

Compliance with Using the Apple Watch for Physical Activity Assessment by Adults with an Intellectual Disability

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Abstract Although research-grade wearables are the predominant tool used to objectively assess physical activity (PA) for adults with an intellectual disability (ID), consumer-grade wearables, such as the Apple Watch® (AW), may hold promise. The objective was to evaluate the compliance of adults with ID with using the AW for PA assessment. The study used a descriptive, observational design. Nine adults with ID were instructed to use the AW Series 4 for a consecutive seven-day PA assessment. Behavioral strategies to support compliance included visual activity schedules and daily activity logs. Demographic, physical, functional, and cognitive/language characteristics were assessed. Heart-rate (HRC; '≥10hrs hourly heart rate') and step-count (SCC; 'between 1,703-24,369 steps/day') compliance criteria were used to define valid days and reduce PA data (i.e., daily energy expenditure and steps). Log entries were coded as self-, caregiver- and researcher-written. Descriptive statistics were calculated. Six participants met the HRC and seven met the SCC for at least four days. Differences for all PA data were observed when reduced based on the HRC vs. SCC. Log entries were 57% researcher-, 40% self-, and 4% caregiver-written. Compliance was comparable to other research-grade wearables used for PA assessment by adults with ID. Additional individualized strategies may enhance compliance with the use of the AW. The findings support the need for an adapted activity log to encourage independent use by adults with ID.

Keywords: activity log, Apple Watch, intellectual disability, physical activity, visual activity schedule, wearable

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1. Introduction

An intellectual disability (ID) is characterized by significant limitations in intellectual functioning and adaptive behaviors with onset before 22 years of age [1]. Adults with an ID experience heightened health disparities compared to adults without an ID, including a greater risk of morbidity and mortality from cardiometabolic diseases [2]. Physical activity (PA), a potent modifiable behavior for the promotion of cardiometabolic health [3,4], is defined as "any bodily movement produced by skeletal muscles that result in energy expenditure (EE)" ([5], p.126). Four main dimensions characterize PA, including duration (i.e., the time of a continuous bout), frequency (i.e., the number of bouts within a specified timeframe), intensity (i.e., rate of EE), and mode (i.e., type of body movement made) [6].

To obtain health benefits, the 2018 *Physical Activity Guidelines for Americans* [7] recommend that each week, adults with disabilities, if able, should participate in at least 150 min of moderate-intensity, or 75 min of vigorous-intensity, or an equivalent combination of

moderate-to-vigorous-intensity aerobic PA; and two days of muscle-strengthening activities [7]. Additional benefits may occur with higher PA levels through higher intensity, greater frequency, and longer duration [7]. Hill's step-count indices categorize PA levels into four categories: inactive (<5,000 steps/day), low-active (5,000-7,499), somewhat-active (7,500-9,999), and active (≥10,000) lifestyle [6]. However, reviews continue to suggest that adults with an ID do not participate in sufficient PA levels [8,9].

1.1. Physical Activity Assessment

With public health efforts to promote PA participation in adults with an ID, standardized PA assessment methods are needed to determine dose-response relationships between PA and health outcomes and inform optimal population-specific guidelines [10]. In the free-living setting, subjective (indirect self- or proxy-reporting) or objective (direct quantification) methods can be used to assess PA. Subjective methods, such as activity logs, have been criticized for potential recall and social desirability biases, high error rates, and reliance on caregiver participation [8,11,12]. Therefore, reviews [8,13] have increasingly called for improved objective methods of PA

assessment in adults with an ID, such as the use of wearables.

Wearables (e.g., pedometers, accelerometers, heart rate monitors) are categorized as either consumer- or research-grade based on their commercial availability. In adults with an ID, research-grade wearables (e.g., ActiGraph accelerometers) have been the predominant tool selected for PA assessment [8,14,15]. Some studies have reported considerable error rates [16] and low compliance rates (<50% of participants had sufficient wear time) when using research-grade wearables in adults with an ID, potentially due to participants perceiving the wearable as “cumbersome” [17] or lacking the motivation to wear them [18]. Meanwhile, consumer-grade wearables have gained credibility for PA assessments in adults without an ID.

1.2. The Apple Watch

The Apple Watch® (AW) is a market-leading, consumer-grade tri-axial accelerometer and heart rate monitor. Growing evidence supports its promising psychometric properties (i.e., validity, reliability, sensitivity, and feasibility) for assessing PA and heart rate (HR) in adults without an ID [19]. Notably, the AW performs well when compared to other consumer-grade wearables [20], research-grade wearables [21], and laboratory-based objective methods, such as whole-room metabolic chambers [22]. Therefore, further investigation is warranted to explore the potential utility of the AW for PA assessment in adults with an ID.

1.3. Compliance

Compliance analysis is an essential precursor for PA assessment to ensure the collected data are reliable [23]. In this study, compliance with ‘using a wearable for PA assessment’ is operationally defined as correctly putting the wearable on the non-dominant wrist, sufficiently wearing the wearable during wake hours, and sufficiently charging the wearable for the assessment timeframe of seven consecutive days. Missing or skewed data may indicate insufficient or improper use of the wearable (e.g., putting the wearable in a pant pocket, wearing an uncharged wearable, or taking off the wearable during wake hours), leading to reduced statistical power and compromised psychometric properties of the PA assessment [23]. To indicate a ‘valid day’ of data collection, two criteria used in adults with an ID have been: (1) the presence of hourly data (i.e., a non-zero step count) for at least 10 hours/day [15], which ensures comprehensive and reliable data; and (2) the step-count range falling between 1,703 and 24,369 steps/day to eliminate outliers and ensure the data are within a reasonable range [24]. A minimum of four days out of seven are typically needed to estimate PA levels reliably [15].

To promote compliance with using wearables for PA assessment, investigators can implement different behavioral strategies that participants can use in the free-living setting [23]. One of the most widely used participant-based behavioral strategies to promote compliance with using accelerometers for PA assessment in adults with an ID is implementing an activity log [15]. However, this strategy has been questioned due to

concerns that adults with an ID may face barriers with writing entries in the log [11,24,25]. To address this issue, a common investigator-based strategy for assessing PA in adults with an ID is to provide explicit written instructions of what is expected of participants during the assessment timeframe [11,24].

1.4. Purpose

A thorough search of the literature yielded no relevant studies that assessed PA in adults with an ID using the AW in the free-living setting. Therefore, the main objective of this study was to examine the compliance with using the AW for PA assessment by adults with an ID in the free-living setting. The research questions were: (1) what percentage of adults with an ID met the compliance criteria for at least four valid days based on the heart-rate compliance criterion (HRC) of ‘≥10 hours of HR data/day’ and the step-count compliance criterion (SCC) of ‘between 1,703-24,369 steps/day’; (2) did PA levels differ when reducing the data based on meeting the HRC or SCC; (3) what percentage of adults with an ID wrote entries in their activity logs; and (4) what were the characteristics of the participants who did not meet the compliance criteria or had the lowest percentage of activity log entries. No pre-specified hypotheses were included, given the novelty of using the AW for PA assessment by adults with an ID.

2. Methods

The study used a descriptive, observational design following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for observational studies. The treatment of participants during the study followed the ethical standards of the American Psychological Association with Institutional Review Board approval (#1437488) before commencement. All participants and their caregivers (if applicable) signed a consent form to participate.

2.1. Participants

Initially, a sample of 11 adults with an ID was enrolled in the study. However, two participants were later discontinued. Although there was a plan to enroll more participants, the sample size was ultimately limited due to the COVID-19 lockdown protocols that began in March 2020. Participants were recruited via an urban non-profit human services organization serving adults with an ID. The inclusion criteria were adults aged 18-45 years who have received state-funded services for an ID with any level of support needs before the age of 18 years and are currently receiving at least six hours of those services. The exclusion criteria included having a skin condition that could worsen when wearing the AW, a severe sensory disability, an unstable psychiatric or neurological disorder, or an uncontrolled cardiac, vascular, respiratory, or kidney disease; using a wheelchair to perform activities of daily living or an implanted heart pacemaker; or being pregnant or undergoing treatment for an illness or injury that could affect PA. The agency’s director emailed potential

participants an invitation letter and written consent forms.

2.2. Materials and Methods

Participants' basic demographic information was collected from their caregivers using the Demographics section of the 2019 *Behavioral Risk Factor Surveillance System Questionnaire* [26]. Body composition was estimated using body mass index (BMI) scores (weight[kg]/height[m]²). Weight and height were measured barefoot to the nearest 0.1 kg and 0.5 cm using a calibrated scale and stadiometer, respectively.

The *Unipedal Stance Test* (UPST) assessed the duration of static balance [27] to the nearest 0.01 s. Participants were asked to stand barefoot on one limb with the other raised near but not touching their stance ankle, cross their arms on their chest, and focus on an eye-level marker on the wall. The best of three trials was recorded. The *Six-Minute Walk Test* (6MWT) assessed aerobic capacity and functional ability [28]. Participants were asked to walk as fast as possible for 6 min on an outdoor track. Following validation studies for adults with an ID [29], a researcher provided standardized encouragement every minute while walking ≥ 10 ft behind the participant [29]. The distance was measured using a wheel with a precision of 1 cm. The 6MWT is a reliable (ICC = .96) and valid test for assessing cardiorespiratory fitness in adults with an ID [30].

The *Wechsler Abbreviated Scale of Intelligence-Second Edition* (WASI-II), a battery of four subtests (Block Design, Vocabulary, Matrix Reasoning, and Similarities) assessed participants' complete cognitive capacity as indicative by the Full-Scale Intelligence Quotient (FSIQ-4) score [31]. The Vocabulary and Similarities subtests form a Verbal Comprehension Index (VCI) score, and the Block Design and Matrix Reasoning subtests form a Perceptual Reasoning Index (PRI) score. The *Receptive One-Word Picture Vocabulary Test-Fourth Edition* (ROWPVT-4) assessed receptive vocabulary skills [32] by indicating how well a person matches a word that is heard to objects, actions, or concepts presented in full-color pictures. The tests were administered by a certified school psychologist using their respective standard administration procedures.

PA data were collected using the newest model of the AW at the time—the Series 4 (Apple, Inc., Cupertino, CA, USA). Participants were instructed to put on and wear the AW for one week on their non-dominant wrist during wake hours (unless swimming in open waters) and put it on a charger before bed. The AW was individualized based on age, sex, race, weight, and height. Access to the AW features and applications was locked to minimize their potential effect on participant compliance and PA. PA level was classified using daily steps and described using daily active EE and resting EE from the AW. Total EE was calculated by summing a participant's active and resting EE.

Activity logs and *visual activity schedules* (VAS) were specifically developed for this study. Each activity log was divided into half-hourly timestamps for up to 48 entries/day (i.e., 336 entries/week) with corresponding room to write in activity entries (see Figure 1). Two VAS were developed to help participants correctly put on and charge the AW (see Supplemental Materials). The second

author (I.O.) first conducted a task analysis, which generated sequences of seven subtasks for putting on and four subtasks for charging the AW. Each subtask consisted of (a) a written list of two to four simple steps, (b) a photo of the subtask enhanced with visual cues to indicate directions of movement and help focus attention on a particular part of the body or device, and (c) a box for the participant or the caregiver to make a checkmark. The relevance and comprehensibility of the schedules' content were assessed by a panel of five content experts, including the first author [C.F.], two exercise science professors, one special education professor, and one graduate student, using a four-point rating scale. The panel was tasked to evaluate each step in the tasks by answering two questions: "How relevant is the statement to the critical steps of the task or subtask?" and "How easily understandable would the statement be for an adult with an ID?". Revisions were made, and additional reviews were conducted until all scores were between 3-4. The Flesch Reading Ease scores for both schedules were 100. The Flesch-Kincaid Reading Grade Level scores for putting on and charging the AW were 1.7 and 1.1, respectively, which corresponds to a first-grade level [33].

Date: _____ Code #: _____

ACTIVITY LOG

I put Apple Watch on at _____ I took Apple Watch off at _____

Did you have to take Apple Watch off during the day? Please tell us what time and for how long.
Remember you can make your watch wet. You can swim with it. Do not wear it when swimming in open waters
(e.g., a river or the Ocean). Do not wear it when working with chemicals.

For each 30-minute period, tell us what kind of activity you did while wearing Apple Watch. You can record more than one activity in the 30-minute interval. Please fill out one chart for each day you wear your Apple Watch.

Time	Name of Activity	Time	Name of Activity
7:00 a.m.		7:00 p.m.	
7:30 a.m.		7:30 p.m.	
8:00 a.m.		8:00 p.m.	
8:30 a.m.		8:30 p.m.	
9:00 a.m.		9:00 p.m.	
9:30 a.m.		9:30 p.m.	
10:00 a.m.		10:00 p.m.	
10:30 a.m.		10:30 p.m.	
11:00 a.m.		11:00 p.m.	
11:30 a.m.		11:30 p.m.	
12:00 p.m.		12:00 a.m.	
12:30 p.m.		12:30 a.m.	
1:00 p.m.		1:00 a.m.	
1:30 p.m.		1:30 a.m.	
2:00 p.m.		2:00 a.m.	
2:30 p.m.		2:30 a.m.	
3:00 p.m.		3:00 a.m.	
3:30 p.m.		3:30 a.m.	
4:00 p.m.		4:00 a.m.	
4:30 p.m.		4:30 a.m.	
5:00 p.m.		5:00 a.m.	
5:30 p.m.		5:30 a.m.	
6:00 p.m.		6:00 a.m.	
6:30 p.m.		6:30 a.m.	

Figure 1. The activity log used black Arial font of 12pt or larger size on white background.

2.3. Procedures

The study was conducted between July 2019-March 2020. The first session was held in a private room to explain study procedures, obtain consent, and complete initial assessments (i.e., demographics, BMI, UPST, WASI-II, ROWPVT-4). The second session was held on the University outdoor track in clear weather (for adequate GPS reception) to calibrate the AW through a 20-min walk; conduct the 6MWT; and familiarize participants

with the AW, VAS, and activity log. With the assistance of the VAS and verbal and visual prompting, participants were taught how to put on and charge the AW. Participants were instructed to seek caregiver assistance as needed for using the AW or completing the activity logs over the next seven consecutive days. Missing entries were completed by the researcher through 24-72-hour activity recall sessions at the day program. The participant used the Heart Analyzer V8 application (Helix Apps LTD, Evesham, UK) on a paired iPhone, which graphically displays highlighted times with HR and PA peaks to aid recall. If participants could not recall an activity based on the time of day, they were asked to provide a comprehensive account of their day or weekend. Participants earned up to \$35.00 in gift cards.

2.4. Data Processing and Analysis

Daily PA data from the AW were downloaded, exported to an Excel spreadsheet, and imported to Stata Statistical Software (StataCorp. 2021. Release 17. College Station, TX: StataCorp LLC). The percentage of participants meeting the HRC and SCC was calculated. For participants who did not meet a valid day based on HRC or SCC, their PA data were analyzed separately. Descriptive statistics were computed for quantitative data. Qualitative data from activity logs were coded as self-, caregiver-, or researcher-written in an Excel spreadsheet, with total entry and percentage breakdowns for each group over the seven-day period.

3. Results

3.1. Participant Characteristics

Participant characteristics are shown in Table 1. Data were analyzed from nine adults, five females and four males, aged 21-36 years. Five of the participants reported their race as Black and four as White. Based on BMI scores, one participant was classified within the normal range, four with overweight, one with Class I, one with Class II, and two with Class III obesity [34]. Due to COVID-19 restrictions, only five participants completed the WASI-II and the ROWPVT-4. All available FSIQ-4 scores were <70 (a diagnostic criterion for an ID), with three participants having FSIQ-4 scores between 52-69 and two between 36-51, indicating intermittent and limited support needs, respectively [31]. Five participants had ROWPVT-4 age-equivalent scores between 8-0 years (range 4-2 to 14-4) [32]. Participant 7 was co-diagnosed with Down syndrome and Participant 8 with cerebral palsy.

3.2. Compliance

Six participants met the HRC, seven met the SCC, and six met both compliance criteria (see Table 2). However, two participants did not meet either of the compliance criteria. Only one participant had ≥ 10 hours/day of HR data and was within the step-count range on all seven days. Two participants remained within the step-count range on all seven days. The mean wear-time for all participants, regardless of meeting the compliance criteria, was

66.7 $\pm$ 38.3 hours/week (range: 12-149) and 9.5 $\pm$ 5.5 hours/day (range: 0-24). For participants who met the HRC or SCC for at least four days, the mean wear-time was 12.0 $\pm$ 4.7 or 11.3 $\pm$ 4.8 hours/day, respectively.

Table 1. Participant Characteristics.

PP	AGE (yrs)	FSIQ [†]	VCI [†]	PRI [†]	ROW PVT	BMI/WT (kg)	DOM/CL UPST (s)	6MWT (m)
1	22	NA [‡]	NA [‡]	NA [‡]	NA [‡]	27.8/82.8	7.9/1.4	563.2
2	36	NA [‡]	NA [‡]	NA [‡]	NA [‡]	39.7/100.3	6.3/2.9	471.8
3	21	57	63	56	101	38.6/99.4	2.2/1.7	522.2
4	31	46	55	45	104	24.5/67.5	12.1/2.0	660.7
5	21	NA [‡]	NA [‡]	NA [‡]	NA [‡]	31.6/80.2	13.7/3.9	477.3
6	24	69	75	66	150	29.4/70.1	32.8/1.8	617.3
7	28	44	45	51	53	48.4/129.0	1.2/0.9	488.6
8	24	53	55	57	98	20.2/40.6	NA [§]	409.8
9	34	NA [‡]	NA [‡]	NA [‡]	NA [‡]	28.7/87.9	20.2/3.3	510.3
M	26.8	53.8	58.6	55.0	101.2	32.1/84.2	12.0/2.2	524.6
SD	5.7	10.0	11.2	7.8	34.4	8.7/24.8	10.5/1.0	77.7

Note. BMI/WT = body mass index and weight; DOM/CL UPST = Dominant-limb and Closed-eyes Unipedal Stance Test; FSIQ = WASI-II's Full Scale Intellectual Quotient composite score (mild ID = 52-69; moderate ID = 36-51); NA = not available; PP = participant; PRI = Perceptual Reasoning Index; ROWPVT = Receptive One-Word Picture Vocabulary Test-Fourth Edition raw score; VCI = Verbal Intelligence Index; 6MWT = six-minute walk test. [†] Confidence interval = 95%. A composite score <70 indicates an extremely low ID. [‡]not assessed due to COVID-19 restrictions. [§]refused to complete the assessment.

Table 2. Wear time of the Apple Watch over a consecutive seven-day recording period.

PP	HOURS			DAYS	
	Per Week	Per Day		With ≥ 10 hrs.	Within 1,703-24,369 Steps
		M	Range	Total (wknd)	Total (wknd)
1	46	6.6	0-18	3 (0)	5 (1)
2	62	8.9	0-16	4 (0)	5 (1)
3	85	12.1	8-15	6 (2)	7 (2)
4	12	1.7	0-10	1 (0)	2 (0)
5	60	8.6	0-12	4 (1)	6 (2)
6	149	21.3	13-24	7 (2)	7 (2)
7	70	10.0	4-13	4 (0)	6 (1)
8	80	11.4	0-16	6 (1)	6 (1)
9	36	5.1	0-14	3 (0)	3 (0)
M	66.7	9.5		4.2 (0.7)	5.2 (1.1)
SD	38.3	5.5		1.9 (0.9)	1.7 (0.8)

Note. PP = participant; wknd = weekend days

3.3. Physical Activity

When comparing data reduced using the HRC and SCC (see Table 3), the average differences were 753.6 $\pm$ 314.6 (11.8 $\pm$ 13.5%, range = 0.0-753.6) steps, 127.6 $\pm$ 44.1 (5.5 $\pm$ 6.3%, range = 0.0-279.2) kcal for total EE, 70.3 $\pm$ 25.0 (14.3 $\pm$ 15.6%, range = 0.0-70.3) kcal for active EE, and 57.3 $\pm$ 20.2 (3.2 $\pm$ 4.0%, range = 0.0-57.3) kcal for resting EE. Using Hill's step-count indices [6], seven participants had an average daily step-count data within the low-active, one within the sedentary, and one within the active lifestyle range when data were reduced using the HRC. In contrast, when data were reduced using the SCC, four participants had step-count data within the sedentary, four within the low-active, and one within the somewhat-active lifestyle range.

Table 3. Daily physical activity over a consecutive seven-day recording period using the Apple Watch.

PP	M PA BASED ON HRC		M PA BASED ON SCC	
	TEE / AEE (kcal/d)	Steps/d	TEE / AEE (kcal/d)	Steps/d
1	2565.4 / 613.2 [†]	11357.0 [†]	2286.2 / 429.2	8711.1
2	2980.5 / 650.4	6794.5	2721.8 / 520.3	5966.6
3	2645.0 / 530.7	5482.9	2604.7 / 508.6	5359.6
4	1615.8 / 373.5 [†]	5854.3 [†]	1351.1 / 250.7 [‡]	4067.6 [‡]
5	2197.8 / 363.6	5074.5	2153.3 / 339.9	4802.2
6	2032.1 / 291.1	3603.7	2032.1 / 291.1	3603.7
7	3706.6 / 789.5	5541.8	3445.7 / 639.6	4415.2
8	1267.2 / 179.8	5158.9	1267.2 / 179.8	5158.9
9	2329.1 / 401.3 [†]	5268.6 [†]	2329.1 / 401.3 [‡]	5268.6 [‡]
M	2371.1 / 465.9	6015.1	2243.5 / 395.6	5261.5
SD	724.9 / 193.7	2169.9	672.3 / 146.0	1479.8

Note. Based on data reduced to valid days defined by the heart-rate compliance criterion (HRC; ≥ 10 hours/day) or the step-count compliance criterion (SCC; 1703-24,369 steps/day). [†] PP did not meet the HRC for ≥ 4 days/week; therefore, data is based on <4 days/week. [‡] PP did not meet the SCC for ≥ 4 days/week; therefore, data is based on <4 days/week.

3.4. Activity Logs

Table 4 displays the frequencies and percentages of activity-log entries written by the participant, caregiver, or researcher. Three participants wrote over 90% of the entries/week, while four did not write any entries in their activity logs. Participants who did not write entries had FSIQ scores ranging from 44-54 and ROWPVT scores from 53-104. Only one caregiver wrote 48 (36%) entries/week. For three of the participants, 100% of their entries were written by the researcher.

Table 4. Half-hourly activity log entries (out of 336 potential) over a consecutive seven-day recording period.

PP	ACTIVITY LOG ENTRIES COMPLETED (%)		
	Self-Written	Caregiver-Written	Researcher-Written
1 [†]	197 (92.5)	0 (0)	16 (7.5)
2	182 (96.8)	0 (0)	6 (3.2)
3	192 (91.4)	0 (0)	18 (8.6)
4 ^{**}	0 (0)	0 (0)	49 (100)
5	0 (0)	0 (0)	97 (100)
6	148 (66.1)	0 (0)	76 (33.9)
7	0 (0)	48 (36.1)	85 (63.9)
8	0 (0)	0 (0)	116 (100)
9 ^{**}	16 (9.0)	0 (0)	162 (91.0)
M	81.7 (39.5)	5.3 (4.0)	69.4 (56.5)
SD	94.2 (45.6)	16.0 (12)	52.1 (43.3)

Note. [†] PP did not meet the HRC for ≥ 4 days/week. ^{**} PP did not meet the SCC for ≥ 4 days/week.

4. Discussion

The study's main objective was to examine the compliance of adults with an ID with using the AW for PA assessment in the free-living setting. Of the nine participants, six (67%) met the HRC (requiring at least 10 hours of hourly HR data/day), and seven (78%) met the SCC (requiring between 1,703-24,369 steps/day) for at least four of the seven consecutive days. These compliance rates were consistent with those reported in a systematic review [15] on accelerometer use for PA assessment in individuals with an ID. The review found

compliance rates between 64.7-100% with the application of behavioral strategies and 44.6-98.5% without them. Furthermore, Leung et al. [15] found that, across 17 studies, individuals with an ID wore research-grade accelerometers for an average of 9.9 hours/day, which is similar to the averages observed in this study (9.5 ± 5.5 hours/day for all participants, 12.0 ± 4.7 hours/day for the six participants who met the HRC, and 11.3 ± 4.8 hours/day for the seven participants who met the SCC for at least four valid days of the seven-day assessment).

Prior research supports the high accuracy of the AW's accelerometer and HR sensors for assessing step and HR counts in adults without an ID, respectively [35]. This study found notable differences in daily steps and EE (total, active, and resting) based on the valid days defined by the HRC or SCC that led to changes to Hill's step-count indices [6]. One potential explanation for the differences in PA levels may be that the HR sensor only registers HR counts when the AW is correctly turned on, worn on the wrist, and charged [36]. Thus, a compliance criterion based on physiological (i.e., HR) rather than behavioral (i.e., step-count) biometrics may be more informative in reducing the data and subsequently characterizing PA levels.

Applying behavioral strategies, such as education and support, can ensure the correct and sufficient use of the AW for PA assessment. In this study, a short (<15 mins) educational session and tailored support [1] were provided to match individual participants' needs, based on their cognitive abilities and language skills, to the environmental demands. The skills for using the AW (i.e., putting on and charging) were taught using the VAS and verbal and visual prompting in a structured setting, later transitioning to an unsupervised free-living setting. However, additional investigator-based behavioral support strategies could further improve compliance, such as providing additional familiarization sessions, reminders (e.g., via text messages or posters), and a concealment technique to hide the wearable from immediate view [15]. Furthermore, a study [37] found that support strategies, including 24-hour versus wake hours instruction, social stories (i.e., a narrative with illustrations to clarify instructions in specific situations), and contingent monetary incentives, significantly improved compliance with wearing an accelerometer for PA assessment (from 51.9% to 97.4%). It is important to consider these strategies to maximize compliance and the accuracy of PA assessment in future studies using the AW or other wearable devices.

Activity logs are frequently used as a participant-based strategy to improve compliance with accelerometer use in individuals with an ID [15]. However, this study found that of the four participants with a mean wear time greater than 10 hours/day, only two self-wrote a majority ($>50\%$) of their activity log entries, while the other two self-wrote no entries. This finding is consistent with a previous study [25] that suggested adults with an ID may have trouble self-writing entries in an activity log. Consequently, it has been recommended that caregivers assist with activity log entries to improve compliance rates [38]. In this study, only one participant had caregiver-written log entries, which accounted for 36% of the participant's total entries. This participant had a mean wear time of 10 hours/day.

Instead, five participants had a majority (>50%) of their activity log entries written by a researcher using a 24–72-hour recall method with the HR Analyzer V8 application on a paired iPhone. Although the 24–72-hour recall method provided 57% (range: 3–100%) of activity log entries, anecdotally, it was time-consuming to provide rich, in-depth data tied to specific times of the day. Overall, it remains uncertain whether self-writing activity log entries, with or without the assistance of a caregiver, during the PA assessment week improves compliance with using the AW by adults with an ID. The low percentage of self-entries in our findings may be due to the activity log itself. The low percentage of self-entries in the findings could be due to the activity log format used in this study or the absence of individualized instructional strategies to teach participants how to use the log. The findings suggest that activity log formats should be adapted based on a person's cognitive abilities, verbal comprehension, and receptive language to improve compliance with using the AW for PA assessment by adults with an ID.

4.1. Strengths and Limitations

The article emphasizes the need for improved PA assessment methods to support the use of the AW and activity logs by adults with an ID in the free-living setting. The study has four main strengths. First, it performed a comprehensive compliance analysis of the use of the AW to assess PA in adults with an ID, comparing two compliance criteria to ensure data reliability. Second, it developed a task-analyzed VAS to assist participants in correctly putting on, charging, and cleaning the AW during the PA assessment. Third, it used an innovative 24–72-hour recall method supplemented with the HR Analyzer V8 application to ensure data quality. Fourth, it analyzed activity log entries based on authorship, distinguishing between self-, caregiver-, and researcher-written entries.

Study limitations included a small sample size of adults with an ID with intermittent-to-limited support needs recruited from the same urban day program, potentially introducing potential selection bias, and limiting generalizability. Additionally, COVID-19 mandates or restrictions prevented cognitive assessments for four participants, which could have impacted the results.

Despite these limitations, the research team deemed the findings significant to warrant publication, providing valuable insights for future research inquiries. The preliminary findings suggest that adults with an ID can correctly and efficiently use the AW for PA assessment (i.e., correctly put it on, wear it during all wake hours, and charge it) in the free-living setting. Nevertheless, there is a need for further development and refinement of behavioral strategies, specifically related to the activity log, to enhance compliance with using the AW for PA assessment in the free-living setting.

5. Conclusion

The study found that compliance of adults with an ID with using the AW for PA assessment may be comparable to other accelerometers used in the free-living setting. To

enhance the validity of future studies, the compliance criterion used for data reduction to valid days should be explicitly reported. To improve the correct and sufficient use of the AW by adults with an ID for PA assessment, further research into investigator-based and participant-based behavioral strategies is necessary. The VAS developed in this study can aid in teaching participants how to correctly put on and charge the AW. It is recommended to explore individualized adaptations to the log format based on participants' cognitive characteristics. Finally, an investigation into using an activity log as a behavioral strategy to enhance compliance with using the AW for PA assessment is needed.

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Statement of Competing Interests

The authors declare no competing interests or disclosures.

List of Abbreviations

AW = Apple Watch®; BMI = Body Mass Index; CP = Cerebral Palsy; DD = Developmental Disability; DS = Down Syndrome; EE = Energy Expenditure; FSIQ-4 = Full-Scale Intelligence Quotient; HR = Heart Rate; HRC = Heart-rate Compliance Criterion; ID = Intellectual Disability; PA = Physical Activity; PRI = Perceptual Reasoning Index; ROWPVT-4 = Receptive One-Word Picture Vocabulary Test- Fourth Edition; SCC = Step-count Compliance Criterion; UPST = Unipedal Stance Test; VAS = Visual Activity Schedule; VCI = Verbal Comprehension Index; WASI-II = Wechsler Abbreviated Scale of Intelligence-Second Edition; 6MWT = Six-Minute Walk Test

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