Clinician's Commentary on Hui et al.¹

An important goal of stroke rehabilitation is to improve physical activity levels and cardiorespiratory fitness (CRF). A recent survey revealed that, of 155 Canadian physiotherapists practicing in the area of neurorehabilitation, 77% reported prescribing aerobic exercise.² Similarly, in the United States, 66.7% of acute care therapists and 93.1% of therapists from other settings reported prescribing aerobic exercise to at least some people after stroke.³ These results are very promising, but prominent barriers to prescribing aerobic exercise in these and other studies were insufficient time during the therapy session and short length of stay in rehabilitation. Combined with the general lack of community based exercise programmes available after discharge, there is a great need for something to bridge the gap between behavioural prescriptions and the ability of patients to adhere to clinical recommendations in the long term. Clinicians must also focus on non-prescription-related activities because they are likely to be an important determinant of the CRF profile, risk factor modification, and reintegration into the community.

Ultimately, physiotherapists need something that will help to educate patients and motivate behavioural change outside the rehabilitation setting and that will foster their independence. This gap may, in part, be filled by home monitoring devices.

Therefore, I read with interest the study conducted by Hui and colleagues,¹ which examined the validity of the Fitbit One accelerometer device for measuring free-living activity in community-dwelling stroke survivors. The study participants had a mean age of 63 (SD 9.3) years; most were male (58%) and 20 (SD 28) months post-stroke with motor deficits. The primary outcome was the correlation between the Fitbit One (Fitbit Inc., San Francisco, CA) and Actical (Philips Respironics, Baltimore, MD) accelerometers for quantifying 3-day step count and activity levels in 12 post-stroke individuals who were participating in a community exercise programme. Time spent by the participants being sedentary and engaged in light, moderate, and vigorous activity was also measured and contrasted. In addition, the investigators measured the relative error between the devices and examined the factors associated with the error. The investigators hypothesized that there would be a strong correlation ($r > 0.80$) between the devices in quantifying step count and time spent at various levels of activity. Both accelerometers were placed on the non-paretic ankle and worn at all times. There was no information about the exercise programme in which the patients were engaged.

The authors should be commended for conducting this study. First, as they pointed out, no study had evaluated the validity of the Fitbit One during free-living activity in individuals with stroke for quantifying the level of physical activity or sedentary time. Also, clinically relevant data were collected to indicate the participants' level of comfort and complications, and the devices' influence on physical activity levels. Regarding the latter, five participants (42%) reported slight and moderate increases in activity because of wearing the device. As indicated by the authors' thorough literature review, in this population optimal positioning of the device for capturing data is on the non-paretic ankle. However, it should be acknowledged that participants may have difficulty observing step counts in real

time when wearing the device on this location. Step counts displayed where a person can easily track them throughout the day would enable spontaneous correction of low step counts. However, for these data to be of optimal clinical use, the step-count benchmark of 6,000 steps per day reported in this study requires examination in people post-stroke.⁴

Further results of the study conducted by Hui and colleagues¹ revealed a significant correlation in step count between the Fitbit One and Actical devices ($r = 0.99$, 0.99 , and 0.97 , respectively, for each of the 3 d). These are strong correlations, and they indicate that there is at least an association. However, it should be acknowledged that there are inherent limitations when examining the validity of a device during free-living activity. For example, use of the Actical could be criticized because there is no strong evidence that it is a gold-standard device for measuring step counts and exercise intensity for people with mobility deficits after stroke. Although the Fitbit One is correlated, it could presumably have an error similar to the Actical. Also, although correlational analysis measures the degree of association, it does not measure agreement, and although the correlation is strong, it is no guarantee of acceptable agreement. A Bland-Altman plot provides a graphical method (scatterplot) of displaying the differences between the two devices. It would also provide an indication of whether the differences were greater when the average step counts were lower or any other trend. A Lin's concordance correlation coefficient is another analysis that would report the level of agreement, and it is appropriate for smaller sample sizes.⁵ Despite these limitations, providing information on the association between the two devices may be a step toward determining the real-world utility of the Fitbit One.

The authors also provided a measure of the mean relative error between the devices, calculated as $[(\text{Actical} - \text{Fitbit step count}) / \text{Actical step count} \times 100\%]$. The mean of the relative error was 3% (SD 25%), which is low but very spread out (most of the error measures fell between -22% and 28%). The authors indicated that the percentage error was higher than that measured in a previous study (<1.3%) conducted by Takacs and colleagues,⁶ with the disparity likely owing to the difference in population and setting. However, Takacs and colleagues measured the absolute relative error— $[(\text{Actical} - \text{Fitbit step count}) / \text{Actical step count} \times 100\%]$ —rather than the relative error, as in the current study. Consider, for instance, two pairs of step counts: A and B. The relative error in pair A is 25% higher for the Actical than the Fitbit One, whereas the relative error for pair B is -25% lower for the Actical than the Fitbit One. The mean relative percentage error is zero; however, the mean absolute relative error is 25%. The latter gives one a better understanding of the error when reported as a mean. Therefore, the mean of the relative error, 3% (SD 25%), and the error between fast and slow gait speeds reported in this study may be underestimating the absolute relative error. Results have recently been published in a well-designed study demonstrating accurate step counts with the Fitbit One compared with a gold-standard measure—mean absolute error ranging from 10.9% (SD 5.3%) at walking velocities of less than 0.4 metres per second to 4.4% (SD 2.8%) at velocities of more than 0.8 metres per second—in a real-world clinical setting.⁷

Finally, a comparison of physical activity intensity categories between the devices was made. This is important given the well-established evidence demonstrating that greater gains in CRF are possible with higher intensity exercise in populations with stroke,⁸ and increases in CRF are associated with reductions in cardiovascular event rates in populations with chronic disease.⁹ As the authors pointed out, significant correlations were found between the devices only for time spent at light-intensity exercise for all 3 days. However, these intensity categories may not be appropriate for people post-stroke. For example, the Actical categorized moderate intensity as 3–6 metabolic equivalents (METs), which is equivalent to an oxygen uptake of 10.5–21 mL · kg⁻¹ · min⁻¹. This would represent about 75% to 150% of the average peak oxygen uptake of people post-stroke (~14.0 mL · kg⁻¹ · min⁻¹).⁸ In other words, 3–6 METs may be light intensity for a very fit individual aged 30 to 40 years, but it may be quite vigorous for a person aged 63 years after stroke. Therefore, it would be a more clinically useful measure if user-defined energy expenditure cut-points were possible for the Fitbit One, as they are with the Actical device.

If the future is for clinicians to send every patient home with an activity monitor and provide feedback on activity levels, valid and reliable data on the participants' physical activity patterns (including resistance training) are needed. The data must provide users with sufficient feedback to gauge and modify their behaviour. Despite its limitations, the current study has contributed to our understanding of the measurement qualities of the Fitbit One.

Susan Marzolini, R.Kin, PhD
Clinical Case Manager,

Toronto Rehab's Risk Factor Modification
and Exercise Program following Stroke (TRI-REPS),
and Scientific Associate,

Toronto Rehab-UHN Cardiovascular Disease Prevention
and Rehabilitation Program, Toronto;
susan.marzolini@uhn.ca.

REFERENCES

1. Hui J, Heyden R, Bao T, et al. Validity of the Fitbit One for measuring activity in community-dwelling stroke survivors. *Physiother Can.* 2018;70(1):81–89. <https://doi.org/10.3138/ptc.2016-40.ep>.
2. Doyle L, Mackay-Lyons M. Utilization of aerobic exercise in adult neurological rehabilitation by physical therapists in Canada. *J Neurol Phys Ther.* 2013;37(1):20–6. <https://doi.org/10.1097/NPT.0b013e318282975c>. Medline:23389387
3. Boyne P, Billinger S, MacKay-Lyons M, et al. Aerobic exercise prescription in stroke rehabilitation: a Web-based survey of US physical therapists. *J Neurol Phys Ther.* 2017;41(2):119–28. <https://doi.org/10.1097/NPT.0000000000000177>. Medline:28263254
4. Tudor-Locke C, Craig CL, Aoyagi Y, et al. How many steps/day are enough? For older adults and special populations. *Int J Behav Nutr Phys Act.* 2011;8(1):80. <https://doi.org/10.1186/1479-5868-8-80>. Medline:21798044
5. Lin L, Hedayat AS, Wu W. A unified approach for assessing agreement for continuous and categorical data. *J Biopharm Stat.* 2007;17(4):629–52. <https://doi.org/10.1080/10543400701376498>. Medline:17613645
6. Takacs J, Pollock CL, Guenther JR, et al. Validation of the Fitbit One activity monitor device during treadmill walking. *J Sci Med Sport.* 2014;17(5):496–500. <https://doi.org/10.1016/j.jsams.2013.10.241>. Medline:24268570
7. Klassen TD, Semrau JA, Dukelow SP, et al. Consumer-based physical activity monitor as a practical way to measure walking intensity during inpatient stroke rehabilitation. *Stroke.* 2017;48(9):2614–7. <https://doi.org/10.1161/STROKEAHA.117.018175>. Medline:28784922
8. Macko RF, Ivey FM, Forrester LW, et al. Treadmill exercise rehabilitation improves ambulatory function and cardiovascular fitness in patients with chronic stroke: a randomized, controlled trial. *Stroke.* 2005;36(10):2206–11. <https://doi.org/10.1161/01.STR.0000181076.91805.89>. Medline:16151035
9. Forman DE, Arena R, Boxer R, et al. Prioritizing functional capacity as a principal end point for therapies oriented to older adults with cardiovascular disease: a scientific statement for healthcare professionals from the American Heart Association. *Circulation.* 2017;135(16):e894–e918.

DOI:10.3138/ptc.2016-40-cc