Enhancing Service delivering, improving Quality of Life, Preserving Independence through Assistive Technology

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IRCCS Fondazione S. Lucia - Rome

Pisa, August 27, 2012
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- Disability
- Assistive Technology
- A clinical problem: osteoporosis
- i-Walker prototype
- Experiments
- Conclusions
Annual Increase in World Population


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Population Pyramids (in thousands), EU27/EA, in 2008 and 2060

Source: European Commission, 2009
Trends in Aging, by World Region

Population Ages 65 and Older - Percent

- World: 7% in 2000, 11% in 2025
- Africa: 3% in 2000, 4% in 2025
- Asia: 6% in 2000, 10% in 2025
- Latin America/Caribbean: 6% in 2000, 10% in 2025
- More Developed Regions: 14% in 2000, 21% in 2025


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Figure 8: Percent with Disabilities, by Age

- % with any disability
  - 65-69: 44.9
  - 70-74: 46.6
  - 75-79: 57.7
  - 80+: 73.6

- % with severe disability
  - 65-69: 30.7
  - 70-74: 28.3
  - 75-79: 38
  - 80+: 57.6

- % need assistance
  - 65-69: 8.1
  - 70-74: 10.5
  - 75-79: 16.9
  - 80+: 34.9
Assistive Technology

“any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities

(www.temple.edu/instituteondisabilities/programs/assistive/atlend/)
AT and disability

- 13.1 million people use AT device for
  - Mobility
  - Communication
  - Assistance in ADL

(Ambrosio et al., 2007)
Type of AT

“National Classification System for Assistive Technology Devices and Services” by The National Institute on Disability and Rehabilitation Research, USA

1. Architectural Elements
2. Sensory Elements
3. Computers
4. Controls
5. Independent Living
6. Mobility
7. Orthotics/Prosthetics
8. Recreation/Leisure/Sports
9. Modified Furniture/Furnishings
10. Services
Integration of AT

1. Smart home technology
2. Remote monitoring
3. Robotics for disabled/elderly people
A clinical problem: Osteoporosis

A systemic skeletal disease characterized by low bone mass and micro architectural deterioration of bone tissue lead to bone fragility and susceptibility to fracture.
Prevalence of osteoporosis

<table>
<thead>
<tr>
<th></th>
<th>Osteopenia</th>
<th>Osteoporosis</th>
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</thead>
<tbody>
<tr>
<td>Female</td>
<td>37-50%</td>
<td>13-18%</td>
</tr>
<tr>
<td>Age &gt; 50 year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>28-47%</td>
<td>3-6%</td>
</tr>
<tr>
<td>Age &gt; 50 year</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NHANES III. J Bone Miner Res.1997
Melton L. J, J Bone Miner Res.1992

- Over 50% of women and 30-45% of men over age 50 have osteopenia/osteoporosis
- White woman over age 50: 50% lifetime risk of osteoporotic fracture, 25% risk vertebral fracture, 15% risk of hip fracture
- Man over age 60 has 25% risk osteoporotic fracture
- 70% over age 80 have osteoporosis
Incidence of osteoporotic Fx

Figure 1. Estimated incidence of osteoporotic fractures in the United States.

Riggs BL. Bone 1995;17(s5)
Incidence of osteoporotic Fx

- Vertebral Fracture
- Forearm Fracture
- Hip Fracture
Diagnosing Osteoporosis

• Outcome of interest: Fracture Risk!

• Outcome measured (surrogate): BMD bone mineral density
  – Key: Older women at higher risk of fracture than younger women with SAME BMD!
  – Other factors: risk of falling, bone fragility not all related to BMD
  – Osteoporosis: disease of bone that increases risk of fracture; more than BMD goes into causing a fracture;

  – BMD is important, but in reducing fractures must also consider falls risk, age and other factors!!!
Fracture Reduction

• Goal: prevent fracture, not just treat BMD bone mineral density

• Osteoporosis treatment options
  – Calcium and vitamin D
  – Calcitonin
  – Bisphosphonates
  – Estrogen replacement
  – Selective Estrogen Receptor Modulators
  – Parathyroid Hormone

1. Decrease osteoporosis/improve BMD
2. Decrease risk of break: hip protectors
3. Decrease risk of fall
Fracture probability (%)

Kanis et al, Osteop. Int., 2001

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Osteoporosis: burden, health care provision and opportunities in the EU

A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA)

O. Ström · F. Borgström · John A. Kanis · Juliet Compston · Cyrus Cooper · Eugene V. McCloskey · Bengt Jönsson

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Table 3.2 Summary of new fractures in 2010 in women and men aged 50 years or more

<table>
<thead>
<tr>
<th>Country</th>
<th>Hip</th>
<th>Vertebral a</th>
<th>Forearm</th>
<th>&quot;Other&quot;</th>
<th>All sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>14,785</td>
<td>10,529</td>
<td>13,580</td>
<td>31,871</td>
<td>70,765</td>
</tr>
<tr>
<td>Spain</td>
<td>29,866</td>
<td>18,936</td>
<td>24,928</td>
<td>64,803</td>
<td>138,533</td>
</tr>
<tr>
<td>France</td>
<td>55,658</td>
<td>36,691</td>
<td>47,647</td>
<td>118,903</td>
<td>258,899</td>
</tr>
<tr>
<td>Italy</td>
<td>70,323</td>
<td>50,602</td>
<td>65,943</td>
<td>152,721</td>
<td>339,590</td>
</tr>
<tr>
<td>UK</td>
<td>56,735</td>
<td>40,369</td>
<td>54,309</td>
<td>191,781</td>
<td>343,194</td>
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<tr>
<td>Germany</td>
<td>98,824</td>
<td>76,460</td>
<td>100,148</td>
<td>219,452</td>
<td>494,884</td>
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<tr>
<td>EU5</td>
<td>311,406</td>
<td>223,058</td>
<td>292,795</td>
<td>747,660</td>
<td>1,575,100</td>
</tr>
<tr>
<td>EU5+</td>
<td>326,191</td>
<td>233,587</td>
<td>306,555</td>
<td>779,531</td>
<td>1,645,865</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>5,507</td>
<td>5,910</td>
<td>2,809</td>
<td>21,985</td>
<td>36,211</td>
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<tr>
<td>Spain</td>
<td>10,370</td>
<td>10,425</td>
<td>4,523</td>
<td>38,928</td>
<td>64,246</td>
</tr>
<tr>
<td>France</td>
<td>18,700</td>
<td>19,511</td>
<td>8,980</td>
<td>73,402</td>
<td>120,593</td>
</tr>
<tr>
<td>Italy</td>
<td>26,254</td>
<td>26,964</td>
<td>11,435</td>
<td>98,090</td>
<td>162,744</td>
</tr>
<tr>
<td>UK</td>
<td>22,757</td>
<td>25,414</td>
<td>12,401</td>
<td>130,817</td>
<td>191,388</td>
</tr>
<tr>
<td>Germany</td>
<td>33,890</td>
<td>38,934</td>
<td>19,566</td>
<td>146,934</td>
<td>239,324</td>
</tr>
<tr>
<td>EU5</td>
<td>111,971</td>
<td>121,248</td>
<td>56,905</td>
<td>488,171</td>
<td>778,295</td>
</tr>
<tr>
<td>EU5+</td>
<td>117,478</td>
<td>127,158</td>
<td>59,714</td>
<td>510,156</td>
<td>814,506</td>
</tr>
</tbody>
</table>

**Men and women**

| EU5     | 423,377 | 344,306 | 349,880 | 1,235,831 | 2,353,395 |
| EU5+    | 443,669 | 360,745 | 366,269 | 1,289,687 | 2,460,371 |

a clinical vertebral fracture
Osteoporosis: burden, health care provision and opportunities in the EU

A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA)

O. Ström · F. Borgström · John A. Kanis · Juliet Compston · Cyrus Cooper · Eugene V. McCloskey · Bengt Jönsson

Table 47 First year direct costs of a hip, vertebral, forearm and other fracture (€, 2010). Age-differentiated costs are presented in ranges.

<table>
<thead>
<tr>
<th></th>
<th>Hip</th>
<th>Clinical vertebral</th>
<th>Forearm</th>
<th>Other</th>
</tr>
</thead>
</table>

a Estimated as a fraction of hip fracture cost based on the morbidity equivalents in Kanis et al. [4].
b Imputed from the UK data by adjusting for differences in health care price levels.
c Imputed from Swedish estimate [4, 6].

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Eugene V. McCloskey · Bengt Jönsson

Table 48 Yearly cost at long-term care facility (€, 2010)

<table>
<thead>
<tr>
<th>Country</th>
<th>Long-term care cost</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>31,512</td>
<td>[8] a</td>
</tr>
<tr>
<td>Germany</td>
<td>34,534</td>
<td>[14] b</td>
</tr>
<tr>
<td>Italy</td>
<td>50,202</td>
<td>[10]</td>
</tr>
<tr>
<td>Spain</td>
<td>51,786</td>
<td>[15]</td>
</tr>
<tr>
<td>Sweden</td>
<td>57,247</td>
<td>[6]</td>
</tr>
<tr>
<td>UK</td>
<td>33,756</td>
<td>[8]</td>
</tr>
</tbody>
</table>

a Imputed from the UK long-term care cost adjusting for differences in the health care price levels
b An average of 4 long-term care facilities

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<table>
<thead>
<tr>
<th>Country</th>
<th>Population (000)</th>
<th>Health care spending (000 €)</th>
<th>% of health care spending on fractures</th>
<th>Burden per capita (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>9,294</td>
<td>31,000</td>
<td>4.6%</td>
<td>153</td>
</tr>
<tr>
<td>Spain</td>
<td>45,000</td>
<td>95,000</td>
<td>3.0%</td>
<td>64</td>
</tr>
<tr>
<td>France</td>
<td>62,634</td>
<td>214,000</td>
<td>2.2%</td>
<td>76</td>
</tr>
<tr>
<td>UK</td>
<td>61,899</td>
<td>142,000</td>
<td>3.9%</td>
<td>89</td>
</tr>
<tr>
<td>Italy</td>
<td>60,098</td>
<td>138,000</td>
<td>5.1%</td>
<td>117</td>
</tr>
<tr>
<td>Germany</td>
<td>82,056</td>
<td>252,000</td>
<td>4.6%</td>
<td>111</td>
</tr>
<tr>
<td>EU5</td>
<td>311,687</td>
<td>841,000</td>
<td>3.7%</td>
<td>94</td>
</tr>
<tr>
<td>EU5+</td>
<td>320,981</td>
<td>871,000</td>
<td>3.5%</td>
<td>96</td>
</tr>
</tbody>
</table>

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Fig. 34 Cost of disease in EU5
Traditional walker

• The most common types of walkers include: the two-wheel and four-wheel walkers

• Walkers provide stability
difficulty balancing
risk of falling
Among the persons in our target population not every person can have full control over a traditional walker.

A traditional walker cannot supply:
- difference in strength between the arms and legs (stroke)
- difficulty in walking uphill or downhill
- Cognitive impairment
Measurement of the forces

i-Walker
i-Walker

Measurement of the forces

Force sensors

F1x

F2x
i-Walker

Measurement of the forces

Force sensors

F1y

F2y
i-Walker

Measurement of the forces

Force sensors

F1z

F2z

F3z

F4z

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Measurement of the forces

Active motor assistance to compensate lack of muscle force in climbs

Active motor assistance to compensate lack of muscle force on descents
Computer-controlled brake actions

The walker can guide the user when his/her orders are wrong
i-Walker: Mechanical Features

• Basic features
  
  – 4 conventional wheels
    • 2 castor-wheels and 2 driven by independent motors
  
  – 2 handles
    • Force sensors allow knowing how the user is exerting forces to the walker
  
  – 2 force sensors located on rear wheels measuring the normal force
i-Walker: services

- Walking assistant
- Evaluation of residual strength
- Compensation between different strengths
- Personalized level of assistance and help
- Security system
- Communication with care-giver
i-Walker: objective of the study

THE USE OF i-WALKER DURING REHABILITATION PROTOCOL:

- to improve mobility
- to reduce risk of falling
- to improve self-sufficiency
## The Study

### INCLUSION CRITERIA:
- hemiparesis post-stroke
- age $\geq 18$
- MMSE $\geq 20$
- Canadian Neurological Scale AI e AS $> 0$

### EXCLUSION CRITERIA:
- hemiplegia
- severe cognitive impairment
- global aphasia
- severe neglect

### SAMPLE:
- 20 subjects, 9 men (45%) e 11 women (55%)
- mean age 59.9 years
- 15 right hemiparesis
- 5 left hemiparesis
Protocol

EXPERIMENTAL GROUP
- treatment with i-Walker 5 times per week
- 20 minutes
- 4 weeks
- plus one day treatment with traditional protocol

CONTROL GROUP
- two traditional treatments with parallel bars
- 5 times per week
- 4 weeks
Assessment phases

- T0 initial stage
- T1 intermediate stage
- T2 final stage
- T3 stage discharge
Assessment areas

- GAIT and BALANCE
  - Tinetti scale
  - Six Minute Walk Test
  - Ten Meter Walk Test
- MUSCLE TONE
  - modified Ashworth scale
- CONSCIOUSNESS and MOTOR FUNCTIONS
  - Canadian scale
- COGNITION
  - Mini Mental State Examination
- SELF SUFFICIENCY
  - Barthel Index
**RESULTS**

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>EXRIMENTAL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Media</td>
</tr>
<tr>
<td>Tinetti</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td>6MWT</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td>10 MWT</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>CONTROL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Media</td>
</tr>
<tr>
<td>Tinetti</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td>6MWT</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td>10 MWT</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
</tbody>
</table>

TINETTI, 6MWT, 10 MWT significant T1-T2
## RESULTS

### THE ANOVA: T1-T2 EXPERIMENTAL GROUP VS CONTROL GROUP

<table>
<thead>
<tr>
<th></th>
<th>Delta*</th>
<th>Deviazione standard</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tinetti</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gruppo 1</td>
<td>8,4</td>
<td>3,3</td>
<td>0,032</td>
</tr>
<tr>
<td>Gruppo 2</td>
<td>5,3</td>
<td>2,6</td>
<td></td>
</tr>
<tr>
<td><strong>6 MWT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gruppo 1</td>
<td>63,5</td>
<td>39,1</td>
<td>ns</td>
</tr>
<tr>
<td>Gruppo 2</td>
<td>70,2</td>
<td>74,1</td>
<td></td>
</tr>
<tr>
<td><strong>10 MWT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gruppo 1</td>
<td>44,7</td>
<td>31,1</td>
<td>0,011</td>
</tr>
<tr>
<td>Gruppo 2</td>
<td>15,5</td>
<td>9,6</td>
<td></td>
</tr>
<tr>
<td><strong>Barthel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gruppo 1</td>
<td>29,6</td>
<td>8,3</td>
<td>0,029</td>
</tr>
<tr>
<td>Gruppo 2</td>
<td>19,9</td>
<td>9,8</td>
<td></td>
</tr>
</tbody>
</table>

**EXPERIMENTAL GROUP SIGNIFICANT INCREASING > CONTROL GROUP: TINETTI, 10MWT e BARTHEL / NO DIFFERENZE 6MWT**

* Delta = modifica dei parametri da T1 a T2

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Conclusions

- Data obtained show positive results in the use of i-Walker to reduce the risk of falling and to improve self-sufficiency
- The AT can help people preserving autonomy
- The AT can help people to reduce falls and fractures
- These results are in line with the European Commission FP7 - CIP - Objective 3.1 ICT solutions for fall prevention and detection

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FATE

Proposal No. 297178

Fall Detector for the Elder
Pilot type B

Call CIP-ICT-PSP-2011-5
Objective 3.1 ICT solutions for fall prevention and detection and ICT and ageing network

Pisa, August 27, 2012
Proposal No. 297225

Integrated prevention and Detection sOlutioNs Tailored to the population and risk factors associated with FALLs

Pilot type B

Call CIP-ICT-PSP-2011-5
Objective 3.1 ICT solutions for fall prevention and detection and ICT and ageing network

Pisa, August 27, 2012
Thank you for your attention

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