Off-the-Shelf Wearable Sensors as a Tool for Recording Upper Extremity (UE) Movement in a patient receiving Constraint Induced Movement Therapy (CIMT)

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Introduction

- CIMT is a form of neurorehabilitation that encourages the use of the more-affected UE by stroke survivors (Morris et al., 2006)
- CIMT uses a multi component protocol that requires adherence to 2 weeks of daily 3.5 hours of treatment in the laboratory
  - motor training in the form of shaping and task practice
  - behavioral transfer package: a set of behavior change techniques intended to help the patient carry over the use of their arm and hand in everyday
  - restraint on the less-affected UE in the form of a mitt
- The primary outcome measure for CIMT is the Motor Activity Log (MAL) (Taub et al., 2013)
  - This is a perceived performance measure based on the participants' rating of the quality of movement and the amount of movement of the more affected UE in daily life tasks
- The main purpose of this case study is to determine if an off-the-shelf sensor can be combined with CIMT as an outcome measure for objective performance
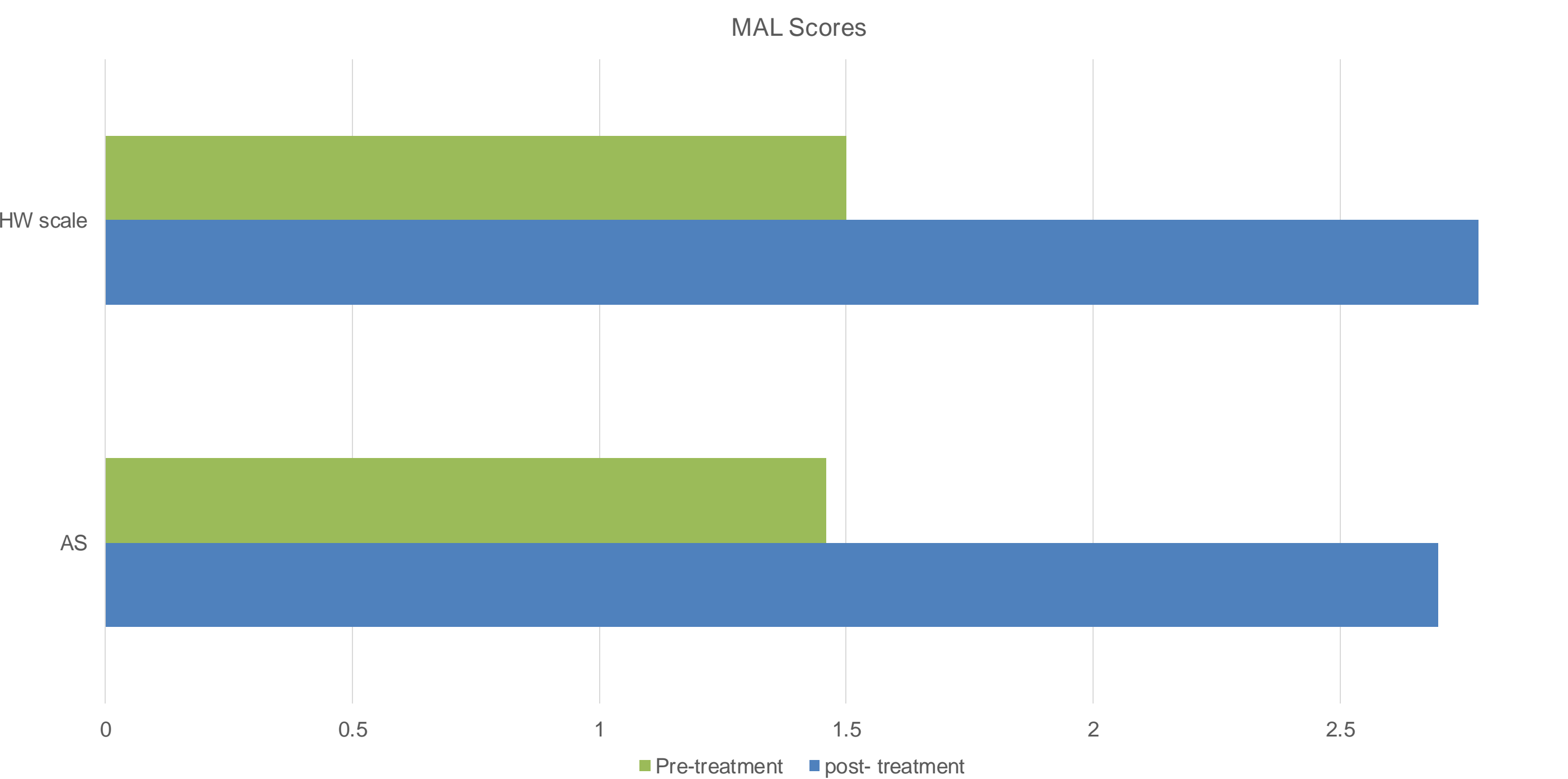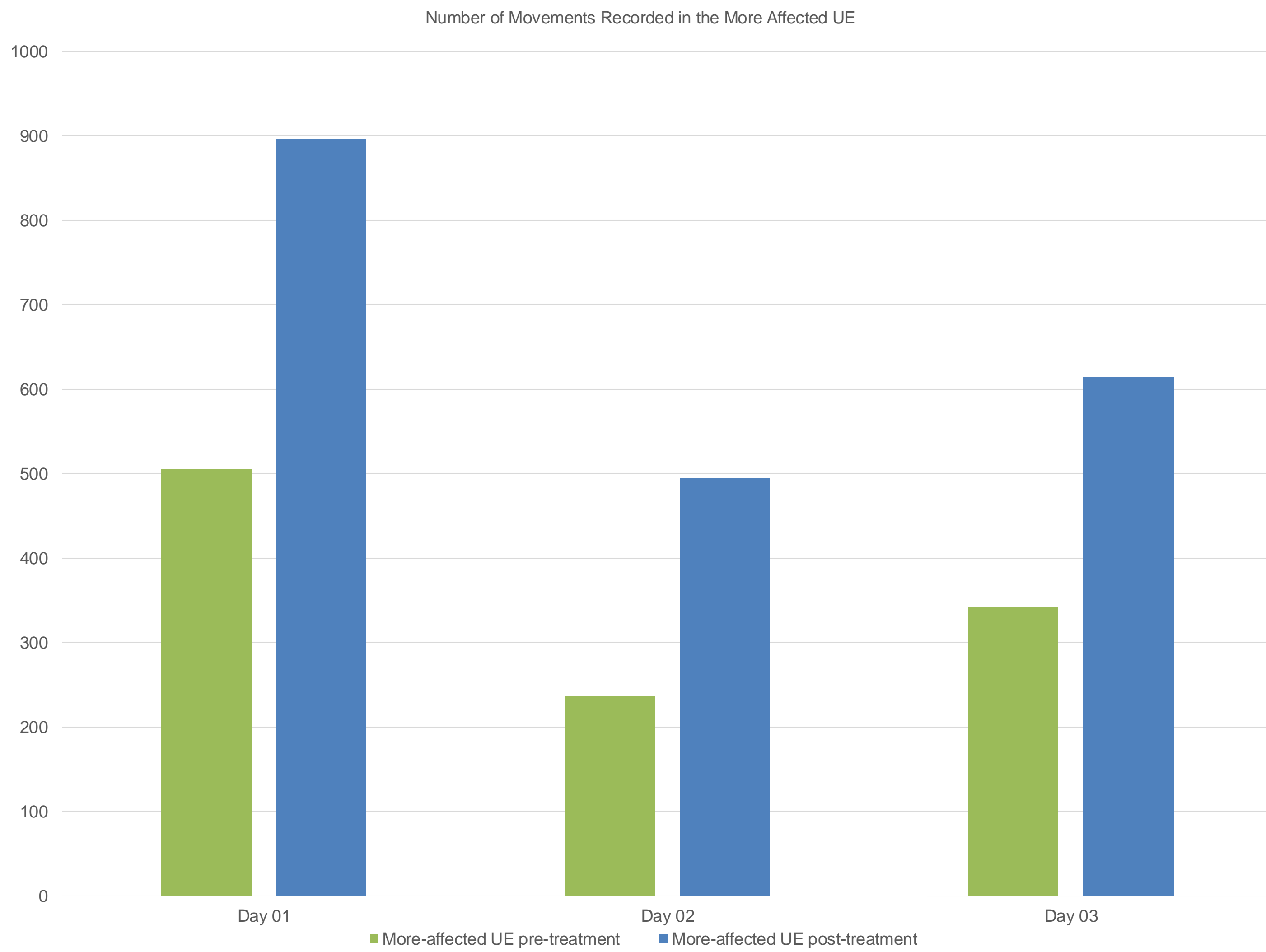
Methods

- Case study with one chronic stroke participant with hemiparesis of his dominant side who met the inclusion criteria for participation in a refinement CIMT
  - Primarily uses a wheelchair for mobility needs with limited ambulation
- Outcome measures were the MAL, WMFT, COPM, and the measurement from the wearable sensors
- The off-the-shelf wearable sensors worn by the participant was the Fitbit Inspire 2
  - Typically, this sensor relies on the number of arm movements to determine the number of steps the user has taken (Chen et al., 2016)
  - For the purposes of this study, the number of steps will be referred to as number of movements
- The participant wore the wearable sensors on each wrist for three days prior to treatment and again three days post treatment
  - The participant was instructed to perform similar day to day activities during pre and post treatment. This was done to have the participant be consistent with their activities to determine if there was an increase in movement in the more affected UE

Results

- This participant completed the full 2-week CIMT protocol
- Testing conducted at pre- and post- treatment was carried out
- Results include scores from the WMFT, COPM, MAL, and Fitbit data
  - **MAL:** The Minimal Clinically Important Change (MCID) for the MAL amount scale (AS) & Quality of movement (QOM) is a 1.0 to a 1.1 (Simpson & Eng, 2013)
    - The QOM and AS represented a ≥ 1.0 to 1.1 increase in scores, which represents a MCID change after receiving CIMT
  - **WMFT:** The participant scored a WMFT FAS median of 2.15 during pre-testing and increased to 2.46 during post testing, which is a .31-point change
    - The MDC for WMFT FAS is 0.2 to 0.4 points (Lin et al., 2009), therefore the participant had an MDC change in score
  - **COPM:** The participant increased his performance score by 2.6 change and his satisfaction scale also increased by 2.0
    - A change of 2 points in both performance and satisfaction is suggested to represent clinical significance (McColl et al., 2023)

Results continued

- According to the data from the Fitbits, the number of movements performed by the more affected UE during post testing displayed an increase in comparison to pre-testing
- The participant demonstrated at least ≥ 250 movements performed by the more affected UE each day after receiving CIMT
- The following data is the increased number of movements produced each day by the more-affected UE based on the information collected by the Fitbits from pre- to post- testing:
  - Day One: 392 more movements
  - Day Two: 257 more movements
  - Day Three: 252 more movements

Number of Movements Recorded in the More Affected UE

■ More-affected UE pre-treatment ■ More-affected UE post-treatment

MAL Scores

■ Pre-treatment ■ post- treatment

Discussion

- The Fit bit gave objective measure of performance that compliment the MAL scores, which is a rating of perceived performance
- The participant and their caregiver demonstrated independence following training for their ability to don and use the Fitbits correctly as shown by the Fitbits able to detect the UE movement performed pre- and post CIMT.
- The Fitbits did not demonstrate any negative effects or disrupt the CIMT testing regimen or treatment protocol as evidenced by not only the Fitbits having an increase in movements, but by the MAL having an increase in score.
- **LIMITATIONS:**
  - The participant had received CIMT at a lower level of function (Grade 5) before and was receiving a refinement treatment, which could be a limitation that he should already be performing more UE movement in their more affected UE since they have received CIMT.

Conclusion

- The purpose of this case study was to gain a better understanding of if an off-the-shelf wearable sensor could be used alongside CIMT
- The results of this research provide supporting evidence that the off-the-shelf wearable sensor in this study, Fitbit, could be used with a patient receiving CIMT
- **IMPLICATIONS:**
  - The Journal of Occupational Therapy cites CIMT as an effective form of stroke treatment that can be performed by OT practitioners to increase their patients' UE movement (Mahoney et al., 2023).
- **FUTURE RESEARCH:**
  - A pedometer, which would measure lower extremity (LE) movement, could be used alongside the Fitbit to measure the number of steps vs arm swings.

References

Chen, M. D., Kuo, C. C., Pellegrini, C. A., & Hsu, M. J. (2016). Accuracy of wristband activity monitors during ambulation and activities. Medicine and Science in Sports and Exercise, 48(10), 1942–1949. https://doi.org/10.1249/MSS.0000000000000984

O'Mahoney, L. L., Routen, A., Gillies, C., Ekezie, W., Welford, A., Zhang, A., Karamchandani, U., Simms-Williams, N., Cassambai, S., Ardavani, A., Wilkinson, T. J., Hawthorne, G., Curtis, F., Kingsnorth, A. P., Almaqhawi, A., Ward, T., Ayoubkhani, D., Banerjee, A., Calvert, M., Shafran, R., Khunti, K. (2022). The prevalence and long-term health effects of Long Covid among hospitalised and non-hospitalised populations: A systematic review and meta-analysis. EClinicalMedicine, 55, 101762. https://doi.org/10.1016/j.eclinm.2022.101762

Lin, K. C., Hsieh, Y. W., Wu, C. Y., Chen, C. L., Jang, Y., & Liu, J. S. (2009). Minimal detectable change and clinically important difference of the Wolf Motor Function Test in stroke patients. Neurorehabilitation and Neural Repair, 23(5), 429–434. https://doi.org/10.1177/1545968308331144

Mahoney, D., Kotler, J. M., Nilsen, D. M., & Gillen, G. (2023). Effectiveness of Task-Oriented Approaches and Occupation-Based Activities to Improve Performance and Participation in Instrumental Activities of Daily Living (IADL) Among Adult Stroke Survivors (2009-2019). The American Journal of Occupational Therapy : Official Publication of the American Occupational Therapy Association, 77(Suppl 1), 7710393080. https://doi.org/10.5014/ajot.2023.77S10008

McColl MA, Denis CB, Douglas K-L, et al. A Clinically Significant Difference on the COPM: A Review. Canadian Journal of Occupational Therapy. 2023;90(1):92-102. doi:10.1177/00084174221142177

Morris, D. M., Taub, E., & Mark, V. W. (2006). Constraint-induced movement therapy: characterizing the intervention protocol. Europa Medicophysica, 42(3), 257–268

Simpson, L. A., & Eng, J. J. (2013). Functional recovery following stroke: capturing changes in upper-extremity function. Neurorehabilitation and Neural Repair, 27(3), 240–250. https://doi.org/10.1177/1545968312461719

Taub, E., Uswatte, G., Mark, V. W., Morris, D. M., Barman, J., Bowman, M. H., Bryson, C., Delgado, A., & Bishop-McKay, S. (2013). Method for enhancing real-world use of a more affected arm in chronic stroke: transfer package of constraint-induced movement therapy. Stroke, 44(5), 1383–1388. https://doi.org/10.1161/STROKEAHA.111.000559

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