Research Update

Stephen Lord
Accelerometers

Philips Lifeline Pendent

McRoberts Move Monitor
Movement analysis for fall prediction – why?

To improve upon current clinical assessments movement analysis needs to be:

• Easier
• Cheaper
• Better
• Complementary
• Remotely

For the prediction of falls
Age-associated changes in head Jerk

Age-associated changes in VT and ML jerk

Brodie, M et al. Experimental Brain Research 2014; 232:51-60
Age-associated changes in head Jerk

Step Length: 71% Accuracy

Head Jerk: 89% Accuracy
Mediolateral stability and gait speed - sub-space clustering of fallers

Fall risk / activity monitoring

Examples: Overall activity monitoring

Walking

Chair rise transfers
Cumulative exposure

89.2% of exposure in walks < 60 s, 50% of exposure in walks < 13.1 s
Gait Intensity

Bi-modal cadence distribution, i.e. there is a clear separation between slow walking (88 steps/per minute) and fast walking (112 steps/min). In 8 out of 18 participants a clear separation between cadence modes was observed.
Step time variability distributions:

- Fallers had significantly (p=0.04) greater mode of variability (0.12 seconds) than non-fallers (0.08 seconds).

- The mean of variability was skewed by the long tails, and showed no significant (p=0.10) difference.

Clinical factors influence daily gait

<table>
<thead>
<tr>
<th>Health</th>
<th>Physiological Capacity</th>
<th>Functional</th>
<th>Psychology</th>
<th>Processing speed</th>
<th>Executive function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Falls</td>
<td>WHODAS</td>
<td>PPA</td>
<td>Strength</td>
<td>Sway</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>83.4 (7.4)</td>
<td>0.61 (1.14)</td>
<td>17.4 (4.3)</td>
<td>2.08 (0.83)</td>
<td>22.7 (10.4)</td>
</tr>
</tbody>
</table>

| Steps per day | -0.63* | -0.33 | -0.45 | -0.55* | 0.14 | -0.50* | -0.65* | -0.66* | -0.50* | -0.72* | -0.47 | -0.44 | -0.46 | -0.48 |
| Walks per day  | -0.51* | -0.22 | -0.46 | -0.36 | 0.07 | -0.39 | -0.62* | -0.61* | -0.64* | -0.64* | -0.32 | -0.44 | -0.42 | -0.33 |
| Vigour (cm/s)   | -0.59* | -0.31 | -0.56* | -0.44 | 0.22 | -0.39 | -0.50* | -0.73* | -0.58* | -0.67* | -0.48* | -0.37 | -0.51* | -0.42 |
| Cadence [steps/min] | -0.35 | -0.11* | -0.10 | -0.53* | 0.38 | -0.22 | -0.60* | -0.43 | -0.05 | -0.49* | -0.72* | -0.20 | -0.38 | -0.20 |
| Step time variability [s] | 0.18 (0.04) | 0.38 | 0.54* | 0.54* | 0.49* | -0.33 | 0.35 | 0.41 | 0.78* | 0.03 | 0.53* | 0.58* | 0.08 | 0.59* | 0.50* |
## Associations with Falls

<table>
<thead>
<tr>
<th></th>
<th>Faller</th>
<th>SD</th>
<th>Non-faller</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walks per day</td>
<td>126</td>
<td>64</td>
<td>167</td>
<td>53</td>
<td>0.17</td>
</tr>
<tr>
<td>Mean Steps per walk</td>
<td>19.0</td>
<td>2.3</td>
<td>22.0</td>
<td>3.2</td>
<td>0.05*</td>
</tr>
<tr>
<td>Cumulative Exposure at 7s [%]</td>
<td>27.2</td>
<td>3.1</td>
<td>22.0</td>
<td>4.1</td>
<td>0.01*</td>
</tr>
<tr>
<td>Longest Walk per day [s]</td>
<td>76</td>
<td>36</td>
<td>112</td>
<td>31</td>
<td>0.04*</td>
</tr>
<tr>
<td>Mean of Variability [s]</td>
<td>0.20</td>
<td>0.05</td>
<td>0.17</td>
<td>0.02</td>
<td>0.10</td>
</tr>
<tr>
<td>Mode of Variability [s]</td>
<td>0.12</td>
<td>0.06</td>
<td>0.08</td>
<td>0.02</td>
<td>0.04*</td>
</tr>
<tr>
<td>Mean Cadence [steps/min]</td>
<td>89</td>
<td>6</td>
<td>94</td>
<td>5</td>
<td>0.10</td>
</tr>
</tbody>
</table>
A decision software application developed for a smartphone was capable of performing real time activity classification for a period of 17 hours on a single battery charge.

- Smartphone technology provides a viable platform on which to perform long-term activity monitoring.
Nine older and seven younger healthy adults walked on a treadmill at self-selected speed in four different conditions: walking only, phone, PASAT and SDMT.

Stability was not affected by any dual-tasks but both older and younger adults walked with significantly wider steps during the phone and SDMT conditions.

Healthy adults may try to control foot placement and walking pattern during cell phone use or another cognitive task with a visual component to ensure sufficient dynamic margins of stability and maintain stability.
Accelerometry – future work

• Fail-proofing / simplifying
• Providing optimal device and body position
• Adding GPS
• Providing feedback to older adults and health care practitioners for an effective tele-health service
• Sorting the ethical issues regarding privacy
Depressive Symptomatology as a Risk Factor for Falls in Older People: Systematic Review and Meta-Analysis

Tasha Kvelde, BPsych,*†‡ Catherine McVeigh, MD,†§ Barbara Toson, BStatEc,* Mark Greenaway, BSc,* Stephen R. Lord, PhD,* Kim Delbaere, PhD,* and Jacqueline C.T. Close, MD,*†§

- Twenty-five prospective studies with 21,455 participants
- The pooled effect of 14 studies reporting odds ratios indicated that a higher level of depressive symptoms resulted in a greater likelihood of falling during follow-up (OR = 1.46, 95%CI = 1.27–1.67)
- In six studies reporting relative risks or hazard ratios, a higher level of depressive symptoms resulted in a greater likelihood of falling during follow-up (RR = 1.52, 95%CI = 1.19–1.84)
- There was no difference between community samples and those with identified healthcare needs with respect to depressive symptoms being a risk factor for falls
Depressive symptoms in addition to visual impairment, reduced strength and poor balance predict falls in older Taiwanese people

Marcella Mun-San Kwan¹,², Sang-I. Lin³,⁴, Jacqueline C. T. Close¹,⁵, Stephen R. Lord¹,²

Age & Ageing 2012;41:606-612

• 280 community-dwelling people not taking anti-depressant medication aged 65–91 years completed the Geriatric Depression Scale and underwent sensorimotor, balance and mobility tasks and were then followed up for 2 years for falls
• Of the 260 participants with follow-up data, 174 (66.9%) experienced no falls, 51 (19.6%) fell once and 35 (13.5%) fell 2+ times
• Depressive symptoms were significantly more prevalent in recurrent fallers (40.0%) and once-only fallers (27.5%) compared with non-fallers (16.1%)
• Negative binomial regression analysis identified depression, poor depth perception, reduced lower limb strength and increased sway as independent and significant predictors of falls
Depressive symptoms increase fall risk in older people, independent of antidepressant use, and reduced executive and physical functioning

Tasha Kvelde a,b,c, Stephen R. Lord a, Jacqueline C.T. Close a,b,d, Simone Reppermund e, Nicole A. Kochan e,f, Perminder Sachdev e,f, Henry Brodaty e,g, Kim Delbaere a,*

- 488 people aged 70+ years
- Depressive symptoms were defined by a GDS (15-item) score ≥ 5
- Depressive symptomatology and antidepressant use were independent of each other, and independent of a high physiological fall risk and poorer executive functioning in predicting falls
- Fall risk increased with the number of risk factors present: i.e. by 55% in participants with any two risk factors (RR = 1.55; 95% CI = 1.17–2.04) and by 144% in participants with three or four risk factors (RR = 2.44; 95% CI = 1.75–3.43)
- The study findings indicate that higher depressive symptoms and antidepressant use predict falls over 12-months, independent of reduced executive and physical functioning
Poor nutritional status is associated with a higher risk of falling and fracture in elderly people living at home in France: the Three-City cohort study

M. J. Torres\textsuperscript{1,2,3} · C. Féart\textsuperscript{1,2} · C. Samieri\textsuperscript{1,2} · B. Dorigny\textsuperscript{3} · Y. Luiking\textsuperscript{4} · C. Berr\textsuperscript{5,6} · P. Barberger-Gateau\textsuperscript{1,2} · L. Letenneur\textsuperscript{1,2}

Osteoporosis International, 2015

• Baseline nutritional status of participants was assessed using the Mini Nutritional Assessment (MNA)
• After a follow-up of 12 years, 6040 individuals with available data for falls and 6839 for fracture were included.
• Poor nutritional status (MNA ≤ 23.5) at baseline was 12.0 % in the fall study sample and 12.8 % in the fracture study sample.
• Incident fall and fracture over 12 years were reported in 55.8% and 18.5 % of the respective samples, respectively.
• In multivariate models, poor nutritional status was significantly associated with a higher risk of falling (hazard ratio (HR) = 1.66, (95 % CI) 1.35-2.04 in men and HR = 1.20, 95 % CI 1.07-1.34 in women) and with a higher risk of fracture (HR = 1.28, 95 % CI 1.09-1.49)
Reactive Step Training

• 212 men and women, aged ≥65 years.
• Participants undertook one training session of either 24 repeated slips (training group) or only a single slip (control group).
• Slips were induced as participants walked over low-friction, movable platforms that could be locked (normal walking trials) or unlocked so that the foot slid forward upon floor contact (slipping trials).

Reactive Step Training – protocol

A: Training Group

- Regular \times 10
- Slips 1–8
- NS 1–3
- Slips 9–16
- NS 4–6
- Slips 17–24
- Mixed Block

B: Control Group

- Regular \times 10
- Slip 1

37 Trials Total
In the 12 month follow-up, the training group had a lower proportion of fallers than the control group (13% versus 25%, p = .019, for intention-to-treat analysis)
Falls prevention – what works

- Highest level of evidence given by meta-analyses of RCTs

- Gillespie LD et al. Interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev. 2012 Sep 12;9

- Cameron ID et al. Interventions for preventing falls in older people in care facilities and hospitals. Cochrane Database Syst Rev. 2012 Dec 12;12:
Gold bar evidence scale

- One good quality RCT
- At least two good quality RCTs – little inconsistency
- Multiple RCTs and/or systematic reviews – little inconsistency
Falls prevention – what works

- High level balance exercise in group or home settings (functional balance exercises, Otago, Tai Chi)
- Occupational therapy interventions (home safety modifications in association with transfer training and education) in high risk populations
- Expedited first eye cataract surgery
- Restriction of multifocal glasses use in older people who take part in regular outdoor activity
- Pharmacist-led education and GP medication review
- Podiatry intervention in people with disabling foot pain
Falls prevention – what works

- Withdrawal of psychoactive medications
- Intensive multidisciplinary assessment of high risk populations
- Intensive interventions in hospitals
- Comprehensive geriatric assessment in residential aged care
- Vitamin D supplementation in residential aged care
- Medication review in residential aged care
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