LAZARIM: Standing-up frame to support mobility for older persons

A. Frizera MSc

R. Ceres PhD

L. Calderón PhD

J.L. Pons PhD

Grupo de Bioingeniería, Instituto de Automática Industrial (CSIC)
Carretera Campo Real, 28500 Madrid, Spain
E: {frizera, ceres, leopoldo, jlpons}@iai.csic.es

A. Frizera, R. Ceres, L. Calderón, J.L. Pons. LAZARIM: Standing-up frame to support mobility for older persons. Gerontechnology 2009; 8(1):38-41; doi: 10.4017/gt.2009.08.01.009.00. Extending the ability to stand up on a daily basis has beneficial effects, such as increasing mobility. This work presents a novel approach to the problem of autonomous standing up and mobility.

Keywords: standing-up, mobility, autonomy, elderly

The inability to stand up or maintain the upright position is one of the most important functional impairments. This situation arises from a variety of pathologies such as spinal cord injuries, musculo-skeletal or articulation problems and neurodegenerative diseases. It is also known that the capacity of moving, walking and maintaining the standing position gradually decreases with age.

In this context, the capability of standing-up is one of the objectives for the autonomy and rehabilitation of a person with any kind of locomotion disability. The benefits of standing are broadly described in the literature[1]. Some of these are (i) avoid loss of bone mass, (ii) improve blood circulation, (iii) improve digestive, respiratory, kidney and urinary functions, (iv) allow efficient use of upper limbs, (v) avoid formation of sores, and (vi) preserve autonomous mobility.

In addition, it is important to consider psychological benefits related to self-esteem and relationship issues[2], which are increased when the person can interact with others at eye level.

Standing assist devices

There are many technical aids that are designed to help the user to maintain an upright position, such as stand-up wheelchairs, lifting or transfer aids, inclined planes, and standing frames[3-7].

Stand-up wheelchairs are designed primarily to allow locomotion and have an extra functionality, permitting the user to be placed in a standing position. However, these devices present many limitations, such as high cost, heavy weight, and poor maneuverability, making them inappropriate for small interior spaces with narrow doorways. Lifting aids have the purpose to ease the transfer of a person (e.g., from bed to chair), demanding the intervention of a caretaker. Inclined planes are hard to be used since considerable strength is required by the caretaker in order to put the subject in different positions.

Finally, standing frames have the goal to maintain the user in an upright position allowing him or her to perform tasks with the upper limbs. Unfortunately, only a few of these devices offer the possibility to place

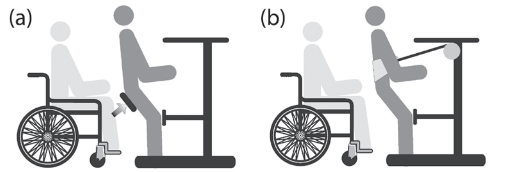

Figure 1. Two standing-up systems; (a) Pushing up the gluteus with an articulated seat[8]; (b) Harness placed on the lumbar area of the user[9]

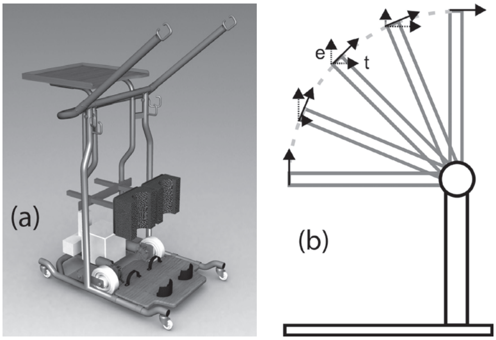

Figure 2. The LAZARIM system (a) Overview; (b) The standing-up principle; e = elevation; t = transverse movement

the user in standing position with an electric and autonomous system.

There are several commercial systems that perform the elevation process through electrical motors, which make them theoretically autonomous (*Figure 1*). One of these uses a mechanism that pushes up the gluteus with an articulated seat[8]. Other electrical standers include a system that consists of two rolling tapes attached to a harness placed on the lumbar area of the user[9]. The first system presents problems related to the initial transfer to the elevation platform, and the second one creates excessive support pressure on the user's knees and femur, causing possible damage, pain or discomfort.

A new elevation and transfer system

The new device (*Figure 2a*) developed under the project LAZARIM solves the above problems, offering simultaneously the benefits of a standing aid and the possibility of autonomous mobility, thus reducing the need of a caregiver, provided the user has some upper limb manipulation capability.

The patented system[10] basically is a horizontal low frame in which the user places their feet, an operation that demands modest manipulation capability. Also, the user wears a dorsal harness in order to perform the elevation process. Two electrically actuated elevating arms or bars, placed on a superior plane, elevate the user by means of the harness. The new elevation *(e)* and transverse *(t)* transfer patterns are harmonic functions following the movement of the bars (*Figure 2b*). During the standing process, it is noticed that initially the elevation motion component is dominant and decreases progressively as the transverse motion component increases.

The elevation and transverse parameters governing the standing process are presented in equations [1] and [2].

$$e = b * \sin \alpha \qquad [1]$$
$$t = b * (1-\cos \alpha) \qquad [2]$$

Where :
b = elevating bars length, e = elevation motion, t = transverse motion, α = the angle between the bars and the horizontal.

The elevation procedure is safe and easy to perform and is optimal for the standing process. This is because, in the initial transfer phase, the elevation process avoids the user being dragged forward, while the progressively increasing transverse process avoids excessive pressure of the user's knees against the knee pads. The elevation function is greater than the transverse one during the first half of the process (*Figure 3*). During the second half of the process, it is ensured that the user has no physical contact with the (wheel-) chair and the transverse function gradually increases, drawing the user in proximity to the device quickly. In this way, the user is first raised and then brought near the device, avoiding any risk of horizontal dragging of the (wheel-) chair and the possibility of a consequent fall.

Once the user is in a standing position, a lumbar harness serves to maintain upper-

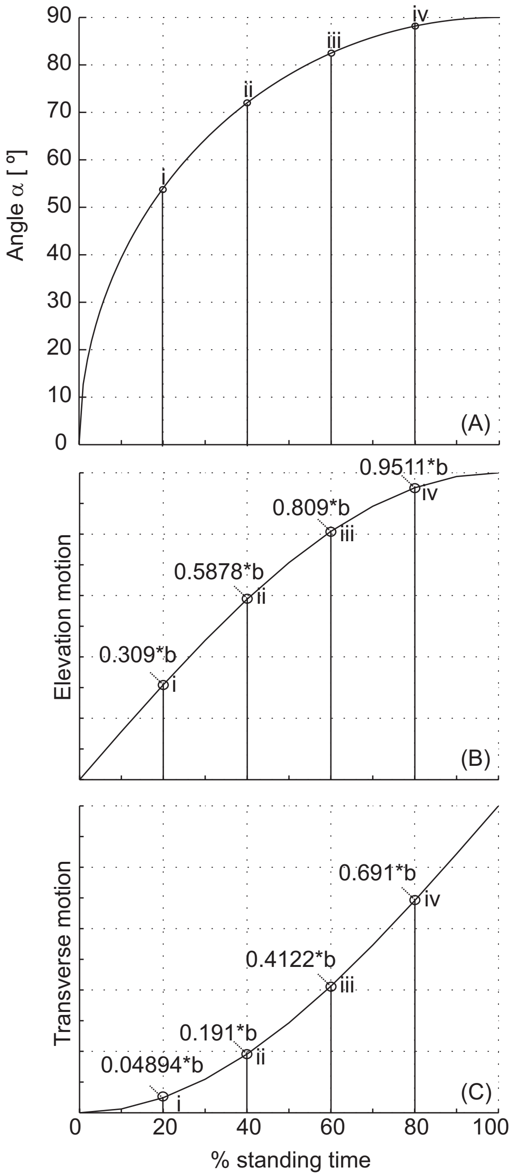

Figure 3. Movements during standing-up with the LAZARIM system; (A) angular process of elevating bars; (B) Elevation motion at times i to iv of part A with sinus alfa (angle between bars and the horizontal) stated, and b = elevating bars length; (C) Transverse motion at times i to iv of part A with 1-cosinus alfa (angle between bars and the horizontal) stated, and b = elevating bars length

body stability and the elevation harness can then be released.

The system is equipped with two additional dc motors (24V, 40 rpm) that are mechanically coupled to a pair of wheels (80 mm of radius) placed at the centre of the base platform, allowing locomotion and reducing the turning radius (~65 cm). To increase the stability of the device, four smaller wheels are placed on the extremities of the base of the device. Such wheels have a radius of 37.5 mm and a passive suspension system, granting smooth locomotion and ensuring that the traction wheels always touch the ground in any kind of indoor environment.

These motors are controlled electronically by the user with an analogue joystick. The maximum speed achieved by the device is 0.36 m/s, ensuring safe locomotion indoors. The system was designed to allow free motion in a normal house, granting the possibility of passing freely through doorways (565 mm of width), turning in regular corridors, and even allowing operation for toilet. Other dimensions of the device are a length of 715 mm and a height of 1200/1550 mm with the elevating bars down/up. The device itself weights about 50 kg and it is designed to support safely a mechanical load (in elevation and locomotion modes) of 120 kg. The total elevation/descent time is a little over 50s.

The developed system was validated experimentally with the involvement of medical and rehabilitation staff from CRMF-AB IMSERSO and the Fundación de Lesionados Medulares de Vallecas (FLMV-Madrid). Three subjects (two men/and one woman, aged respectively 33, 49 and 45) with spinal cord injury at D5, D7 and D12 participated during the iterative design of the prototype, helping to adjust several parameters of the mechanical and electronic systems. After a final prototype was prepared, the device was taken to FLMV, where ten subjects participated in the validation experiments. The medical/rehabilitation staff elaborated (under ethical aspects) the experimental protocol including: (i) Personal data; (ii) Subjective appreciation of the device before using it; (iii) Validation experiments, in which the subjects evaluated the learning stage, the standing and mobility processes, the ability

Table 1. Assessment by users and medical staff regarding the LAZARIM stander as compared to other standing-up other devices

Advantages	Disadvantages
No pressure on knees	Pressure on underarms
Upper body stability	Need for two harnesses
Toilet option	
No caregiver needed	
Suitable for home use	
Low weight	
Small size	
Possibility of locomotion	
Good manoeuvrability	

to control the device, etc.; (iv) An after-use appreciation of the device by the medical staff and users; (v) A subjective comparison with other standing devices used by each subject in previous personal experiences (*Table 1*); and (vi) Safety aspects during the experiments, such as stability in elevation and locomotion modes (postural and falling risk).

During the experiments with the users no problems with system stability on elevation and mobility arose. The reduced turning radius improved manoeuvrability in regular interior spaces and halls[11] compared to other commercial systems tested by the subjects. Only three of the ten users needed the help of a caregiver during the entire process of standing, while six only needed help putting on the harnesses and one was able to realize the entire standing process without the help of the rehabilitation staff. This was a great improvement in the users' independence, since they were unable to perform the same operations with other passive commercial standers. At present, the system is being commercialized by ORTOTECSA S.A.-Spain that collaborated on the development of LAZARIM.

Acknowledgements
The authors thank FLMV-Madrid, CRMF-AB and IMSERSO-MTAS for financial support.

References

1. Eng JJ, Levins SM, Townson AF, Mah-Jones D, Bremner J, Huston G. Use of Prolonged Standing for Individuals With Spinal Cord Injuries. Physical Therapy 2001;81(8):1392-1399
2. Abizanda P, Saro B, Sánchez P M, Ceres R, Sánchez F, Bonivardo G. Validación clínica del Andador Pseudorobótico de Alta Seguridad (ASAS) Proceedings of the III Congreso Iberoamericano sobre Tecnologías de Apoyo para la Discapacidad – IBERDISCAP, 2004
3. Barattia EC. Standing frame with lift, support and transport of user. Patent Application Publication US2005/0217025 A1
3. Tholkes AL. Modular Standing Frame. Patent US 05292130.1
5. Meaney JJ. Apparatus for Assisting a Person Between a Substantially Standing Posture and a Seated Posture. Patent WO2006025040
6. Ablett RH, Green EM, Mulcahy CM, Nelham RL, Pountney TE, Tutt PE. Standing Frame. Patent GB2252045
7. Meaney JJ. Apparatus for Assisting a Person Between a Substantially Standing Posture and a Seated Posture. Patent WO2006025040
8. Struzzo; www.telethon.it/sites/tecnothon/prodotti/struzzo/default.aspx; retrieved February 5, 2009
9. StrapStand; www.easystand.com/strapstand/index.cfm; retrieved February 5, 2009
10. Ceres R, Pons JL, Calderón L, Pastor J, Frizera A. Dispositivo para Bipedestación y Rehabilitación de Marcha para Personas con Minusvalías Motoras. Patent 200603073
11. Ceres R, Pons JL, Frizera A, Pastor, Calderón L, Gonzalez I, Saro B, Rodríguez J. New Standing Up Patterns and Autonomous Mobility for SCI Patients. In Eizmendi G, Azkoitia JM, Craddock GM, editors. Challenges for Assistive Technology AAATE 07. Amsterdam: IOS; 2007; pp 434-438