A Multi-State Model of Cognitive Dynamics in Relation to Resistance Training: The Contribution of Baseline Function

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Abstract

Purpose—We investigated: 1) the effect of different targeted exercise training on an individual's overall probability for cognitive improvement, maintenance, or decline; and 2) the simultaneous effect of targeted exercise training and baseline function on the dynamics of executive functions using a multi-state transition model.

Methods—Analyses are based on a 12-month randomized clinical trial including 155 community-dwelling women 65 to 75 years old who were randomly allocated to once-weekly resistance training (1x RT; n=54), twice-weekly resistance training (2x RT; n=52), or twice-weekly balance and tone training (BAT; n=49). The primary outcome measure was performance on the Stroop Test, an executive cognitive test of selective attention and conflict resolution. Secondary outcomes of executive functions were set shifting and working memory.

Results—Individuals in the 1x RT or 2x RT group demonstrated a significantly higher probability for improved performance on the Stroop Test (0.49; 95% CI=0.41 to 0.57) compared with those in the BAT group (0.25; 95% CI=0.25 to 0.40). Resistance training had significant effects on transitions in selective attention and conflict resolution.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.

Author Contributions:

TLA: Conceptualization, data collection, analysis, writing, and critical review.

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Sponsor's Role:

None.

Conclusions—Resistance training is efficacious in improving a measure of selective attention and conflict resolution in older women – probably more so among those with higher baseline cognitive function.

Keywords

Resistance Training; Executive Functions; Multi-State Transition Model

Introduction

Cognitive decline among seniors is a pressing health care issue. Current evidence strongly suggests that physical activity is a promising approach to reduce the risk of cognitive impairment and dementia [1–5]. Physical activity is attractive as an intervention strategy as it can be feasibly delivered at a population-level [6–8].

However, we still do not have a comprehensive understanding of the impact of physical activity on cognitive health in older adults. For example, we do not know the effect of different types of targeted exercise training on cognitive function (i.e., improvement, maintenance or decline). Majority of studies to date have only examined the average response of the group to an exercise intervention [5–8]. As a result, we have no understanding of the variability in cognitive change in relation to exercise. Also, we currently do not know the simultaneous impact of different types of targeted exercise training and relevant baseline factors on dynamics, or transitions, in cognitive function. Yet, it is important to understand the impact of baseline function, or individual characteristics, on dynamics in cognitive function secondary to targeted exercise training as this would increase our capacity to refine current interventions to maximize benefits.

For multi-dimensional analysis of cognitive change and physical activity, the multi-state transition model (probabilities of transition between the different states) is an attractive option. This computational approach allows many states of cognitive function and many risk factors to be analyzed without the loss of statistical power while, minimizing multiple testing issues. This multivariable stochastic model of cognitive state transitions has been used in various Canadian, UK and US health surveys to study the effects of physical activity, education, gene, sex and age on cognition and frailty [18–24]. The Multi-state transition model can also be studied using with other family of generalized linear model [7, 8] such as logistic regression model, multinomial and ordinal logistic regression but they are more suitable for small number of states. However, this multi-state transition model is more appropriate when greater number of states is considered. In this study, we have applied the multi-state transition model in a new domain of cognitive tests for comprehensive analyses of longitudinal change of executive functions.

Here we aim to extend our current knowledge in the area of physical activity and cognitive health by applying this novel statistical approach – multi-state transition modeling. We applied the model to data collected from a 12-month randomised controlled trial of exercise in community-dwelling women aged 65 to 75 years old [8]. We aimed to investigate: 1) the effect of targeted exercise training on an individual's probability for improved, maintained, or declined performance of executive functions at trial completion; and 2) the simultaneous

effect of targeted exercise training and baseline function on changes in executive functions using a multi-state transition model. We focused on executive functions because they are essential for the maintenance of functional independence among older adults [17–20].

Methods

Study Design

We conducted a secondary analysis of data collected from a randomised, controlled 52-week study of exercise [8]. The assessors were blinded to the participants' assignments. Randomization of study participants was previously described [8].

Participants

This study sample consisted solely of women because cognitive response to exercise differs between the sexes [6, 7]. The inclusion and exclusion criteria of this study have been previously described [8]. Women who lived in Vancouver, Canada, were eligible for study entry if they: 1) were aged 65 to 75 years; 2) were living independently in their own home; 3) scored > 24 on the Mini-Mental State Examination (MMSE); and 4) had a visual acuity of at least 20/40, with or without corrective lenses. We excluded those who: 1) had a current medical condition for which exercise is contraindicated; 2) had participated in resistance training in the last six months; 3) had a neurodegenerative disease and/or stroke; 4) had depression; 5) did not speak and understand English fluently; 6) were taking cholinesterase inhibitors; 7) were on oestrogen replacement therapy; or 8) were on testosterone therapy. Ethical approval was obtained from the Vancouver Coastal Health Research Institute and the University of British Columbia's Clinical Research Ethics Board. All participants provided written informed consent.

Study Variables

At baseline, participants underwent a physician assessment to confirm current health status and eligibility for the study. Global cognition was assessed using both MMSE and the Montreal Cognitive Assessment (MoCA) [21]. The MoCA is a brief screening tool for Mild Cognitive Impairment (MCI) [21] with high sensitivity and specificity. We used the 15-item Geriatric Depression Scale (GDS) [22] to screen for depression. Current level of physical activity was determined by the Physical Activities Scale for the Elderly (PASE) self-report questionnaire [23]. Designed for those aged 65 years and older, participants use this 12-item scale to self-report the average number of hours per day spent participating in leisure, household, and occupational physical activities over the previous seven-day period. We used the Timed Up and Go Test (TUG) to assess general mobility [24]. Participants were instructed to rise from a chair with their arms crossed (seat height 45 cm), walk a distance of three meters, turn around, walk back to the chair, and sit down with their arms crossed around their chest. We timed each trial and took the mean of two trials for our statistical analysis. We measured functional capacity using the Six-Minute Walk Test (6MWT) [25], a walking test of physical status to assess general cardiovascular capacity in seniors. The total distance walked in six minutes was recorded.

Primary Outcome Measure

This study focused on three executive cognitive functions: selective attention and conflict resolution, set shifting, and working memory. According to Miyake and colleagues [26], although all three executive processes are moderately correlated, each has a distinct purpose. Conflict resolution involves goal maintenance while deliberately inhibiting dominant, automatic, or prepotent responses (i.e., self-regulation). Set shifting requires one to go back and forth between multiple tasks or mental sets [26]. Working memory involves monitoring incoming information for relevance to the task at hand and then appropriately updating the informational content by replacing old, no longer relevant information with new incoming information[28].

Our primary cognitive outcome measure was the specific executive cognitive process of selective attention and conflict resolution, as measured by the Stroop Test [27]. First, participants read out words printed in black ink (e.g., BLUE). Second, they named the display colour of coloured-X's. Finally, they were shown a page with colour-words printed in incongruent coloured inks (e.g., the word "BLUE" printed in red ink). Participants were asked to name the ink colour in which the words were printed (while ignoring the word itself). There were 80 trials for each condition and we recorded the time participants took to read each condition. We calculated the time difference between the third condition and the second condition (i.e., interference score). Smaller interference time differences indicate better selective attention and conflict resolution.

Secondary Outcome Measures

Set shifting and working memory were secondary measures of executive functions. We used the Trail Making Tests to assess set shifting [28]; this test requires participants to draw lines connecting encircled numbers sequentially (Part A) or alternating between numbers and letters (Part B). The difference in time to complete Part B and Part A was calculated, with smaller difference scores indicating better performance.

We used the verbal digits forward and backward tests to index working memory [29]. Participants repeated progressively longer random number sequences in the same order as presented (forward) and the reversed order (backward). The difference in score between the two tests was calculated, with smaller differences indicating better performance.

Randomization and Sample Size

The randomization sequence was generated by www.randomization.com. Participants were enrolled and randomized to one of three groups: once-weekly resistance training (1x RT), twice-weekly resistance training (2x RT), or twice-weekly balance and tone (BAT).

The required sample size for this study was calculated based on predictions of 12-month changes in the Stroop Test [8]. Specifically, we predicted 6% improvement for the 1x RT and a 12% improvement for the 2x RT. We also estimated 10% deterioration in the BAT group (i.e., control group). These estimates were based on our previous work [30]. Assuming a 20% attrition rate and using an alpha level of $\alpha = 0.05$, 52 participants per group ensured a power of 0.80.

Exercise Intervention

All classes were led by certified fitness instructors and were 60 minutes in duration. The fitness instructors were blinded to the study hypotheses.

Resistance Training

Both a Keiser[®] Pressurized Air system and free weights were used [8]. The Keiser-based exercises consisted of biceps curls, triceps extension, seated row, latissimus dorsi pull downs, leg press, hamstring curls, and calf raises. The intensity of the training stimulus was at a work range of 6–8 repetitions (two sets). The training stimulus was subsequently increased using the 7RM method – when two sets of 6–8 repetitions were completed with proper form and without discomfort. Other key strength exercises included mini-squats, mini-lunges, and lunge walks.

Balance and Tone

The BAT program consisted of stretching exercises, range of motion exercises, balance exercises, functional and relaxation techniques [8]. Other than bodyweight, no additional loading (e.g., hand weights, etc.) was applied. This group served to control for confounding variables such as physical training received by traveling to the training centres, social interaction, and changes in lifestyle secondary to study participation.

Statistical Analysis

For the purpose of our analysis, the 1x RT and the 2x RT groups were combined and treated as one experimental group (i.e., RT group). We used a multi-state stochastic model [9–14] to describe dynamics, or transitions, in individual status of executive functions from baseline to trial completion. This model estimates the probabilities of all transitions, in fixed time (12 months) for improvement, stability and decline in each executive function. Details regarding the model are available in the appendix.

We converted the raw cognitive scores to new state scores. For the Stroop Test, 5-second intervals in the interference score were used to define cognitive states. We considered zero-state for less than 20-second difference in baseline interference score, first state for 20 to 24-second difference, and so forth until the 13th state which corresponded to > 80 seconds in the interference score. We chose a 5-second interval based on the normative data published from the Maastricht Aging Study [31]. Based on the published data, a 5-second interval represents the difference in interference among women with average to high level of education between the mean ages of 65, 70, and 75 years. To our knowledge, there is no published data indicating what a 5-second improvement in the Stroop Interference score represents in terms of delaying the onset of dementia or institutionalization. Further, the Stroop Interference time is significantly associated with dementia risk [32]. Thus, given the limited data available currently on clinically meaningful changes scores in the Stroop Interference, we chose to categorize the Stroop Inference score using these previously demonstrated 5-second intervals. Missing at follow-up (i.e., drop-outs) was added as a last state (absorbing state).

For Trail Making Tests, 5-second intervals were also used define states. Less than a 5-second difference between Part B and Part A was considered as zero-state, a 5- to 10-second

difference as first-state, and so forth until the 19th state which corresponded to more than a 95-second difference. For verbal digits forward and backwards tests, one point intervals were used to define states. Specifically, a difference score of 0 was considered as zero-state, a difference score of one as first state, and so forth until the ninth state which corresponded to a difference score of nine or greater.

Results

Baseline Characteristics

Table 1 summarizes the baseline demographic characteristics of 155 participants. The mean age of the cohort was 69.6 + 2.9 years. The exercise adherence, expressed as the percentage of the total classes attended was 67.9% and was not significantly between the groups ($p=0.10$) using chi-square test. Linear correlation between baseline Stroop Test performance and exercise adherence were not significantly associated (Pearson $r=0.06$, $p=0.47$). Physical activity levels did not differ significantly between the groups at trial completion ($p=0.68$) using the ANCOVA test.

Overall Percentage of Improvement, Maintenance, and Decline at Trial Completion

Overall, those in the RT group had a significantly higher percentage ($p=0.04$) for improved performance on the Stroop Test 49.1%; (95% CI 41.2% to 57%) compared with those in the BAT group 32.6%; (95% CI 25.2% to 40%). Conversely, the percentage of decline was significantly higher ($p=0.04$) for the BAT group 36.8%, (95% CI 29.2% to 44.4%) compared with the RT group 21.7%, (95% CI 15.2% to 28.2%). There was no significant difference in the percentage ($p=0.96$) of maintenance between the BAT group 16.3%; (95% CI 10.5% to 22.1%) and the RT group 16%; (95% CI 10.2% to 21.8%).

For set shifting and working memory, there were no significant differences in the probability for improvement, maintenance, or decline between the BAT group and the RT group ($p>0.05$).

Transitions in Executive Functions at Trial Completion in Relation to Resistance Training and Baseline Function

In the multivariable analysis, baseline performance of executive functions was significantly associated with performance at trial completion. Importantly, resistance training had significant state-specific effects on transitions in selective attention and conflict resolution. Resistance training had no significant state-specific effects on transitions in set shifting and working memory (Table 2).

The dynamic change in selective attention and conflict resolution in relation to the state of transition is illustrated by Figure 1, a multi-state transition graph. In Figure 1, the solid line represents the density distribution of the BAT group and the dashed line represents the RT group (i.e., 1x RT and 2x RT combined). The BAT group's transition probability curves are to the right of the RT group. This suggests that the probability of improving selective attention and conflict resolution was higher with resistance training compared with balance

and tone training. Importantly, this was most evident among those whose baseline Stroop Test interference scores were less than 50 seconds (i.e., up to the 6th state).

To further explore the differences in baseline function between those whose baseline Stroop Test performance was < 50 seconds (i.e., 0 to 6th state) and whose baseline was > 50 seconds (i.e., 7th and 8th states), we compared their baseline MoCA, baseline MMSE, baseline TUG, and baseline 6MWT (Table 3). All measures were not significantly different between the two groups.

Missingness

Missingness, defined as missing data from participants who either dropped out of the 12-month trial or from those who did not complete the entire assessment battery, was not associated with baseline performance of executive functions, resistance training, or with baseline MoCA.

Discussion

By applying a novel statistical approach known as multi-state transition modeling to data collected from a 12-month randomized controlled trial, we provide new knowledge regarding the variability in cognitive change in relation to targeted exercise training. We demonstrated that the probability of improving selective attention and conflict resolution in older women was higher with resistance training compared with balance and tone training. Importantly, this was most evident among those with higher baseline selective attention and conflict resolution function as measured by the Stroop Test. In the literature, the Stroop Test is also commonly used to measure the construct of self-regulation [33]. To our knowledge, this study is the first to demonstrate that an individual's baseline self-regulatory capacity impacts the degree of cognitive benefit s/he will reap from targeted exercise training. This study highlights the need for cutting edge models in neuroscience due to complexity of this field [34].

Initially, our findings may appear counterintuitive as it is almost a ubiquitous observation in randomized controlled trials of exercise that the greatest benefits are observed among those who are most frail [35]. However, our results do concur with recent work in the area of individual health behaviour. Specifically, our current findings support the proposition that intact executive functions are essential to one's ability to carry out and adhere to health-promoting behaviours [36].

In this study our results specifically suggest that among community-dwelling women with an average age of 70 years old, those with baseline Stroop Test interference scores less than 50 seconds will experience the greater cognitive benefit from resistance training than those with Stroop Test interference scores > 50 seconds. Based on the normative data published from the Maastricht Aging Study [31], the mean Stroop Test interference score for women aged 70 years old with high level of education is 47.16 seconds; 88% of our study participants had either a university degree or a university certificate. The mean baseline Stroop Test interference score was 46.07 seconds for 2x RT group, 45.71 seconds for 1 x RT

group, and 44.03 for the BAT group. Thus, our results do coincide with relevant published normative values of Stroop Test performance.

We note that our study sample consisted exclusively of independent community-dwelling senior women who were without significant physical and cognitive impairments. Thus, the results of our study may not generalize beyond this population of senior women. Also, to allow the application of the multi-state transition model to our data, we had to merge the two resistance training groups. Hence, future studies with larger sample sizes are needed to confirm our results of our secondary analysis.

In summary, resistance training is efficacious in improving a measure of selective attention and conflict resolution in older women – probably more so among those with higher baseline cognitive function. Thus, to maximize the cognitive benefits of resistance training among older adults, especially those with executive dysfunction, clinicians may wish to consider parallel delivery of strategies that target executive functions. Indeed, our results imply that targeted exercise training for older adults should be delivered in parallel with specific cognitive training aimed at improving self-regulatory capacity.

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List of abbreviation

1x RT	once-weekly resistance training
2x RT	twice-weekly resistance training
6MWT	Six-Minute Walk Test
ANCOVA	Analysis of Covariance
BAT	twice-weekly balance and tone training
GDS	Geriatric Depression Scale
MCI	Mild Cognitive Impairment
MMSE	Mini-Mental State Examination
MoCA	Montreal Cognitive Assessment
PASE	Physical Activities Scale for the Elderly
TUG	Timed Up and Go Test

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Appendix

Marginal, Mixed and Transition Models

Marginal models can describe the relationship of the mean of the outcome (dependent variable) and risk factors (independent variables). However, capturing change at both population and individual level can be described better with mixed model. Mixed model develops regression relationship on an individual by separating variance component into two

parts. Random effects are representative of heterogeneity of subject or varying in individuals however fixed effects are assumed identical relationship for every subject. In contrast, transition model utilizes previous outcomes as predictors of future outcomes. Some type of this model, also known as Markov model, builds a joint distribution that is conditioned on previous measurement of outcome for each individual. Main idea of this approach is the best predictor of future is past history. In next section we describe the multi-state transition model which is developed for a fixed time interval of count data.

Multi-state transition model for count data

A novel approach of a multi-state transition model to describe longitudinal changes in cognitive status is presented. The model is based on the parametric Markov chain with a few interpretable parameters. Model can compute the probabilities of improvements, stabilization, worsening and missing/dying as a function of baseline cognitive status and the covariates according to modified truncated Poisson distribution. Recently a novel approach to modeling transition in cognition has been suggested [11]. Later, this model was developed by Fallah et al [9] to cognitive functions assessed as by the Modified Mini-Mental State Examination to incorporate covariates. In earlier works [9,11] a non-linear least square algorithm was used to estimate the parameters, later model was developed by using maximum likelihood estimation (MLE) to find parameters [12–14] with truncated Poisson distribution frameworks.

Let $P_{n_i k_j}$ be the probability that individual i in state S_{n_i} transits to state S_{k_j} at the time of the next assessment, modeled here as truncated Poisson, given survival,

$$P_{n_i k_i} = \frac{\rho_{n_i}^{k_i} / k_i!}{\sum_{s=0}^N \rho_{n_i}^s / s!} (1 - P_{n_i D}) \quad n_i, k_i = 0, \dots, N \quad (1)$$

Where $P_{n_i D}$ is the probability of missing/dying before the next assessment. The transition probabilities satisfy the evident condition:

$$\sum_{k_i=0}^N P_{n_i k_i} + P_{n_i D} = 1 \quad (2)$$

Here, $\rho_{n_i} = g(n_i)$, where g is an appropriate link function which may be nonlinear. In some of our applications, the identity link seems adequate, with

$$\rho_{n_i} = a_{1i} + b_{1i} n_i. \quad (3)$$

For transitions to state D, there is a parallel formulation,

$$\text{logit} \left(P_{n_i D} \right) = a_{2i} + b_{2i} n_i. \quad (4)$$

Each of the parameters a_{1i} , b_{1i} , a_{2i} , b_{2i} are modulated by covariates.

The probabilities of transition between the different states including missing/mortality can also be formulated using other approaches such as logistic regression or multinomial/ordinal logistic regression [15–16].

Figure 1.

The probability of transitions from n state (i.e., baseline) to k state (i.e., 12-month trial completion) is shown for resistance training (RT) and balance and tone training (BAT). Panels show the transitions from the zero-state (i.e., Stroop Test interference scores less than 20 seconds) to 8th state (i.e., Stroop Test interference scores between 55 to 59 seconds). Lower states indicate better Stroop performance. The Y axis shows the probability of transition to the new Stroop state, k (on the X axis). The dashed lines show the density distribution of the RT group, the solid lines indicate the BAT group.

Those in the RT group had a higher probability for improved performance on the Stroop Test compared with those in the BAT group, but more so among those with better baseline performance. For example, among participants who had baseline Stroop Test interference scores between 20 to 24 seconds (i.e., $n=1$), those in the RT group would have ~ 20% of reducing their interference score to less than 20 seconds (i.e., transition to $k=0$) compared with ~ 10% for those in the BAT group. These differences are less apparent among participants who had baseline Stroop Test interference scores 50 seconds (i.e., $n=7$).

Table 1

Baseline data characterization ^a

Variable	Balance & Tone Training (n=49)	Resistance Training (n=106)	Missingness (n=21)	Total (n=155)	p-value
Age, year	70.0 (3.3)	69.4 (2.8)	69.8 (3.7)	69.6 (3)	0.29
Height, cm	161.0 (6.9)	161.8 (6.8)	160.7 (8.0)	161.6 (6.8)	0.54
Weight, kg	67.0 (11.5)	70.6 (16.5)	67.7 (22.2)	69.5 (15.2)	0.20
Education, No. (%)					0.45
<i>No high school</i>	1 (1.9)	1 (1.9)	3 (1.9)	3 (2.0)	
<i>Grades 9–12 without certificate or diploma</i>	2 (4.1)	7 (6.6)	1 (4.8)	9 (5.8)	
<i>High school certificate or diploma</i>	6 (12.2)	19 (17.9)	2 (9.5)	25 (16.1)	
<i>Trade or professional certificate or diploma</i>	14 (28.6)	16 (15.1)	5 (23.8)	30 (19.4)	
<i>University certificate or diploma</i>	7 (14.3)	21 (19.8)	3 (14.3)	28 (18.1)	
<i>University degree</i>	19 (38.8)	41 (38.7)	8 (38.1)	60 (38.7)	
MMSE Score, max. 30 pts ^b	28.80 (1.2)	28.58 (1.37)	28.76 (1.04)	28.65 (1.31)	0.35
Geriatric Depression Scale ^c	0.51 (1.79)	0.60 (1.80)	0.67 (1.32)	0.57 (1.8)	0.76
MoCA, max. 30 pts ^d	25.0 (3.2)	25.2 (3.9)	25.5 (2.4)	25.1 (3)	0.71
Timed Up & Go Test, sec ^e	6.77 (1.44)	6.58 (1.40)	6.70 (1.79)	6.64 (1.41)	0.44
6MWT, meters ^e	523.8 (70.4)	515.9 (78.7)	507.9 (57.6)	518.3 (76.1)	0.57
Exercise Adherence, % ^f	62 (24)	71 (22)	28 (24)	68 (23)	0.10
PASE Score ^g	126.1 (51)	118.7 (60.7)	108.7 (47.9)	121.1 (57.7)	0.68

^aUnless otherwise indicated, data are expressed as mean (SD). Percentages have been rounded and may not total 100.^bMini-Mental State Examination, Maximum was 30 points.^cMaximum was 15 points.^dMontreal Cognitive Assessment, Maximum was 30 points.^e6-Minute Walk Test.^fA percentage score for each subject by dividing the total class attended by the total classes prescribed throughout the 12-month trial.^gPhysical Activity Scale for the Elderly.

Table 2

Parameter estimates and their 95% confidence intervals in multivariable models for Stroop Test, Trail making Tests and Verbal digit span test at trial completion

Variable	Parameter	Stroop CW-Stroop C [†] Mean (95%CI)	Trail B – Trail A Mean (95%CI)	Digit Forward – Digit Backward Mean (95%CI)
Basic model	α_1	1.80 (0.89, 2.71) *	1.81 (0.83, 2.77) *	3.12 (2.24,4.01) *
	β_1	0.64 (0.49,0.79) *	0.49 (0.38,0.61) *	0.28 (0.11,0.45) *
	α_2	-1.66 (-2.79,-0.54) *	1.54 (-2.58,-0.49) *	-1.81 (-2.98,-0.62) *
Resistance training	β_2	0.01 (-0.13,0.15)	0.03 (-0.06,0.12)	0.02 (-0.20,0.24)
	γ_{11}	-0.84 (-1.67,-0.02) *	-0.31 (-1.26,0.64)	-0.54 (-1.32,0.24)
	δ_{21}	-0.10 (-1.07,0.88)	-0.40 (-1.31,0.54)	0.07 (-0.96,1.09)
MoCA ¹	γ_{12}	0.36 (-0.39,1.12)	3.69 (2.57,4.81)	0.09 (-0.61,0.78)
	δ_{22}	-0.41 (-1.36,0.54)	-0.44 (-1.39,0.51)	-0.54 (-1.52,0.44)

[†] Stroop CW = Stroop colour-words condition; Stroop C = Stroop coloured-X's condition

* Statistically significant parameters(p<0.05)

¹ Montreal Cognitive Assessment.

α_1 : Intercept (mean follow-up cognitive state from baseline)

β_1 : Increment of cognitive state

α_2 : Logit-Probability of missingness from the baseline

β_2 : Baseline cognition effect on the probability of missingness

γ_{11} : Resistance training effect on cognitive transitions

δ_{21} : Resistance training effect on missingness

γ_{12} : Effects of MoCA score on cognitive transitions

δ_{22} : Effects of MoCA score on missingness

Comparing baseline function between those whose baseline Stroop Test interference scores were < 50 seconds (i.e., n states of 0 to 6th) and whose baseline Stroop Test interference scores were ≥ 50 seconds (i.e., n states of 7th and higher)

Table 3

Variables	Stroop Test < 50 seconds	Stroop Test ≥ 50 seconds	<i>p</i> -value
Age, year	69.6 (3.1)	69.1 (2.9)	0.91
Montreal Cognitive Assessment, max. 30 pts	25.5 (2.8)	24.5 (3.3)	0.09
Mini-Mental State Examination, max. 30 pts	28.8 (1.2)	28.4 (1.5)	0.11
Timed Up & Go Test, seconds	6.6 (1.4)	6.8 (1.5)	0.71
6-Minute Walk Test, meters	526.3 (70.8)	500.5 (85.1)	0.06