ORIGINAL RESEARCH

Does Adding Mindfulness to Instability Resistance Training Enhance Dual-Task Mobility and Fall-Related Outcomes in Older Adults with Motoric Cognitive Risk Syndrome? A Randomized Controlled Trial

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ABSTRACT

Background

Older adults with motoric cognitive risk syndrome (MCR) exhibit impairments in dual-task mobility. Non-pharmacological interventions, such as physical exercise and cognitive strategies, have been proposed to mitigate physical and cognitive decline. However, the effectiveness of combining these approaches remains unclear.

Objective

To evaluate the effects of instability resistance training (IRT) performed with or without mindfulness on mobility under single- and dual-task conditions and fall-related outcomes in older adults with MCR.

Methods

In this parallel-group randomized controlled trial, 56 community-dwelling older adults with MCR (≥65 years) were allocated to IRT or combined with mindfulness (IRT + Mind). Both groups trained twice weekly for 24 weeks. Primary outcomes included single- and dual-task Timed Up and Go (TUG). Secondary outcomes were dual-task cost, concern about falling (Falls Efficacy Scale–International), and balance confidence (Activities-specific Balance Confidence Scale). Outcomes were analyzed using generalized mixed models.

Results

For single-task TUG, a significant main effect of time was observed ($p < .001$), with similar improvements in both groups (0.62–0.80 s). Dual-task TUG performance improved over time for both cognitive conditions, with significant group × time interactions favoring the IRT group ($p \leq .049$). Dual-task cost did not change significantly. Balance confidence improved significantly over time in both groups (mean increase ≈14 points; $p < .001$), whereas concern about falling remained unchanged.

Conclusion

IRT improved mobility and confidence in balance in older adults with MCR. The addition of mindfulness did not provide incremental benefits, suggesting that motor-based training alone is sufficient to promote functional gains in this population.

Key words: motoric cognitive risk syndrome, unstable surface, dual-task performance, falls, resistance training, mindfulness

INTRODUCTION

Global population ageing has been accompanied by a substantial increase in the prevalence of dementia and falls, reinforcing the need for early identification and targeted interventions in older adults at high risk of developing geriatric syndromes.[1] Beyond their clinical consequences, these conditions are major drivers of functional decline, loss of independence, and healthcare utilization in later life. Importantly, falls and cognitive impairment frequently coexist and interact, amplifying vulnerability and adverse outcomes in older populations.[2,3]

Within this context, motoric cognitive risk syndrome (MCR) has emerged as a pragmatic clinical construct for identifying older adults at increased risk of dementia and falls.[4] Defined by the coexistence of slow gait and subjective cognitive complaints in the absence of dementia, MCR has been consistently associated with incident cognitive decline and falls.[5] However, while MCR provides a useful screening framework, growing evidence suggests that assessments of mobility performed under dual-task conditions may offer greater sensitivity in detecting functional vulnerability, as they capture the integration of motor and cognitive processes required for everyday activities.[6]

Mobility in daily life rarely occurs under single-task conditions. Walking while conversing, navigating obstacles, or responding to environmental demands requires continuous allocation of attentional resources and executive control. Consequently, impairments in dual-task mobility have been strongly associated with increased fall risk and reduced functional independence in older adults.[7] Despite this clinical relevance, dual-task mobility performance and other indicators of functional complexity remain insufficiently investigated in individuals with MCR,[8,9] representing a critical gap in the literature.

Beyond early identification, effective interventions are essential to mitigate functional decline in this high-risk population. Regular physical exercise, particularly resistance training,[10] has demonstrated robust benefits in reducing fall risk and improving mobility and cognitive outcomes in older adults without MCR.[7,11] More recently, resistance training performed on unstable surfaces has been proposed as a strategy to increase motor complexity and sensorimotor demands, thereby enhancing postural control and movement adaptability.[12,13] Resistance training with instability has been associated with improvements in mobility, balance, and concern about falling, suggesting potential relevance for populations characterized by motor–cognitive vulnerability.[13-15]

In parallel, mind–body interventions such as mindfulness have gained attention as strategies to enhance attentional control and self-regulation in older adults. Mindfulness-based interventions aim to cultivate sustained present-moment awareness through practices such as mindful breathing, body scanning, and mindful movement.[16] Emerging evidence indicates that mindfulness may positively influence mobility[17,18] and cognitive function in apparently healthy older adults.[19,20] Importantly, mindfulness practices may be particularly relevant for tasks requiring divided attention and task prioritization, which are central to mobility under cognitively demanding conditions.

Recent evidence further suggests that combining physical exercise with cognitively oriented interventions may potentiate functional gains, particularly in complex mobility tasks such as dual-task walking.[15] Theoretical models propose that the acute neurophysiological effects of exercise, including increased cerebral blood flow and activation of prefrontal networks, may prime the brain for subsequent cognitive engagement, thereby enhancing motor–cognitive integration and learning.[21] However, empirical evidence supporting this combined approach in high-risk geriatric populations remains limited.

To date, only one randomized controlled trial has examined the effects of exercise combined with mindfulness in older adults with subjective memory complaints, reporting no significant cognitive benefits.[16] Moreover, to our knowledge, no randomized trial has specifically investigated exercise-based interventions in individuals with MCR, particularly with respect to mobility under cognitively demanding conditions and fall-related outcomes. From a clinical perspective, addressing both motor and cognitive demands within a single intervention better reflects real-life functional challenges in older adults with MCR. Integrating instability resistance training (IRT) with mindfulness supports targeted strategies to improve functional performance and key risk factors associated with falls and cognitive decline. This approach also contributes to more efficient and scalable interventions in clinical and community settings, supporting the maintenance of independence in ageing populations.

Given the clinical relevance of dual-task mobility as a marker of functional vulnerability and fall risk, the present study aimed to evaluate the additional effects of mindfulness combined with resistance training with instability on dual-task mobility performance, balance, and fall-related outcomes in older adults with MCR. We hypothesized that resistance training with instability would improve mobility under both single- and dual-task conditions and reduce fall-related risk indicators, and that the addition of mindfulness would further enhance dual-task performance and attentional control, resulting in greater improvements in complex mobility outcomes compared with resistance training alone.

METHODS

Study Design

This study presents secondary analyses of a randomized controlled trial, focusing on pre-specified outcomes related to functional mobility under complex task conditions and fall-related outcomes in older adults with MCR. The trial followed a parallel-group design and was conducted between the first semesters of 2022 and 2023 in Petrolina, Pernambuco, Brazil. The study protocol was approved by the Research Ethics Committee of the University of Pernambuco (CAAE: 38402120.0.0000.5195) and was prospectively registered in the Brazilian Registry of Clinical Trials (ReBEC; protocol number RBR-5z5h789). All procedures were performed in accordance with the principles of the Declaration of Helsinki. The reporting of this manuscript follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized trials.[(22)]

Participants and Eligibility Criteria

Community-dwelling older adults living in Petrolina, Pernambuco, and the surrounding São Francisco Valley region were recruited for this study. Eligible participants were aged 65 years or older and met the diagnostic criteria for MCR. MCR was defined by the presence of (i) subjective cognitive complaints, identified using item 10 of the Geriatric Depression Scale ("Do you feel you have more problems with memory than most people?")[(23)]; (ii) slow gait speed, operationalized as values below age- and sex-specific normative thresholds[(24)]; and (iii) absence of dementia.

Additional inclusion criteria required participants to be able to walk at least 10 m independently, without the use of mobility aids (e.g., canes or walkers), and to have not engaged in structured exercise programs for at least 3 months before enrollment. Participants were also required to present adequate visual and auditory capacity to complete physical and cognitive assessments.

Individuals were excluded if they presented conditions that could substantially interfere with gait or mobility performance, including severe musculoskeletal disorders (e.g., advanced osteoarthritis, lower-limb amputation) or neurological conditions associated with motor impairment (e.g., Parkinson's disease, stroke with residual motor deficits). Additional exclusion criteria included current use of antipsychotic medication, a diagnosis of depression, unstable cardiovascular or metabolic diseases (e.g., angina pectoris, uncontrolled diabetes), chronic complications such as neuropathy or retinopathy, or the occurrence of significant health events during the study period (e.g., cardiovascular instability, uncontrolled blood pressure, or glycaemia). Participants were also excluded if they initiated another structured exercise program with a frequency of two or more sessions per week during the trial.

Sample Size Considerations

Sample size was determined by the parent randomized controlled trial and feasibility constraints. The present manuscript focuses on pre-specified mobility outcomes, including dual-task Timed Up and Go (TUG). Based on preliminary data collected at the beginning of the trial, the between-group difference expected at 24 weeks for the TUG dual-task (numbers) would require approximately 76 participants (38 per group) to achieve 80% power at a two-sided α of 0.05. Therefore, the current sample may have been underpowered to detect small-to-moderate between-group differences in dual-task mobility outcomes, and the findings should be interpreted accordingly.

Randomization and Blinding

After completion of baseline assessments, participants were randomly allocated to the intervention groups using a concealed allocation sequence based on permuted blocks. Randomization was generated by an independent researcher using an online randomization tool (www.randomizer.org) and was stratified by sex and age group (65–74 years or ≥75 years) to account for the potential moderating effects of these variables on mobility and fall-related outcomes and to ensure balanced group distribution. Participants were allocated in a 1:1 ratio. In cases where couples or close acquaintances were enrolled, they were assigned to the same intervention group to minimize the risk of cross-contamination or group switching during the intervention period.

Instability Resistance Training (IRT)

All eligible participants completed an instability-based resistance training program. Both intervention groups trained twice weekly on nonconsecutive days for 24 weeks, under the supervision of trained instructors. Each training session included a set of five exercises performed without a fixed sequence: squat, dumbbell bench press, horizontal leg press, abdominal exercise, and seated row.

Training progression was achieved through systematic manipulation of external load, repetition range, and the incorporation of unstable devices, such as suspension systems (TRX®), Swiss balls, BOSU® balls, and balance discs, in order to increase postural and motor control demands. Detailed descriptions and visual representations of the exercises and their progression are provided in Figure S1 in the supplemental material.

The training protocol was informed by previous studies conducted by our research group that investigated IRT in apparently healthy older adults[(13,15)] and in individuals with cognitive complaints or probable cognitive impairment.[(12)] Both groups followed an identical instability-based resistance training program.

The exercises were performed without speed control, but with an approximate duration of 2 s for the concentric phase and 2 s for the eccentric phase. Exercise intensity was based on the individual's ability to complete the target repetition range with proper technique. Intensity monitoring was performed throughout the intervention, attempting to progress the load every 3 weeks, ensuring that the exercises were performed close to voluntary exhaustion within the prescribed repetition range. It should be noted that our strength training protocol with instability presented a moderate to low intensity,[(25)] depending on the period and type of instability device used.

The prescription consisted of three sets per exercise, with repetition ranges progressing over time: 8–10 repetitions during weeks 1–6, 10–15 repetitions from weeks 7–18, and 15–20 repetitions from week 19 until the end of the intervention. Rest intervals ranged from 60 to 90 s between sets and up to 120 s between exercises. Each training session lasted approximately 45–60 minutes. Additional details regarding exercise progression and training parameters are presented in Tables S1 and S2 in the supplemental material.

Mindfulness-Based Intervention

Participants allocated to the IRT plus mindfulness group (IRT + Mind) completed a structured mindfulness-based intervention throughout the 24-week program. Mindfulness sessions were delivered immediately after each IRT session and lasted approximately 10–15 minutes. The intervention followed a progressive structure, with practices increasing in complexity every 2 weeks.

Six formal mindfulness practices were implemented sequentially: (i) body scan, (ii) mindful breathing, (iii) mindful walking, (iv) awareness of sounds and thoughts, (v) mindful movement, and (vi) compassion-based practice. This progression was designed to gradually enhance attentional focus, body awareness, and cognitive engagement during movement-related tasks. A detailed description of the intervention schedule and examples of each practice are provided in Tables S3 and S4 in the supplemental material.

Mindfulness sessions were delivered by trained professionals who completed formal training in mindfulness-based practices following established protocols originally proposed by Kabat-Zinn and later adaptations used in clinical and geriatric populations.[16] All sessions adhered to a standardized protocol to ensure consistency across the intervention period.

Descriptive and Baseline Characteristics

Sociodemographic information, including age, sex, and years of formal education, was collected through structured interviews conducted by trained physiotherapists and physiotherapy students from the University of Pernambuco (Petrolina campus). Anthropometric assessments were performed in person at the Laboratory of Health and Functional Performance. Body mass was measured in kg and height in m, and body mass index was subsequently calculated as body mass divided by height squared (kg/m^2).

Habitual physical activity was monitored using a wearable activity tracker (Xiaomi Inc., Beijing, China). Participants were instructed to wear the device continuously for 7 consecutive days, and the mean daily step count across this period was used as an indicator of overall physical activity level.

Global cognitive status was assessed using the Brazilian validated version of the Montreal Cognitive Assessment (MoCA). This measure was used for sample characterization and to confirm eligibility, ensuring that participants did not meet criteria for mild cognitive impairment based on established cutoff scores.[26]

Timed Up and Go (TUG)

The TUG test was used to assess dynamic mobility and balance. The test measures the time required for a participant to rise from a chair, walk to a line marked on the floor at a distance of 3 m, turn 180 degrees, return to the chair, and sit down again.[27] Participants were instructed to perform the test as quickly as possible while maintaining safety and comfort. Prior to testing, the procedures were explained and demonstrated by the assessor to ensure comprehension and minimize execution errors.

All participants wore a G-WALK® inertial sensor to record performance time. Two trials were performed for the single-task TUG. Subsequently, participants completed two additional trials under dual-task conditions: (i) TUG with backward counting and (ii) TUG with animal naming. For each condition, the fastest time from the two trials was retained for analysis.

Timed Up and Go—Backward Counting

The dual-task TUG with backward counting followed the same procedures as the single-task condition, with the addition of a concurrent cognitive task. During test execution, participants were instructed to perform a backward count by single digits (e.g., 30, 29, 28…). Each participant selected a starting number between 20 and 100. This dual-task condition is considered to place demands on working memory and attentional resources.[28]

Dual-task cost (DTC) was calculated according to the formula proposed by Cullen et al.,[28] expressed as the percentage change in performance time attributable to the concurrent cognitive task. Participants were instructed to divide their attention equally between the motor and cognitive tasks, without prioritizing either component.

$$\frac{\text{DTC (\%)} = (\text{single-task TUG time} - \text{dual-task TUG time}) \times 100}{\text{Single-task TUG time}}$$

Timed Up and Go—Animal Naming

The TUG with animal naming was used to assess dual-task performance involving semantic verbal fluency.[29] This condition followed the same procedures as the previous TUG tests; however, participants were asked to name as many different animals as possible while completing the TUG as quickly and safely as possible. DTC was also calculated for this condition using the same formula described above.

Falls Efficacy Scale–International (FES-I)

Concern about falling was assessed using the Falls Efficacy Scale–International (FES-I), which evaluates the degree of concern related to falling during activities of daily living. The scale consists of 16 items, each rated on a four-point scale ranging from 1 (not at all concerned) to 4 (very concerned). Total scores range from 16 (no concern about falling) to 64 (extreme concern about falling).[30]

Activities-specific Balance Confidence Scale—Short Form (ABC-6)

Perceived balance confidence was assessed using the short form of the Activities-specific Balance Confidence Scale (ABC-6). This instrument quantifies an individual's confidence in maintaining balance during specific activities, using a scale ranging from 0% (no confidence) to 100% (complete confidence).

The six items included in the ABC-6 represent activities of moderate to high postural challenge, such as “standing on tiptoes to reach for an object above the head.” The total score is calculated as the mean of the six item scores ($(Q1 + Q2 + Q3 + Q4 + Q5 + Q6)/6$), with higher values indicating greater balance confidence.[31]

Participant Adherence, Engagement Strategies, and Adverse Events

Participant adherence was quantified as the proportion of attended training sessions relative to the total number of sessions offered over the 24-week intervention period. Attendance was systematically recorded using standardized logs for both intervention groups.

To promote engagement and reduce attrition, participants who missed two consecutive sessions without prior justification were contacted by telephone or text message to encourage continued participation and to identify potential barriers to attendance. In addition, social activities unrelated to the intervention itself (e.g., group breakfasts) were organized on at least three occasions throughout the study period to foster group cohesion and enhance participant motivation.

Adverse events were defined as any worsening of health status or the occurrence of cardiovascular, metabolic, or musculoskeletal symptoms, as well as exercise-related injuries, during the intervention period. Information on adverse events was collected on a weekly basis prior to training sessions through face-to-face interviews using standardized forms, or by telephone when participants were unable to attend a session. All reported events were documented and monitored throughout the study.

Statistical Analysis

Preliminary exploratory analyses were conducted to examine data distribution, identify outliers, assess missing data patterns, and inspect potential asymmetries. Descriptive statistics were used to characterize the sample, with continuous variables summarized using measures of central tendency and dispersion, and categorical variables presented as frequencies and percentages.

Intervention effects on the outcomes of interest were examined using generalized mixed models, with group (IRT alone vs. IRT + Mind) and time (baseline and post-intervention) included as fixed effects, and participants treated as random effects to account for within-subject correlation. This approach allows for the inclusion of all available data and accommodates unbalanced observations over time.

All analyses were conducted according to the intention-to-treat principle, whereby participants were analyzed in the groups to which they were originally allocated, regardless of adherence to the intervention protocol. Results are presented as estimated mean differences with corresponding 95% confidence intervals (CIs). Statistical significance was set at $p < .05$ for all analyses. Data management and statistical analyses were performed using Jamovi software version 2.3 (The jamovi Project, Sydney, Australia).

RESULTS

Participant Flow, Adherence, and Adverse Events

The study flow diagram is presented in Figure 1. Of the 165 individuals initially screened, 109 were excluded for not meeting the eligibility criteria for MCR. A total of 56 community-dwelling older adults with MCR completed baseline assessments and were randomized into two intervention groups: IRT + Mind (n = 29) and IRT alone (n = 27). Two participants were randomized together because they belonged to the same family.

During the intervention period, nine participants discontinued the training program (IRT + Mind = 5; IRT = 4), as detailed in Figure 1. Regarding intervention-related adverse events, one participant from the IRT group reported low back pain attributed to the exercise program and withdrew from the study. All other dropouts were unrelated to the intervention, as indicated in the study flowchart.

Mean adherence to the training sessions was 76.5% in the IRT + Mind group and 77.9% in the IRT group, with no significant differences between groups.

Baseline Characteristics

Baseline characteristics of the participants are presented in Table 1. The sample consisted predominantly of women (89.3%), with a mean age of 70 years. Most participants had 12 or more years of formal education (60.7%), and the mean score on the MoCA was 20.0 points, consistent with subjective cognitive complaints without dementia.

Overall, participants demonstrated reduced physical performance and mobility, as reflected by low-to-moderate baseline scores on functional measures. Notably, 39% of participants reported at least one fall in the previous 12 months, indicating a high prevalence of falls in this population. Detailed descriptive statistics for all baseline variables are provided in Table 1.

For single-task TUG performance, no significant main effect of group ($p = .241$) or group × time interaction ($p = .598$) was observed. In contrast, a significant main effect of time was detected ($p < .001$), indicating improvements in mobility over the intervention period irrespective of group allocation. As shown in Table 2, both groups demonstrated reductions in TUG completion time, with mean improvements ranging from 0.62 to 0.80 s following the 24-week intervention.

For dual-task TUG performance, no significant main effect of group was observed for either cognitive condition ($p > .356$). Significant main effects of time were identified for both backward counting ($p = .003$) and animal naming ($p = .012$), along with significant group × time interactions ($p = .049$ and $p = .042$, respectively), indicating differential changes between groups over the intervention period. As shown in Table 2, participants in the IRT group demonstrated significant reductions in dual-task TUG completion time for both cognitive conditions, with mean improvements of approximately 1.1 s. In contrast, changes in the IRT + Mind group were smaller and did not reach statistical significance.

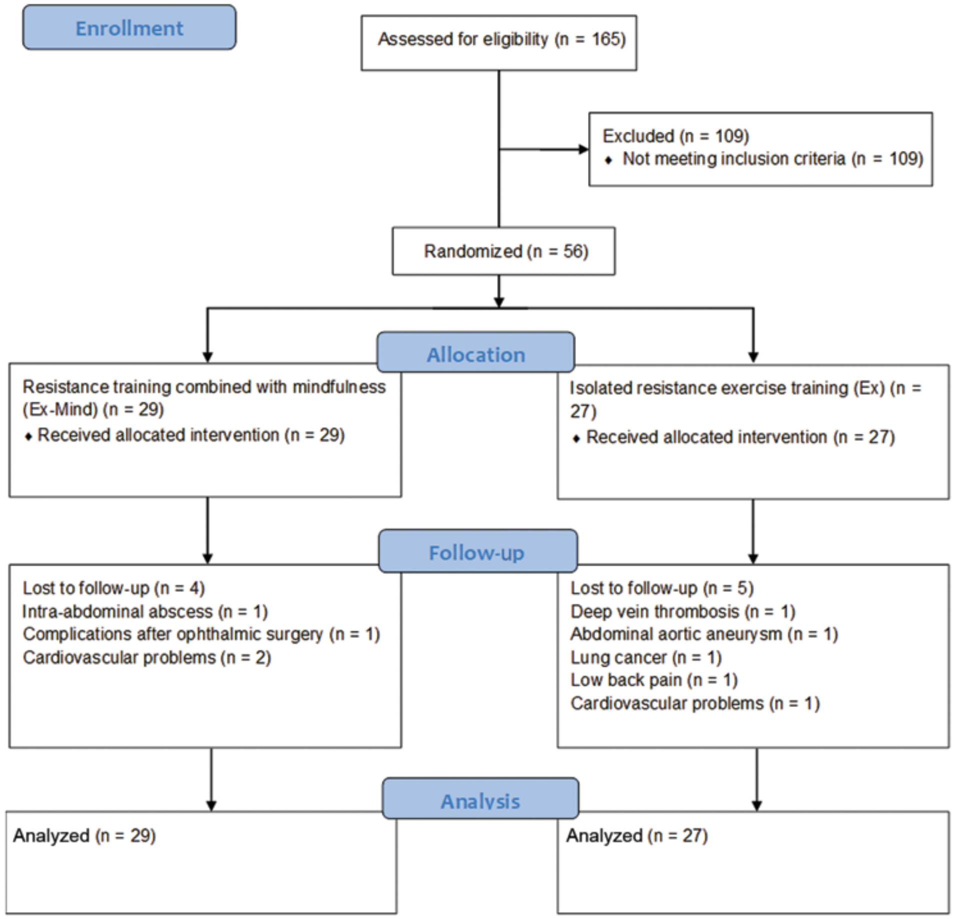

FIGURE 1. Study flowchart.

TABLE 1.
Baseline characteristics of participants

Variables	*IRT + Mind (n = 29)*	*IRT (n = 27)*	*Total (n = 56)*
Age (years)	70.24 (6.10)	70.63 (5.95)	70.43 (5.98)
Sex, n (%)			
Men	3 (10.30)	3 (11.10)	6 (10.70)
Women	26 (89.70)	24 (88.90)	50 (89.30)
Body mass (kg)	67.63 (11.10)	64.84 (11.60)	66.28 (11.33)
Height (meters)	1.55 (0.06)	1.55 (0.08)	1.55 (0.07)
Body mass index (kg/m^2)	28.12 (3.69)	26.77 (3.90)	27.47 (3.82)
Education, n (%)			
<12 years	11 (37.90)	11 (40.70)	22 (39.30)
≥12 years	18 (62.10)	16 (59.30)	34 (60.70)
MoCA score (0–30)	20.62 (5.02)	19.42 (5.27)	20.05 (5.13)
Mean daily steps (steps/day)	5,473 (2,671)	5,473 (2,594)	5,473 (2,610)
SPPB score (0–12)	7.27 (1.60)	8.03 (2.22)	7.64 (1.94)
Fallers in the previous 12 months, n (%)	11 (37.9)	11 (40.7)	22 (39.3)

Note: Data are presented as mean (standard deviation) or number (%).
IRT = instability resistance training; Mind = mindfulness; MoCA = Montreal Cognitive Assessment; SPPB = Short Physical Performance Battery.

TABLE 2.
Changes in mobility, dual-task performance, and fall-related outcomes at baseline and post-intervention in the IRT + Mind and IRT groups

			Baseline	*Post-Intervention*	*Intragroup Difference*	*Between-Group Difference*
Outcomes	*Group*	*n*	*Mean (SE)*	*Mean (SE)*	*Mean Diff (95% CI)*	*Mean Diff (95% CI)*
Single-task TUG (s)	IRT + Mind	29	9.90 (0.33)	9.28 (0.33)	**0.62 (0.01 to 1.24)**	0.61 (−0.62 to 1.85)
	IRT	27	9.48 (0.33)	8.68 (0.34)	**0.80 (0.17 to 1.47)**	
Dual-task TUG—backward counting (s)	IRT + Mind	29	11.49 (0.52)	11.24 (0.54)	0.25 (−0.65 to 1.15)	1.11 (−0.87 to 3.08)
	IRT	27	11.27 (0.55)	10.14 (0.56)	**1.13 (0.32 to 1.94)**	
Dual-task TUG—animal naming (s)	IRT + Mind	29	12.01 (0.50)	11.89 (0.53)	0.12 (−0.62 to 0.86)	1.04 (−0.41 to 2.50)
	IRT	27	12.03 (0.52)	10.85 (0.53)	**1.18 (0.48 to 1.88)**	
DTC—backward counting (%)	IRT + Mind	29	15.20 (3.19)	23.55 (3.52)	−8.35 (−21.67 to 4.45)	10.74 (−2.57 to 24.04)
	IRT	27	17.30 (3.24)	12.81 (3.52)	4.49 (−8.23 to 17.20)	
DTC—animal naming (%)	IRT + Mind	29	19.62 (3.34)	30.61 (3.77)	−10.99 (−24.54 to 2.56)	5.94 (−8.08 to 19.97)
	IRT	27	26.63 (3.41)	24.67 (3.70)	1.96 (−11.43 to 15.35)	
FES-I	IRT + Mind	29	30.06 (1.46)	28.66 (1.91)	1.40 (−1.81 to 4.62)	0.80 (−3.75 to 5.35)
	IRT	27	28.76 (1.53)	27.86 (1.62)	0.90 (−2.36 to 4.14)	
ABC-6	IRT + Mind	29	31.11 (4.74)	48.16 (5.10)	**−17.20 (−27.99 to −6.41)**	−0.97 (−19.58 to 17.63)
	IRT	27	37.42 (4.91)	49.13 (4.92)	**−11.71 (−22.99 to −0.44)**	

ABC-6 = Activities-specific Balance Confidence Scale (short form); CI = confidence interval; Diff = difference; DTC = dual-task cost; FES-I = Falls Efficacy Scale–International; IRT = instability resistance training; Mind = mindfulness; SE = standard error; TUG = Timed Up and Go.
Bold values indicate statistically significant differences ($p < 0.05$).

For DTC, no significant main effects of group ($p > .216$) or time ($p > .228$), nor significant group × time interactions ($p > .067$), were observed for either cognitive condition. These findings indicate that, despite improvements in absolute dual-task TUG performance, the relative cost associated with performing concurrent cognitive and motor tasks remained unchanged over the intervention period (Table 2).

Concern about falling, assessed by the FES-I, did not show significant main effects of group ($p = .581$) or time ($p = .318$), nor a significant group × time interaction ($p = .826$). In contrast, balance confidence assessed by the ABC-6 demonstrated a significant main effect of time ($p < .001$), with a mean improvement of approximately 14 points following the intervention period. No significant group × time interaction was observed for balance confidence ($p = .392$), indicating comparable improvements between groups (Table 2).

Training progression was comparable between groups across the 24-week intervention period. A significant between-group difference was observed only for total workload during weeks 7–18 in the dumbbell bench press exercise, favoring the IRT group (Table S5 in the supplemental material). Total workload and the number of repetitions were calculated for all participants who completed the intervention and are presented in Tables S5 and S6 in the supplemental material.

DISCUSSION

The present study hypothesized that adding mindfulness practices to IRT would potentiate improvements in dual-task mobility and reduce fall-related outcomes in older adults with MCR. This hypothesis, however, was not supported. The findings indicate that 24 weeks of IRT led to statistically significant improvements in mobility under both single- and dual-task conditions, as well as to increased balance confidence, irrespective of the addition of mindfulness. Notably, improvements in dual-task mobility were predominantly observed in participants who performed IRT alone, whereas the inclusion of mindfulness did not confer additional measurable benefits. In contrast, concern about falling remained unchanged throughout the intervention period.

The improvements observed in single-task TUG performance suggest that IRT may be associated with modest gains in overall functional capacity in older adults with MCR. Both groups demonstrated statistically significant reductions in TUG completion time over the 24-week intervention period, indicating positive adaptations in basic mobility. The average magnitude of change observed in the present study is comparable to that reported in previous investigations employing instability-based resistance training protocols of similar duration in older populations, in which mean reductions of approximately 0.98–1.02 s in single-task TUG performance have been described.[13,15] Comparable findings have also been reported in interventions using *mind–body* strategies, such as mindfulness and/or Tai Chi, conducted over 24 weeks, which demonstrated significant within-group reductions in single-task TUG performance ranging from approximately 0.60 to 1.76 s in apparently healthy older adults.[18,32] However, it is important to note that the changes observed in the present study occurred in a population with greater motor and cognitive vulnerability[33] and were of smaller magnitude than values commonly considered clinically meaningful, underscoring the need for caution when interpreting their clinical relevance.[34]

In addition, performance on the TUG test involves additional demands related to dynamic balance, postural control, and changes of direction, components that require greater recruitment of executive functions and enhanced cognitive–motor integration.[35] Evidence suggests that gait tasks involving directional changes impose a higher cognitive load, particularly in populations with mobility and cognitive impairments, which may further constrain functional gains following exercise-based interventions.[7,36]

With respect to dual-task mobility, significant reductions were observed in absolute TUG completion times under both backward counting and animal naming conditions, with group × time interaction effects favoring the group that performed IRT alone. This finding suggests that the high motor complexity inherent to instability-based training, characterized by continuous postural control, rapid balance adjustments, and frequent directional changes, may function as an embedded cognitive stimulus by consistently demanding divided attention, postural monitoring, and executive processing.[14] Evidence from interventions combining postural challenges with implicit cognitive demands in older adults indicates beneficial effects on both gait performance and executive function, supporting the notion that IRT alone may be sufficient to induce meaningful cognitive–motor adaptations in older adults with MCR, particularly for tasks requiring integration of motor control and attention.[37]

An additional explanation for the fact that only IRT improved dual-task mobility may relate to the adaptive threshold of this population. Older adults with MCR exhibit reduced cognitive reserve and higher attentional costs during complex motor tasks, such that highly demanding motor–cognitive stimuli may bring individuals closer to an adaptive limit, thereby constraining further incremental gains when an additional cognitive component is introduced. In this context, IRT alone may have been sufficient to approach this adaptive threshold for dual-task mobility, whereas the sequential addition of a cognitive intervention such as mindfulness may not have provided an additional stimulus capable of eliciting measurable improvements, suggesting a potential adaptive saturation effect. Similar patterns have been described in dual-task training studies involving older adults with cognitive impairment.[38]

Another relevant aspect concerns the manner in which mindfulness-based interventions were implemented in the present study. Mindfulness practices were delivered after the physical training session and for relatively short durations, characterizing a sequential rather than a simultaneous intervention approach. Emerging evidence indicates that protocols integrating motor and cognitive demands concurrently, such as structured dual-task interventions combining cognitive stimulation with physical exercise in real time, may offer greater potential to improve both mobility and cognitive function in older adults compared with interventions delivered in separate blocks. Trials employing simultaneous dual-task approaches have reported more consistent gains in executive function, gait speed, and dual-task performance in older adults with cognitive decline or frailty, suggesting that simultaneity may be a critical component for effective transfer to tasks requiring concurrent attentional allocation.[38,39] Accordingly, the absence of additional benefits from mindfulness observed in the present study may be partly attributable to the sequential format adopted.

Despite improvements in absolute dual-task TUG performance, no significant changes were observed in DTC following the intervention. This pattern, where participants become faster in both single- and dual-task conditions while maintaining a similar proportion of interference between tasks, has been previously reported in dual-task interventions involving older adults with cognitive impairment and Alzheimer's disease.[37] Such findings have been interpreted as reflecting predominantly motor adaptations and a reorganization of performance strategies, particularly those prioritizing gait execution. In this context, participants appear to have improved overall task execution without substantially modifying the relative allocation of attentional resources between single- and dual-task conditions. Therefore, the absence of changes in DTC does not negate the functional gains observed in absolute performance but rather suggests that, in older adults with MCR, training-related adaptations occurred mainly within the motor domain, with a persistence of relative vulnerability to cognitive interference.

Regarding fall-related outcomes, concern about falling, assessed by the FES-I, did not change significantly over the intervention period, whereas balance confidence, measured by the ABC-6, increased over time. Previous studies have demonstrated moderate to strong negative correlations between the FES-I and balance confidence measures such as the ABC ($r \approx -0.7$ to -0.8), indicating that greater concern about falling is generally associated with lower functional confidence.[40] However, the literature also suggests that the FES-I captures broader emotional and contextual components, including prior fall experiences, anxiety-related symptoms, and environmental factors,[40] which may render it less responsive to change than task-specific measures of balance confidence.

Importantly, for the full ABC (16 items), a recent study in older adults estimated a minimal clinically important difference (MCID) of approximately 11–13 points on a 0–100 scale, depending on the calculation method and clinical context (e.g., fall risk, mobility), and clinical guides highlight that changes exceeding the minimal detectable change and approaching 10–15 points are typically perceived as meaningful improvements in balance confidence.[41] The ABC-6 is a short version that is strongly correlated with the original scale ($r \approx 0.95$) and retains good discriminative ability to distinguish fallers from non-fallers, with mean scores around 66–81 points reported in community-dwelling older adults and in populations with neurological conditions.[42] Although a specific MCID has not yet been firmly established for the ABC-6 in older adults, the mean improvement of 14 points observed in the present study is of similar or greater magnitude than the MCID proposed for the full ABC, supporting the interpretation that the increase in ABC-6 scores likely reflects a clinically important enhancement in balance confidence. Taken together, these findings suggest that functional confidence in balance-related situations may be more sensitive to motor improvements induced by instability-based training than global perceptions of fall risk, which may require longer intervention periods and/or targeted psychological components to be modified in a more consistent manner.

Several limitations of the present study should be acknowledged. First, the relatively small sample size may have limited statistical power to detect smaller between-group differences, particularly for outcomes with greater interindividual variability. Nevertheless, it is important to consider the low prevalence of MCR and the inherent challenges of recruiting this specific population for long-term interventions. Second, the absence of a non-exercise control group precludes conclusions regarding the natural trajectory of mobility and cognitive outcomes in older adults with MCR over 24 weeks. However, considering the clinical vulnerability of this population and the well-established benefits of resistance training in older adults, a two-arm active intervention design was deemed more appropriate and ethically justified, as it avoids prolonged exposure to physical inactivity.[43] Third, the sample was predominantly composed of women, which may limit the generalizability of the findings to older men with MCR. Finally, although mindfulness-based interventions are frequently associated with improvements in psychological well-being and quality of life, such outcomes were not assessed in the present study and may have provided additional insight into the potential benefits of combining mindfulness with exercise.

Future research should explore intervention strategies that more directly integrate cognitive and motor demands in real time, particularly in populations with reduced cognitive reserve such as individuals with MCR. Studies employing simultaneous dual-task training paradigms, longer intervention durations, or tailored cognitive components may help clarify the conditions under which combined interventions yield additive or synergistic effects. Additionally, future trials with larger and more diverse samples, inclusion of non-exercise control groups, and assessment of patient-centered outcomes such as quality of life and perceived functional ability are warranted to better inform clinical practice.

CONCLUSION

In older adults with MCR, 24 weeks of IRT were associated with modest changes in mobility under single- and dual-task conditions, as well as with clinically meaningful gains in balance confidence. However, the addition of mindfulness practices did not confer additional benefits beyond those observed with IRT. Improvements in dual-task mobility were predominantly observed in participants who performed IRT in isolation, while DTC and concern about falling remained unchanged. These findings suggest that the high motor complexity inherent to instability-based training may be sufficient to elicit cognitive–motor adaptations and meaningful improvements in perceived balance confidence in this population. Future studies should examine whether interventions that integrate cognitive and motor demands simultaneously, or that include more targeted psychological components, can further enhance dual-task performance and fall-related outcomes in older adults with MCR.

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CONFLICT OF INTEREST DISCLOSURES

We have read and understood the *Canadian Geriatrics Journal*'s policy on conflicts of interest disclosure and declare that we have none.

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SUPPLEMENTARY MATERIALS

Supplemental material linked to the online version of the paper (https://doi.org/10.5770/cgj.29.945):

- **Figure S1:** Exercise illustrations with instability progressions
- **Table S1:** Description of volume and intensity during the 24 weeks of training
- **Table S2:** Description of instability progressions for each exercise
- **Table S3:** Description of mindfulness-based interventions
- **Table S4:** Description of the progression of mindfulness-based interventions
- **Table S5:** Results of the comparison of total training volume and number of repetitions between the training groups
- **Table S6:** Results of the comparison of the number of repetitions performed for bodyweight exercises.

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