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
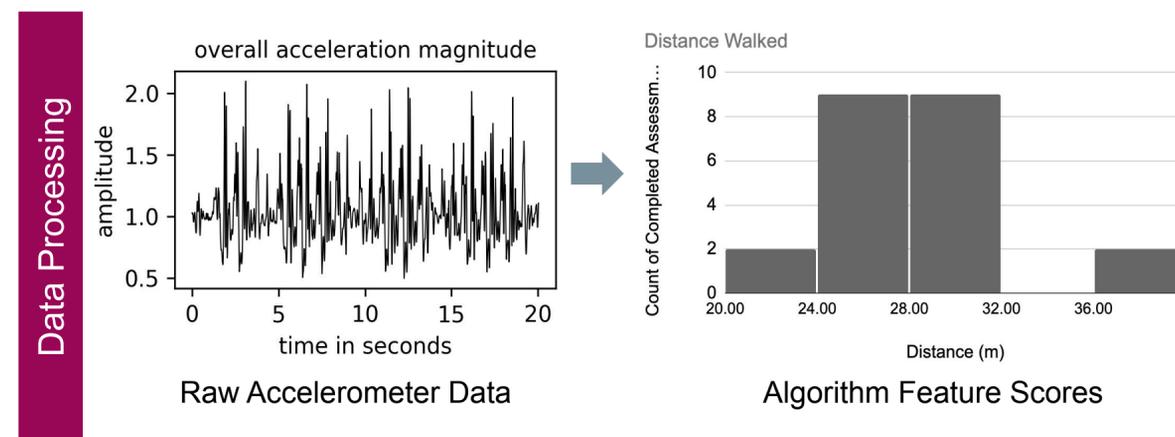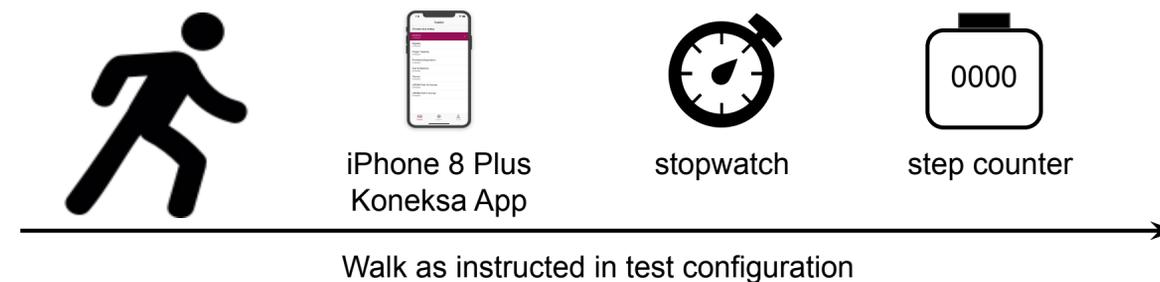
Method

- 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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