Development of an algorithm for the evaluation of gait and balance impairments in CNS disorders

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Introduction

- Gait and balance is impaired in CNS disorders such as Parkinson's disease (PD) [1] and quantified in surveys e.g. MDS-UPDRS Part III items [2]

- Gait and balance symptom features can be measured using smartphone applications[3,4,5,6]

- Koneksa Health developed a new algorithm to calculate gait and balance symptom feature scores (duration, distance, steps, speed, stride period, etc.) and an application for deployment on iPhones

- This study is to determine analytical validity and operational tolerance of this algorithm in healthy subjects using an app deployed on an iPhone 8 plus
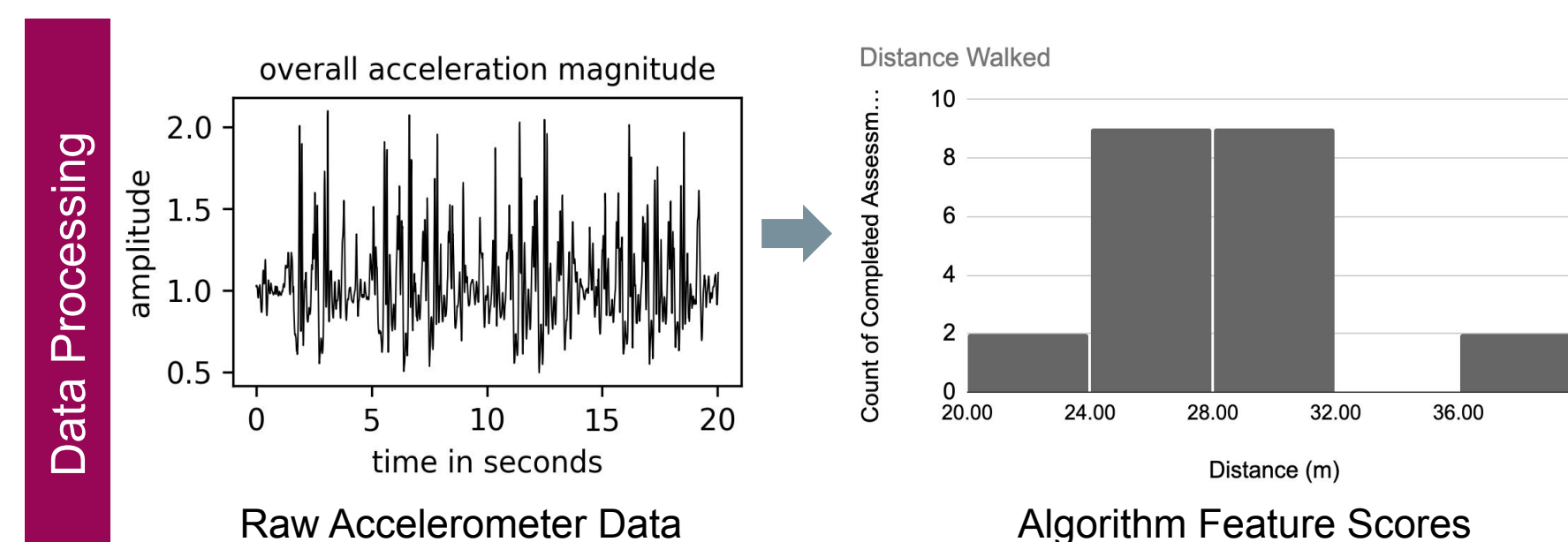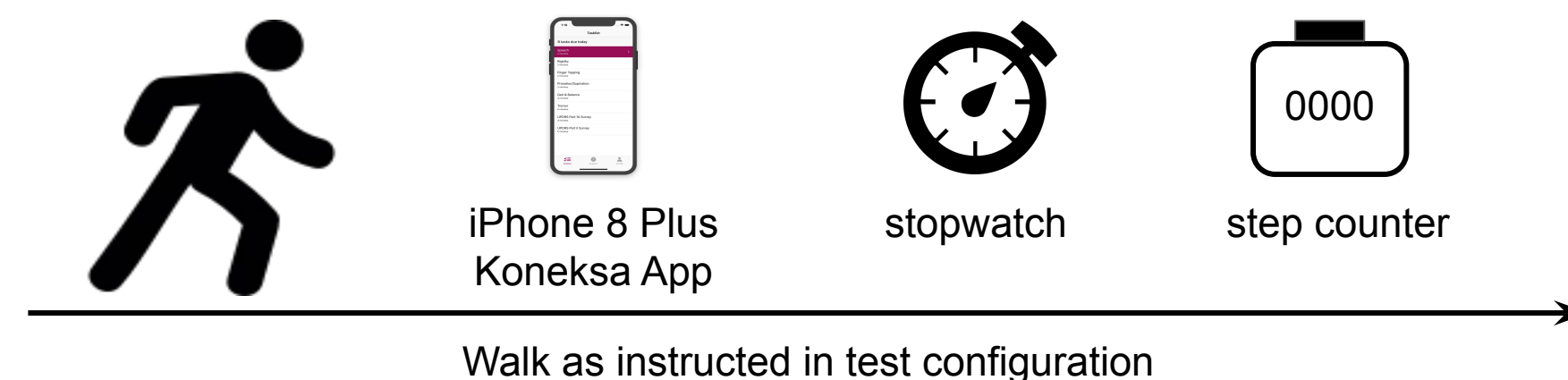
Method

- Work under IRB approved study VS001 with 11 self-certified healthy individuals

- Subjects walked a marked course in a large office for each of 5, 10, 15 and 20 seconds under supervision from 3 raters
  - Turns were allowed if a subject walked far enough that they had to turn within space available

- Rater feature scores used as "gold standard" in comparison with corresponding algorithm feature scores
  - Direct measures: duration, steps, distance
  - Derived measures: speed, stride period

- **Analytical validity** was determined by Intraclass Correlation Coefficient (ICC) for agreement between matching algorithm and rater feature scores
  - Classified as excellent (ICC≥0.9), good (0.75≤ICC<0.9), moderate (0.5≤ICC<0.75), or poor (ICC<0.5)[7]

- **Operational tolerance** was examined by comparing ICC for the same 20-second walk in
  - Default configuration: placing the phone in a tight trouser pocket
  - Deviations from the default: placing the phone in a loose shorts pocket, and in a shoulder bag

Results

- Total of 83 completed assessments: each subject completed a minimum of 2 attempts at each of the walking test configurations - average subject compliance was 80%

- **Analytical validity**: excellent agreement (ICC≥0.9) in **duration, distance, and steps** between algorithm and "gold standard" rater feature scores

- **Operational tolerance**: good agreement (ICC≥0.75) in **distance, steps, stride period** (and speed - except for loose pocket 0.741, close to cutoff)

iPhone 8 Plus Koneksa App   stopwatch   step counter

Walk as instructed in test configuration

Data Processing

Raw Accelerometer Data   Algorithm Feature Scores

Agreement ICC	Duration	Distance	Steps	Speed	Stride Period
Analytical Validity (combined results for 5s, 10s, 15s, 20s walk)	0.989	0.987	0.992	0.764	0.593
Operational Tolerance (Loose Pocket)	N/A 20s walk of fixed duration	0.850	0.868	0.741	0.850
Operational Tolerance (Shoulder Bag)	0.932	0.858	0.837	0.798

Conclusions

- The new algorithm and iPhone application can accurately measure gait and balance symptom feature scores, i.e. is analytically valid, in healthy individuals under supervision

- The new algorithm is operationally tolerant of different wear modalities

- The new algorithm may be of use in studies of (central nervous system) CNS disorders, such as Parkinson's disease

Reference

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