers weighing between 140 and 175 pounds. Electromyographic recordings from the front of the thigh, knee action and weight shift were all recorded, having the test subject rise and lower himself in the chairs with and without the external power. Upper limbs were not used during the act of standing. Figure 1 illustrates the recording system with the subject rising from the chair.

Fig. 1. Subject and recording system.

Results

1) *Electromyography.* Electrical activity from anterior thigh during standing was recorded for all subjects. The voltages from the electromyographic recordings were consistently 50 percent greater when the subject was rising under his own power than when assisted by the chairs. However, duration of the electromyographic activity was several times longer when using motor-assist than when rising to stand unassisted. Significant electromyographic recording still occurred after the motor stopped, indicating quadriceps muscles were required during the final phase of standing from all chairs. Electromyographic results were similar in all chairs except for total duration of electromyographic activity. Duration ranged from ten seconds for the seats with linkages to thirty seconds for the pneumatic seat.

2) *Knee Goniometry.* In the sitting position, the knee angle was such that the standing required exactly 90 deg of motion to assume upright posture. The main result with power-assist was to help subjects extend through 15-40 deg of the 90 deg required. This assistance occurred during the initial phase of the act. The remaining motion as noted by the electromyographic recordings had to be achieved by the subject's own muscles. In regard to knee extension, the Ortho-Kinetic chair performed better than the other two models as shown in Figure 2.

3) *Body Weight Shift on an Electronic Scale.* Although the three chairs use different mechanisms to shift body weight to the feet, the overall ability to actually accomplish this was quite limited (Figure 3). The chairs were capable of shifting the subject in such a manner that 15-30 percent of his total weight was transferred to the feet when the motor completed its

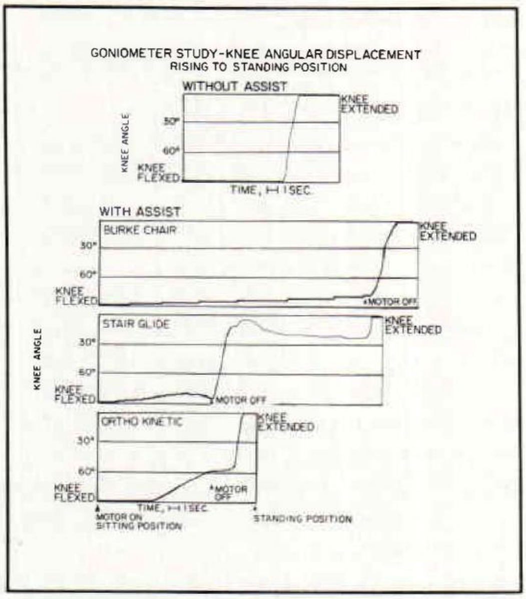

Fig. 2. Goniometer study

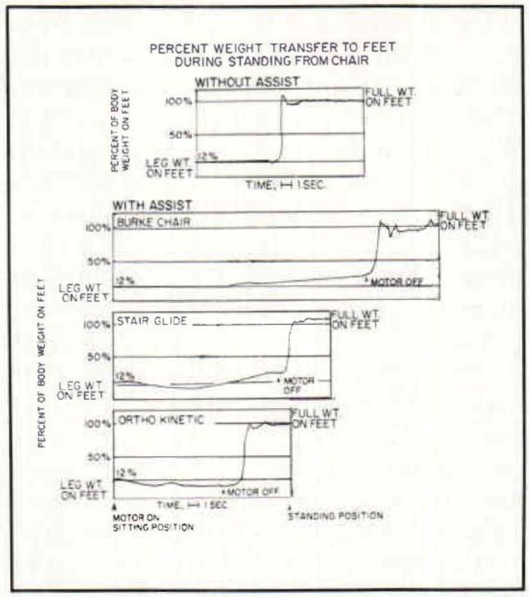

Fig. 3. Weight-shift study

cycle. Therefore, subjects had to perform the remaining of the 70-85 percent weight shift using their own muscles. Without assistance, the act of standing requires shifting somewhat less than 90 percent of body weight. It takes one second for a subject to rise to a standing position unassisted. Motor-assisted chairs shifted weight over a period of fifteen to thirty seconds, as observed in this study.

4) *Survey of Users.* Questionnaires and survey which was started late in the study had a very satisfactory response of 216 (43.2 percent) out of 500. It was conducted on patients who had purchased the Burke Chair in 1975. Those using the chair ranged from 21 to 99 years of age with a majority of 64.5 percent over the age of 60. Mean age was 72 years of age. The slightly higher ratio of females to males, 124:92, probably reflected the increased number of females in this age group. Most patients had used the chair for at least 24 months and some for up to 33 months. We found the commonest reason for purchase of the chair was arthritis, 131 out of 215, or 60.7 percent. This was closely followed by patients with Parkinsonism, stroke and fractures as shown in table 1. It is notable that four major disease categories, arthritis, Parkinsonism, stroke and fractures of the lower limb accounted for almost all of the users. Although 42, or 20 percent, reported multiple medical problems, presumably these four major disorders accounted for the primary reason for purchase in almost all cases. 166, or 76.8 percent of the respondents were still using the chair. The usefulness of the chair was reflected in how frequently the patients were using it, as also shown in Table 1. Those not using the chair were mostly patients who had died or had improved in their medical condition. Very few were not using it because of dissatisfaction and this was reflected in some very favorable comments. Actually, only four out of the entire survey said that the chair was undesirable.

A telephone survey produced a very similar result. 14 out of 30 randomly selected patients were reached by telephone and diagnoses were similar as shown in Table 1. Ten of these patients were using the chair frequently and were very favorably impressed.

Other comments from the survey were of interest. Mechanical or service problems were only mentioned by three patients on both surveys. Many commented favorably on the benefit to family as it assisted the aged relative in keeping him more mobile and less assistance was needed in his care by the family.

Discussion

This study was carried out to determine the value of these chairs as a medical piece of equipment rather than a specialized piece of furniture or special gadget. In determining the effects of the chairs, it was important to make a comparison between mechanical chairs and normal chairs when standing without assistance. Goniometry tracings (top of Figure 2) suggest a smooth, rapid, unlabored knee motion during normal standing. The efficient way of rising unassisted requires a center of gravity to move forward with feet placed slightly under the chair, one slightly ahead of the other. The individual then bends forward from the hips, placing the center of gravity over the feet and then rising by contracting extensor muscles. Sitting is the reverse of this, but in addition requires the hip and knee extensor muscles to exert undue stress on the knee joints. Smidt (3) points out that shear forces on the knees are probably maximal when the flexed knee is loaded as during rising or sitting down. Thus, it might be particularly important to unload the painful knee of the arthritic patient during the first phase of standing. This would be one purpose in using the power-assisted chair as it could encourage the arthritic to stand up more often.

There are other acts of motion, when standing and sitting, which can modify to some degree lower limb joint motion and muscle action and duration of transfer. These motions include head positioning, upper limb assistance, arm positioning, back extensor muscle contraction, and ankle motion. Any abnormal movements, as in spasticity or ataxia or lack of certain movements as in joint ankylosis will change the act of sitting and rising, hampering these maneuvers. A power-assisted chair might assist or substitute for these trunk and arm motions.

In normal sitting, these chairs provide assistance of less than 30 percent of the actual standing and only one-third of the decrease in the knee movement required for rising. Three quantitative studies concur with our personal observations on motions that normal subjects undertake to complete the action of standing. Electromyographic studies, when the power-assisted chair is used, indicated the maximum level of quadriceps contraction is lower than when standing unassisted. Since it is stress across the knee joints which produces pain in arthritis, this suggests that slow speed of sitting allowed by this chair may also be important in the arthritic. The results of the knee goniometry study shows that the knee motion is possibly helped more than percentage of weight shift. This would also suggest that patients with arthritis of the knee would benefit from these chairs.

The Body Weight Shift Transfer Study indicated that weight is not significantly shifted by the mechanical action. Therefore, patients with significant paralysis might not complete the final weight shift necessary to stand when using these chairs. That is, such patients still need muscle contraction to complete the motion. One might conclude that arthritic patients would gain more from using these chairs than paralyzed patients. Although our clinical experience with paralyzed patients and these chairs has been limited, we have a definite impression that patients with serious leg paralysis did not feel the chairs were particularly helpful.

The survey of users did not confirm or seem to respond with our attempt to quantitate the assistive functions of the chair. In general, those responding were very enthusiastic about the chair. As might be expected, the largest users of the chair are patients with arthritis. It seems, in some instances, the chaïr may serve as a stimulus to further exercise to the patient. Some patients with fractured hips, for example, stopped using the chair's assisting feature as strength returned in their thigh muscles following the fracture.

Although the survey could be criticized for its incompletion, in our opinion 216 replies out of 500 is an acceptable response from this type of mailed questionnaire. Further studies may be indicated to find out the appeal of these chairs such as the importance of initiating motion or psychological factors. Subjective reaction by the patients and staff in the Rehabilitation Medicine Department were that the Burke Chair seemed to take longer to elevate but had the desirable feature of lowering the patient slowly. The American Stair-Glide Chair was perhaps a little more versatile and quieter than the other two. Of the three chairs, the Ortho-Kinetic Chair was the best as far as the actual assistance with knee angle correction, but it was considered the least desirable as it was quite noisy and did not have as attractive an appearance as the other two chairs.

Conclusions and Summary

Measurements made in this study did not support the claims of the manufacturers that their chairs have a very significant effect in assisting certain categories of patients rising from the sitting position. Probably, the most significant help is in two categories of patients—those with arthritis and Parkinson's disease and, according to the survey, those with lower limb fractures and strokes also find them useful. The power-assisted chairs relieve stresses on the knee during early standing for the arthritic. They presumably initiate motion for the Parkinson's disease patient who has great difficulty adjusting the center of gravity over his base of support. We would stress that the chairs are most effective when they are individually fitted. Because persons vary in height and weight, suppliers should make proper measurements to insure optimal sitting on the seat for the users. As there are such differences between the observed mechanical effects and the acceptance by the users of these chairs, further studies of psychological effects or simply the initiation of motion provided by the lift in these chairs needs to be further investigated.

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Footnotes

[1]Professor and Chairman, Department of Rehabilitation Medicine, University of Kansas Medical Center.

[2]Resident, Rehabilitation Medicine, University of Kansas Medical Center.

[3]Assistant Professor, Biomedical Engineering, University of Kansas Medical Center.

TABLE I

Response to Mail Survey of Chair Users—216 of 500 Questionnaires.

Age Group	No.	Diagnosis	No.	Utilization	No.	Comments	No.
Age Unknown	10	Arthritis	131	Often or as needed	134	Very favorable	116
Under 39	3	Parkinsonism	30	Under 4-5 times daily	28	"Helpful" or	
40 - 49	6	Stroke	30	Only 1-2 times daily	13	"No comment"	96
50 - 59	27	Fracture	24	Never or rarely	24	Unfavorable	4
60 - 69	37	Cardiac Disease	16	Response not clear	17		
70 - 79	71	Muscular Dystrophy	8		216		
80 - 89	54	Multiple Sclerosis	6				
Over 90	8	Other	14				
			258				
	216	Multiple problems including those above	42				

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