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Timed instrumental activities of daily living tasks in adults with irreversible vision impairment: validation to visual function and self-report

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Abstract

Background Instrumental activities of daily living (IADL) are typically self-reported ability to perform complex tasks vital for independent living. There is a need for a complementary objective, performance-based approach especially in tracking outcomes in visual rehabilitation for patients with irreversible vision impairment ("low vision"). Our goals are: (1) To describe the validity of timed performance of instrumental activities of daily living (timed IADL or TIADL) tasks in individuals with irreversible vision impairment, by examining its association with visual function (visual acuity, contrast sensitivity, visual field), (2) To explore the correlation between TIADL and self-reported IADL.

Methods Twenty TIADL tasks were administered to 88 patients (median age 63.3 years, IQR 37.4–78.0) recruited from the UAB Department of Ophthalmology, Callahan Eye Hospital Clinics. An average Z-score incorporating time and accuracy of task completion was constructed. Minor accuracy errors were penalized 1 standard deviation from their calculated Z-score and major accuracy errors were assigned maximum allotted time. Linear regression was used to analyze the association between TIADL score and measured visual acuity (Early Treatment Diabetic Retinopathy Study, ETDRS chart), contrast sensitivity (Pelli-Robson), and binocular visual field (Esterman) with an unadjusted model and an adjusted model accounting for age, comorbidities, and depression scale (Center for Epidemiological Studies Depression, CES-D). Pearson correlation was used to estimate the correlation between TIADL and IADL.

Results Increased time to task completion was associated with decreased visual function. Each decreased line of ETDRS read was associated with an increase of 0.002 (95% CI 0.001, 0.002) Z-score ($P < 0.01$). A decreased ability to discern each Pelli-Robson letter was associated with an increase of 0.26 (95% CI 0.19, 0.33) Z-score ($P < 0.01$). For each less Esterman target identified, there was an increase of 0.01 (95% CI 0.003, 0.02) Z-score. Self-reported IADL and TIADL were correlated for reading tasks such as newspapers, nutrients on food can, and microwave timer ($P < 0.05$).

Conclusions Longer time to perform TIADL is associated with decreased visual acuity, contrast sensitivity, and binocular visual field. TIADL and self-reported IADL are significantly correlated for reading tasks providing an accurate, complementary outcome measure in clinical practice and research.

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Keywords Activities of daily living, Irreversible vision loss, Timed activities of daily living, Performance based measures of visual function

Background

Instrumental activities of daily living (IADL) are a measure of major functional domains employed to measure functional impairment, changes over time, and responses to interventions in both clinic practice and research settings [1, 2]. IADL is typically assessed via self-report questionnaires that have been validated in specific subpopulations, such as the Older Americans Resources and Services Multidimensional Functional Assessment Questionnaire in older adult patients [3]. In populations with irreversible vision impairment (or low vision), several self-report questionnaires have been developed including the National Eye Institute-25 [4], Activity Inventory [5], Low Vision Quality-of-Life Questionnaire [6]. IADL questionnaires target degree of difficulty in performing task in domains for living, including financial management, transportation, medication, food preparation, and communication [1]. Previous studies have shown that individuals with comorbidities may overestimate or underestimate their ability to perform IADL tasks [2, 7–9]. Thus, self-reported IADL questionnaires may not fully characterize degree of difficulty in performing tasks in daily life including in individuals with irreversible vision impairment. Furthermore, the validity of IADL scores have not been systematically compared to actual task performance in patients with irreversible vision impairment.

IADL questionnaires are commonly used as outcome measures in clinical trials examining the effect of interventions in low vision [10–12]. This highlights the need for a complementary approach for an objective, performance-based approach to measure functional autonomy. Recent literature has focused on establishing objective measures and their association with visual outcomes in patients with varying pathology and age ranges, highlighting the utility of a performance-based measure of visual function [13–23]. Timed instrumental tasks of daily living (timed IADL or TIADL) provide a quantitative measurement of performance in task domains that have been previously established as potential measures of functional independence [17, 18]. By quantifying the time it takes one to perform a task, TIADL presents a metric that is particularly important in individuals who are visually impaired since maintaining or improving functional independence can be a major goal of vision rehabilitation as well as clinical research [24]. While the literature has established that visual metrics are predictors of task performance [13–23], the association between TIADL and visual outcomes and the correlation between TIADL and self-reported IADL remains unclear.

The main goal of this study was to assess the validity of TIADL in patients with irreversible vision impairment by examining its association with visual function, including visual acuity, contrast sensitivity, visual field and with self-reported IADL. Furthermore, the correlation between TIADL and self-reported IADL of similar tasks was examined.

Methods

Study population

Patients aged 19 and older with irreversible vision impairment who presented to the University of Alabama at Birmingham, Callahan Eye Hospital Clinics (Birmingham, Alabama) were eligible for recruitment. Participants were included in the study sample if they had one of the following diagnoses: retinal detachment and defects (ICD9 361), other retinal disorders (ICD9 362), chorioretinal inflammations, scars, and other disorders (ICD9 363), and/or diagnoses of blindness and low vision (ICD9 369). Exclusion criteria included non-English speaking and a previous diagnosis of a dementing illness. The study was approved by the Institutional Review Board of the University of Alabama at Birmingham and followed the tenets of the Declaration of Helsinki. All participants provided written informed consent.

Enrolled participants ($n=93$) completed interviewer-administered questionnaires on demographics, comorbid health conditions, current medications, the Center for Epidemiologic Studies Depression Scale (CES-D) and the Mini-Mental State Examination (MMSE). A comorbidity score was created for each participant as a cumulative sum of self-reported medical conditions (Supplementary Table 1). Instrumental Activities of Daily Living were recorded as timed task performance (TIADL) and a self-reported questionnaire IADL that asked the participant about difficulties with doing the TIADL tasks. TIADL consisted of 20 tasks, including whether participants were able to complete the task, accuracy of task, and time to complete. IADL questions consisted of 17 tasks to mirror the kinds of tasks in the TIADL assessment, including if task was performed in past 3 months, with what degree of difficulty (not at all, a little, moderate, extreme), if due to vision, and how bothersome/important the task was (not at all, a little, moderate, extreme). The items on the questionnaire are based on asking the participant whether they had difficulty with each of the TIADL tasks. Detailed phrasing of the questions, the tasks, and the response options for TIADL and self-reported IADL are listed in Supplementary Tables 2 and 3, respectively.

Vision was measured binocularly. Visual acuity was assessed using the Early Treatment of Diabetic Retinopathy (ETDRS) chart and defined as the logarithm of the minimum angle of resolution (logMAR) [25]. Contrast sensitivity was measured using the Pelli-Robson chart and defined as log sensitivity [26]. The visual field was assessed by the Esterman Binocular Visual Field [27]; performance was scored as the number of targets seen out of 120 (maximum score).

Statistical analysis

Participant characteristics were summarized using mean (standard deviation) or median (interquartile range, IQR) for continuous variables and proportions for categorical variables. TIADL was quantified as a single score for each participant, from an average of Z-scores recorded for the 20 administered tasks. Every task was assigned a Z-score that incorporated the time and accuracy of task as detailed below. For participants who completed the task with no errors, the time of task completed as recorded was used. For participants who completed the task with minor errors, the time of task completed penalized by 1 standard deviation of the completion time from subset of participants who completed that task with no errors. For participants who completed with major errors, the time of task completion was set to 6 min, which was the maximum time allotted. Participants were excluded if data was missing or TIADL could not be completed.

An adjusted model using simple linear regression was used to determine the independent association between TIADL scores and binocular measures of visual function, specifically visual acuity, contrast sensitivity, and visual field. The model was adjusted for age, number of comorbidities, and CES-D using multiple linear regression. The variables were chosen a priori incorporating literature review, risk factors and confounders. Each visual function was assessed in separate models to avoid potential collinearity, given the correlation between the measures of visual function.

Table 1 Characteristics of study participants ($n=88$)

Demographics	
Median Age (IQR)	63.3 (37.4–78)
Males (%)	40 (45.5)
Race	
White (%)	67 (76.1)
Black (%)	20 (22.7)
Asian/Pacific Islander (%)	1 (1.1)
High school or less education (%)	22 (25)
Median Comorbidity Score (IQR)	3 (1–5)
Median CES-D Score (IQR)	2.5 (0–8)
Median MMSE Score (IQR)	29 (28–30)

Values for continuous variables are given as mean (standard deviation) or median (interquartile range); values for categorical variables are given as percentage

We also assessed whether the time to complete a task varied by the degree of error in completing a task. The were four categories of TIADL completion: completed with no errors, completed with minor errors, completed with major errors, and not completed. The were four categories for IADL self-report responses: completed with no difficulty at all, a little difficulty, moderate difficulty, and extreme difficulty (Supplementary Table 3). Since all participants were able to complete TIADL task #6 without mistakes, there was not enough variation to compute chi-square statistics. For task #12, IADL task ("reading a restaurant menu") and TIADL task ("find food item and read ingredients and price") prompt were not directly comparable. For task #17, since IADL asked about finding change and TIADL asked about finding pennies, nickels, dimes, and quarters (TIADL #17–20), chi-square was calculated between IADL responses and average of TIADL responses.

Statistical significance was set a priori as two-sided P-value of 0.05. All analyses were done in R version 3.5 (Vienna, Austria). Sensitivity analyses were conducted with models excluding participants with severe cognitive impairment (MMSE <18) or clinical depression (CES-D >16). We also excluded tasks that were correlated to each other ($r^2>0.8$) in a series of sensitivity models (Supplementary Fig. 1).

Results

Of the 93 recruited participants, there were 88 participants without missing data. Median age (IQR) of participants was 63.3 years (37.4–78) and 60% were female (Table 1). A majority were either White (76.1%) or Black (22.7%) and 75% of the participants were more than high school educated. Most participants had at least one comorbidity, with median being 3 (IQR 1–5). Most participants did not meet criteria for clinical depression with median CES-D of 2.5 (IQR 0–8), and most had high mental status with MMSE of 29 (IQR 28–30).

The completion status of each TIADL task ranged from 68 to 88 participants, with varying number of participants who were able to complete the task with no errors, minor errors, major errors (Supplementary Table 4). In general, the completion times were statistically significantly longer for participants who completed the task with major errors vs. minor errors vs. no errors. However, there was no dose-response or statistical significance noted in accuracy and time to look up telephone number, to find dimes and to find quarters (Supplementary Table 5).

A longer TIADL completion time was statistically significantly associated with worse visual function in both unadjusted and adjusted models (Table 2). With one less line read on the ETDRS chart, there is an increase of 0.002 (95% CI 0.001, 0.002) in TIADL score ($P<0.01$)

Table 2 Association between TIADL and visual outcomes

Variables	Unadjusted		Adjusted	
	Beta (95% CI)	*P*-value	Beta (95% CI)	*P*-value
A. Visual Acuity ($n=88$)				
LogMAR	-0.02 (-0.03, -0.01)	< 0.01	-0.02 (-0.02, -0.01)	< 0.01
Age			0.02 (0.01, 0.02)	< 0.01
Comorbidities			-0.01 (-0.08, 0.06)	0.71
CES-D			0.03 (0.02, 0.05)	< 0.01
B. Contrast Sensitivity ($n=84$)				
Pelli-Robson	-0.33 (-0.39, -0.26)	< 0.01	-0.26 (-0.33, -0.19)	< 0.01
Age			0.01 (0.01, 0.02)	< 0.01
Comorbidities			-0.02 (-0.08, 0.04)	0.50
CES-D			0.02 (0.01, 0.04)	< 0.01
C. Field of Vision ($n=79$)				
Esterman	-0.01 (-0.02, 0)	< 0.01	-0.01 (-0.02, -0.003)	< 0.01
Age			0.02 (0.01, 0.03)	< 0.01
Comorbidities			-0.02 (-0.1, 0.07)	0.68
CES-D			0.04 (0.02, 0.06)	< 0.01

Table 3 Correlation between TIADL and Self-reported IADL

Task	Chi-square	*P*-value
1. Read newspaper	20.04	0.02
2. Read medicine bottle	16.16	0.06
3. Read nutrients on food can	33.65	< 0.01
4. Look up telephone number	8.95	0.44
5. Key and lock in dim light	0.57	0.90
6. Find objects in drawer		
7. Read bill amount	0.86	0.99
8. Write check	13.39	0.15
9. Tell time on wrist watch	11.48	0.24
10. Tell time on digital clock	0.82	0.99
11. Find specified food can	13.21	0.04
12. Read a restaurant menu in dim light	19.77	0.02
13. Read food package instructions	6.02	0.20
14. Set microwave timer	38.02	< 0.01
15. Dial phone number	14.76	< 0.01
16. Key and lock	0.45	0.93
17. Find change	3.87	0.28

adjusted for age, number of comorbidities, and CES-D. In the adjusted model, a decreased ability to discern letters on the Pelli-Robson chart is associated with an increase of 0.26 (95% CI 0.19, 0.33) in TIADL score ($P<0.01$). In the adjusted model, there is an increase of 0.01 (95% CI 0.003, 0.02) in TIADL score for each item unable to be discriminated on Esterman binocular visual field.

The association between self-reported IADL and observed TIADL varied by task (Table 3). There was a significant association between the IADL and TIADL for reading newspapers, reading restaurant menu in dim light, reading nutrients on food can, finding specified food can, setting microwave timer, and dialing phone number ($P<0.05$). In our sensitivity analysis, there were no tasks that were strongly correlated with each other ($r^2>0.9$) (Supplementary Fig. 1). When the average Z-score excluded tasks that were correlated $r^2>0.8$, there were no changes to the association reported in Table 2 and therefore are not presented in detail here. When we excluded participants with severe cognitive impairment or MMSE<18 ($n=1$) and clinical depression or CES-D>16 ($n=11$), the associations reported in the adjusted models in Table 2 did not vary.

Discussion

Our study demonstrates that an increased time needed to complete everyday tasks by visually impaired persons is associated with decreased visual function domains including visual acuity, contrast sensitivity, and binocular visual field, independent of the effects of age, comorbidities, and presence and severity of clinical depression. In summary, increased time to perform the task or decreased accuracy of performing the task is associated with worse visual acuity, contrast sensitivity and binocular visual field. Our study also illustrates that the majority of TIADL and IADL tasks are not statistically significantly associated with each other, highlighting the variability between self-reported and observed time-based performance of daily activities.

Our results highlight that time and accuracy in performing IADL tasks are associated with visual outcomes independent of the effects of major contributors of the domains of functional autonomy including age and comorbidities. The observed associations are consistent with previous literature that focused on vision outcomes in the context of self-reported IADL [24, 28–31]. Our results are also consistent with existing evidence between the association between objective measures of task performance and visual outcomes [13–23]. In particular, the time to complete IADL has been previously associated with visual acuity, contrast sensitivity, visual field sensitivity, and field of view [13, 17, 19, 21–23]. Performance in driving simulation [15] and facial recognition [16] have also been associated with visual function. Our results from the adjusted models also highlight the independent association between TIADL and visual outcomes by accounting for potential confounders in line with prior studies [17, 18, 21–23].

The use of objective measures of functional independence utilizes a reliable, adjunctive method to the established, self-reported IADL. Our study demonstrates that TIADL provides insight into many of the reading tasks (medicine bottle, telephone number, bill amounts, food package instructions, checks, clocks) as well as motor tasks (fitting key into locks, finding change). A possible explanation for the differences observed between TIADL and IADL could be lack of self-awareness as well as the mild differences in wording of the tasks. One of the main determinants of self-awareness is cognitive status and comorbidities [32, 33]. Finally, since the TIADL score incorporates both accuracy and time of completion, TIADL provides a more nuanced understanding of the domains of functional autonomy compared to self-reported IADL.

Our study is novel in its evaluation of the independent association of TIADL with contrast sensitivity, visual acuity, and binocular visual field as well as its assessment of the correlation between TIADL and self-reported IADL in a population with irreversible vision loss and other comorbidities. Another strength of this study is that the recruitment of participants was done through a clinical and research facility that has a major catchment in the Southern U.S. representing heterogeneity of participants. In addition, participants were included in the study based on rigorous data on ICD coding. Participant data was also collected on many of the major risk factors and confounders important in low-vision rehabilitation and research. Finally, TIADL incorporated accuracy of task completion as well as the timing of task completion, thereby adding an extra dimension to the measure of IADL especially in patients with irreversible vision loss. However, we cannot discount the possibility of residual confounding from unmeasured variables that may be important in performance of daily activities and vision outcomes. Similarly, while our study captures a variety of patients with low vision, it is possible that this heterogeneity may mask a difference in effect that may be explained unaccounted factors. Our questionnaires were also developed and utilized in the same study population and therefore, the utility of the questionnaire may be limited in other populations. Finally, while we assessed the correlations between TIADL and each visual outcome in separate models, the visual outcome measures are not truly independent and would be warranted to study within a comprehensive model.

Conclusions

In summary, this study demonstrates that TIADL estimates have added benefit in conjunction with self-reported IADL in a clinical and research setting especially for individuals with irreversible vision loss and multiple comorbidities. We have also highlighted the association between increased TIADL and decreased visual function, including visual acuity, contrast sensitivity, and the binocular Esterman field. These measures of visual function are particularly important in patients with low vision that are evaluated routinely during rehabilitation. Therefore, TIADL tasks provide a potential metric to assess the effectiveness of rehabilitation in low-vision patients over time. Future studies are needed to assess these long-term effects of TIADL in the context of low-vision rehabilitation.

Abbreviations

IADL	Instrumental Activities of Daily Living
TIADL	Time to Perform Instrumental Activities of Daily Living
ETDRS	Early Treatment Diabetic Retinopathy Study
CES-D	Center for Epidemiological Studies Depression
LogMAR	Logarithm of the Minimum Angle of Resolution
IQR	Interquartile Range
MMSE	Mini-Mental State Examination

Supplementary Information

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Supplementary Material 1: Supplementary Table 1. Summary of Self-Reported Medical History

Supplementary Material 2: Supplementary Table 2. Components of TIADL

Supplementary Material 3: Supplementary Table 3. Components of Self-Reported IADL

Supplementary Material 4: Supplementary Table 4. TIADL Completion Status and Accuracy of Completion

Supplementary Material 5: Supplementary Table 5. TIADL Completion Times by Accuracy Status

Supplementary Material 6: Supplementary Figure 1. Correlation between TIADL Tasks

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Author contributions
PB analyzed and interpreted the patient data and was a major contributor of the manuscript. GM supervised the analysis and interpretation of data and was a major contributor in the design of the study. CO was a major contributor in the design of the study and contributor of the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was performed in accordance with the Declaration of Helsinki and was approved by the ethics committee of University of Alabama at Birmingham. Written informed consent was obtained from each patient prior to participation in the study.

Competing interests
The authors declare no competing interests.

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