

Motoric cognitive risk syndrome and its association with falls: a secondary analysis of the Mexican Health and Aging Study

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Abstract

Objective. To reveal whether motoric cognitive risk syndrome (MCR) is associated with falls, recurrent falls, and complicated falls in older Mexican adults. **Materials and methods.** This is a secondary analysis of the Mexican Health and Aging Study. MCR was assessed in 2012 and included fall-related outcomes (recurrent [≥ 2], complicated [need for medical treatment] and number) in the 2018 follow-up. Competing risks analysis was performed, and subhazard ratios (sHRs) were estimated, adjusting for different variables. Negative binomial regression was used to estimate the incidence rate ratio (IRR) of the number of falls. **Results.** A total of 1 929 participants were included, with a median age of 62 years and 58.3% female. The prevalence of MCR was 17.4% and was associated with falls sHR 1.11 (95%CI: 1.11, 1.12), recurrent falls sHR 1.16 (95%CI: 1.15, 1.16) and complicated falls sHR 1.25 (95%CI: 1.24, 1.25). The number of falls was also independently associated with baseline MCR (IRR 1.19; 95% CI 1.01, 1.40; $p=0.039$). **Conclusion.** MCR is independently associated with falls. Increasing the evidence on how MCR anticipates burdensome problems in older adults could lead to actions to halt them; therefore, including it in screening assessments could be clinically useful.

Keywords: falls; motoric cognitive risk syndrome; older adults; geriatric syndromes; Mexico

Resumen

Objetivo. Revelar si el síndrome de riesgo cognitivo motor (SCM) se asocia con caídas, caídas recurrentes y caídas complicadas en adultos mayores mexicanos. **Material y métodos.** Análisis secundario del Estudio Mexicano de Salud y Envejecimiento. El SCM se evaluó en 2012 y los desenlaces relacionados con caídas (recurrente [≥ 2], complicado [necesidad de tratamiento médico] y número) en 2018. Se realizó análisis de riesgos competitivos (subhazard ratios [sHR]) y regresión binomial negativa (número de caídas, razones de tasas de incidencia [IRR]). **Resultados.** De 1 929 participantes la mediana de edad fue de 62 años y 58.3% eran mujeres. La prevalencia de SCM fue de 17.4% y se asoció con caídas sHR 1.11 (intervalo de confianza [IC] 95%: 1.11, 1.12), caídas recurrentes sHR 1.16 (IC95%: 1.15, 1.16), caídas complicadas sHR 1.25 (IC95%: 1.24, 1.25) y número de caídas (IRR 1.19, IC95%: 1.01, 1.40; $p=0.039$). **Conclusión.** Los resultados muestran que el SCM se asocia de forma independiente con caídas y otros desenlaces relacionados. Aumentar la evidencia sobre cómo el SCM se anticipa a los síndromes geriátricos como las caídas podría conducir a acciones para intervenir estos problemas.

Palabras clave: accidentes por caídas; síndrome de riesgo cognitivo motor; anciano frágil; rendimiento físico funcional; México

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Falls are one of the main conditions impacting the health of older adults since they usually lead to different negative health outcomes.¹ Moreover, it has been reported that one-third of community-dwelling older adults fall at least once a year, and 5 to 10% need medical treatment.² On the other hand, compared with single falls, recurrent falls are more frequently related to significant injuries, increased healthcare needs, and a higher impact on physical function.³

Regarding its causes, falls have been conceptualized as a geriatric syndrome,⁴ with a multifactorial nature and different conditions that converge into a single manifestation (i.e., the fall). Gait and cognitive status are considered to have a main role in the genesis of falls.⁵ Gait integrates multiple bodily systems, including the nervous and musculoskeletal systems, and its slowness could mean early stages of overt mobility disability.⁶ On the other hand, cognition has been evidenced to be involved in lack of attention and depression.⁷ In fact, it has been suggested that the coexistence of cognitive decline and lower gait speed increases the risk of falls since they share common brain regions such as the fronto-hippocampal circuits, the prefrontal-striatal networks, and the primary motor cortex.⁸ Therefore, the combination of slow gait speed and subjective memory complaints might increase the risk of falling by reducing their ability to compensate for physical impairment with an integral cognitive function and vice versa.⁹

Motoric cognitive risk syndrome (MCR) is a pre-dementia/predisability condition defined by the presence of subjective memory complaints and slow gait speed without cognitive or functional impairment.¹⁰ The reported prevalence from a multicountry study showed that MCR is present in 9.7% of the population.¹¹ Moreover, a recent analysis of the Mexican Health and Aging Study (MHAS) showed a higher prevalence (14.3%) in older Mexican adults.¹²

The underlying mechanisms by which MCR could be related to falls remain unclear, but epidemiological studies have evidenced their association.¹³⁻¹⁵ Noteworthy, the combination of a higher prevalence of MCR with accelerated population aging makes Mexican older adults a particularly interesting group to be studied. Therefore, we aim to reveal whether MCR is associated with falls, recurrent falls, and complicated falls in older Mexican adults.

Materials and methods

Study design and sample selection

This is a secondary analysis of the MHAS, a cohort study initiated in 2001, with follow-up assessments in 2003,

2012, 2015, and 2018. It included a national and urban/rural representation of adults aged 50 years or older from Mexico. Details on the objectives and procedures are available elsewhere.¹⁶ For this work, the 2012 dataset subsample with anthropometric measurements was used (n=1 929). These subjects were followed up until 2018 (six years), and the outcomes were registered in this time interval. Moreover, since MHAS collects next-of-kin information from those individuals who died between waves, outcome data (i.e., falls) were also recovered from these questionnaires (2015 and 2018).

Outcomes

We defined three fall-related outcomes:

- At least one fall in the last two years: "Have you fallen down in the last two years?"
- Number of falls: "Approximately how many times has this happened?"
- Fall that required medical treatment: "Have you hurt yourself in these falls badly enough to need medical treatment?"
- Recurrent falls are defined as three or more falls two years before the interview.

Motoric cognitive risk syndrome

First described in 2013 by Joe Verghese and colleagues.¹⁰ In that first work, subjective memory complaints were assessed with the Consortium to Establish a Registry for Alzheimer's Disease questionnaire; gait speed was assessed with a timed 4.57-meter walking test (slowness defined as ≤ 1 standard deviation [SD] or less below the average gait speed for age and sex group); independent function was understood as the performance of activities of daily living without difficulty; and finally, dementia was categorized with an adaptation of the criteria of the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders.¹⁰

To classify someone as having MCR, we used the definition previously used by Aguilar-Navarro and colleagues in MHAS:¹²

- Gait speed: the individual is asked to walk a 4-meter straight line at its normal pace. After transforming into speed (m/s), the average of two trials was used to determine slowness. An individual with ≤ 0.8 m/s was considered slow, apart from women with a height < 1.45 m (≤ 0.66 m/s).¹⁷
- Subjective memory complaints: considered present if the answer to the question "How would you evaluate your memory currently?" was 'fair' or 'poor'.

- Independent function: for those subjects without difficulty in performing instrumental activities of daily living: preparing a hot meal, shopping for groceries, managing money, and taking medications.
- Absence of dementia: Cognitive function was assessed in the MHAS using the Cross-Cultural Cognitive Examination. This test assesses cognitive function, exploring the following cognitive domains: verbal learning, visuospatial memory, verbal learning, verbal recall, visual scanning, orientation, semantic verbal fluency, and working memory. A score above 1.5 SD from the average score for each test (adjusted for years in school and sex) was considered normal cognitive function.¹⁸

Accordingly, subjects were considered to have MCR if they had: low gait speed, subjective memory complaints, independent function, and the absence of dementia.

Covariates

We included sociodemographic characteristics such as age, sex, marital status, and years of education. Since having a previous fall has been related to future falls, this variable was included with the question: "Have you fallen in the last two years?". Vision problems have also been associated with falls; therefore, the question "How is your vision (with glasses)?" was used.

Multimorbidity was defined as having two or more chronic conditions.¹⁹ High blood pressure, diabetes, respiratory illness, arthropathies, stroke, and heart attack were included. All of them were assessed by self-report, with the question: "Has a doctor or medical personnel ever diagnosed you with ...?".

Smoking, alcohol consumption and physical activity were included in the analysis as lifestyle behaviors using the following questions:

- "Do you smoke cigarettes now?"-three categories: never, used to smoke, currently smokes.
- "Currently, do you ever drink any alcoholic beverages such as beer, wine, liquor or pulque?": yes or no.
- "On average during the past two years, have you exercised or done hard physical three or more times a week?": yes or no.

Statistical analysis

Baseline characteristics were summarized with descriptive statistics, with median and interquartile range (IQR) and relative and absolute frequencies. Time-to-event in days was calculated from the baseline interview date

(2012) until the outcome of interest occurred (between 2012 and 2018) or the follow-up was completed (2018). Survival was registered since mortality is the competing risk for the other fall-related outcomes. Expansion weights for the anthropometric measurements subsample were used for the analysis.

For the following outcomes, competing risks analysis was used: falls, the need for treatment after a fall, and recurrent falls. Subdistribution hazard ratios (sHRs) with 95% confidence intervals (CI) are reported. For the number of falls, negative binomial regressions were fitted, with incidence rate ratios (IRRs) and their 95%CI. Models without adjustment and fully adjusted for all covariates are presented. Statistical analyses were performed with Stata SE 17.0 (Copyright 1985-2021 StataCorp LLC, 4905 Lakeway Drive, College Station, Texas, 77845, USA).

Ethical issues

The MHAS was approved by the Institutional Review Boards and Ethics Committees of the University of Texas Medical Branch in the USA, the *Instituto Nacional de Estadística y Geografía* (INEGI), and the *Instituto Nacional de Salud Pública* (INSP) in Mexico. Additionally, it is partly supported by the National Institute of Health/National Institute of Aging (R01AG018016, R. Wong, PI) in the United States and the INEGI in Mexico.

Results

From the 18 465 interviews available in 2012, a subsample for anthropometric measurements was selected (n=2 086), and 1 929 individuals were 50 years or older (final sample). The median age was 62 years (IQR 18), and 58.3% were women (n=1 126). Regarding outcomes, 44.1% had at least one fall, 43.1% had recurrent falls, and 20.4% required treatment for the consequences of falling. The prevalence of MCR was 17.4% (n=335), with the highest prevalence for those individuals who required fall treatment (24.2%), followed by at least one fall (20.1%) and recurrent falls (16.7%) (table I and figure 1).

The competing risks analysis showed that MCR had an independent association with all the outcomes, with the highest strength of association for fall-related treatment (sHR 1.25, 95%CI: 1.24,1.25, $p<0.001$). Having at least one fall in the previous year had an sHR of 1.11 (95%CI: 1.11,1.12, $p<0.001$), and recurrent falls had an sHR of 1.16 (95%CI: 1.15,1.16, $p<0.001$) (table II). The number of falls showed a significant association with MCR, with an IRR of 1.19 (95%CI: 1.01,1.40, $p=0.039$) (table III).

Table I
DESCRIPTIVE ANALYSIS OF THE BASELINE ASSESSMENT (2012) AND BY OUTCOMES (FOLLOW-UP BETWEEN 2012 AND 2018). DATA FROM MHAS 2012, 2015 AND 2018, OWN ELABORATION, 50-YEAR OR OLDER SAMPLE FROM NATIONAL REPRESENTATIVE MEXICAN INDIVIDUALS

	Total (N=1 929)	Falls (n=852)	Recurrent falls (n=831)	Treatment for falls (n=393)
Age, median (IQR)	62 (18)	63 (14)	62 (13)	64 (15)
Years in school, median (IQR)	6 (7)	6 (6)	6 (6)	5 (6)
Marital status Married/free union, n (%)	1 000 (51.8)	442 (51.8)	549 (50)	214 (54.4)
Female, n (%)	1 126 (58.3)	573 (67.2)	597 (54.4)	280 (71.2)
MCR, n (%)	335 (17.4)	171 (20.1)	183 (16.7)	95 (24.2)
Multimorbidity, n (%)	678 (35.7)	339 (40.6)	377 (34.8)	180 (46.6)
Previous falls, n (%)	1 007 (52.2)	556 (65.3)	380 (34.6)	288 (73.3)
Smoking status, n (%)				
Never smoked	1 185 (61.5)	534 (62.7)	660 (60.1)	250 (63.6)
Used to smoke	501 (25.9)	206 (24.2)	298 (27.1)	99 (25.2)
Currently smokes	243 (12.6)	112 (13.1)	140 (12.8)	44 (11.2)
Physical activity, n (%)	854 (44.3)	374 (43.9)	481 (43.8)	160 (40.7)
Alcohol consumption, n (%)	151 (7.8)	58 (6.8)	89 (8.1)	27 (6.9)
Self-reported vision Fair/Poor/Blind, n (%)	134 (7.1)	76 (9.2)	68 (6.3)	42 (10.9)

MHAS: Mexican Health and Aging Study; IQR: interquartile range; MCR: motoric cognitive risk syndrome

Discussion

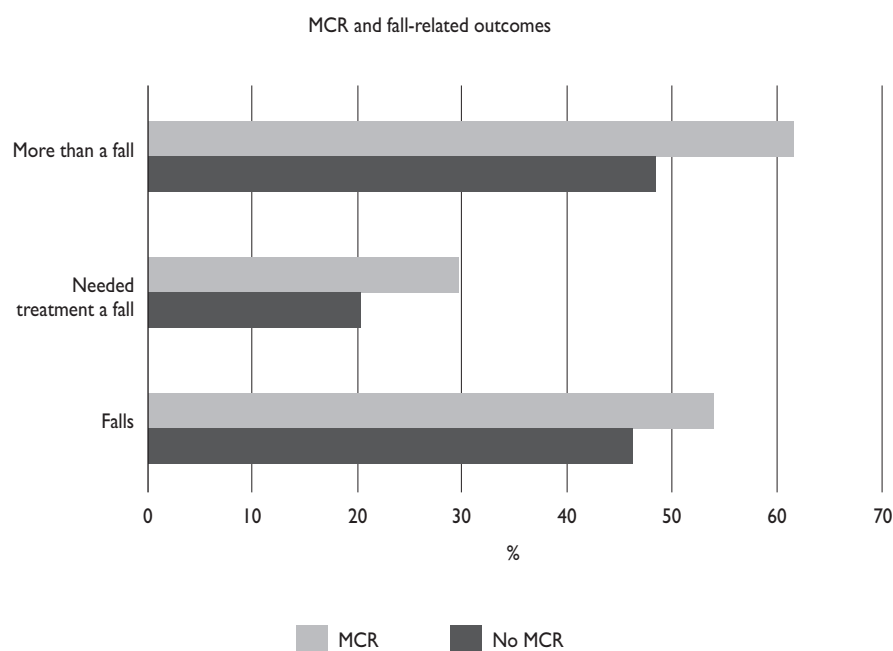
Our results showed that individuals with MCR have a higher risk of falling, recurrent falls, and fall-related treatment. Moreover, MCR was also associated with the number of falls; thus, individuals with MCR have at least one more fall than healthy older adults. Our findings align with recent literature that evidenced a risk of 44% falling in individuals with MCR.¹³ It has also been reported that individuals with MCR are at a higher risk of recurrent falls and post-fall hip fractures.¹⁴ The coexistence of both poor self-reported cognition and gait impairment due to anatomical relationships is thought to mediate MCR's clinical expression.

Thus, the combination of gait performance and cognition in MCR has a central role in the association observed in the present analysis. There are shared pathophysiological pathways that drive changes in mobility and cognition. Some are related to senescence, such as mitochondrial dysfunction, cellular aging, impaired intercellular communication, and genomic instability.²⁰ Additionally, gait is a motor function that implies the interaction of multiple body systems, such as the cardiovascular, musculoskeletal, and central nervous systems. In fact, the brain's fronto-subcortical circuits, prefrontal cortex, and supplementary motor area are the main structures involved in gait control and cognition.²¹

Having mentioned the anatomical and functional link between gait and cognition, it is fair to state that walking is not purely a motor function but also a cognition-related one. Gait requires executive functions, attention, information processing, and sensory integration to adapt mobility in everyday environments.²² Impairment in these functions can put older adults with MCR at a higher risk of falling, impacting the number of falls and their severity.

Having a previous fall, multimorbidity, and smoking status were positively associated with the three competitive risk analysis outcomes. The same association was found between multimorbidity, previous falls, and the number of falls in the binominal negative analysis. Thus, having a previous fall increases the risk of falling in the future, having fall-related injuries requiring medical treatment, falling recurrently, and influencing the number of falls. Findings on other variables associated with fall-related outcomes (i.e., previous fall, multimorbidity, smoking status, etc.) are supported by previous reports.²³

In contrast, physical activity showed a negative association with fall-related outcomes. Regular physical activity is a core element for maintaining good health and functional independence in older adults, not only for its benefits in the cardiovascular system but also for its effect on lower limb strength, balance, muscle mass, and cognition.²⁴



MCR: motoric cognitive risk syndrome; MHAS: Mexican Health and Aging Study

FIGURE 1. FREQUENCY OF OUTCOMES ACCORDING TO MCR STATUS: FALLS, MORE THAN ONE FALL OR NEEDED TREATMENT AS A CONSEQUENCE OF A FALL, DATA FROM MHAS 2012, 2015 AND 2018, OWN ELABORATION, 50-YEAR OR OLDER SAMPLE FROM NATIONAL REPRESENTATIVE MEXICAN INDIVIDUALS

Table II
COMPETING RISKS ANALYSIS FULLY ADJUSTED REGRESSION MODELS HAVING MCR AS THE DEPENDENT VARIABLE, DATA FROM MHAS 2012, 2015 AND 2018, OWN ELABORATION, 50-YEARS OR OLDER SAMPLE FROM NATIONAL REPRESENTATIVE MEXICAN INDIVIDUALS

Independent variables	Fall	Treatment for falls	Recurrent falls
	sHR (CI95%, p value)	sHR (CI95%, p value)	sHR (CI95%, p value)
Age	1.00 (1.00-1.01, <0.001)	1.03 (1.03-1.04, <0.001)	0.98 (0.97-0.98, <0.001)
Years of education	0.98 (0.97-0.98, <0.001)	1.01 (1.01-1.02, <0.001)	0.98 (0.98-0.99, <0.001)
Marital status (married/free union)	0.86 (0.85-0.86, <0.001)	1.18 (1.17-1.18, <0.001)	0.91 (0.91-0.92, <0.001)
Female	1.28 (1.13-1.29, <0.001)	1.88 (1.88-1.92, <0.001)	0.90 (0.90-0.91, <0.001)
MCR	1.11 (1.11-1.12, <0.001)	1.25 (1.24-1.25, <0.001)	1.16 (1.15-1.16, <0.001)
Multimorbidity	1.04 (1.03-1.04, <0.001)	1.24 (1.23-1.24, <0.001)	1.16 (1.15-1.16, <0.001)
Previous falls	1.39 (1.38-1.39, <0.001)	1.88 (1.86-1.89, <0.001)	0.63 (0.62-0.63, <0.001)
Smoking status (never smoked as reference)			
Used to smoke	1.19 (1.18-1.19, <0.001)	1.53 (1.52-1.54, <0.001)	1.16 (1.15-1.16, <0.001)
Currently smokes	1.22 (1.21-1.23, <0.001)	1.38 (1.37-1.39, <0.001)	1.31 (1.31-1.32, <0.001)
Physical activity	0.76 (0.75-0.76, <0.001)	0.80 (0.80-0.81, <0.001)	0.68 (0.68-0.69, <0.001)
Alcohol consumption	0.68 (0.67-0.68, <0.001)	0.59 (0.58-0.59, <0.001)	0.79 (0.78-0.79, <0.001)
Self-reported vision (fair/poor/blind)	1.42 (1.42-1.43, <0.001)	1.89 (1.87-1.89, <0.001)	0.79 (0.78-0.80, <0.001)

sHR: subhazard ratio; CI: confidence interval, MCR: motoric cognitive risk syndrome; MHAS: Mexican Health and Aging study

Table III
NEGATIVE BINOMIAL REGRESSION FOR NUMBER OF FALLS FULLY ADJUSTED REGRESSION MODELS HAVING MCR AS THE DEPENDENT VARIABLE, DATA FROM MHAS 2012, 2015 AND 2018, OWN ELABORATION, 50-YEAR OR OLDER SAMPLE FROM NATIONAL REPRESENTATIVE MEXICAN INDIVIDUALS

	IRR (CI95%, p value)
Age	1.00 (0.99-1.01, 0.375)
Years of education	0.97 (0.95-0.98, <0.001)
Marital status (married/free union)	1.29 (0.94-1.210.311)
Male	0.77 (0.66-0.60, 0.001)
MCR	1.19 (1.01-1.40, 0.039)
Multimorbidity	1.29 (1.13-1.48, <0.001)
Previous falls	1.81 (1.58-2.07, <0.001)
Smoking status (never smoked as reference)	
Used to smoke	1.03 (0.88-1.21, 0.700)
Currently smokes	1.21 (0.98-1.49, 0.063)
Physical activity	1.16 (1.02-1.32, 0.029)
Alcohol consumption	1.02 (0.87-1.20, 0.761)
Self-reported vision status (fair/poor/blind)	1.36 (1.07-1.73, 0.010)

IRR: incidence rate ratio; CI: confidence interval; MCR: motoric cognitive risk syndrome; MHAS: Mexican Health and Aging Study

Our results should be carefully interpreted since we have a few limitations to acknowledge. First, outcomes were self-reported and might have some memory bias. Second, our MCR definition had some modifications from the original; future research should aim at understanding how different definitions could have other associations. Third, dementia is a clinical diagnosis, and we used a categorization provided by the MHAS team; clinical studies are needed to corroborate our epidemiological findings. Finally, this is a cohort of older Mexican adults, the results cannot be generalized to other populations, and information from other countries is still needed.

In summary, MCR is a novel preclinical stage for neurocognitive disorders that can be easily used not only to predict the progression to dementia but also to study other geriatric syndromes. Thus, changes in motor function due to slow gait speed and subtle changes in self-rated cognition might influence falls, the number of falls, and the severity of fall-related injuries in Mexican older adults.

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Author contributions

The idea was conceived by Isabel Márquez. Statistical analysis was designed by Dr. Mario Ulises Pérez-Zepeda. Isabel Márquez helped draft the manuscript and performed the statistical analysis with the guidance of Dr. Mario Ulises Pérez-Zepeda and Dra. María Fernanda Carrillo-Vega. All authors discussed the results and contributed to the final manuscript.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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