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Factors associated with digital health literacy among community-dwelling older adults in Japan: An in-person cross-sectional study

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Abstract: Digital health literacy (DHL) is increasingly important as health information, appointment systems, patient portals, and other services move online. However, evidence in older adults remains limited and is often based on online surveys that may underrepresent digitally disadvantaged groups. This in-person cross-sectional study examined factors associated with DHL among 91 community-dwelling older adults in Japan. Participants completed paper-based questionnaires and performance-based assessments, including a modified 15-item score from the Japanese Digital Health Literacy Instrument (DHLI-J), the Japanese version of the Montreal Cognitive Assessment (MoCA-J), and the Nine-Hole Peg Test (NHPT). Group comparisons, bivariate correlations, and hierarchical multiple regression analyses were performed, with structural equation modeling (SEM) as a supplementary analysis. Higher modified DHLI-J scores were associated with younger age, longer personal computer use, better cognitive function, better manual dexterity, greater digital confidence and interest, and better well-being. In the final regression model (adjusted $R^2 = 0.37$), older age was independently associated with lower modified DHLI-J scores, whereas better cognitive function and greater confidence in using digital devices were independently associated with higher scores. The exploratory supplementary SEM showed acceptable fit ($\chi^2(11) = 13.96$, $p = 0.24$; $\chi^2/df = 1.27$; comparative fit index (CFI) = 0.97; root mean square error of approximation (RMSEA) = 0.06) and indicated positive cross-sectional associations between digital attitudes and DHL and between DHL and well-being; these associations should not be interpreted as causal. These findings may inform user- and system-level strategies intended to reduce digital exclusion and support more equitable digital health access, although access to digital health services and equity outcomes were not measured.

***Keywords*:** digital divide, digital confidence, community-based assessment, health care access, well-being

1. Introduction

Digital transformation in health care has accelerated worldwide, with health information, appointment systems, telehealth, and patient portals increasingly delivered through digital technologies (*1*). However, benefits of these services are not distributed evenly. Older adults may face barriers related to access, usability, confidence, and opportunities for meaningful engagement, resulting in persistent digital exclusion, even when devices are available (*1,2*). In Japan, one of the most rapidly aging countries, this issue is particularly important as the public and private sectors continue to expand digital health-related services and expect citizens to navigate them independently.

Digital health literacy (DHL) refers to the skills required to seek, understand, appraise, and apply digital health information and services (*2*). The Digital Health Literacy Instrument (DHLI) conceptualizes DHL as a multidimensional construct that includes operational and navigation skills, information searching, reliability evaluation, and relevance determination (*2*). A Japanese version of the DHLI (DHLI-J) was recently developed, enabling empirical examination of DHL in older Japanese populations (*3*). Existing reviews indicate that DHL in later life is associated with age, educational and socioeconomic resources, confidence-related constructs, health status, and broader social resources (*4-7*). At the same time, these reviews noted considerable heterogeneity in study populations and measurement approaches, making it difficult to determine which correlates remain robust when assessing digital skills in older adults who are not selected on the basis of digital participation.

A methodological challenge in this literature is that many studies rely on online surveys (*4-7*).

Because online participation requires a degree of digital access and competence, such designs may systematically underrepresent older adults with lower skills, confidence, or greater functional difficulty (*8,9*). Consequently, the average DHL and its correlates may be estimated from samples that are already selectively digitally engaged. This limitation is especially important when the variables of interest include cognition and hand function, because these factors may influence not only digital task performance but also willingness or ability to participate in online-only research. In-person assessment may reduce selection based on the ability or willingness to complete an online survey and may therefore include device-owning older adults with lower digital confidence or greater functional limitation. However, an in-person design does not capture digital exclusion arising from a lack of device ownership, which may represent a barrier before DHL can be assessed.

The functional demands of contemporary digital health environments are increasingly complex (*2,8*). Searching for health information, navigating websites or patient portals, interpreting unfamiliar terminology, and recovering from input errors can place substantial demands on attention, working memory, comprehension, and executive control (*2,8*). Likewise, common digital operations, such as tapping, scrolling, typing, and handling authentication procedures, depend on fine motor control and manual dexterity (*10,11*). Although cognitive aging and age-related upper-limb changes are well recognized, few DHL studies have directly integrated performance-based cognitive and manual assessments into explanatory models, especially within Japanese community settings (*4-7,10,11*). Clarifying these task-related demands is important because they represent plausible real-world barriers, even for older adults who nominally have access to devices.

DHL may also have broader relevance to healthy aging, community participation, and equitable access to care. Technology use has been linked to quality of life and psychosocial well-being among older adults (*12*). Digital inclusion may support independence, access to health information, communication, and health-related decision-making, whereas limited DHL may deepen existing inequities when essential services are shifted online. Scoping reviews suggest that DHL is positively associated with mental health and well-being (*5-7*), although evidence focused specifically on community-dwelling older adults remains limited. From a public health perspective, clarifying how cognitive function, manual dexterity, digital attitudes, and well-being are interconnected may help municipalities, community health providers, and health systems design digital services that are not only available but also genuinely usable for older adults.

This study aimed to identify factors associated with DHL among community-dwelling older adults in Japan using an in-person assessment. Specifically, we compared participant characteristics across descriptive categories of the modified DHLI-J score, examined bivariate associations between the modified DHLI-J score and demographic, digital-use, cognitive, physical, and psychosocial variables, and identified its independent correlates using hierarchical multiple regression. In addition, we used supplementary structural equation modeling (SEM) to examine a prespecified pattern of cross-sectional associations among age, cognitive/physical functioning, digital attitudes, DHL, and well-being. By combining in-person community-based assessments with functional and psychosocial measures, this study sought to generate methodologically sound evidence that may inform strategies for more equitable digital health access in an aging society.

2. Materials and Methods

2.1. Study design and participants

This cross-sectional study recruited community-dwelling older adults from a municipality in Japan through community centers and local outreach linked to community-based preventive activities. The eligibility criteria were age ≥ 65 years and ownership of a personal computer or mobile device, such as a smartphone or tablet. Individuals were excluded if cognitive impairment, including dementia, made it difficult to complete the questionnaire or if informed consent could not be obtained. Individuals were also excluded if they were unable to rise from a chair, maintain standing, or walk, because these abilities were required to complete the physical function assessments. Written informed consent was obtained from all participants.

In total, 96 individuals attended the assessment sessions. Five were not included in the final analytical sample: one did not provide informed consent, one did not meet the prespecified device-ownership eligibility criterion because they owned neither a personal computer nor a mobile device, two were aged < 65 years, and one had incomplete questionnaire data. The final sample included 91 participants.

The study was approved by the Research Ethics Committee of the Faculty of Human Sciences, University of Tsukuba (Tokyo Area Committee) (approval number: TO23-112) and conducted in accordance with the Declaration of Helsinki.

2.2. Procedures

Participants completed paper-based questionnaires and underwent in-person assessments administered by trained rehabilitation professionals. Data were collected across two community assessment sessions. The in-person design was chosen to reduce reliance on online survey completion among device-owning participants and to measure cognitive and physical functions directly.

2.3. Measures

DHL was assessed using the DHLI-J (*3*). The full DHLI-J consists of 21 items covering seven domains: operational skills, information searching, evaluating reliability, determining relevance, navigation skills, adding self-generated content, and protecting privacy. Items 16–18 assess the ability to add self-generated content, whereas items 19–21 assess privacy protection when posting messages on web forums, community websites, or social media. Because of substantial noncompletion of these six posting-related items, the content-creation and privacy-protection domains were excluded from the score. The modified score was the mean of items 1–15 after reverse scoring. Possible scores ranged from 1 to 4, with higher scores indicating greater DHL. Internal consistency of the retained 15 items was assessed using Cronbach's alpha. This modified 15-item score covers five of the seven original DHLI-J domains and should not be regarded as psychometrically equivalent to the validated 21-item DHLI-J.

Cognitive function was assessed using the Japanese version of the Montreal Cognitive Assessment (MoCA-J) (*13*). Manual dexterity was measured with the Nine-Hole Peg Test (NHPT), with shorter completion times indicating better dexterity. The NHPT has demonstrated acceptable reliability in adult patients (*14*). The test was administered once for each hand, and the mean completion times for the dominant and nondominant hands were used for analysis.

Physical function was characterized by grip strength, usual gait speed, and skeletal muscle index (SMI). Grip strength was measured twice per hand, and the maximum value for each hand was recorded; the mean of the left and right maxima was used for analysis. Usual gait speed was assessed using a 6-m walk test performed twice at a comfortable pace, and the mean speed was calculated. Body composition was assessed using the InBody 570 (InBody Co., Ltd., Seoul, Korea), from which SMI was derived.

Additional variables included age, sex, body mass index (BMI), number of cohabiting family members, educational attainment, self-rated economic status, current digital device use, years of digital device use, daily duration of digital device use, confidence in using digital devices, and interest in digital technologies. Confidence in using digital devices was assessed using a single item with five response options: not confident at all, not confident, neutral, confident, and very confident. Responses were coded from 1 to 5, with higher scores indicating greater confidence. Interest in digital technologies was assessed using a separate single item with five response options: not interested at all, not very interested, neutral, interested, and very interested. Responses were coded from 1 to 5, with higher scores indicating greater interest. Well-being was measured with the World Health Organization Five Well-Being Index (WHO-5) (*15,16*). Frailty risk was screened with the Kihon Checklist (KCL). Life satisfaction was recorded as a supplementary psychosocial variable.

2.4. Sample size planning

The sample-size calculation was based on the planned bivariate association analysis. Using G*Power version 3.1.9.7 (Heinrich Heine University, Düsseldorf, Germany), a minimum sample of approximately 82 participants was estimated to detect a medium correlation ($r = 0.30$) with an alpha of 0.05 and power of 0.80. The final analyzable sample included 91 participants. This calculation was not specifically designed to establish adequate statistical power for the full 11-predictor regression model or the supplementary SEM.

2.5. Statistical analysis

For descriptive comparison only, participants were divided at the midpoint of the modified 1–4 DHLI-J score into groups with scores ≥ 2.5 and < 2.5. This threshold has not been validated as a clinical or public health cutoff. All primary correlation and regression analyses treated the modified DHLI-J score as a continuous variable. Between-group comparisons used independent-samples *t* tests for approximately normally distributed continuous variables, Mann–Whitney *U* tests for non-normally distributed variables, Fisher's exact tests for 2×2 categorical variables, and Fisher–Freeman–Halton exact tests for $r \times c$ contingency tables. No inferential tests were conducted for variables with no between-group variation.

Bivariate associations between the modified 15-item DHLI-J score and study variables were examined using Pearson or Spearman correlation coefficients, as appropriate. No adjustment for multiple comparisons was applied; therefore, the between-group comparisons and bivariate correlation analyses should be interpreted as exploratory. Hierarchical multiple linear regression analyses were performed using the modified 15-item DHLI-J mean score as the dependent variable. Demographic variables were entered into Model 1; cognitive and physical function variables were added to Model 2; and digital attitudes were added to Model 3. Variables were selected to reflect plausible explanatory domains rather than to maximize statistical parsimony alone. Multicollinearity was assessed with tolerance and variance inflation factor values. Independence of residuals was evaluated using the Durbin–Watson statistic. Linearity and homoscedasticity were assessed with a plot of standardized residuals against standardized predicted values, and normality of residuals was examined using a normal probability–probability (P–P) plot. Influential observations were evaluated using standardized residuals and Cook's distance. A sensitivity analysis was performed by repeating the final regression model after excluding the observation with the largest Cook's distance.

As a supplementary exploratory analysis, SEM was used to examine a prespecified pattern of cross-sectional associations among age, a latent cognitive/physical function construct, a latent digital attitudes construct, the modified DHLI-J score, and well-being. Model fit was evaluated with the chi-square statistic, comparative fit index (CFI), and root mean square error of approximation (RMSEA). Because the sample size was planned for bivariate association analysis and the data were cross-sectional, the SEM was interpreted as exploratory; the directions of the specified paths did not establish temporal ordering or causal relationships.

All analyses were performed using IBM SPSS Statistics version 30.0 and IBM SPSS Amos version 30.0 (IBM Japan Ltd., Tokyo, Japan). Statistical significance was set at $p < 0.05$.

3. Results

3.1. Participant characteristics and group comparisons

The participant flow is summarized in Figure 1. All 91 participants (100%) completed items 1–15, whereas 43 (47.3%) completed all six posting-related items (items 16–21). Cronbach's alpha for the modified 15-item DHLI-J was 0.94. Table 1 presents participant characteristics by descriptive DHLI-J score group. The participants (n = 91) had a mean age of 74.7 ± 4.6 years; 71 (78%) were women and 20 (22%) were men. Participants scoring ≥ 2.5 were younger than those scoring < 2.5 (73.6 ± 3.9 *vs.* 76.0 ± 5.3 years, $p = 0.014$), reported better self-rated economic status ($p = 0.032$), and were more likely to use a personal computer (77% *vs.* 49%, $p = 0.008$). They also had a longer duration of personal computer use (22.6 ± 11.1 *vs.* 15.2 ± 9.2 years, $p = 0.015$).

In addition, participants with modified DHLI-J scores ≥ 2.5 reported greater confidence in using digital devices ($p = 0.008$) and greater interest in digital technologies ($p = 0.003$). They also had better well-being (WHO-5, 17.2 ± 4.7 *vs.* 14.7 ± 4.6; $p = 0.014$), faster NHPT completion time (median, 21.1 *vs.* 22.6 s; $p = 0.028$), and higher MoCA-J scores (median, 26 *vs.* 24; $p = 0.001$). No between-group differences were observed in sex, BMI, number of cohabiting family members, educational attainment, years of smartphone use, daily duration of digital device use, life satisfaction score, KCL score, grip strength, SMI, or gait speed (all $p > 0.05$). These descriptive comparisons suggest that scores ≥ 2.5 were associated with more favorable digital attitudes and better cognitive and manual performance rather than with general physical function alone; however, the grouping should not be interpreted as distinguishing clinically high from low DHL.

3.2. Bivariate associations with the modified DHLI-J score

The correlational analyses are shown in Table 2. Higher modified DHLI-J scores were negatively associated with age ($r = -0.35$, $p < 0.001$) and NHPT completion time (ρ = −0.25, $p = 0.019$), indicating lower DHL with older age and slower manual performance. They were also positively associated with years of smartphone use (ρ =

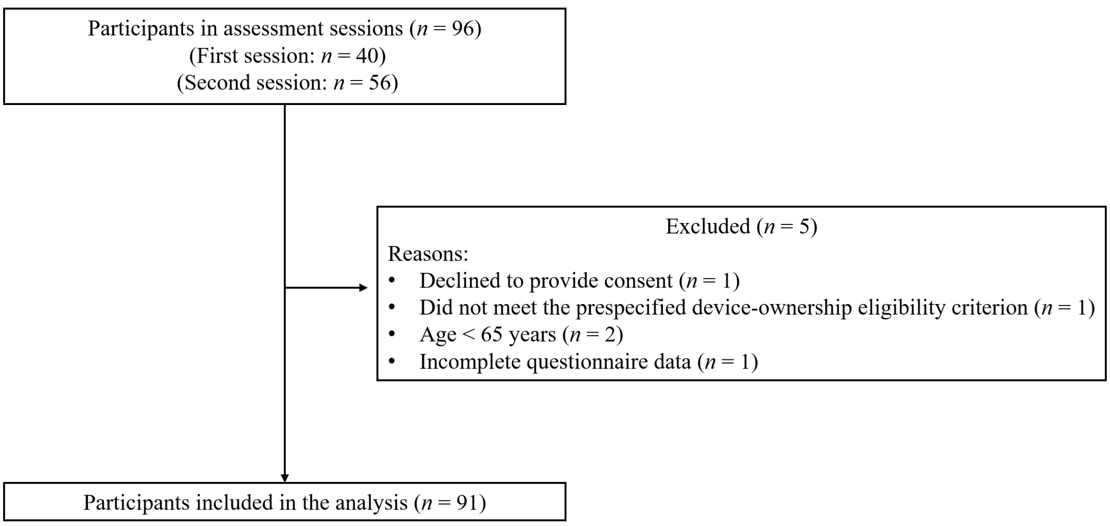

Figure 1. Participant flow diagram. *Note*: A total of 96 individuals attended the assessment sessions (Session 1: n = 40; Session 2: n = 56). Five individuals were not included in the final analytical sample because they did not provide informed consent (n = 1), did not meet the prespecified device-ownership eligibility criterion (n = 1), were aged < 65 years (n = 2), or had incomplete questionnaire data (n = 1). The final analytical sample included 91 participants.

Table 1. Participant characteristics according to modified 15-item DHLI-J groups

Variable	Total (n = 91)	Modified DHLI-J score ≥ 2.5 (n = 52)	Modified DHLI-J score < 2.5 (n = 39)	p
Age, years, mean ± SD[a]	74.7 ± 4.6	73.6 ± 3.9	76.0 ± 5.3	0.014*
Sex, n (%)[b]				0.804
Male	20 (22)	12 (23)	8 (21)	
Female	71 (78)	40 (77)	31 (79)	
BMI, kg/m², mean ± SD[a]	22.5 ± 2.8	22.7 ± 2.6	22.4 ± 3.0	0.643
Long-term care insurance certification, n (%)[b]				
Not certified	91 (100)	52 (100)	39 (100)	—
Number of cohabiting family members, n (%)[c]				0.292
0	15 (17)	5 (10)	10 (28)	
1	40 (44)	26 (50)	14 (36)	
2	25 (27)	15 (29)	10 (26)	
3	8 (9)	4 (8)	4 (10)	
4	0 (0)	0 (0)	0 (0)	
5	3 (3)	2 (4)	1 (3)	
Educational attainment, n (%)[c]				0.193
Junior high school	1 (1)	0 (0)	1 (3)	
High school	54 (59)	33 (63)	21 (54)	
Vocational school	10 (11)	3 (6)	7 (18)	
Junior college	16 (18)	11 (21)	5 (13)	
University	9 (10)	4 (8)	5 (13)	
Graduate school	1 (1)	1 (2)	0 (0)	
Economic status, n (%)[c]				0.032*
Very poor	0 (0)	0 (0)	0 (0)	
Poor	24 (27)	9 (17)	15 (38)	
Comfortable	64 (70)	40 (77)	24 (62)	
Very comfortable	3 (3)	3 (6)	0 (0)	
Digital devices currently used, n (%)[b]				
Smartphone (yes)	91 (100)	52 (100)	39 (100)	—
Personal computer (yes)	59 (65)	40 (77)	19 (49)	0.008**
Tablet (yes)	18 (20)	9 (17)	9 (23)	0.597
Feature phone (yes)	15 (16)	8 (15)	7 (18)	0.781
Duration of digital device use, years				
Smartphone, median [IQR][d]	8 [5–10]	10 [6–10]	6 [5–10]	0.326
Personal computer, mean ± SD[a]	20.2 ± 11.0	22.6 ± 11.1	15.2 ± 9.2	0.015*
Tablet, median [IQR][d]	5 [3–7]	7 [5–10]	4 [3–7]	0.387
Feature phone, median [IQR][d]	15 [10–20]	12.5 [10–25]	20 [8–20]	0.955
Daily duration of digital device use, n (%)[c]				0.877
Less than 30 min	18 (20)	9 (17)	9 (23)	
30–59 min	34 (37)	19 (37)	15 (38)	
60–119 min	28 (31)	17 (33)	11 (28)	
120–179 min	7 (8)	5 (10)	2 (5)	
≥ 180 min	4 (4)	2 (4)	2 (5)	
Confidence in using digital devices, n (%)[c]				0.008**
Not confident at all	7 (8)	3 (6)	4 (10)	
Not confident	39 (43)	16 (31)	23 (59)	
Neutral	40 (44)	28 (54)	12 (31)	
Confident	5 (5)	5 (10)	0 (0)	
Very confident	0 (0)	0 (0)	0 (0)	
Interest in digital technologies, n (%)[c]				0.003***
Not interested at all	1 (1)	0 (0)	1 (3)	
Not very interested	21 (23)	7 (13)	14 (36)	
Neutral	27 (30)	13 (25)	14 (36)	
Interested	38 (42)	28 (54)	10 (26)	
Very interested	4 (4)	4 (8)	0 (0)	
WHO-5 score, mean ± SD[a]	16.1 ± 4.8	17.2 ± 4.7	14.7 ± 4.6	0.014*
Life satisfaction score, median [IQR][d]	7 [5–8]	8 [5–9]	7 [5–8]	0.066
Modified 15-item DHLI-J mean score, mean ± SD[a]	2.49 ± 0.54	2.88 ± 0.29	1.98 ± 0.32	< 0.001***
Kihon Checklist score, median [IQR][d]	3 [1–5]	2.5 [1–4.5]	3 [2–5]	0.387
Grip strength, kg, median [IQR][d]	23.5 [21.0–28.5]	24.0 [21.0–29.5]	23.5 [20.5–28.5]	0.558

Note: Values are reported as mean ± SD, median [IQR], or n (%). Participants were categorized descriptively using modified DHLI-J scores ≥ 2.5 and < 2.5; this midpoint is not a validated clinical or public health cutoff. [a]Independent-samples t-test; [b]Fisher's exact test (2 × 2); [c]Fisher–Freeman–Halton exact test (2 × k); [d]Mann–Whitney U test. No statistical test was performed for variables with no between-group variation (—), including long-term care insurance certification and smartphone use. *p < 0.05, **p < 0.01, ***p < 0.001. *Abbreviations*: DHLI-J, Japanese version of the Digital Health Literacy Instrument; BMI, body mass index; WHO-5, World Health Organization Five Well-Being Index; KCL, Kihon Checklist; SMI, skeletal muscle index; MoCA-J, Japanese version of the Montreal Cognitive Assessment; SD, standard deviation; IQR, interquartile range.

Table 1. Participant characteristics according to modified 15-item DHLI-J groups (continued)

Variable	Total (n = 91)	Modified DHLI-J score ≥ 2.5 (n = 52)	Modified DHLI-J score < 2.5 (n = 39)	p
Skeletal muscle index (SMI), median [IQR][d]	6.20 [5.80–7.00]	6.30 [5.85–7.00]	6.10 [5.75–6.90]	0.659
Usual gait speed, m/s, mean ± SD[a]	1.37 ± 0.18	1.39 ± 0.20	1.34 ± 0.16	0.234
Nine-Hole Peg Test, s, median [IQR][d]	21.4 [19.8–23.8]	21.1 [19.7–22.7]	22.6 [20.2–27.7]	0.028*
MoCA-J score, median [IQR][d]	25 [22–27]	26 [24–27.5]	24 [20–26]	0.001**

Note: Values are reported as mean ± SD, median [IQR], or n (%). Participants were categorized descriptively using modified DHLI-J scores ≥ 2.5 and < 2.5; this midpoint is not a validated clinical or public health cutoff. [a]Independent-samples t-test; [b]Fisher's exact test (2 × 2); [c]Fisher–Freeman–Halton exact test (2 × k); [d]Mann–Whitney U test. No statistical test was performed for variables with no between-group variation (—), including long-term care insurance certification and smartphone use. *p < 0.05, **p < 0.01, ***p < 0.001. *Abbreviations*: DHLI-J, Japanese version of the Digital Health Literacy Instrument; BMI, body mass index; WHO-5, World Health Organization Five Well-Being Index; KCL, Kihon Checklist; SMI, skeletal muscle index; MoCA-J, Japanese version of the Montreal Cognitive Assessment; SD, standard deviation; IQR, interquartile range.

Table 2. Correlations between the modified 15-item DHLI-J score and participant characteristics and functional measures

Variable	Correlation coefficient	p
Age (years)†	r = –0.35	< 0.001***
BMI (kg/m²)†	r = 0.06	0.558
Years of smartphone use‡	ρ = 0.21	0.046*
Years of tablet use‡	ρ = 0.38	0.124
Years of personal computer use†	r = 0.33	0.012*
Years of feature phone use‡	ρ = 0.13	0.639
WHO-5†	r = 0.35	< 0.001***
Kihon Checklist (KCL)‡	ρ = –0.21	0.050
Life satisfaction‡	ρ = 0.27	0.010*
Grip strength (kg)‡	ρ = 0.09	0.414
Nine-Hole Peg Test (s)‡	ρ = –0.25	0.019*
Skeletal muscle index (SMI)‡	ρ = –0.01	0.899
MoCA-J‡	ρ = 0.37	< 0.001***
Usual gait speed (m/s)†	r = 0.11	0.290
Confidence in using digital devices‡	ρ = 0.62	< 0.001***
Interest in digital technologies‡	ρ = 0.56	< 0.001***

Note: †Pearson's correlation coefficient; ‡Spearman's rank-order correlation coefficient. *Correlations for years of device use were calculated among users of each device.* *p < 0.05, ***p < 0.001. *Abbreviations*: DHLI-J, Japanese version of the Digital Health Literacy Instrument; BMI, body mass index; WHO-5, World Health Organization Five Well-Being Index; KCL, Kihon Checklist; SMI, skeletal muscle index; MoCA-J, Japanese version of the Montreal Cognitive Assessment.

0.21, p = 0.046), years of personal computer use (r = 0.33, p = 0.012), confidence in using digital devices (ρ = 0.62, p < 0.001), interest in digital technologies (ρ = 0.56, p < 0.001), MoCA-J score (ρ = 0.37, p < 0.001), WHO-5 score (r = 0.35, p < 0.001), and life satisfaction (ρ = 0.27, p = 0.010). KCL score showed a borderline negative association with the modified DHLI-J score (ρ = −0.21, p = 0.050). These patterns suggest that DHL was most strongly associated with digital attitudes, although it was also meaningfully associated with cognition, manual dexterity, and subjective well-being.

3.3. Hierarchical multiple regression

The results of the hierarchical multiple regression analysis are presented in Table 3. In Model 1, older age and poorer self-rated economic status were associated with lower modified DHLI-J scores. After cognitive and physical variables were added to Model 2, the MoCA-J score emerged as a significant positive correlate, whereas association with economic status was attenuated. In the final model (Model 3), which also included digital attitudes, older age remained independently associated with a lower modified DHLI-J score (B = −0.03, p < 0.01), whereas a higher MoCA-J score (B = 0.04, p < 0.05) and greater confidence in using digital devices (B = 0.17, p < 0.05) were independently associated with a higher modified DHLI-J score. The final model explained 44.8% of the variance in the modified DHLI-J score (adjusted R^2 = 0.37). Interest in digital technologies was not statistically significant after accounting for confidence and the other covariates (B = 0.12, p > 0.05).

Regression diagnostics indicated no substantial violations of the model assumptions. In the final model, tolerance values ranged from 0.204 to 0.928 and variance inflation factors ranged from 1.078 to 4.905, indicating no severe multicollinearity. The Durbin–Watson statistic was 2.172. Standardized residuals ranged from −1.775 to 2.106. The plot of standardized residuals against standardized predicted values showed no clear evidence of nonlinearity or heteroscedasticity, and the normal P–P plot indicated no substantial departure from normality. The maximum Cook's distance was 0.119. A sensitivity analysis excluding the observation with the largest Cook's distance did not materially alter the main findings; therefore, all 91 participants were retained in the primary analysis.

3.4. Supplementary exploratory structural equation model

As a supplementary exploratory analysis, SEM was used to examine prespecified cross-sectional associations among age, cognitive/physical functioning, digital attitudes, DHL, and well-being (Figure 2). The model showed acceptable fit: $\chi^2(11)$ = 13.96, p = 0.24; χ^2/df = 1.27; CFI = 0.97; RMSEA = 0.06. Age was negatively associated with the latent cognitive/physical function construct (β = −0.49, p = 0.002). Within the specified model, digital attitudes were positively associated with DHL (β = 0.45, p = 0.001), and DHL was positively associated with well-being (β = 0.34, p < 0.001). The direct paths from the cognitive/physical function construct to DHL (β = 0.56, p = 0.074) and from age to DHL (β = −0.04, p = 0.820) were not statistically significant. Given the cross-sectional design and modest sample size, these coefficients describe associations within the specified model and do not establish temporal ordering or causal relationships.

4. Discussion

4.1. Main findings

This in-person cross-sectional study examined factors associated with DHL among community-dwelling older adults in Japan and yielded three main findings.

Table 3. Hierarchical multiple regression models for the modified 15-item DHLI-J mean score

Factor	Model 1 B (SE)	Model 1 β	Model 2 B (SE)	Model 2 β	Model 3 B (SE)	Model 3 β
Age, years	–0.04 (0.01)***	–0.38***	–0.04 (0.01)**	–0.30**	–0.03 (0.01)**	–0.25**
Sex (female = 1)	0.11 (0.13)	0.09	0.42 (0.25)	0.32	0.20 (0.24)	0.15
Educational attainment	–0.02 (0.05)	–0.03	–0.03 (0.05)	–0.06	–0.01 (0.04)	–0.04
Economic status	0.35 (0.10)***	0.33***	0.26 (0.10)*	0.24*	0.19 (0.10)	0.17
MoCA-J score			0.04 (0.02)*	0.27*	0.04 (0.02)*	0.23*
Nine-Hole Peg Test (s)			–0.02 (0.01)	–0.19	–0.02 (0.01)	–0.15
Skeletal muscle index (SMI)			–0.05 (0.10)	–0.09	0.03 (0.09)	0.06
Usual gait speed, m/s			–0.02 (0.28)	–0.01	0.08 (0.26)	0.03
Grip strength, kg			–0.01 (0.01)	–0.10	–0.01 (0.01)	–0.17
Confidence in using digital devices					0.17 (0.08)*	0.23*
Interest in digital technologies					0.12 (0.06)	0.20

Note: The dependent variable was the modified 15-item DHLI-J mean score. *B*, unstandardized coefficient; SE, standard error; β, standardized coefficient. Model 1 included age, sex, educational attainment, and economic status as covariates. Model 2 additionally included the MoCA-J score, Nine-Hole Peg Test completion time, skeletal muscle index, gait speed, and grip strength. Model 3 also included confidence in using digital devices and interest in digital technologies. Sex was coded as 1 = female and 0 = male. R^2: Model 1 = 0.23, Model 2 = 0.34, Model 3 = 0.45. Adjusted R^2: Model 1 = 0.20, Model 2 = 0.26, Model 3 = 0.37. $F(df_1, df_2)$: Model 1 = 6.58*** (4, 86), Model 2 = 4.55*** (9, 81), Model 3 = 5.82*** (11, 79). *p < 0.05, **p < 0.01, ***p < 0.001. *Abbreviations*: DHLI-J, Japanese version of the Digital Health Literacy Instrument; MoCA-J, Japanese version of the Montreal Cognitive Assessment.

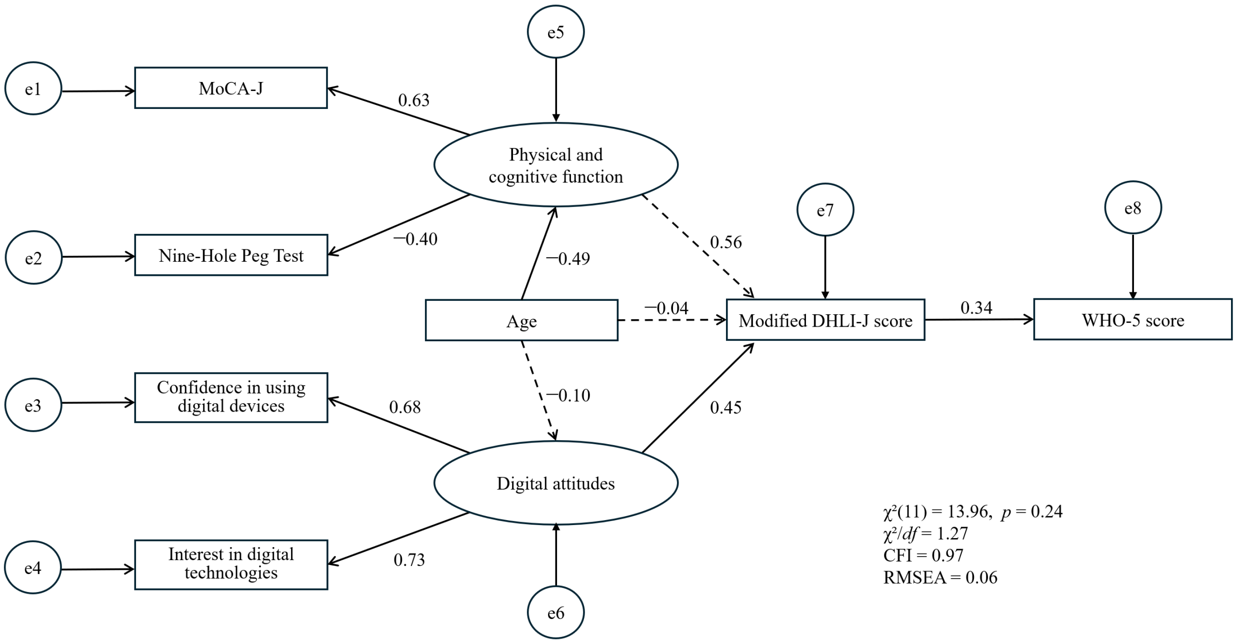

Figure 2. Exploratory structural equation model of cross-sectional associations among digital attitudes, cognitive/physical function, the modified DHLI-J score, and well-being. *Note*: n = 91. The values shown are the standardized regression coefficients. Solid lines indicate significant paths (P < .05), and dashed lines indicate nonsignificant paths. Arrows indicate prespecified cross-sectional relations and do not imply temporal or causal direction. Model fit indices were $\chi^2(11)$ = 13.96, p = 0.24; χ^2/df = 1.27; CFI = 0.97; RMSEA = 0.06. *Abbreviations*: DHLI-J, Japanese version of the Digital Health Literacy Instrument; WHO-5, World Health Organization Five Well-Being Index; MoCA-J, Japanese version of the Montreal Cognitive Assessment; CFI, comparative fit index; RMSEA, root mean square error of approximation; df, degrees of freedom.

First, DHL was associated with age, cognitive function, manual dexterity, digital attitudes, and well-being at descriptive and bivariate levels. Second, after adjusting for demographic and functional variables, older age, lower cognitive function, and lower confidence in using digital devices were independently associated with lower modified DHLI-J scores. Third, the exploratory supplementary SEM was broadly consistent with the regression findings and indicated positive cross-sectional associations between digital attitudes and DHL and between DHL and well-being. Taken together, these findings suggest that DHL in later life is associated not only with age and digital experience but also with cognitive demands and confidence-related factors; however, the cross-sectional design does not establish causal relationships among these variables.

A key feature of this study was its in-person design. Online recruitment may disproportionately include older adults with sufficient digital confidence, skills, and functional capacity to complete an online survey. By using paper-based questionnaires and direct performance-based assessments, the present study may have included device-owning older adults with lower digital confidence or greater cognitive and physical difficulty than those who typically participate in online-only research. However, ownership of a personal computer or mobile device was a prespecified eligibility criterion. Therefore, the in-person design reduced reliance on online survey participation but did not capture older adults without access to their own digital devices. This distinction is important because lack of device ownership may constitute a barrier before DHL can even be assessed.

4.2. Comparison with previous studies

Our results are broadly consistent with previous reviews indicating that age, socioeconomic resources, and self-efficacy-related constructs are associated with digital or eHealth literacy among older adults (*4-7*). The present study extends the literature in two ways. First, it provides in-person evidence from a Japanese community sample using the DHLI-J, together with performance-based measures. Second, the findings suggest that the apparent importance of specific correlates may depend on how participants are recruited and assessed. In this study, confidence was strongly associated with DHL in both the correlational analysis and the final regression model, whereas the contribution of self-rated economic status weakened after cognitive and attitudinal variables were included in the analysis. This pattern is consistent with the possibility that socioeconomic advantage may operate partly through greater opportunities to accumulate successful digital experiences and, in turn, increase confidence in using digital tools.

The association between cognitive function and the modified DHLI-J score is plausible, given the task demands of contemporary digital health environments. This interpretation is also consistent with broader evidence linking technology use and digital engagement to cognitive aging (*17*). Searching for health information, navigating patient portals, comparing sources, interpreting instructions, and recovering from errors require attention, working memory, comprehension, and executive function. The MoCA-J score remained significant in the final regression model, suggesting that these demands are relevant beyond chronological age or device ownership alone. In practical terms, some older adults who appear to have adequate access to digital devices may still struggle with multi-step or unfamiliar health-related digital tasks because these tasks rely on higher-order cognitive processes.

Manual dexterity may represent one of several task-related constraints. This interpretation is consistent with previous findings that manual dexterity is associated with executive functioning in community-dwelling older adults and with broader cognitive processes related to manual performance (*18,19*). Common digital actions, such as tapping, typing, scrolling, and authentication, rely on precise finger movements. In this study, NHPT performance differed between the descriptive score groups and correlated significantly with the modified DHLI-J score, although it did not remain independently significant in the final regression model. This pattern is nonetheless informative, suggesting that hand function may contribute to DHL, in part, through variance shared with age, cognition, and digital experience. For service design, this suggests that apparently minor manipulation demands, especially on touch screens or small interfaces, may accumulate into substantial access barriers for some older adults.

4.3. Public health and community implications

The positive association between the modified DHLI-J score and WHO-5 well-being is also noteworthy and consistent with prior discussions of the role of technology use in quality of life and psychosocial well-being in older adults, as well as reviews linking DHL to mental health and well-being indicators (*5,12*). Because the study was cross-sectional, the direction of this association cannot be determined. Higher DHL may facilitate engagement with health information and digitally delivered services; conversely, better well-being may increase the motivation or capacity to engage with digital technologies, and both variables may be influenced by unmeasured social or health-related factors. The positive coefficient between DHL and well-being in the exploratory SEM should therefore be interpreted as a cross-sectional association within the specified model rather than evidence that DHL improves well-being. From a global health and health systems perspective, DHL may nevertheless be relevant when considering older adults' engagement with increasingly digital services, although actual service access, use, and equity outcomes were not measured in this study.

Confidence in using digital devices may be a target for intervention, consistent with prior work linking eHealth literacy to self-efficacy in community-dwelling older adults (*20*). Recent evidence also suggests that DHL interventions in older adults can improve literacy-related outcomes and associated self-efficacy constructs, although the intervention content and measurement approaches remain heterogeneous (*21*). However, because confidence was assessed using a single item and the present study was cross-sectional, intervention studies are needed to determine whether increasing confidence improves DHL.

The findings may inform two complementary types of intervention. User-level interventions could focus on confidence-building through guided practice, repeated successful experiences, reassurance that mistakes can be corrected, and opportunities to ask for help without embarrassment. System-level interventions could reduce task burden through plain language, simpler navigation, larger touch targets, less burdensome authentication, accessible design, timely human support, and continued availability of non-digital alternatives. Community salons, preventive care programs, municipal outreach activities, and rehabilitation-led education sessions may be suitable settings for identifying older adults who need additional support with digital health tasks before such difficulties limit their access to care. These findings may therefore inform community-based digital inclusion strategies in super-aged societies.

4.4. Interpretation of the supplementary SEM

SEM served as a supplementary exploratory analysis rather than the primary analytic framework. The model showed acceptable fit ($\chi^2(11) = 13.96$, $p = 0.24$; $\chi^2/df = 1.27$; CFI = 0.97; RMSEA = 0.06), and the pattern of associations added context to the regression findings. Within the specified cross-sectional model, age was associated with the latent cognitive/physical function construct, whereas digital attitudes were associated with DHL. The nonsignificant association between the cognitive/physical latent factor and DHL may reflect limited power or overlap with age and digital attitudes and should not be interpreted as evidence that functional constraints are unimportant. Because the model was based on cross-sectional data from a modest sample, the directions of the arrows reflect the hypothesized model specification and do not establish temporal ordering, mediation, or causality. The SEM should therefore be regarded as complementary and hypothesis-generating rather than confirmatory.

4.5. Strengths and limitations

This study has several strengths. The most important is its in-person design, which reduced dependence on online survey participation among device-owning older adults and allowed us to include performance-based measures of cognition and manual dexterity. The study also incorporated demographic, digital, physical, and psychosocial variables, allowing a broader characterization of the factors associated with DHL than would have been possible with questionnaires alone. In addition, the convergence of findings across group comparisons, correlations, regression analyses, and supplementary SEM increased confidence in the overall interpretation.

This study has some limitations. First, participants were recruited from community-based prevention activities and may therefore have been relatively health-conscious, socially active, and functionally independent, which may limit the generalizability of the findings to the broader older population. In addition, ownership of a personal computer or mobile device was a prespecified eligibility criterion, and one attendee who owned neither device was excluded. The findings therefore primarily apply to community-engaged older adults who own digital devices and may underestimate barriers among frail, homebound, socially isolated, or cognitively impaired older adults. Moreover, the study could not assess digital exclusion among older adults who do not own digital devices, because such exclusion may occur before DHL can be meaningfully evaluated. Exclusion of individuals who were unable to rise from a chair, maintain standing, or walk further limits the generalizability of the findings to older adults with substantial mobility limitations. Second, because the study was cross-sectional, the direction of the observed associations could not be determined. Better well-being may facilitate digital engagement, and higher DHL may in turn be associated with better well-being. The study also did not directly measure access to or use of digital health services or equity outcomes; therefore, the findings should be interpreted as informing strategies for equitable access rather than demonstrating equity. Third, the present study used a modified 15-item DHLI-J because only 43 of 91 participants completed all six items concerning content creation and privacy protection in online posting contexts. Although the retained items showed high internal consistency (Cronbach's $\alpha = 0.94$), the modified score covered only five of the seven original domains and should not be considered psychometrically equivalent to the validated 21-item DHLI-J. Accordingly, the findings do not reflect skills related to online content creation or privacy protection during posting. Fourth, potentially important contextual variables such as occupational history, prior technology-related work experience, social support, and availability of assistance from family members or peers were not measured. In addition, confidence in using digital devices and interest in digital technologies were assessed with single-item measures rather than validated multidimensional scales. Fifth, dichotomization at a mean score of 2.5 served only for descriptive comparison and should not be interpreted as a validated clinical or public health cutoff. Finally, the sample size was modest for SEM, and the cross-sectional design precluded causal interpretation; therefore, the supplementary model should be regarded as exploratory despite its acceptable fit indices.

5. Conclusions

In this in-person cross-sectional study of community-dwelling older adults in Japan, the modified DHLI-J score was independently associated with age, cognitive function, and confidence in using digital devices. Manual dexterity was also associated with DHL at the bivariate level, indicating that digital health tasks involve meaningful motor and cognitive demands. The exploratory supplementary SEM indicated positive cross-sectional associations between digital attitudes and DHL and between DHL and well-being, but these associations should not be interpreted as causal. These findings may inform user-level strategies that build confidence and system-level strategies that reduce the cognitive and manual demands of digital health environments. However, the findings primarily apply to community-engaged older adults who own digital devices and do not provide direct evidence regarding equitable access to digital health services. Further research should directly examine access to and use of digital health services, particularly among older adults who do not own digital devices.

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