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Physical Activity and Eye-Hand Coordination Among Older Adults: A Cross-Sectional Study

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Abstract
Background: Aging is associated with progressive declines in neuromuscular and sensorimotor functions, including eye-hand coordination, which is important for maintaining functional independence in older adults. Physical activity may help preserve visuomotor integration and motor performance during aging.
Objective: This study aimed to determine the relationship between physical activity and eye-hand coordination among older adults in Demulih Village, Bangli Regency.
Methods: This analytical observational study employed a cross-sectional design. A total of 59 older adults aged 60–74 years were recruited using purposive sampling. Physical activity was assessed using the Indonesian version of the Physical Activity Scale for the Elderly (PASE-INA), while eye-hand coordination was measured using the Alternate Hand Wall Toss Test (AHWT). Data were analyzed using Spearman's rho correlation test with a significance level of $p < 0.05$.
Results: The mean physical activity score was 202.68 ± 72.09, while the mean AHWT score was 7.64 ± 4.09. Spearman's rho analysis demonstrated a significant positive correlation between physical activity and eye-hand coordination ($r = 0.752$; 95% CI: 0.614–0.845; $p < 0.001$). The correlation coefficient indicated a strong effect size, suggesting that higher physical activity levels were associated with better visuomotor coordination performance among older adults.
Conclusion: Physical activity was significantly associated with eye-hand coordination among older adults. Regular physical activity may contribute to the preservation of visuomotor integration, upper extremity coordination, and functional independence, supporting the development of community-based geriatric physiotherapy programs.

Keywords
Aged; Physical Activity; Eye-Hand Coordination; Motor Skills; Geriatric Assessment

Introduction

Population aging has become a major global public health issue due to increasing life expectancy and improvements in healthcare services. The World Health Organization (WHO) estimated that by 2030, one in six individuals worldwide will be aged 60 years or older, and the global older adult population is projected to reach 2.1 billion by 2050.[1] Aging is associated with progressive physiological changes affecting multiple body systems, particularly neuromuscular, sensorimotor, and cognitive functions, thereby reducing functional capacity and independence among older adults.[2] These age-related changes may impair activities of daily living and increase the risk of disability, falls, and reduced quality of life.[3]

Eye-hand coordination is one of the motor functions that plays an important role in maintaining independence among older adults. Eye-hand coordination refers to the ability to integrate visual information with motor responses in order to produce accurate, rapid, and goal-directed movements.[4] This function is essential for performing daily activities such as grasping objects, eating, writing, opening doors, and completing household tasks. Neurophysiologically, eye-hand coordination involves complex interactions among the visual cortex, sensorimotor cortex, cerebellum, basal ganglia, and peripheral neuromuscular systems that regulate motor planning, movement precision, reaction timing, and adaptive motor control.[5,6]

Advancing age is associated with deterioration in visuomotor integration and sensorimotor processing. Previous studies demonstrated that older adults experience slower reaction times, impaired movement accuracy, reduced motor adaptation, and decreased coordination performance due to cortical degeneration, cerebellar changes, declining neural conduction velocity, and reduced muscle function.[7,8] In addition, age-related declines in proprioception and sensory feedback may further compromise upper extremity coordination and motor control.[9] These impairments have important clinical consequences because poor eye-hand coordination has been associated with functional limitations, fall risk, and reduced independence among older adults.[10]

Physical activity is considered an important modifiable factor that may help maintain physiological and functional capacity during aging. According to the WHO, physical activity includes any bodily movement produced by skeletal muscles requiring energy expenditure, including exercise, transportation, occupational tasks, household activities, and recreational movement.[11] Regular physical activity has been associated with improvements in muscle strength, balance, cardiovascular fitness, cognitive function, and neuromuscular performance among older adults.[12] Furthermore, physically active older adults tend to demonstrate better mobility and motor performance compared with sedentary individuals.[13]

Several neurophysiological mechanisms may explain the relationship between physical activity and eye-hand coordination. Repetitive physical movement stimulates sensorimotor integration and contributes to cortical plasticity, cerebellar adaptation, and neuromuscular activation, which are essential for coordinated movement performance[14] Physical activity may also improve cerebral blood flow, synaptic efficiency, motor learning, and sensory feedback processing, thereby supporting visuomotor accuracy and movement control during aging.[15] Recent evidence suggested that regular physical activity may attenuate age-related sensorimotor decline through repeated activation of central and peripheral nervous system pathways.[16]

Previous studies have reported positive associations between physical activity and motor coordination among older adults. Wang et al. demonstrated that older adults with moderate-to-high physical activity levels experienced slower motor function decline than those with lower activity levels.[12] Similarly, Parwangsa et al. reported a significant relationship between physical activity and eye-hand coordination among older adults using the Alternate Hand Wall Toss Test (AHWT), with a correlation coefficient of $r = 0.359$ and $p = 0.017$.[7] Despite these findings, several methodological limitations remain evident in previous studies, including relatively small sample sizes, limited control of confounding variables, insufficient explanation of visuomotor mechanisms, and inadequate representation of rural community-dwelling older adults. Furthermore, evidence regarding the relationship between habitual physical activity and eye-hand coordination among older adults in rural Indonesian settings remains limited.

The present study also considered limitations related to coordination measurement tools used in previous research. Compared with other coordination assessments, the AHWT offers several practical and methodological advantages because it is simple, inexpensive, easy to administer, and capable of evaluating dynamic visuomotor integration through bilateral throwing-and-catching activities involving reaction speed, visual tracking, upper extremity motor control, and coordination simultaneously.[17] In addition, AHWT has demonstrated acceptable validity and reliability for coordination assessment and is considered representative of functional upper extremity movement patterns among older adults.

Demulih Village, Bangli Regency, represents a rural community in which many older adults remain physically active through farming, gardening, household work, and social activities. These characteristics provide an important contextual setting for investigating the relationship between physical activity and eye-hand coordination among community-dwelling older adults. Nevertheless, data regarding the association between these variables among older adults in Demulih Village are currently unavailable. Understanding this relationship may provide evidence supporting the development of preventive and community-based geriatric physiotherapy programs aimed at preserving functional independence and motor performance among older adults.

Therefore, this study aimed to determine the relationship between physical activity and eye-hand coordination among older adults in Demulih Village, Bangli Regency. We hypothesized that higher physical activity levels would be associated with better eye-hand coordination performance among older adults.

Methods

This study employed an analytical observational design with a cross-sectional approach to investigate the relationship between physical activity and eye-hand coordination among older adults. A cross-sectional design was selected because the independent and dependent variables were measured simultaneously, allowing identification of associations between variables within the study population without determining causal relationships. The study was conducted in Demulih Village, Bangli Regency, Bali, Indonesia, from March to April 2026. Data collection was carried out directly by the researchers with assistance from trained enumerators who received standardized instructions regarding interview procedures, participant screening, and measurement protocols.

The target population consisted of community-dwelling older adults residing in Demulih Village. Participants were recruited using purposive sampling to ensure that respondents met specific functional, cognitive, and sensory criteria required for coordination assessment. Although purposive sampling may increase the risk of selection bias, this technique was considered appropriate to obtain participants capable of completing visuomotor coordination testing safely and consistently.

The inclusion criteria were older adults aged 60–74 years, possessing functional visual acuity of at least 6/18 based on Snellen Chart examination with or without visual aids, having low sarcopenia risk indicated by a Strength, Assistance in Walking, Rise from a Chair, Climb Stairs, and Falls (SARC-F) score of <4, demonstrating normal cognitive function with a Mini Mental State Examination (MMSE) score of ≥ 24, and agreeing to participate by signing written informed consent. The exclusion criteria included older adults with hand tremors interfering with coordination assessment, severe uncorrected visual impairment, vestibular disorders, neurological disorders, or musculoskeletal conditions affecting upper extremity movement that could interfere with test performance.

Sample size calculation was performed using the correlation formula for observational analytical studies with a 95% confidence level and 80% statistical power based on the expected correlation coefficient from previous research. The minimum required sample size was achieved, and 59 eligible participants were successfully recruited through coordination with local community leaders.

The exposure variable in this study was physical activity level, defined as any bodily movement produced by skeletal muscles requiring energy expenditure, including occupational, recreational, transportation, and household activities. The dependent variable was eye-hand coordination, defined as the ability to integrate visual and motor responses to produce rapid and goal-directed movements. Several potential confounding variables, including cognitive function, visual ability, sarcopenia risk, vestibular disturbance, and musculoskeletal impairment, were minimized through participant screening and eligibility criteria.

Physical activity was assessed using the Indonesian version of the Physical Activity Scale for the Elderly (PASE-INA). This questionnaire evaluates physical activity performed during the previous seven days, including leisure activities, occupational activity, and household tasks. Total PASE scores were calculated according to standardized scoring procedures based on the frequency and duration of activities performed by participants. PASE-INA has demonstrated acceptable psychometric properties in Indonesian older adult populations, including good internal consistency with a Cronbach's alpha value of 0.844 and adequate test–retest reliability with an intraclass correlation coefficient (ICC) of 0.728.[18]

Eye-hand coordination was measured using the Alternate Hand Wall Toss Test (AHWT), which evaluates dynamic visuomotor integration, bilateral coordination, upper extremity motor control, and reaction speed. AHWT was selected because it is simple, practical, inexpensive, and suitable for community-based assessment among older adults. Previous studies have demonstrated acceptable validity and reliability of AHWT for coordination assessment in adult and older adult populations.[19]

The AHWT procedure was standardized for all participants. A standard tennis ball was used during testing. Participants stood upright facing a wall at a distance of one meter with feet positioned shoulder-width apart. Before the main assessment, each participant completed one familiarization trial to reduce learning effects and ensure understanding of the testing procedure. During the main trial, participants were instructed to throw the ball against the wall using one hand and catch it using the opposite hand alternately for 30 seconds. Only one main measurement trial was performed following adequate rest after familiarization. The final AHWT score was determined based on the number of successful catches completed during the testing period.

Data collection was conducted directly by the research team. Before data collection, all participants received explanations regarding the study objectives and procedures. Respondents who agreed to participate signed informed consent forms prior to assessment. Participant characteristics, including age, sex, education, and occupation, were recorded using a standardized data collection sheet. Subsequently, physical activity assessment was conducted using PASE-INA interviews, followed by AHWT measurement according to standardized procedures. No missing data were identified because all questionnaires and measurements were completed and verified immediately during the data collection process.

Several procedures were implemented to minimize potential bias. Standardized instructions and identical testing procedures were applied to all participants to reduce measurement bias. All AHWT measurements were conducted by the same assessor to maintain procedural consistency. In addition, the assessor performing AHWT measurements was blinded to participants' physical activity scores to reduce observer bias. Potential recall bias during physical activity assessment was minimized through the use of structured questions and the short seven-day recall period of the PASE-INA questionnaire.

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 24. Descriptive statistics were used to summarize participant characteristics in the form of means, standard deviations, frequencies, percentages, and minimum–maximum values. Data normality was assessed using the Kolmogorov–Smirnov test. Although Shapiro–Wilk is commonly recommended for sample sizes below 100, Kolmogorov–Smirnov was selected because it is widely applied in observational health research and was considered adequate for evaluating distributional assumptions in the present dataset. Because physical activity data were not normally distributed, the relationship between physical activity and eye-hand coordination was analyzed using Spearman's rho correlation test. Statistical significance was established at $p < 0.05$ with a 95% confidence interval. Correlation strength interpretation followed established statistical guidelines categorizing correlation coefficients into weak, moderate, and strong associations. [20]

To improve transparency of participant recruitment and selection according to STROBE recommendations, the participant flow process is described narratively to facilitate future conversion into a visual flowchart. Initially, 120 older adults residing in Demulih Village were identified as the target population. Following purposive sampling, 74 individuals underwent eligibility screening consisting of cognitive assessment using MMSE, sarcopenia screening using SARC-F, visual acuity examination using Snellen Chart, and observation for tremor or musculoskeletal disorders. Fifteen individuals were excluded due to MMSE scores <24 (n = 6), SARC-F scores ≥4 (n = 4), visual acuity <6/18 (n = 3), hand tremor (n = 1), and musculoskeletal impairment interfering with testing (n = 1). Finally, 59 participants fulfilled all eligibility criteria, completed informed consent procedures, underwent physical activity and coordination assessments, and were included in the final analysis without missing data.

This study received ethical approval from the Research Ethics Commission of the Faculty of Medicine, Udayana University, with ethical clearance number 1014/UN14.2.2.VII.14/LT/2026. All participants provided written informed consent before participation. Participant confidentiality and data privacy were maintained throughout the study.

Results

A total of 59 older adults participated in this study and all respondents fulfilled the eligibility criteria and completed the entire assessment process. Therefore, all collected data were included in the final analysis without missing values. The study was conducted in Demulih Village, Susut District, Bangli Regency, Bali.

To improve transparency of participant recruitment and selection according to STROBE recommendations, the participant flow process is presented below in text format to facilitate future conversion into a visual flowchart (Figure 1).

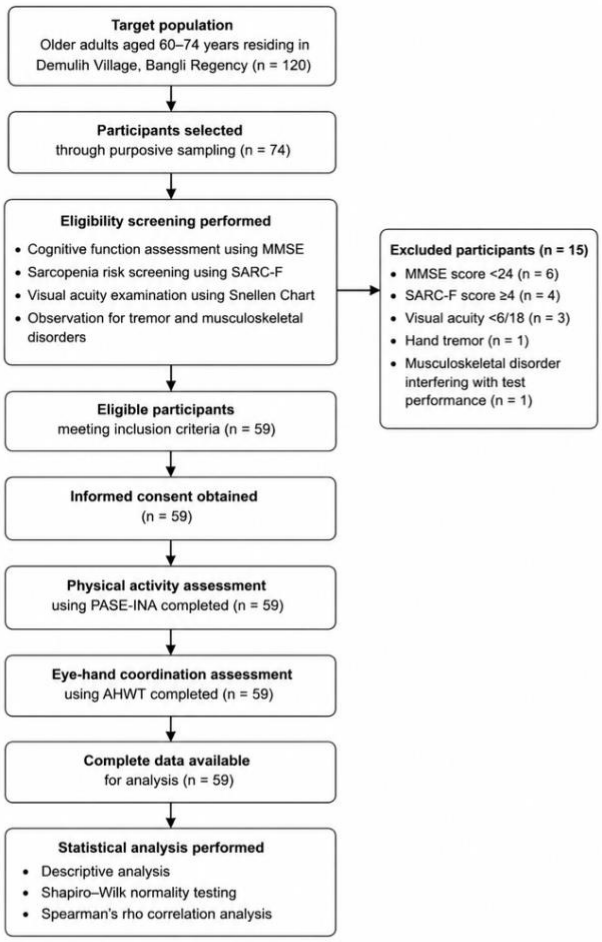

Figure 1. Flow Diagram of Participant Recruitment, Eligibility Screening, and Study Procedures

Participant characteristics were analyzed descriptively to provide an overview of demographic and clinical profiles relevant to the study variables. The majority of participants were female (64.4%), while males accounted for 35.6% of the sample. The mean participant age was 65.85 ± 4.55 years, ranging from 60 to 74 years. Most participants were still actively working (93.2%), primarily in farming, gardening, trading, and other physically active occupations commonly observed in rural communities.

Table 1 presents the demographic and clinical characteristics of study participants, including physical activity level, eye-hand coordination performance, cognitive status, sarcopenia risk, visual acuity, and occupational status. The table was included to provide a comprehensive overview of participant profiles potentially related to functional performance and visuomotor coordination.

Table 1. Characteristics of Study Participants

Variables	n	%	Mean ± SD	Min–Max
Female	38	64.4	–	–
Male	21	35.6	–	–
Age (years)	59	100	65.85 ± 4.55	60–74
Physical Activity (PASE-INA)	59	100	202.68 ± 72.09	75.80–359.80
Eye-Hand Coordination (AHWT)	59	100	7.64 ± 4.09	1–19
MMSE Score	59	100	26.73 ± 1.91	24–30
SARC-F Score	59	100	1.56 ± 1.00	0–3
Visual Acuity (Snellen)	59	100	0.43 ± 0.08	0.4–1.0
Working Status	55	93.2	–	–
Not Working	4	6.8	–	–

The descriptive analysis demonstrated variability in physical activity levels among participants. The mean PASE-INA score was 202.68 ± 72.09, indicating relatively active daily lifestyles among older adults in Demulih Village. Reported activities included walking, farming, gardening, household tasks, and participation in community-based social activities. Meanwhile, the mean AHWT score was 7.64 ± 4.09, indicating variability in visuomotor coordination performance among respondents.

All participants demonstrated normal cognitive status according to the inclusion criteria, with a mean MMSE score of 26.73 ± 1.91. In addition, all respondents were categorized as having low sarcopenia risk, reflected by a mean SARC-F score of 1.56 ± 1.00. Visual screening results also confirmed that all participants met the minimum visual acuity requirement for coordination testing, indicating that visual impairment was minimized as a potential confounding factor during AHWT assessment.

Prior to correlation analysis, data normality was assessed using the Shapiro–Wilk test. Physical activity data were not normally distributed ($p = 0.023$), whereas eye-hand coordination data demonstrated normal distribution ($p = 0.200$). Therefore, non-parametric analysis using Spearman's rho correlation test was applied.

The primary objective of this study was to determine the relationship between physical activity and eye-hand coordination among older adults. Table 2 summarizes the correlation coefficient, confidence interval, significance value, and strength interpretation of the observed association between study variables.

Table 2. Correlation Between Physical Activity and Eye-Hand Coordination

Variables	Correlation Coefficient (r)	95% CI	p-value	Interpretation
Physical Activity and Eye-Hand Coordination	0.752	0.614–0.845	<0.001	Strong positive correlation

Spearman's rho analysis demonstrated a statistically significant positive correlation between physical activity and eye-hand coordination among older adults ($r = 0.752$; 95% CI: 0.614–0.845; $p < 0.001$). Based on the correlation interpretation framework proposed by Mukaka, correlation coefficients between 0.70 and 0.90 indicate a strong correlation strength.[19] Therefore, the findings suggested that older adults with higher physical activity levels tended to demonstrate better visuomotor coordination performance.

To further illustrate the relationship between study variables, the correlation pattern was visualized using a scatterplot. The scatterplot demonstrated a positive linear trend, indicating that participants with higher PASE-INA scores generally achieved higher AHWT scores. This visualization supported the statistical findings and provided a clearer representation of the positive association between physical activity and eye-hand coordination among older adults.

Additional subgroup observation based on sex demonstrated relatively similar trends between male and female participants, although formal subgroup statistical testing was not performed because the primary objective of the study focused on overall correlation analysis within the study population.

Overall, the results consistently demonstrated that physically active older adults tended to exhibit better eye-hand coordination performance compared with less active individuals. These findings supported the study hypothesis regarding the association between physical activity and visuomotor coordination among community-dwelling older adults in Demulih Village.

Discussion

This study demonstrated a significant positive relationship between physical activity and eye-hand coordination among older adults in Demulih Village, Bangli Regency, with a strong correlation coefficient ($r = 0.752$; $p < 0.001$). These findings indicate that older adults with higher physical activity levels tended to demonstrate better visuomotor coordination performance. The observed association supports the study hypothesis and suggests that physical activity may play an important role in maintaining sensorimotor and coordination function among community-dwelling older adults.

The present findings are consistent with previous studies reporting positive associations between physical activity and motor coordination among older adults. Parwangsa et al. reported a significant correlation between physical activity and eye-hand coordination measured using the Alternate Hand Wall Toss Test (AHWT), although the correlation strength observed in their study was lower than that identified in the present research.[7] Similarly, Wang et al. demonstrated that physically active older adults experienced slower declines in motor performance and functional ability compared with individuals with lower physical activity levels.[12] These findings collectively support the concept that habitual physical activity is associated with preservation of motor coordination and functional movement capacity during aging.

Several neurophysiological mechanisms may explain the relationship observed in this study. Physical activity stimulates repeated activation of sensorimotor pathways, thereby enhancing neuromuscular coordination, reaction speed, motor learning, and visuomotor integration. Repetitive movement also contributes to cortical plasticity and cerebellar adaptation, which are essential for maintaining coordinated and goal-directed movement.[14] In older adults, regular physical activity may help preserve neural conduction velocity, proprioceptive feedback, and upper extremity motor control, thereby supporting eye-hand coordination performance.

Furthermore, physical activity has been associated with improved cerebral blood flow, synaptic efficiency, and maintenance of functional connectivity within sensorimotor brain regions, all of which contribute to better movement accuracy and coordination during aging.[15]

The relatively high correlation coefficient observed in this study should nevertheless be interpreted cautiously. Although the results demonstrated a strong association, the cross-sectional design does not allow conclusions regarding causality. It is possible that physically active older adults tend to maintain better coordination abilities; however, reverse causality may also occur, whereby older adults with better coordination and functional capacity are more likely to engage in physical activity. Therefore, the findings should be interpreted as an association rather than evidence of a direct causal effect.

Another factor potentially contributing to the strong correlation observed in this study is the sociocultural and occupational characteristics of the study population. Most participants were still actively involved in farming, gardening, household work, trading, and community activities requiring repetitive upper extremity movement, postural control, and visuomotor coordination. Rural older adults in Demulih Village generally maintain physically active lifestyles as part of daily living rather than through structured exercise programs. These habitual activities may continuously stimulate sensorimotor integration and motor coordination, potentially strengthening the observed relationship between physical activity and eye-hand coordination.

The present findings also have important implications from a geriatric physiotherapy perspective. Community-based physical activity programs may contribute to preservation of visuomotor integration, upper extremity coordination, and functional independence among older adults. Physiotherapy interventions incorporating coordination exercises, dual-task training, visual-motor exercise, balance training, and upper extremity motor control activities may provide additional benefits for maintaining functional performance in aging populations. Furthermore, integrating meaningful daily activities such as gardening, household tasks, and recreational movement into geriatric rehabilitation programs may improve adherence and functional relevance among community-dwelling older adults.

This study used the Alternate Hand Wall Toss Test (AHWT) as the coordination assessment instrument because it evaluates dynamic visuomotor integration through bilateral throwing-and-catching movements involving visual tracking, reaction speed, and upper extremity motor control simultaneously. Compared with more complex laboratory-based coordination assessments, AHWT offers practical advantages for community-based research because it is inexpensive, easy to administer, and capable of reflecting functional movement performance relevant to daily activities among older adults. The use of standardized familiarization trials and uniform testing procedures in the present study may also have contributed to improved measurement consistency and reduced learning effects during assessment.

Several methodological strengths should be acknowledged. The study applied strict inclusion and exclusion criteria to minimize confounding influences from cognitive impairment, visual dysfunction, sarcopenia risk, vestibular disorders, and musculoskeletal impairment. In addition, all measurements were conducted using standardized procedures and validated instruments, while observer bias was minimized by ensuring that the assessor conducting AHWT measurements was blinded to participants' physical activity scores.

Nevertheless, several limitations should be considered when interpreting the findings. First, the cross-sectional design precludes establishment of temporal or causal relationships between variables. Second, purposive sampling may increase the risk of selection bias and limit external validity. Third, physical activity assessment using PASE-INA relied partly on self-reported responses, which may introduce recall bias despite the relatively short recall period. Fourth, all participants demonstrated normal cognitive status and low sarcopenia risk due to eligibility criteria, potentially reducing variability in these characteristics and contributing to a possible ceiling effect for certain functional variables. Finally, because the study was conducted within a rural community with predominantly active older adults, generalization of the findings to urban or less physically active populations should be interpreted cautiously.

Future studies are recommended to employ longitudinal or interventional designs to clarify temporal and causal relationships between physical activity and eye-hand coordination among older adults. Additional studies involving larger and more diverse populations are also needed to improve generalizability and explore the influence of other potential confounding variables such as nutritional status, depression, educational background, and chronic disease burden. Furthermore, future physiotherapy research may investigate the effectiveness of coordination-based exercise programs, dual-task interventions, and visuomotor training strategies for improving functional performance and preventing age-related motor decline among older adults.

Overall, the present findings suggest that higher physical activity levels were associated with better eye-hand coordination among community-dwelling older adults in Demulih Village. These findings reinforce the importance of maintaining active lifestyles during aging and provide preliminary evidence supporting the development of community-based geriatric physiotherapy strategies aimed at preserving sensorimotor and functional capacity among older adults.

Conclusion

This study demonstrated a significant and strong positive relationship between physical activity and eye-hand coordination among older adults in Demulih Village, Bangli Regency. Older adults with higher physical activity levels tended to exhibit better visuomotor coordination performance, indicating the potential importance of maintaining active lifestyles to support sensorimotor and functional capacity during aging.

The findings suggest that regular physical activity may contribute to the preservation of upper extremity coordination, visuomotor integration, and functional independence among community-dwelling older adults. From a geriatric physiotherapy perspective, these results support the development of community-based interventions incorporating physical activity, coordination exercise, visual-motor training, and functional movement activities to promote healthy aging and reduce functional decline among older populations.

Despite these findings, the cross-sectional nature of the study does not allow causal inferences regarding the relationship between physical activity and eye-hand coordination. Therefore, future studies using longitudinal or interventional designs are recommended to further clarify temporal relationships and evaluate the effectiveness of targeted physiotherapy interventions aimed at improving coordination and functional performance among older adults.

Clinical Implications

The present findings emphasize the importance of maintaining physical activity among older adults as part of preventive and rehabilitative physiotherapy strategies. Community-based physiotherapy programs integrating coordination exercise, upper extremity motor training, dual-task activities, and functional daily movement practice may help preserve sensorimotor performance and independence among older adults, particularly in rural community settings.

Study Limitations

Several limitations should be acknowledged in this study. First, the cross-sectional design limited the ability to establish causal relationships between variables. Second, purposive sampling may increase the risk of selection bias and reduce generalizability of findings. Third, physical activity assessment using PASE-INA partly relied on self-reported responses, potentially introducing recall bias. In addition, the study population consisted predominantly of physically active rural older adults, which may limit applicability of the findings to urban or sedentary older adult populations.

Author Contribution

Ni Made Cahya Dewayani contributed to conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing original draft, writing review and editing, visualization, project administration, and funding acquisition.
Anak Agung Gede Angga Puspa Negara contributed to conceptualization, methodology, validation, formal analysis, data curation, and writing review and editing.
Made Hendra Satria Nugraha contributed to conceptualization, methodology, validation, formal analysis, data curation, and writing review and editing.
I Made Niko Winaya contributed to conceptualization, methodology, validation, formal analysis, data curation, and writing review and editing.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study was approved by the Research Ethics Commission of the Faculty of Medicine, Udayana University with ethical clearance number 1014/UN14.2.2.VII.14/LT/2026. All participants provided written informed consent prior to participation.

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