Objective. Engaging in physical activity (PA) and/or cognitive activity (CA) retains function in older adults, but whether the combination of these activities is associated with disability onset is still unknown. This study aimed to examine the prospective association of PA and/or CA with disability onset in older adults.

Methods. This was an ongoing prospective community-based cohort study. Data collection was conducted through a health check. An analyzable sample of 2668 participants (mean age = 75.5 years; 51.6% female) were categorized into 4 groups based on quartile 1 (low) and 2 to 4 (high) values of accelerometer-measured moderate-to-vigorous PA and CA scale scores based on the frequency of 6 activities including reading, writing for pleasure, doing crossword puzzles, and playing board games or cards. Disability onset was monitored through long-term care insurance certification for at least 2 years.

Results. A log-rank test showed significantly lower incidence of disability in the high PA and low CA group and the high PA and high CA group compared with the low PA and low CA group. Cox-proportional hazards models (referring to the low PA and low CA group) showed that only the high PA and high CA group was significantly associated with a lowered hazard ratio for disability onset (0.51; 95% CI = 0.29–0.90) after adjusting for covariates.

Conclusions. Engaging in both PA and CA is effective for reducing risk of disability onset, but engaging in either PA or CA is not effective.

Impact. Physical therapists can be guided by this research to design intervention strategies for people at risk of disability.
Disability that leads to difficulty in living independently is a serious worldwide health problem affecting the rapidly increasing population aged 60 years and older. During aging, activities of daily living (ADL) are likely to be inhibited by many factors, including functional decline and chronic diseases such as diseases of the sense organs, low back and neck pain, diabetes, and dementia. Public health services should make efforts to prevent disability and prolong the population's healthy life expectancy.

An active lifestyle contributes to the prevention of chronic diseases and suppresses functional decline. Many studies have reported that, for older adults, physical activity (PA) reduces the risk of disability, of many chronic diseases, and the decline of physical and cognitive function. To maintain cognitive function, cognitive activity (CA) has been also recommended. Engaging in both PA and CA might lead to retaining functional abilities more effectively and better reducing disability onset compared with engaging in either PA or CA alone, but no studies have reported such findings. Thus, the present study aimed to examine the prospective associations of engaging in PA and/or CA with disability onset.

Methods
Participants
This study was conducted using prospective epidemiological data from the National Center for Geriatrics and Gerontology—Study of Geriatric Syndromes. This is a community-based cohort study that aimed to establish a screening system for preventing geriatric syndromes. As described in the existing literature, a health check, including a face-to-face interview and tests measuring physical and cognitive function, was conducted targeting community-dwelling older people in Nagoya, Japan, from July to December 2013. The participation eligibility criteria were an age of 70 or more years and the ability to understand the instructions for the questionnaires and the physical and cognitive performance tests. An invitation letter to participate in the National Center for Geriatrics and Gerontology—Study of Geriatric Syndromes was sent to the 24,271 Midori ward residents aged 70 or older who had no long-term care needs or support. After the health check for the 5257 participants, the Japanese public long-term care insurance system (LTCI) managed by municipal government tracked monthly new-onset disability for at least 2 years. Among the participants, 5178 agreed to an additional survey and were provided with an accelerometer as a measurement of daily physical activity. Exclusion criteria were as follows: invalid accelerometer data (n = 1980); 1627 participants did not visit any of the 9 pharmacies specified for data downloads within 60 days; 335 participants did not wear the accelerometers for 10 h/d for at least 7 days, and 18 participants experienced technical errors with the data reader; the need for support or care certified by LTCI before or within 60 days after the health check (n = 10); having a self-reported basic activities of daily living (BADL) disability (n = 5); having a medical history that included stroke, dementia, or Parkinson disease (n = 227); having a general cognitive impairment (Mini-Mental State Examination score less than 21 [n = 58]); requiring the use of a cane in daily life (n = 79); inability to walk (n = 2); having strong knee pain (n = 28); died or moved to another city during the follow-up period (n = 27); or had missing data for all the variables (n = 94). In total, 2668 participants were included in the analysis. All participants provided written informed consent before participation.

This study was conducted according to the guidelines proposed in the Declaration of Helsinki, and the study protocol was reviewed and approved by the research ethics committee of the National Center for Geriatrics and Gerontology.

Assessment
Disability. In the present study, disability was identified by an LTCI certification that the patient required care or support. The details of the LTCI system in Japan have been described elsewhere. Briefly, a trained local government official visits the individual’s home and administers a questionnaire regarding the patient's current physical and mental status (73 items in 7 dimensions including paralysis and limitation of joint movement, movement and balance, complex movement, conditions requiring special assistance, ADL/instrumental ADL (IADL), communication and cognition, and behavioral problems) and use of medical procedures (12 items). From the results of this questionnaire, the applicant’s standardized scores are calculated for the 7 dimensions described above as well as the estimated time for 9 categories of care (grooming/bathing, eating, toileting, transferring, eating, assistance with IADL, behavioral problems, rehabilitation, and medical services), and they are assigned a care-needs level based on the total estimated care minutes. After that, the Nursing Care Needs Certification Board reviews and confirms the care need level: “Support Level 1 or 2” to indicate a need for assistance to support ADL or “Care Level 1 through 5” to indicate a need for continuous care. We defined disability onset as the point at which a participant was certified as needing care according to LTCI classification regardless of the care level.

Physical activity. PA assessment was conducted by using a triaxial accelerometer (GT40-020: Kao Corporation, Tokyo, Japan). The accelerometer set the display as blinded, and participants wore it on either the left or right side of the waist during waking hours for a month except during water-based activities such as bathing or swimming. The FeliCa RC-S380 data reader (Sony, Tokyo, Japan) was installed in 9 regional cooperative pharmacies, and participants were instructed to go there to have the data downloaded. Inclusion criteria for accelerometer data...
were those who downloaded the data within 60 days of receiving the accelerometer and had more than 7 days of data with at least 10 hours of recording,\textsuperscript{20} excluding nonwearing time designated as at least 35 min of nonrecorded time.

The accelerometer estimates the intensity of PA and recorded the duration in 4-second epoch lengths similarly to the Kenz Lifecoder (Suzuken Corporation Ltd, Aichi, Japan).\textsuperscript{17} The accelerometer estimates the PA intensity using 11 levels, where level 4 or higher corresponds to 3.0 or more metabolic equivalents (METs), that is, moderate-to-vigorous intensity. We considered time spent in moderate-to-vigorous PA because it is recommended for health and successful aging.\textsuperscript{18,19}

**Cognitive activity.** CA was determined using a cognitive activity scale assessing the frequency of engagement in 6 activities\textsuperscript{22}: reading books or newspapers, writing for pleasure, doing crossword puzzles, playing board games or cards, participating in organized group discussion, and playing musical instruments. The scale assigned a score based on frequency (daily: 7 points; several days per week: 4 points; once weekly: 1 point; monthly: 0 point; occasionally: 0 point; never: 0 point). Total scores ranged from 0 to 42, with higher scores indicating more frequent engagement in CA. In a prospective cohort study among 469 community-dwelling individuals older than 75 years, a 1-point increment in the score was significantly associated with a reduced risk of dementia (hazard ratio [HR]: 0.93; 95% CI = 0.90–0.97) over a median follow-up period of 5.1 years.\textsuperscript{20}

**Combining Physical and/or Cognitive Activity**

To identify engagement level in PA and CA, accelerometer-measured PA and CA scale scores were dichotomized into quartile 1 (low PA/low CA) and quartiles 2 to 4 (high PA/high CA). The participants were then categorized into 4 groups: low PA and low CA, low PA and high CA, high PA and low CA, and high PA and high CA.

**Covariates**

Sociodemographic characteristics (age, sex, and education years), whether the patient had chronic diseases (diabetes mellitus, heart and cardiovascular diseases, and respiratory diseases), chronic pain in any part of the body lasting at least 2 months, and depressive symptoms were assessed via face-to-face interview. Depressive symptoms were assessed using the 15-item Geriatric Depression Scale, providing a score ranging from 0 to 15. The score was dichotomized into less than 6, and equal to or greater than 6 using the cutoff point.\textsuperscript{23} Body mass index was calculated using patients’ measured height and weight. Normal walking speed was measured on a 6.4-m walking path, with 2.4 m of measurement space in the middle surrounded in the front and back with 2 m of space for acceleration and deceleration.

**Statistical analyses**

Differences in participants’ characteristics at the baseline among the 4 groups were examined using analysis of variance for continuous variables and \( \chi^2 \) tests for ordinal variables. The cumulative incidence of disability was assessed during the follow-up for each group using the Kaplan-Meier curve, and the differences were examined using the log-rank test. The associations between disability onset and the 4 groups were examined using Cox proportional hazards regression models. HR and 95% CI of disability onset referred to how the low PA and low CA group was calculated. Considering that gait speed affected the association between PA and mobility disability onset in a previous study,\textsuperscript{22} model 1 was adjusted for covariates except for gait speed, and model 2 was adjusted for covariates including gait speed. All analyses were performed using SPSS version 25 (IBM, Armonk, New York). Significance level was set at \( P < 0.05 \) in all analyses.

**Role of Funding Source**

The funders played no role in the design, conduct, and reporting of this study.

**Results**

The characteristics of 2668 participants (mean [SD] age: 75.5 [3.9] years; 51.6% female) are summarized in Table 1. The mean (SD) for PA time and CA scale were 23.9 (18.3) min/d and 11.5 (5.6) scores, respectively. There were 122 participants who were certified as having disability during the follow-up period. The number of participants with disability onset was 18 of 204 (8.8%) for the low PA and low CA group, 55 of 472 (7.0%) for the low PA and high CA group, 25 of 571 (4.4%) for the high PA and low CA group, and 46 of 1421 (3.2%) for the high PA and high CA group. There were significant group differences in most covariates.

The cumulative incidence rates in each group were 41.3/1000 person years (95% CI = 26.1–65.3) for the low PA and low CA group, 32.0/1000 person years (95% CI = 22.8–44.9) for the low PA and high CA group; 20.0/1000 person years (95% CI = 13.6–29.6) for the high PA and low CA group; and 14.9/1000 person years (95% CI = 11.1–19.8) for the high PA and high CA group. The Kaplan-Meier curves showed the most decline of survival probability in the low PA and low CA group followed by the low PA and high CA group, the high PA and low CA group, and the low PA and low CA group (Figure). A log-rank test identified significant differences in the incidence of disability. Compared with the low PA and low CA group, the high PA and low CA group (\( P = 0.016 \)) and the high PA and high CA group (\( P < 0.001 \)) showed significantly lower incidence of disability, but the low PA and high CA group did not show a significant difference (\( P = 0.278 \)).
## Table 1.
### Characteristics of Overall Participants and Comparison Between Groups of Low and High Engagement in PA and CA

|                      | Overall (n = 2668) | Low PA and Low CA (n = 204) | Low PA and High CA (n = 472) | High PA and Low CA (n = 571) | High PA and High CA (n = 1421) | P for Group Difference 
|----------------------|--------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------------|-----------------------
| Age, y               | 75.5 (3.9)         | 76.2 (4.3)                  | 76.4 (4.3)                  | 75.2 (3.9)                  | 75.2 (3.7)                    | <.001                 
| Female, n (%)        | 1377 (51.6)        | 94 (46.1)                   | 260 (55.1)                  | 282 (49.4)                  | 741 (52.1)                    | .108                  
| Education, y         | 12.1 (2.6)         | 11.7 (2.6)                  | 12.0 (2.7)                  | 11.5 (2.6)                  | 12.4 (2.6)                    | <.001                 
| BMI, kg/m²           | 22.9 (3.0)         | 23.4 (3.3)                  | 23.1 (3.1)                  | 23.0 (3.4)                  | 22.7 (2.8)                    | <.001                 
| Diabetes, n (%)      | 314 (11.8)         | 32 (15.7)                   | 44 (9.3)                    | 81 (14.2)                   | 157 (11.0)                    | .022                  
| Heart disease, n (%) | 478 (17.9)         | 41 (20.1)                   | 92 (19.5)                   | 97 (17.0)                   | 248 (17.5)                    | .573                  
| Respiratory disease, n (%) | 478 (17.9) | 35 (17.2)                   | 114 (24.2)                  | 82 (14.4)                   | 247 (17.4)                    | <.001                 
| GDS ≥6 score, n (%)  | 325 (12.2)         | 28 (13.7)                   | 54 (11.4)                   | 97 (17.0)                   | 146 (10.3)                    | <.001                 
| Chronic pain, n (%)  | 970 (36.4)         | 87 (42.6)                   | 173 (36.7)                  | 212 (37.1)                  | 498 (35.0)                    | .194                  
| Gait speed, m/s      | 1.25 (0.20)        | 1.16 (0.2)                  | 1.20 (0.19)                 | 1.24 (0.21)                 | 1.29 (0.2)                    | <.001                 
| PA, min/d            | 23.9 (18.3)        | 7.6 (2.8)                   | 7.6 (2.9)                   | 28.8 (17.6)                 | 29.6 (18.2)                   | <.001                 
| CA scale, score      | 11.5 (5.6)         | 5.6 (2.4)                   | 13.6 (4.5)                  | 5.4 (2.4)                   | 14.0 (4.7)                    | <.001                 
| Disability, n (%)    | 122 (4.6)          | 18 (8.8)                    | 33 (7.0)                    | 25 (4.4)                    | 46 (3.2)                      | <.001                 

*All values are reported as mean (SD) unless otherwise indicated. BMI = body mass index; CA = cognitive activity; GDS = Global Depression Scale; PA = physical activity.

*Continuous variables and category variables between groups were compared using independent analysis of variance and χ² test, respectively.

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**Figure.**

Kaplan-Meier curves for estimating survival rates according to the incidence of disability and low and high engagement in physical activity (PA) and cognitive activity (CA). Compared with the low PA and low CA group, a significant difference was observed in the high PA and low CA group (P = 0.016) and the high PA and high CA group (P < 0.001) in the log-rank test.
In the Cox proportional hazards regression model, a crude model indicated that the high PA and low CA group and the high PA and high CA group had significant associations with lowered HR (HR: 0.36–0.48; all P < 0.05; Tab. 2), which was similar in model 1 (HR: 0.44–0.54; all P < 0.05; Tab. 2). After gait speed was also adjusted for in model 2, only the high PA and high CA group was significantly associated with lowered HR (HR: 0.51; 95% CI = 0.29–0.90; P = 0.019; Tab. 2). The low PA and high CA group showed no significant association with disability onset in any model.

Discussion

This study examined the association of PA and/or CA with disability onset. We found that the high PA and low CA group and the high PA and high CA group showed lower incidence of disability compared with the low PA and low CA group, whereas the Cox proportional regression model adjusted for covariates including physical function showed that only the high PA and high CA group was associated with a lowered risk of disability onset.

Only those who engaged in high PA and high CA showed a significant reduction of their risk of disability onset after adjusting for all covariates, including gait speed. A prospective cohort study explored the prospective association of the functional decline in BADL and IADL with physical activity (habit of taking a walk) and intellectual activities (filling out forms for pension; reading newspapers, books, or magazines; and having interest in news stories or programs dealing with health), suggested that the lack of a habit of taking a walk was one of the predictors for the decline in BADL, and poor intellectual activity was also a predictor for decline in Instrumental Activities of Daily Living. According to this finding, PA could be a factor of independence in BADL, whereas CA could be a factor for a higher level of ADL. Because the disability certified by LTCI in the present study included the loss of independence in BADL and Instrumental Activities of Daily Living, the engagement in both PA and CA has an effect on the reduction of disability development.

The high PA and low CA group had a significantly lower incidence of disability than the low PA and low CA group, but the association with disability onset differed before and after gait speed was included in the statistical model. This association indicated that PA had positive effects via the enhancement of physical function on a lowered risk of disability. Although previous studies reported the effect of PA on preventing disability, in a randomised controlled trial of PA intervention for older adults, the effect of PA intervention on the incidence of mobility disability was significant in the less than 0.8 m/s group (HR: 0.81; 95% CI = 0.66–0.99) but not in the 0.8 m/s or greater group (HR: 0.88; 95% CI = 0.64–1.22). The study also reported that an increase in PA improved the physical function assessed by gait speed and short physical performance battery score. In other words, PA can be associated with a decrease in the incidence of
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disability onset via robust physical functions and can be effective in preventing disability onset, especially for those with weakened physical function. In the present study, the sample size of participants with lower gait speed (<0.8 m/s; n = 26) was insufficient to conduct analysis. Further research should clarify the association between PA and disability via physical function.

The high CA and low PA group was not associated with a lowered risk of disability onset. To our knowledge, the independent association between CA and disability onset has been insufficiently examined. The CA assessed in this study mainly involved static activity that included cognitive stimulation and probably slight physical stimulation; therefore, engaging in high CA and low PA might not have the effect of lowering the risk of disability onset. However, it is too soon to conclude that engaging in abundant CA and less PA was not associated with disability onset. There have been reports that engaging in CA reduced the risk of Alzheimer disease and dementia and major causes of disability. In addition, a 2-year follow-up period might be too short to observe disability onset because the overall sample in this study was relatively healthy judging from the mean gait speed (mean [SD] = 1.25 [0.20] m/s). Further research should examine whether engaging in abundant CA and less PA is effective for reducing the risk of disability onset by targeting the general older population with a longer follow-up period.

The strength of this study is that the objective assessment of PA using an accelerometer differs from a self-reported assessment because it has no inherent recall bias. A prospective study design with a large sample enabled us to discuss the causal association PA and/or CA has with disability development. A limitation is that the sample for this study was recruited nonrandomly from communities. Most of the participants were relatively healthy, and the incidence of disability could be lower than in the general population. Another limitation is that the 2-year follow-up period was relatively short. It will be necessary to verify whether the association between PA and/or CA and disability onset differs when the follow-up period is longer. Furthermore, the definition of disability in this study contained a wide range of functional declines and caused difficulty in interpretation of what function PA and CA each affected.

Conclusions
According to observation during at least a 2-year follow-up period, engaging in higher levels of PA and CA was effective for reducing disability onset. When either PA or CA is conducted, PA can be associated with a lowered risk of disability onset via physical function, whereas CA does not lower the risk.

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Ethics Approval
This study was conducted according to the guidelines proposed in the Declaration of Helsinki, and the study protocol was reviewed and approved by the research ethics committee of the National Center for Geriatrics and Gerontology (no. 637–3). All participants provided written informed consent before participation.

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Disclosures
The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.
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