



Effects of silent myocardial ischemia on functional fitness and physical independence in 60–79-year-old adults



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ABSTRACT

Objective: We examined the effect of silent myocardial ischemia (SMI) on functional fitness levels and physical independence in 60–79-year-old individuals.

Methods: We conducted a cross-sectional study with 716 older adults and used an electrocardiograph and an ambulatory electrocardiogram to diagnose those with SMI. Physical independence was assessed using the Composite Physical Function scale, whereas physical fitness was assessed using the Senior Fitness Test battery.

Results: The 60–79-year-old females and males with SMI were more likely to have lower scores for lower and upper body strength, agility/dynamic balance, and aerobic endurance ($p < 0.05$) than those without SMI. The scores for lower and upper body flexibility in all age groups for both genders were not significant ($p > 0.05$). Binary logistic regression analysis revealed that old adults with SMI had a higher risk of losing physical independence later in life than those without SMI ($p < 0.05$).

Conclusion: This study showed that individuals with SMI have lower fitness levels and increased risk of losing physical independence than those without SMI.

Introduction

Silent myocardial ischemia (SMI) is defined as the objective evidence of myocardial ischemia in the absence of clinical manifestations.¹ It is manifested as a combination of an increased demand for oxygen and an altered oxygen supply that is secondary to abnormal microvascular or endothelial responses.² SMI may be identified during routine daily activities or stress testing in patients with or without known coronary artery disease (CAD).³

SMI prevalence in adults is approximately 10% based on an exercise electrocardiogram (ECG) and as much as 25% based on a 24-h ambulatory electrocardiogram (AECG).⁴ In patients with CAD, SMI prevalence during AECG monitoring was found to range from 50 to 80% in different studies.⁵ To add, SMI prevalence is estimated to be between 20 and 35% in patients with diabetes mellitus⁶ and range from 15 to 80% in patients with hypertension.^{7–9} The prevalence of SMI increases with age. In fact, SMI incidence increases in number (12.12%, 19.75%, 22.25%, and 31.48% for less than 50 years, 50–59 years, 60–69 years, and greater than or equal to 70 year-old, respectively) and duration (episodes of ischemia

per patient of each age group 37, 37.5, 50.8, and 85.1 min, respectively) of ischemia episodes with aging.¹⁰

SMI has a significant impact on the quality of life (QOL) of old adults as it may cause them to become anxious, scared, and depressed.¹¹ These emotional complications limit their activities in daily life, work, and in relationships. Among these factors, physical independence is most important.^{12,13} Physical independence is defined as possessing the physical capacity required to perform common everyday activities without assistance.¹⁴ These activities include simple housework, lifting and carrying objects, negotiating steps, and being able to walk whilst shopping and running errands.¹⁵

Measures of physical function, including mobility, balance, and strength, have been previously investigated for their predictive value for future incidence of dependence in basic activities of daily living (ADLs) among older adults.^{16,17} In response to the need for valid field-based measurement tools to assess fitness parameters in older adults, Rikli and Jones developed a comprehensive functional fitness test battery.¹⁵ The functional decline that occurs with aging is a growing issue affecting the health and medical treatment for a range of conditions, including musculoskeletal conditions, due to the influence of frailty on mortality,

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Abbreviations

SMI	silent myocardial ischemia
CAD	coronary artery disease
ECG	electrocardiogram
AECG	ambulatory electrocardiogram
QOL	quality of life
ADLs	activities of daily living
PAR-Q	Physical Activity Readiness Questionnaire
IPAQ	International Physical Activity Questionnaire
SMIG	SMI group
nSMIG	non-SMI group
CPF	Composite Physical Function
PA	physical activity
BMI	body mass index
CI	confidence interval

risk of complications, and recovery and responsiveness to health interventions.¹⁸

As SMI increases^{10,19} while physical fitness decreases with age,¹⁵ we hypothesized that SMI will negatively impact functional fitness and physical independence in older adults. Therefore, the primary aim of this investigation was to compare scores of functional fitness and the risk of losing physical independence in patients with and without SMI. Indeed, we can improve the QOL in older adults through early prevention and improved treatment for SMI.

Materials and methods

Design and participants

A total of 716 participants between 60 and 79 years of age were enrolled from community senior centers, public and private institutions, sporting clubs, and at sports and social events in Tianjin, China. This study was approved by the Ethics Committee at Tianjin University of Sport and the local ethics committee of Tianjin, China. Exclusion criteria were: (1) elderly people at risk as assessed by the Physical Activity Readiness Questionnaire (PAR-Q), (2) A history of stroke, cancer, recent fracture, heart surgery, and malignant hypertension, (3) Inability to perform all testing for participants in the recovery phase of an acute illness, and (4) Deafness or blindness. All participants confirmed that they conformed to the inclusion criteria, understood the test purposes and testing procedures, provided written informed consent, and completed an assessment questionnaire prior to participation (Fig. 1).

The examination included a questionnaire (the International Physical Activity Questionnaire, IPAQ), ECG diagnosis, functional fitness tests, which were conducted indoors at the rehabilitation department of Tianjin Yanan hospital in the morning (8–11 a.m.) with temperature ranging from 22 °C to 25 °C. Sixty-two participants dropped out or failed to complete the test; hence, 716 participants completed the tests for data analysis. Sample characteristics are presented in Table 1.

Silent myocardial ischemia diagnosis

Two cardiologists used 12-lead ECG to examine all participants and diagnose myocardial ischemia. Acute myocardial ischemia, myocardial infarction, and atrial fibrillation, etc. were excluded. AECG monitoring was performed for 24 h and the V5 and V1 leads were recorded. Participants with AECG and at least 20 h of reliable records were included. SMI was diagnosed when the ST segment was depressed by at least 1 mm or with reversibility of ST segment depression lasting at least 60 s.²⁰ According to the diagnosis results, participants were divided into the SMI group (SMIG) and the non-SMI group (nSMIG).

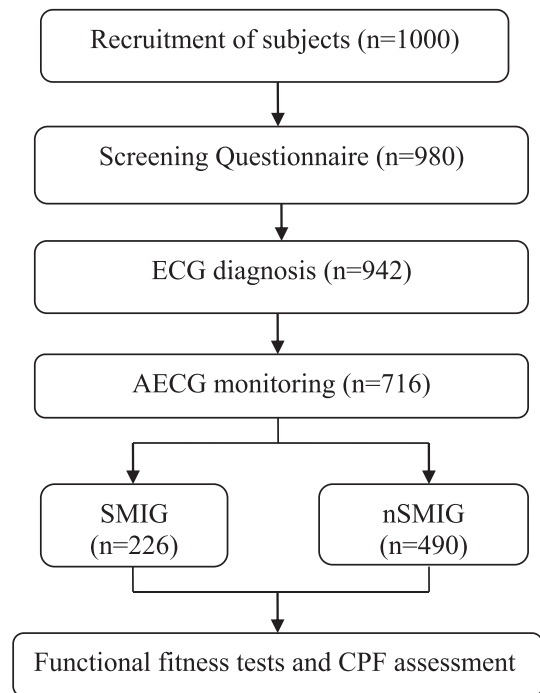


Fig. 1. Flow chart for participant enrollment and the subsequent testing. ECG, electrocardiogram; AECG, ambulatory electrocardiogram; SMIG, silent myocardial ischemia group; nSMIG, non-silent myocardial ischemia group.

Functional fitness tests

Functional fitness of the participants was assessed by using the Senior Fitness Test Manual.^{21,22} This test battery is designed to assess the physiological capacity for carrying out normal daily activities independently and safely without the appearance of fatigue. The battery includes tests for lower and upper body strength, agility/dynamic balance, lower and upper body flexibility, and aerobic endurance. The tests include chair stand (repetitions/30 s), arm curl (women 2.3 kg, men 3.6 kg) (repetitions/30 s), 8-foot up-and-go, upper body back scratch; chair sit-and-reach, and a 6-min walking test. Before the test, all participants had their blood pressure measured and undertook a 10-min warm-up with instructions given by a rehabilitation therapist.²³

Physical independence

Physical independence was assessed via self-reporting using the 12-item Composite Physical Function (CPF) scale.¹⁵ The CPF scale describes a wide range of functional abilities, from those associated with basic to instrumental, or intermediate to advanced ADL. For scoring, the participants selected one of three responses associated with each of the 12 items. Total scores were then summed with a potential range between 0 (cannot perform any of the 12 tasks) and 24 (can perform all 12 tasks independently). Using the age-adjusted scoring, moderate to high functioning independence was defined as: a, 70–79 years: ≥ 18 (can perform at least 9 activities without help); and b, 60–69 years: ≥ 20 (can perform at least 10 activities without help),¹⁵ which is close to the decline observed for a range of functional fitness tests in the Portuguese older adult population.²⁴ Accordingly, physical independence was dichotomized as low function (high risk) and moderate to high function (low risk). The use of the age-adjusted option allows for early detection of risk for loss of mobility and independence prior to the 90s age cohort.¹⁵

Level of physical activity (PA)

The long version of the IPAQ was used; this contains four domains of

Table 1
Characteristics of study participants (M±SD).

Variable	Female			Male		
	SMIG (n = 154)	nSMIG (n = 294)	Total (n = 448)	SMIG (n = 72)	nSMIG (n = 196)	Total (n = 268)
Age (y)	67.02 ± 5.35	67.04 ± 5.23	67.04 ± 5.27	68.25 ± 5.54	68.21 ± 5.16	68.23 ± 5.25 ^a
Height (cm)	156.29 ± 5.57	156.54 ± 5.55	156.45 ± 5.55	167.95 ± 6.44	168.01 ± 5.59	167.99 ± 5.81 ^a
Weight (kg)	62.66 ± 8.86	60.48 ± 8.58 ^b	61.23 ± 8.73	73.45 ± 10.23	70.37 ± 10.1 ^b	71.20 ± 10.15 ^a
BMI (kg/m ²)	25.94 ± 3.25	24.96 ± 3.19 ^b	25.34 ± 3.37	25.29 ± 3.24	24.90 ± 3.12 ^b	25.19 ± 3.08
Waist (cm)	87.67 ± 8.56	85.28 ± 8.83 ^b	86.10 ± 8.80	91.67 ± 7.51	89.29 ± 8.63 ^b	89.93 ± 8.39 ^a
Hip circumference	98.20 ± 6.94	96.97 ± 7.27 ^b	97.39 ± 7.17	99.77 ± 5.45	97.85 ± 6.57 ^b	98.37 ± 6.34 ^a
Waist-to-hip ratio	0.89 ± 0.06	0.88 ± 0.06 ^b	0.88 ± 0.06	0.92 ± 0.04	0.91 ± 0.05	0.91 ± 0.05 ^a
Hypertension (%)	34.42	30.27	31.70	30.56	35.71	34.32
Diabetes (%)	12.99	14.29	13.84	13.88	11.73	12.31
Hyperlipemia (%)	22.73	21.77	22.10	20.83	18.37	19.03
Arthritis (%)	11.04	15.64	14.06	12.50	6.12	7.84 ^a
Low PA (n)	46	29	75	28	19	47
Moderate PA (n)	119	132	251	68	66	134
High PA (n)	44	78	122 ^b	31	56	87 ^b

Abbreviations: nSMI, non-silent myocardial ischemia group; SMI, silent myocardial ischemia group; PA, physical activity.

^a Significant differences between sexes ($p < 0.05$).

^b Significant differences between nSMI and SMI ($p < 0.05$).

PA: work-related, transportation, housework/gardening, and leisure-time activity. Questions related to sitting and sedentary habits, which were not pertinent to this research, were excluded from the analysis. For each domain, participants recorded separately the number of days and time spent each day undertaking vigorous and moderate-intensity activities, as well as the time spent walking. These values (vigorous activity, moderate activity, and walking) were used to calculate the PA levels, as specified in the official IPAQ instruction manual.^{25,26}

Statistical analyses

Statistical analyses were performed using IBM SPSS@Statistics version 19.0 for Windows (SPSS Inc., an IBM Company, Chicago, IL, USA). Chi-squared tests were used to derive the differences between groups for categorical variables. For differences in proportions between gender and SMI vs nSMI, independent sample t-tests were performed. The relationship between SMI and the risk of losing physical independence was evaluated using binary logistic regression models. In these analyses, a score of 1 was assigned to individuals with a low risk of losing physical independence while a score of 0 was assigned to those at high risk; these were used as dummy variables while re-coded values were used as the dependent variable. Age at baseline investigation, SMI, history or current presence of disorders (positive: 1; negative: 0), gender (female:1; male:0), and body mass index (BMI) were used as covariate variables. The odds ratio (OR) with 95% confidence interval (CI) were calculated.

Results

Participant characteristics are presented in Table 1. Average age of participants in the final sample was 67.48 ± 5.29 years (females: 67.04 ± 5.27 years; males: 68.23 ± 5.25 years). Age, height, and history

Table 2
Differences in functional fitness between the nSMI group and SMI group.

Variable	Females		Males	
	SMIG (n = 154)	nSMIG (n = 294)	SMIG (n = 72)	nSMIG (n = 196)
Upper Body Strength (Rep/30s)	19.21 ± 3.19	20.50 ± 3.97 ^a	20.13 ± 4.15	21.74 ± 4.75 ^a
Lower Body Strength (Rep/30s)	16.52 ± 4.13	18.79 ± 4.71 ^a	16.47 ± 4.60	18.40 ± 5.09 ^a
Upper Body Flexibility (cm)	-10.85 ± 11.37	-9.21 ± 14.12	-26.45 ± 14.19	-23.51 ± 14.60
Lower Body Flexibility (cm)	2.16 ± 11.23	0.81 ± 11.69	-9.34 ± 14.14	-9.31 ± 12.00
Agility/Dynamic Balance (s)	6.14 ± 1.11	5.70 ± 1.21 ^a	6.49 ± 1.25	5.99 ± 1.34 ^a
Aerobic Endurance (m)	384.45 ± 54.05	401.04 ± 61.57 ^a	374.04 ± 45.63	409.93 ± 61.06 ^a

Abbreviations: nSMIG, non-silent myocardial ischemia group; SMIG, myocardial ischemia group.

^a Significant differences between nSMIG and SMIG ($p < 0.05$).

or current presence of disorders (hypertension, diabetes, hyperlipemia, and arthritis incidence) did not significantly differ between SMI and nSMI patients, but body weight, BMI (weight/height², kg/m²), waist, hip circumference, waist-to-hip ratio (except for waist-to-hip ratio in men), and level of PA were significantly different between the groups. As most characteristics were significantly different between females and males, gender was analyzed as a covariate in the binary logistic regression models.

Table 2 summarizes the results for physical functioning between SMI and nSMI participants. Upper and lower body strength, agility/dynamic balance, and aerobic endurance in the nSMIG were significantly better than in the SMIG group ($p < 0.05$). There were no differences in upper and lower body flexibility between SMIG and nSMIG ($p > 0.05$).

Table 3 contains data on the risk of losing physical independence in later life. From the listed factors, SMI, gender, aging, BMI, and arthritis were recognized to significantly increase the risk of losing physical independence in later life ($p < 0.05$). Old adults with SMI also had a 1.486-

Table 3
Effects of silent myocardial ischemia on the risk of losing physical independence in later life.

Factor	OR	95%CI	p
SMI	1.486	1.023–2.157	0.037
Gender	2.054	1.387–3.043	0.000
Age	1.109	1.072–1.148	0.000
BMI	1.084	1.024–1.148	0.005
Arthritis	1.961	1.185–3.246	0.009
Hypertension	1.263	0.863–1.849	0.230
Diabetes	1.084	0.649–1.808	0.759
Hyperlipemia	1.033	0.644–1.656	0.893

Abbreviations: OR, odds ratio; CI, confidence interval, SMI, silent myocardial ischemia.

(CI 95%:1.023–2.157) fold greater loss of physical independence in later life than those with nSMI.

Discussion

This study examined the effects of SMI on functional fitness and physical independence in older adults. Using of all physical fitness components to derive a model that included all physical fitness parameters was utilized to comprehensively investigate the effects of SMI. To add, age, history or current presence of disorders (hypertension, diabetes, hyperlipemia, and arthritis incidence), and BMI were used as covariates in the binary logistic regression models, with OR to predict the risk of loss of physical independence in older adults with SMI.

Age-related physiological changes affect a wide range of tissues, organ systems, and functions, which, cumulatively, can impact the preservation of physical independence,¹⁴ thereby resulting in a reduction in QOL and life expectancy, and elevating long-term healthcare costs.²⁷ Some previous researches suggested that obesity,²⁸ BMI,^{29,30} high blood pressure,³¹ and physical inactivity levels³² are associated with an impaired functional status. Few studies have reported the effects of SMI on the functional fitness of older adults. Recently, SMI was shown to be associated with a higher risk of cardiovascular disease.^{33,34} The main risk factors for developing myocardial ischemia are the same as those for CAD, namely hypertension, diabetes, and aging.¹⁹ Prospective studies indicate a low prevalence of myocardial ischemia and a low cardiac event rate in unselected asymptomatic cohorts, and even diabetics. To add, approximately one fourth to one third of coronary events appear to progress from a silent to a manifested state.³⁵ As a result, more attention should be given to SMI in older adults.

The maintenance of physical fitness by older adults is a key factor in preserving their mobility and physical independence later in life.³⁶ The selected physical fitness measurements in this study included lower and upper body strength, agility/dynamic balance, and aerobic endurance. Lower-body strength is needed for activities such as climbing the stairs, walking, and getting out of a chair or bathtub. Maintaining strength and muscle function is also important because strength plays a significant role in reducing the risks of falls and fall-related injuries and has a positive effect on other age-related health conditions.³⁷ Muscular strength can help reduce bone loss, improve glucose utilization, maintain lean body tissue, and prevent obesity.³⁸ In our study, muscular strength of older adults with SMI was lower than of those with nSMI. This low muscular strength would impact their health and reduce PA.

Upper-body strength is important for carrying groceries, lifting a suitcase, picking up a grandchild or a pet, and many other common tasks. Mean values for lower and upper body strength of 60–79-year-old adults with SMI were poorer than those without SMI. Hence, older adults with SMI are more likely to experience a decrease in ADL.

Flexibility impairs most of the functions needed for good mobility, including bending, stooping, lifting, reaching, walking, and stair climbing. Maintaining lower-body flexibility, especially in the hip joint and hamstrings, is important because of the role played by flexibility in preventing lower-back pain, musculoskeletal injury, gait abnormalities, and reducing the risk of falling.³⁹ The results of this study showed that SMI had no effect on flexibility in this population, with most older adults being physically independent. Performing basic daily activities can assist older adults in maintaining their range of motion. To add, a great energy expenditure is not necessary for the development of good flexibility as a greater energy expenditure is more likely dependent on heart function and repeated large muscle activity.

Agility is the ability to move the body and quickly change one's direction. Dynamic balance involves the maintenance of postural stability during movement. Agility and dynamic balance are important for many common mobility tasks that require quick maneuvering. In our research, agility and dynamic balance in male and female participants with SMI were poorer than in those with nSMI. To add, the changes in agility and dynamic balance that occurred with aging in males were almost the same

as those found in females. Older adults with nSMI were better able to perform in these areas of functional fitness than those in the SMI group; however, males with SMI had a faster decline with aging than females with SMI.

Aerobic endurance is the ability to sustain large-muscle activity over time. Adequate functional levels are necessary to perform many everyday activities, such as walking, shopping, sightseeing while on vacation, and participating in recreational or sporting activities. The results of this study showed that aerobic endurance was poorer in 60–79-year-old adults with SMI than in adults with nSMI.

Some studies have proposed standards for selecting fitness parameters that are associated with physical independence.^{15,40} Maintaining functional physical fitness is a key factor for preserving mobility and physical independence later in life. Physical fitness declines with age, however physically-active older adults who maintain their activity and fitness levels may postpone such functional decline.^{27,36}

Our findings support the concept that functional physical fitness in older adults with SMI is worse than in those with nSMI. In the past 20 years, many prospective studies have described the independent effects of cardiorespiratory fitness^{41–43}. However, no research has reported the effects of SMI on physical independence in old adults. In this study, we analyzed the factors influencing physical independence in old adults. As a result, we found that older adults with SMI had a higher risk of losing physical independence. Other factors such as gender, aging, BMI, and arthritis were also found to increase the risk of loss of physical independence. To add, old female adults were more likely to lose physical independence than old male adults. Although a disability can originate from disease or pathology, a physically inactive lifestyle can also be a primary cause of frailty and disability.²⁴ Hence, SMI is likely to result in less PA, thereby reducing ADL, accelerating physical decline, and increasing the risk of losing physical independence.

Conclusions

Older adults with SMI were found to have lower functional physical fitness levels and higher risk of losing physical independence. Such findings indicate that more attention to SMI is needed and active measures for early detection and prevention should be recommended.

Submission statement

The manuscript has not been published and is not under consideration for publication elsewhere.

Each authors' contributions

Each author contributed equally to the drafting of this manuscript and designing of the study. Data were collected by Longjun Cao, Linke Li, Lei Wang, Shen Li, Yingwu Chen and Shilei Yuan. Data interpretation and manuscript preparation were undertaken Longjun Cao and Liping Huang. All authors approved the final version of the paper.

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Conflict of interest

The authors have no conflicts of interest to report.

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