Evaluation of the MOBIL Walking & Lifting Aid

Christian BÜHLER, Helmut HECK, Janus NEDZA, Rainer WALLBRUCH
Forschungsinstitut Technologie-Behindertenhilfe (FTB) der Evangelischen Stiftung
Volmarstein, Grundschötteler Str. 40, D-58300 Wetter/Ruhr, Germany

Abstract. Within the European MOBIL project, an integrated walking & lifting aid has been developed. In order to support walking and standing, the system operates similar to a rollator; to support standing up and sitting down from/to a seat or floor, the system incorporates an electro-mechanical lifting function as well as a mechanical splaying function of the frame in combination with ball castor wheels. Additional modular functionality, like force-enhancing powered driving and an automatic follow mode have been implemented in a test bed for experimental purposes. Two prototypes were systematically tested by rehabilitation experts and potential users. The results show that the MOBIL system meets a real need in rehabilitation, the combination of a walking, standing and lifting aid, and that the concept works. However, there are still mechanical modifications necessary to improve its ergonomic characteristics.

1. Introduction

There is a huge variety of walking aids available on the market [1]. They support the mobility of older and frail people and people with walking disability in different ways. Many of these persons also have problems in getting up from a chair or from the toilet and in smoothly sitting down. For these purposes there are special chairs/toilet equipment and hoist systems available. Their disadvantages are obvious: limitation to only a few special seats in the user's home, the requirement for storing a hoist in the home, the need for an assisting person.

Within the European MOBIL project, a concept for an integrated "walking & lifting aid" has been developed [2]. Two prototype systems have been built and were systematically tested by rehabilitation experts and potential users.

In order to upgrade the functionality of the manually pushed MOBIL walking & lifting aid in the future, an electrically powered "test bed" has been developed for experimental purposes. It enhances the user's pushing force or, alternatively, is able to follow a walking user when it is applied for transportation tasks.

2. Description of the MOBIL 'Walking & Lifting Aid' and the 'Test Bed'

The MOBIL 'walking & lifting aid' [3] is a combination of a mechanical rollator with handles and arm rests to support walking and standing (figure 1) and a battery-powered
lifting mechanism to raise or lower the user from or to a sitting position or even from/to a kneeling position on the floor (figure 2).

The prototype system, built for user-oriented evaluation purposes, consists of a strong frame to support frail users with complete confidence. During walking the user's body weight is partly supported by the handles, like in standard rollators. When the user wants to rest for a while in a standing position, or when he tends to fall forwards or backwards while walking then the arm rest brakes are automatically activated – simply by the body's weight on the forearms – without the need to change the hand position in order to grip a hand brake.

The powered lifting capacity is combined with a unique "splaying" action in the rear frame links. There are two modes of splaying: In the first mode the rear wheels just move straight backwards, while the front wheels are fixed by the arm rest brakes (figure 2). In the second mode the rear wheels additionally make a sideways splay. By this, the width of the rollator frame during movement in rooms and through doors is minimised while the frame width can be maximised when performing its lifting function. The splaying of the frame increases the stability of the system when the user's centre of gravity is further back in a sitting or kneeling position than it is during walking. The sideways splaying enables a user to draw the frame much closer to a chair or to the toilet than possible with a conventional rollator, when he wants to sit down or to get up. The passive steering geometry with "free" castor wheels in the front allows easy movement in any direction. Special "ball castors" at the rear support stable standing and safe walking, like fixed wheels do, whilst enabling the frame to splay sideways when lifting or lowering the user.

The user operates the combined lifting/splaying function with two switches at the handles; the action is performed by a single motor.

The prototype system has a weight of 33 kg, a width of 64 cm (in the high position and splaying mode 1) up to 118 cm (in splaying mode 2), and a depth of 60 cm (high position) up to 89 cm (splaying mode 1).
The MOBIL "test bed" for additional functionality comprises two different steering concepts, based on two electrically powered wheels:

In the "force-enhanced pushing" mode the body weight is supported by the arm rests, and the force-sensitive handles are used for steering the system's force/speed and direction of movement (figure 3). This force amplification enables frail persons to use the system for walking support – even on ramps – and for transportation of objects in the household.

In the "follow-me" mode the system automatically follows the user walking ahead in a certain distance. The system is capable of collision avoidance by applying a set of ultrasonic transducers (figure 4). Communication between the user and the system is via ultrasound/infrared transmitters. The user wears a "communication belt" with infrared transponders (for commanding the system) and ultrasonic transducers (for detecting the user's relative position by the system). This mode enables persons who cannot push or pull a transportation aid (e.g. arm amputees, or people who need to apply other walking aids) to carry things in a private or vocational environment.

3. Evaluation Settings

The evaluation of the MOBIL system was done in two phases:
- the verification of system functionality and
- the demonstration and tests with potential users.

There were two prototype systems of the 'walking & lifting aid' and two 'test bed' systems available for evaluation.
In the verification test, the MOBIL system was critically evaluated from a technical, but usage-oriented point of view. The overall goal was to describe the strong features, and to analyse and to explain the weaknesses of the system in such a detailed way that the results could be used to design the final MOBIL product version. However, the criteria applied for the 'lifting & walking aid', as a prototype close to the market, were much stricter than the criteria for the experimental evaluation of the 'test bed'.

The verification tests of the 'walking & lifting aid' with selected users as well as technical and rehabilitation experts were done in the test centre of FTB (laboratory and fully equipped test & demonstration dwelling) and in a foster home of the rehabilitation centre Evangelische Stiftung Volmarstein.

Objectives of the verification were the test of technical feasibility, implementation of functionalities [4], satisfaction of user requirements, user-friendliness, and impact on the user environment.

In order to achieve the objectives the following tests and checks were performed: expert testing under controlled conditions with ratings, comments of expert/professional test persons, interviews with experts and users, systematical check against user requirements. A set of usability criteria was used that usually is applied to new products on the German market for approval as technical aids in rehabilitation.

The verification protocol comprised different aspects, like ergonomics, adaptability, functionality, usability, versatility, stability, acceptance, maintainability, and safety.

For the functionality tests and observations a course for rollators with different surfaces, little obstacles, curves, and a ramp had to be run. Typical situations and problems of housing were realised. Situations in which furniture was involved were investigated.

The verification test of the 'test bed' was done in the laboratory of Scuola Superiore S.Anna at Pisa by rehabilitation engineers and several walking impaired persons.

These tests focused on the additional, more advanced functionality modules. The applied method was a check against requirements and functional specification.

The demonstration tests of the prototypes were conducted by Rehab Robotics in England and Euroflex in Sweden in private homes and some 18 institutions for elderly and disabled people.

Objectives were to demonstrate the system functionality of the 'walking & lifting aid' and of the 'test bed' and to receive feedback from a large sample of potential users and care staff with respect to satisfaction of users' demands, and benefit for the users and the society.

The protocol comprised demonstration of the systems, video presentations, practical trials by the potential users and carers, and interrogation of the test persons with structured questionnaires.

4. Evaluation Results

The tests of the 'walking & lifting aid' showed that the new concept of a combination of walking and lifting support got a strong positive response. It was perceived as a very useful combination of aids.

In general the test persons felt that the system was comfortable to use and had satisfactory stability and speed in walking and lifting.

Test persons compared the 'walking & lifting aid' with common rollators and expected a similar low weight and a similar (or even more) attractive appearance.

There were divided opinions about the brake system. For those users who used the handles for relatively few support of weight during walking, the arm-rest brakes were quite
usefull because they were activated only during standing or lifting/lowering. However, those persons who needed relative much support would have preferred to use the arm-rests to support their bodies' weight during walking – but they could not because of the built-in brakes. These users would definitely have needed another (conventional) brake system.

Improved safety would require a holding brake and an improved design, e.g. without edges especially in the feet area.

Further suggestions for improvements included: parking brakes reachable from all positions (standing and walking / sitting); arm rests not with brake function during walking to allow resting with whole body load; adjustable arm rests; height adjustment to different body sizes; options for handles and controls; lifting lever more robust, if possible only one lever for both functions, rising and lowering; lamps or display to show the state of the system (on/off) and of the battery and charging.

Suggestions for additional features comprised: tray, basket, warning e.g. of a step ahead, plastic covers, support under arms, a strap around the back as additional support of holding the body during lifting, cushion to lean against in front.

In the trials with the 'test bed' system most of the users were quite content with its functionality. They found the 'follow mode' and the wearing of the communication belt safe and comfortable or very comfortable.

Also the 'force-enhanced pushing mode' was perceived as comfortable. Two third of the users found it easy to move on a straight line, to turn left/right, or to turn on the spot. During the trials, the controls were accepted intuitively and the learning curve was steep. Reasons for the difficulties of some few users in controlling the system apparently lay in the inability to lower the arm rests to a sufficient height for the users.

However, in both modes, most users felt the speed of the system too slow.

Besides suggestions for improvement of ergonomic design and appearance there were also suggestions for improvement of the functionality: adjustable speed control; vibration alert to warn the user that the system has stopped or lost tracking in the 'follow mode'; a harness option would be important to some users being in the process of rehabilitation.

5. Conclusion

The main results of the evaluation were a detailed list of criteria for the MOBIL system, detailed discussions of ergonomic aspects of the sub-systems, and lists of suggestions for improvements.

The MOBIL 'walking & lifting aid' is in an advanced stage of a product prototype. The novel concept of combining rollator functionality with lifter functionality was verified. There were very positive and encouraging responses from potential users as well as from care staff. However, it needs major improvements with respect to ergonomics and a new concept for the brakes.

The additional high-tech functionality demonstrated in the 'test bed' was proofed to be feasible in principle: the direct control applying force sensitive grips and the follow mode.

The MOBIL system proofed to be a novel system with high potential addressing real needs of elderly and walking disabled people. However, more effort needs still to be spent to make it a product family with a 'walking & lifting aid' as a core system and optional high-tech features.
6. Acknowledgement

The work described was supported by the European Commission within the MOBIL project of the Telematics Applications Programme, Disabled and Elderly. It was undertaken by the following partners: FernUniversität Hagen (Germany), FTB (Germany), Domus Academy (Italy), Scuola Superiore S.Anna (Italy), Oxford Intelligent Machines (UK), Rehab Robotics (UK), Euroflex Systems (Sweden).

References

[1] REHADAT. German Database on Technical Aids for People with Disability.