

StepWatch™ Activity Monitor: Reference Guide

Outcomes Research Committee Resource created by Rachel Rudolf & Barber Prosthetics

Introduction

The StepWatch™ Activity Monitor is a tool used to objectively measure and monitor step count in patients with and without gait abnormalities in both adult and pediatric populations¹. It measures stride rate through the use of a microprocessor controlled two-dimensional accelerometer that is worn on the ankle of the participant². This instrument was originally developed for long term assessment in the field of Prosthetics³ and Orthotics but has since been found to be valid and reliable for other populations such as Parkinson's Disease (PD)⁴ Multiple Sclerosis (MS)^{2, 4}, Charcot-Marie-Tooth (CMT)⁵, Stroke^{6, 7, 8, 9, 10, 11}, Traumatic Brain Injury (TBI)^{12, 13}, incomplete spinal cord injuries (SCI)⁸, and patients using gait aids¹⁴.

Establishing authors: Coleman, K. L., Smith, D. G.,
Boone, D. A., Joseph, A. W., & del Aguila, M. A¹

Data Type: Interval

Measurement Type: performance-based

Assessment Type: measured

Required Resources

Time: ~5 minutes to upload data

Personnel: Clinician familiar with StepWatch™ Activity Monitor software.

Equipment: StepWatch™ Activity Monitor, StepWatch™ docking station, and computer compatible with StepWatch™ software

Space: Hallway or walkway

Cost: Each StepWatch costs approximately \$500-600 per but price is dependent on the version. Please contact Modus Health for more information.

Test Administration

The StepWatch™ has dimensions 6.5 x 5.0 x 1.5cm and a weight of 65g¹⁶. It is to be worn on the medial or lateral side of the ankle of either leg with the rounded side pointed up¹⁸. The StepWatch™ should be placed on the distal pylon for persons with amputations. The StepWatch™ can be worn for minimum two days¹⁷ or until the memory is full for more accurate results (minimum of 40 days and maximum of 50 days)^{3, 10}. The StepWatch™ has no display and gives no immediate feedback. To access data, StepWatch™ must be connected to the software through a docking station that plugs into a USB port¹³.

The settings of the StepWatch™ are customized to each participant's height and gait characteristics and can be adjusted by adjusting the options of quick stepping, walking speeds, range of speeds and leg motion. Once the programming is completed, the light on the StepWatch™ will blink for the first 40 steps¹⁸. Confirm the setting suitability by checking the light on the top of the StepWatch™ blinks with each step. If it is double blinking on slow steps or missing fast steps, reprogram the StepWatch¹⁸. Several parameters are available from StepWatch™ data such as steps per day, total step counts for 1, 5, 20, 30 and 60 minutes, the peak activity index, which represents the average step rate of the fastest 30 minutes, and number of steps at high (>60 steps/min), medium (30-60 steps/min) and low (<30 steps/min) activity over a 24-hour period¹⁰.

Psychometric Properties

Reliability.

StepWatch™ has been found to be the most accurate pedometer detecting steps within 1-3% of actual steps for all speeds^{19, 15, 20}. It has an accuracy of between 96% and 99% for indoor and outdoor walking²¹. The leg mounted StepWatch™ was found to have accuracies of between 85.6 and 97.0% over different surfaces. In healthy adults, excellent intrarater reliability was found (ICC=0.96)²¹.

In older adult populations, excellent test-retest reliability has been established for non-impaired, impaired and those using a cane (ICC=0.87, 0.91 and 0.98, respectively)²⁹. The cane mounted StepWatch™ had similar results except for stairs and ramps (64%) indicating that the StepWatch™ could be used on a cane if calibrated properly⁷. The StepWatch™ is the most accurate for stride rates between 32 and 65 strides/minute⁹. Accuracy was reduced to 89% at speeds below 0.2m/s and stride lengths <0.4m but still considered the most reliable activity monitor²². Cadence, double support stance phase percentage, and gait variability did not appear to have a strong influence on the accuracy of the StepWatch™ for monitoring in inpatient rehabilitation²².

In patients with stroke, the 6MWT was found to be a significant predictor for the StepWatch™ outputs of Peak Activity Index ($r=0.72$) and Highest Step Rate in 1 minute ($r=0.73$)¹⁰. Furthermore, it had good to excellent test-retest reliability was found for all StepWatch™ outputs (ICC=0.83-0.989)^{10, 12}.

In populations with MS, the StepWatch™ was found to be 99.8-99.9% accurate at measuring steps across slow to fast walking speeds.

In populations with CMT, TBI, and incomplete SCI, it was found to have excellent test-retest (ICC >0.90)^{5, 12, 8}.

Validity.

In healthy adults, moderate correlation was found with high, medium and low activity ($p=0.59$, 0.48 and 0.42 , respectively)²¹. For populations with incomplete SCI, there is excellent concurrent validity with the 6MWT and 10MWT (ICC= 0.97 and 0.99 , respectively)⁸. For populations with PD and MS, there is a strong relationship with the GaitMat ($r=0.99-1.0$)⁴. In populations with CMT, a higher step rate was found to be related with quality of life⁵. In individuals with stroke, there is a strong concurrent correlation with the FitBit One ($r=0.99$)¹¹. In individuals with unilateral TT amputation, there is a significant correlation with the 10-meter walk test (10MWT) and Activity-Specific Balance Confidence Scale (ABC) ($r=0.53$ and 0.55 , respectively)^{23, 26}, excellent concurrent validity with the 6-Minute Walk Test (6MWT) and Four Square Step Test (FSST) or Figure or 8 Walk Test (F8WT) (ICC= 0.99 , 0.90)²³. It was also found that a 1-point increase in the Prosthetic Evaluation Questionnaire (PEQm) and Houghton Scale of Prosthetic Use resulted in an increase of 172 and 1532 steps/day, respectively, and that with each 1-year increase in age, there is an 87-98 step decrease in average step daily count²⁴. Inpatient rehabilitation demonstrated good to excellent validity with observed step count for the unaffected and affected sides (ICC= 0.972 and 0.823 , respectively)²².

Responsiveness.

The StepWatch™ was found to be responsive to heel tapping, leg swinging, and cycling (detected 100% of cycle pedal revolutions) and additionally, recorded zero steps while driving a car¹⁹.

Interpretation

The sampling frequency can impact the data that is obtained from the StepWatch™, for example when evaluating changes in bouts of activity rather than percentage of walking time within an hour⁶. It has been found that patterns of activity rather than total step count can be important indicators of changes in functional status¹³.

Table 1. Normative StepWatch™ data for different populations

Population	Average steps/day	% low activity (<15 steps/min)	% medium activity (16-40 steps/min)	% high activity (>40 steps/min)
5-11 years ²⁵	7604 ± 2337	55 ± 8	31 ± 4	14 ± 4
Healthy younger adults (n=30, aged 31-40) ²⁶	11,074 ± 534	n/a	n/a	n/a
Healthy older adults (n=28, aged 80-88) ²⁶	9982 ± 553	n/a	n/a	n/a
Older adults reporting functional limitations (n=12, aged 74-87) ²⁶	7682 ± 844	n/a	n/a	n/a
MS (n=10) ²¹	5970	n/a	n/a	n/a
PD (n=10) ²¹	7636	n/a	n/a	n/a
Muscular dystrophy (n=10) ²¹	6006	n/a	n/a	n/a
Diabetic TT (n=21) ²⁷	3882 ± 2168	n/a	n/a	n/a
Unilateral amputee post rehabilitation (n=77) ²⁸	6126 ± 3786	n/a	n/a	n/a
Chronic hemiparesis (n=59) ⁸	Household ambulators (walking speed <0.4m/s): 1411 ± 803 Limited community ambulators (walking speed 0.4-0.8m/s): 2668 ± 1193 Community ambulators (walking speed >0.8m/s): 3659 ± 1447	n/a	n/a	n/a

Limitations

The StepWatch™ only records stride rate, therefore step count must be calculated by multiplying the data by two¹⁹. StepWatch™ is not able to distinguish between different activities¹ and slower walking speeds or lower levels of activity (<2500 steps/day) have been found to result in higher underestimations of step count⁶. Furthermore, it has many parameters creating the potential for confusion within the assessment process⁵.

Documentation in Clinical Notes

Example: This patient was fit with a prosthesis approximately 1 year ago. They now wear their prosthesis all day but they are variable in when they don their prosthesis in the morning. Sometimes they don it at 5 am and other days closer to noon but they wear it to midnight each night. Over the last month, they took on average 6960 steps a day. This is very similar to the post-rehab average reported in literature of 6126 ± 3786 steps per day.

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