Criterion validity of an ankle or waist mounted Actigraph GT3X accelerometer in measurement of body position and step count

Jayne Anderson[1,2], Angela Green[1], L. Samantha Yoward[2] & Howard Hall[2] * [1] Hull and East Yorkshire Hospitals NHS Trust * [2] York St John University
E-mail : jayne.anderson@hey.nhs.uk Twitter @Anderson10Jayne

1. Rationale and study aims

- High levels of inactivity are reported for adult hospital ward patients recovering from critical illness.[1-2]
- Immobility in hospital contributes to irreversible functional decline in older populations.[3]
- Conventional methods of activity monitoring (self report, observation) are prone to methodological or operational weaknesses.[4]
- Wearable motion-sensors (accelerometers) offer an objective and unobtrusive alternative to monitoring the type and regularity of activity undertaken by hospitalised patients.
- To be considered a viable alternative, the data they capture must be valid and clinically meaningful.
- This study aimed to investigate if the Actigraph GT3X accelerometer (Figure 1) could identify body position and quantify step count during typical activities undertaken on a hospital ward by simulated patients recovering from critical illness.

Figure 1. The Actigraph GT3X accelerometer

2. Method

- Observational and prospective in design.
- Ethical approval from NHS Research Ethics Committee (14/NI/1023) and York St John University (UC/25/2/14/JA)
- 30 healthy volunteers enrolled, age matched to a Hull and East Yorkshire Hospitals NHS Trust (HEYHT) critical care population admitted during 2012.
- Research undertaken within a closed hospital ward at HEYHT.
- Participants undertook a movement protocol consisting of postural transitions on a bed (e.g. lying to sitting/ sitting to standing) and ten metre distance walks with walking aids.
- Video recordings formed the criterion measure against which accelerometer data was compared.
- Agreement between accelerometer data and activity observed from the video recordings was analysed using Bland Altman analysis for continuous data (step count) and Kappa (κ) for categorical data (body position).

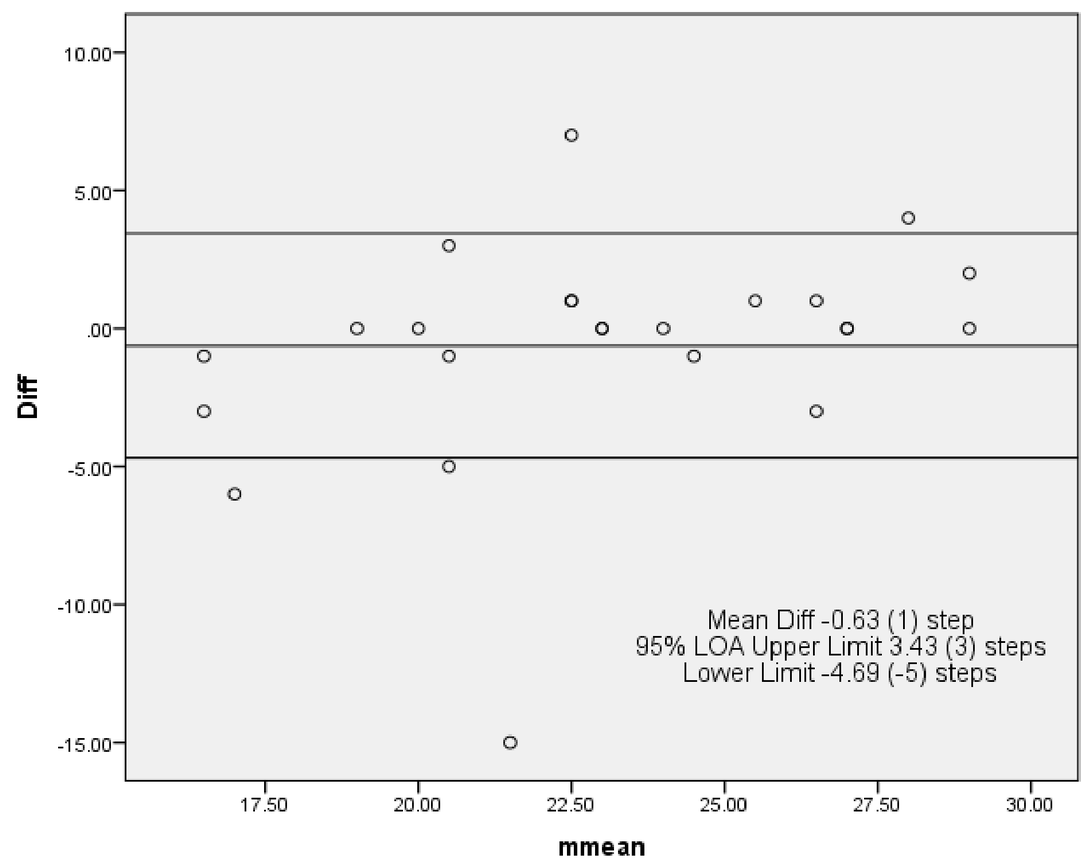
3. Results

- Fair agreement between waist accelerometer data and video recordings for recognition of lying, sitting and standing postures ($\kappa = 0.21 : p < 0.001$)
- Moderate agreement between ankle accelerometer data and video recordings ($\kappa = 0.43 : p < 0.001$)
- Ankle accelerometer correctly identified lying position on 91% of occasions, standing 99%, sitting 32%)
- Mean differences in step count recorded by the ankle accelerometer compared to observed step count when using a stick or walking frame were smaller than the waist placement (Table 1)
- Figure 2 presents the Bland Altman plot constructed for agreement between step count quantified by the ankle accelerometer and observed step count for the ten metre walk using a stick.

Table 1: Mean differences in step count recorded by accelerometry and direct observation (speed ≥ 0.3m/s).

Walk type	*n*	Mean difference (95% limits of agreement - LOA) WAIST PLACEMENT	Mean difference (95% LOA) ANKLE PLACEMENT
Frame	18	-6.72 steps (-24.83 to 11.39 steps)	- 0.28 steps (- 5.98 to 5.42 steps)
Stick	24	-6.58 steps (-22.63 to 9.47 steps)	- 0.63 steps (- 4.69 to 3.43 steps)

Figure 2. Bland Altman plot for ankle accelerometer and stick



4. Conclusions

- The Actigraph GT3X accelerometer exhibited a delay in recognition of a postural change of ≤ nine seconds compared to observation
- Ankle placement was superior to waist placement for identification of body position and step count when undertaking activities typically undertaken by patients recovering from critical illness within a hospital ward environment.
- Whilst the ankle placement accurately identified both lying and standing postures, it often misclassified the sitting position as standing.
- Future studies investigating the validity of this model to capture purposeful activity should enrol hospitalised patients recovering from critical illness.
- Combinations of accelerometer placement sites may improve identification of the sitting position with this model, using data from multiple placement sites to construct an algorithm.

5. Acknowledgements

Special thanks is given to Hull and East Yorkshire Hospitals NHS Trust for their permission to undertake the study within a closed ward and to Dr Victoria Allgar (Hull York Medical School) for statistical advice.

References

[1] Borges RC., Carvalho CR., Colombo AS., da Silva Borges MP. & Soriano FG. Physical activity, muscle strength, and exercise capacity 3 months after severe sepsis and septic shock. *Intensive Care Medicine*. 2015; 41(8):1433-44.
[2] Hopkins RO., Miller III RR., Rodriguez, L., Spuhler, V. & Thomsen, GE. Physical therapy on the wards after early physical activity and mobility in the Intensive Care Unit. *Physical Therapy.* 2012; 92**:** 1518-1523.
[3] Graf C. Functional decline in hospitalized older adults. *The American Journal of Nursing*. 2006;106(1):58-67.
[4] Cheung, VH., Gray, L. & Karunanithi, M. Review article (meta-analysis): Review of Accelerometry for determining daily activity among elderly patients. *Archives of Physical Medicine and Rehabilitation.* 2011; 92**:** 998-1014.