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ORIGINAL RESEARCH

Neuromuscular Impairments Contributing to Persistently Poor and Declining Lower-Extremity Mobility Among Older Adults: New Findings Informing Geriatric Rehabilitation

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Abstract

Objective: To identify neuromuscular impairments most predictive of unfavorable mobility outcomes in late life.

Design: Longitudinal cohort study.

Setting: Research clinic.

Participants: Community-dwelling primary care patients aged ≥65 years (N=391) with self-reported mobility modifications, randomly selected from a research registry.

Interventions: Not applicable.

Main Outcome Measures: Categories of decline in and persistently poor mobility across baseline, 1 and 2 years of follow-up in the Lower-Extremity Function scales of the Late-Life Function and Disability Instrument. The following categories of impairment were assessed as potential predictors of mobility change: strength (leg strength), speed of movement (leg velocity, reaction time, rapid leg coordination), range of motion (ROM) (knee flexion/knee extension/ankle ROM), asymmetry (asymmetry of leg strength and knee flexion/extension ROM measures), and trunk stability (trunk extensor endurance, kyphosis).

Results: The largest effect sizes were found for baseline weaker leg strength (odds ratio [95% confidence interval]: 3.45 [1.72−6.95]), trunk extensor endurance (2.98 [1.56−5.70]), and slower leg velocity (2.35 [1.21−4.58]) predicting a greater likelihood of persistently poor function over 2 years. Baseline weaker leg strength, trunk extensor endurance, and restricted knee flexion motion also predicted a greater likelihood of decline in function (1.72 [1.10−2.70], 1.83 [1.13−2.95], and 2.03 [1.24−3.35], respectively).

Conclusions: Older adults exhibiting poor mobility may be prime candidates for rehabilitation focused on improving these impairments. These findings lay the groundwork for developing interventions aimed at optimizing rehabilitative care and disability prevention, and highlight the importance of both well-recognized (leg strength) and novel impairments (leg velocity, trunk extensor muscle endurance).

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Limitations in mobility activities such as walking, climbing stairs, and getting up from a chair are highly prevalent among older adults, affecting approximately 25% of adults aged ≥70 years and 50% of adults aged ≥80 years.[1] Such activities are indicative of adverse outcomes in late life, including development of disability, nursing home admission, and mortality.[2] Since mobility limitations pose a significant threat to the health and independence of older adults, studies informing treatment strategies are vital.

Rehabilitation providers strive to apply evidence-based approaches to treat mobility problems; however, significant knowledge gaps exist for treating older adults with mobility limitations.[3] No consensus exists on optimal types of exercise that should be prescribed, and evidence is lacking on which treatable physical impairments are most responsible for changes in mobility.[3] Establishing this evidence to guide effective and parsimonious approaches to care is especially crucial, given the constraints of both time and cost, coupled with the limited physical capacity of this patient population.

The Boston Rehabilitative Impairment Study of the Elderly (Boston RISE) was designed to investigate key research issues identified by geriatric rehabilitation experts, such as identifying underlying neuromuscular predictors of poor and declining mobility.[3,4] Cross-sectional findings from Boston RISE show that lower-extremity strength and range of motion (ROM) are important for mobility, but also that less commonly recognized impairments in leg velocity, trunk extensor endurance, and strength asymmetry may play a key role.[4,5] Longitudinal investigation is needed to determine the relationship between potential neuromuscular targets for rehabilitation and unfavorable outcomes in late-life mobility.

The aim of this study was to identify the neuromuscular impairments associated with unfavorable mobility outcomes across baseline, 1 and 2 years of follow-up. Based on previous cross-sectional findings,[4] we hypothesized that impairments in leg strength, leg velocity, trunk extensor endurance, asymmetry, and ROM would predict unfavorable mobility outcomes longitudinally.

Methods

Boston RISE is a prospective, longitudinal cohort study designed to investigate which combinations of neuromuscular impairments are most responsible for changes in function and mobility. Study methods have been described previously in detail.[4,6] Briefly, participants aged ≥65 years who were at risk for mobility decline[7,8] were recruited from a registry of 9 different primary care practices located across the greater Boston area from December 2009 to January 13, 2012. Eligibility included difficulty or task modification with walking one-half mile, climbing 1 flight of stairs,[7] or both, and no moderate or severe dementia (Mini-Mental State Examination score <18) or severe mobility limitation (Short Physical Performance Battery score <4).[9,10] Targeted recruitment was used to approximate ethnic/racial representation of older adults residing within a 10-mile radius of the facility. Methods were approved by the Spaulding Rehabilitation Hospital Institutional Review Board, and written consent was obtained from all participants. Of 430 participants who completed baseline visits, analyses included 391 with the outcome measure at baseline and at either or both follow-up assessments (n=8 died, n=8 withdrew because of illness, n=23 withdrew or were lost to follow-up). We compared baseline characteristics between participants with and without follow-up assessments. Participants without follow-up assessments were less likely to have had postgraduate schooling (10.3% vs 26.1%, $P=.03$), and had worse baseline leg strength (8.6±2.4N/kg vs 9.5±2.5N/kg, $P=.03$), average reaction time (274.6±70.2ms vs 246.2±48.6ms, $P<.02$), trunk extension endurance (71.0±53.2s vs 97.9±58.6s, $P=.01$), gait speed (.81±.20m/s vs .92±.21m/s, $P<.003$), Short Physical Performance Battery scores (7.8±2.4 vs 8.8±2.2, $P<.01$), and advanced lower-extremity function scores (35.9±17.1 vs 42.4±14.3, $P=.008$). They did not differ from participants with follow-up assessments by age, sex, race, body mass index, number of comorbidities, leg strength, rapid leg coordination, knee or ankle ROM, asymmetry of leg strength or ROM measures, kyphosis, or basic lower-extremity function score.

List of abbreviations:

Boston RISE	**Boston Rehabilitative Impairment Study of the Elderly**
ICC	**intraclass correlation coefficient**
LLFDI	**Late-Life Function and Disability Instrument**
MDC_{90}	**minimal detectable change with 90% confidence**
ROM	**range of motion**

Neuromuscular and mobility assessments were conducted by research assistants who were trained based on standardized materials developed for the study. Training sessions included lectures, demonstrations of techniques, and practice with other staff and senior volunteers. Coinvestigators assisted with the training process relevant to their areas of expertise. Research assistants underwent a formalized certification process in which they were required to demonstrate competence in performing data collection during supervised pilot administrations of the protocols. Recertification and additional training, if indicated, took place every 6 months throughout the data collection. Because of limited staffing, the same examiner often assessed the neuromuscular predictors and mobility outcomes and, therefore, was not blinded.

Outcome

We measured patient-reported mobility across baseline and 1 and 2 years of follow-up during clinic visits or by phone (when participants were unable to return). We included 2 subdomains of the Late-Life Function and Disability Instrument (LLFDI), which assesses limitations in 25 physical tasks applicable to daily life.[11] Basic Lower-Extremity Function includes activities involving standing, stooping, and basic walking tasks. Advanced Lower-Extremity Function includes activities involving higher levels of physical ability and endurance, such as walking several blocks or standing up from the floor. Both subscales are transformed to a score from 0 to 100, with higher scores indicating better function. Evidence supports the test-retest reliability (intraclass correlation coefficient [ICC]=.91−.98) and psychometric properties of the LLFDI, including (1) known-groups validity, confirming the ability of the test to discriminate among groups of older adults with different levels of function; (2) minimal floor and ceiling effects[11]; (3) high predictive validity for poor self-rated health, hospitalizations, and disability; and (4) moderate to high responsiveness to change over 2 years.[12] The minimal detectable change with 90% confidence (MDC_{90}) for the LLFDI has been established previously in this cohort. A change of 4.4 points for Basic Lower-Extremity Function and 6.3 points for Advanced Lower-Extremity Function is required to indicate true change beyond measurement error on the LLFDI.[12]