Analytical validity of a walk detection and gait algorithm in different wear configurations

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Introduction

A previous study[1] established the analytical validity and operational tolerance of the walk detection and gait algorithm developed by the authors for walk periods of duration 10 seconds and longer when applied to accelerometry data collected by wrist-worn and hand-held devices.

While wrist-worn devices are typical for studies into Parkinson's disease, in other diseases (e.g. Multiple Sclerosis) waist-worn devices are more common. The aim of this study is to establish analytical validity of the algorithm when applied to data from waist-worn and in-pocket devices, such that it can be used in a wider range of applications and for a broader range of demographics.

Method

10 healthy subjects performed a series of walking tests while wearing 6 ActiGraph GT9X Link devices concurrently, one for each of 6 wear positions. Each subject completed two visits, each time performing each test twice.

The tests comprised:

- **WD5S** : alternately walking for 5 seconds, then stopping for 5 seconds
- **WD10S** : alternately walking/stopping for 10 seconds
- **WD20S** : alternately walking/stopping for 20 seconds
- **20SW** : 20-second walk test
- **T25FW** : timed 25-foot walk test

These tests were chosen to be consistent with the previous study and because T25FW is commonly used in Multiple Sclerosis studies.

Trained raters recorded the start and end times of each walking period, distance walked and the number of steps as the "gold standard". Speed, walk duration, and stride period were derived from the rater-recorded measures.

- For start/end times and walk duration the Mean Absolute Error (MAE) between algorithm and rater measures was calculated.
- For steps, speed, and stride period, the Intraclass Correlation Coefficient (ICC) for agreement between algorithm and rater measures was determined and classified[2] as:
  - excellent (ICC>0.9)
  - good (0.9>ICC>0.75)
  - moderate (0.75>ICC>0.5)
  - poor (ICC<0.5)

  Excellent and good ICCs were deemed analytically valid.

Results

- In total 260 tests were completed, comprising 743 walk periods (tests involving walking/stopping resulted in multiple walk periods per test).
- The algorithm detected 76% of walk periods,
  - the majority (98%) of missing walk periods corresponded to walks of 5-second duration (WD5S).
  - Of the 10-second and 20-second walk periods (WD10S and WD20S), 99.3% were detected.
- For the new (non-wrist) wear positions for WD10S and WD20S, MAEs for start/end times and duration range from 0.424 to 0.990 seconds.
  - These results are better than those found for the wrist-worn position (WC1)

- For the 20-second walk test (20SW), ICC values for steps, stride period and speed are good or excellent (ICCs in range 0.762 to 0.912) for all the new wear positions except loose pocket.
- For the timed 25-foot walk test (T25FW), ICC values for steps and stride period are generally moderate or poor (ICCs from 0.0 to 0.676).
  - This test typically takes 6 or 7 seconds so this is consistent with the algorithm not being valid for walk durations of less than 10 seconds.
- ICC values for speed for T25FW are good (ICCs from 0.781 to 0.797), except for the loose pocket wear position.

Conclusions

For the new wear positions for walk periods of duration 10 seconds or longer, the algorithm reliably detects walk periods with start and end times accurate to better than 1 second and is analytically valid (ICC values good or excellent) for number of steps, speed and stride period for all wear positions other than loose pocket. It is also analytically valid for gait speed in T25FW.

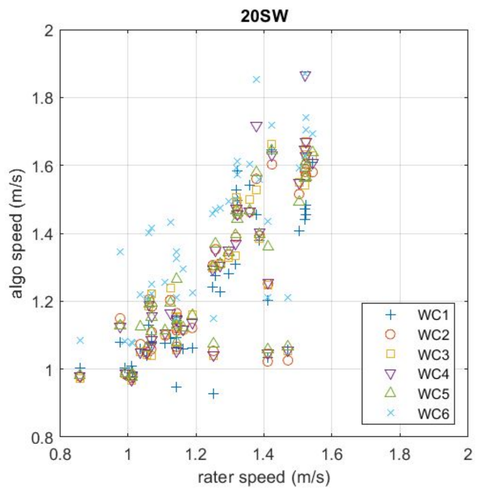
We conclude that the algorithm is analytically valid for waist-worn and tight-pocket positions for walk durations of 10 seconds or longer. This supports its use in these alternative wear positions in clinical research.

MAE (seconds)	Measure	WC1 - wrist	WC2 - waist clip	WC3 - waist pouch	WC4 - clothing	WC5 - tight pocket	WC6 - loose pocket
WD10S	Start Time	0.903	0.653	0.631	0.630	0.690	0.880
	End Time	0.756	0.564	0.608	0.573	0.632	0.723
	Duration	0.737	0.434	0.461	0.525	0.424	0.576
WD20S	Start Time	1.042	0.730	0.619	0.614	0.732	0.990
	End Time	0.804	0.552	0.552	0.541	0.548	0.735
	Duration	0.845	0.487	0.557	0.544	0.555	0.765

Mean absolute errors for start/end times and durations for WD10S and WD20S

ICC (agreement)	Measure	WC1 - wrist	WC2 - waist clip	WC3 - waist pouch	WC4 - clothing	WC5 - tight pocket	WC6 - loose pocket
20SW	Steps	0.757	0.794	0.762	0.787	0.906	0.702
	Stride Period	0.930	0.912	0.912	0.911	0.913	0.905
	Gait Speed	0.740	0.785	0.788	0.774	0.799	0.568
T25FW	Steps	0.000	0.000	0.079	0.676	0.062	0.059
	Stride Period	0.576	0.562	0.559	0.568	0.563	0.564
	Gait Speed	0.804	0.794	0.784	0.781	0.797	0.521

ICC values for steps, stride period and speed for 20SW and T25FW.
Good & excellent ICCs marked in green.



Comparison of speeds derived from rater-recorded measures and those calculated by the algorithm for 20SW.

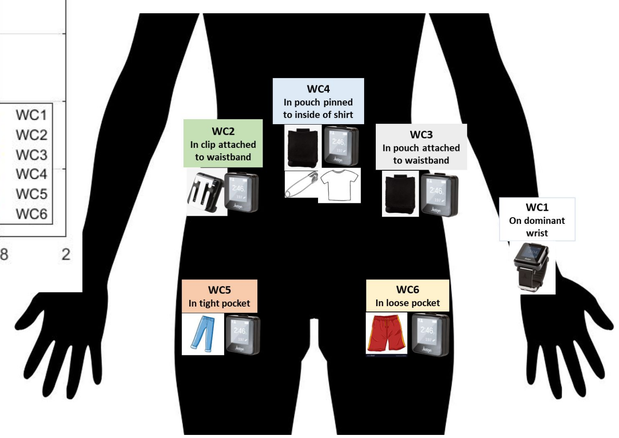


Illustration of the 6 wear configurations used in this study

References

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The authors report no conflicts of interest for this work