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RESEARCH ARTICLE

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Lifestyle for brain health and cognitive functioning in midlife to early late-life New Zealanders: Utility of the LIBRA index

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Abstract

Objectives: There is enormous potential to improve brain health and reduce the risk of cognitive decline and dementia based on modifiable risk factors. The Lifestyle for Brain Health (LIBRA) index was developed to quantify modifiable dementia risk or room for brain health improvement. The objective of the study was to investigate the utility of the LIBRA index in relation to cognitive functioning in a midlife to early late-life sample of New Zealanders.

Methods: A subsample (n = 1001) of the longitudinal New Zealand Health, Work and Retirement (NZHWR) study completed face-to-face cognitive assessments using the 'Kiwi' Addenbrooke's Cognitive Examination—Revised (ACE-R) in 2010 and again in 2012, in addition to completing biennial NZHWR surveys on socioeconomic, health and wellbeing aspects. The LIBRA index was calculated incorporating information on 8 out of 12 modifiable health and lifestyle factors for dementia. Unadjusted and adjusted regression models and mixed effects models were used to inspect associations of LIBRA with cognitive functioning, cognitive impairment, and cognitive decline.

Results: The analytical sample (n = 881 [88.0%], after considering exclusion criteria and missing data) had a mean age of 63.1 (SD = 6.5) years, 53.3% were female, 26.2% were Māori, and 61.7% were highly educated. Higher LIBRA scores (indicating higher modifiable dementia risk) were associated with lower cognitive functioning (B = −0.33, 95% CI = −0.52;−0.15, $p < 0.001$) and a higher likelihood of cognitive impairment (OR = 1.22, 95% CI = 1.04; 1.42, p = 0.013), but did not predict cognitive decline over 2 years (B = −0.03, 95% CI = −0.22; 0.16, p = 0.766), adjusted for age, age^2, gender, education, and ethnicity.

Conclusions: The LIBRA index indicated promising utility for quantifying modifiable dementia risk in midlife and early late-life New Zealanders. For local use, refinement of the LIBRA index should consider cultural differences in health and lifestyle risk factors, and further investigate its utility with a wider range of modifiable factors over a longer observation period.

KEYWORDS
cognitive functioning, cohort study, dementia, LIBRA, lifestyle, New Zealand, prevention, risk reduction

Key points

- A higher Lifestyle for Brain Health (LIBRA) score was associated with lower cognitive functioning and a higher likelihood for cognitive impairment in midlife to early late-life New Zealanders
- LIBRA can thus indicate room for improvement in brain health in New Zealanders aged 49–75 years old
- Future studies that investigate a broader range of modifiable risk factors for dementia might improve the utility of the LIBRA index

1 | INTRODUCTION

The rise of dementia due to population ageing is a global public health challenge.[1] Just as worldwide, the number of people with dementia is projected to more than double in Aotearoa New Zealand. In the Oceania country with 5 million inhabitants, the number will rise from 70,000 in 2020 to at least 170,000 by 2050, associated with a total economic cost increase from NZ$1.9 billion to NZ$4.5 billion.[2] This requires strategies aimed at reducing the scale and impact of dementia.

Opportunities for the risk reduction and prevention of cognitive decline and dementia have recently gained much attention.[3] The 2020 Lancet Commission on dementia prevention, intervention, and care postulated a life course model specifying 12 modifiable risk factors for dementia: less education in early life; hearing loss, traumatic brain injury, hypertension, more than moderate alcohol consumption, obesity in midlife; smoking, social isolation, physical inactivity, air pollution, depression, and diabetes in later life.[4] Approximately 40% of all dementia cases could theoretically be prevented or at least delayed if these risk factors were eliminated, highlighting the enormous dementia prevention potential. Notably, the risk factors included in the life course model are not exhaustive but rather reflect current robust evidence. It could be viewed as a dynamic modelling approach, and risk factors may change considering new scientific findings. Other emerging factors, for example, are cognitive stimulation,[5] chronic kidney disease,[6] sleep,[7] chronic stress,[8] hypercholesterolaemia,[9] access to green space[10] or creative practices.[11,12] This suggests that the overall dementia prevention potential may be even higher and encourages to be ambitious about the room for improvement in brain health across the lifespan.

Using the 2020 Lancet model, Ma'u et al. found that 47.7% of all dementia in Aotearoa New Zealand could be attributed to the 12 modifiable risk factors, suggesting a higher dementia prevention potential than worldwide.[13] Moreover, there was a marked difference in the prevention estimates regarding Aotearoa New Zealand's main ethnic populations, ranging from 40.8% for New Zealanders of Asian (mainly Chinese and Indian) descent, 47.6% for European New Zealanders, 50.8% for Pacific Peoples, to 51.4% for Māori, the native population. The high proportion in Pacific Peoples and Māori is likely associated with structural socioeconomic disadvantages.[13] Importantly, while the dementia prevention potential in Aotearoa New Zealand is large and highly varying among ethnic groups, effective tailored public health strategies that utilise the potential and target the modifiable risk factors are lacking.

Against the need of developing, evaluating, and implementing tailored approaches for primary prevention and early intervention to reduce the risk of cognitive decline and dementia, it is imperative to be able to quantify room for improvement. The "Lifestyle for Brain Health" (LIBRA) index has been created for that.[14,15] LIBRA is a composite score, which was developed based on a systematic literature review and a Delphi expert panel consensus on modifiable risk and protective factors for dementia. The LIBRA index indicates one's potential for brain health improvement with significant overlap with the Lancet model. Numerous studies have shown the utility of the score in demonstrating associations with cognitive functioning and prevalent and incident cognitive impairment, cognitive decline and incident dementia in diverse midlife and early late-life (up to 75 years of age) populations.[12,16–20] As opposed to other dementia risk indices like ANU-ADRI (Australian National University - Alzheimer's Disease Risk Index) and Cardiovascular Risk Factors, Ageing and Dementia (CAIDE) (Cardiovascular Risk Factors, Ageing, and Incidence of Dementia),[21] LIBRA only contains individual-level modifiable factors, which allows for a range of applications. For example, LIBRA can be useful in identifying individuals with risk profiles, monitoring and investigating intervention outcomes in dementia trials, studying modifiable pathways to cognitive decline and dementia in association with environmental factors, such as the social determinants of health, and helping individuals understand their room for brain health improvement.[12,22–24]

Against this background, the study aims to investigate the utility of the LIBRA index in relation to cognitive functioning in a midlife to early late-life sample of New Zealanders.

2 | MATERIALS AND METHODS

The study is part of the New Zealand Health, Work and Retirement Study (NZHWR), a longitudinal nationwide cohort study on healthy ageing among New Zealanders from midlife.[25] Biennial surveys have been conducted since 2006.[26] Recruitment was based on random sampling from the national electoral roll and over-sampling of persons of Māori descent for adequate representation. Over 12,000 older adults responded to one or more of the nine biennial surveys completed 2006–2022, with roughly half of the respondents being of Māori descent. Moreover, several subsample studies have been conducted to focus on specific research topics.

2.1 | Study sample

The study sample was drawn from a population sample of the 2010 NZHWR study wave who volunteered to do face-to-face interviews in addition to the postal surveys. In 2010, the subsample study focused on cognitive assessments. In total, 1001 participants took part in the baseline face-to-face interviews. Their age ranged from 49 to 84 years, 55.8% were women and 25.8% identified as Māori. Compared to the general population, the volunteer sample was more highly educated, under-sampled in the 45–54 age group and 75+ age group, and oversampled Māori. In 2012, follow-up face-to-face interviews were completed by 873 of the baseline participants. At both waves, identical measures were used to assess cognitive functioning in addition to information collected by the postal surveys. Interviews were conducted in the participants' homes by trained research assistants and took approximately 1 hour to complete.

2.2 | Cognitive functioning and cognitive impairment

Cognitive functioning was assessed with an adapted and validated version of the Addenbrooke's Cognitive Examination—Revised[27] for culturally acceptable use with New Zealanders (the 'Kiwi' ACE-R).[28] Internationally, culturally relevant adaptations had little impact on the solid psychometric properties of the measure (internal consistency: $\alpha = 0.80$; concurrent validity: −0.32 in relation to the Clinical Dementia Rating Scale).[29,30] The ACE-R is a comprehensive neuropsychological test that includes 26 items to assess five cognitive domains: orientation and attention (e.g., asking for location and date), memory (tasks related to short-term, long-term, anterograde, and retrograde memory), verbal fluency (naming words beginning with a specific alphabetic letter), language (e.g., writing sentences, repeating words), and visuospatial (e.g., drawing a clock and copying a pentagon). The domain scores are summed up, with a maximum score of 100. Higher scores indicate higher cognitive functioning. The ACE-R is a valid screening test for cognitive impairment and possible dementia (cutoff 82: sensitivity = 0.84, specificity = 1.00; cutoff 88: sensitivity = 0.94, specificity = 0.98).[27] It is sensitive to mild cognitive impairment (MCI), and comprehensive details on the 'Kiwi' version of the assessment have been published elsewhere.[31] In this study, cognitive impairment was defined as scoring 1.5 standard deviations (*SD*) or more below the mean total ACE-R score across the sample.

2.3 | LIBRA index

We computed the LIBRA index for all study participants aged ≤75 years old. It contains up to 12 modifiable health and lifestyle factors,[16] and information on eight of them was available in the NZHWR study in the 2010 wave: coronary heart disease, chronic kidney disease, diabetes, hypertension, low-to-moderate alcohol consumption, smoking, physical inactivity, depression; with information on obesity, hypercholesterolaemia, healthy diet, and high cognitive activity not being available. A standardised weight was assigned to each factor, reflecting its relative risk as extracted from a systematic literature review and agreed upon in a Delphi consensus.[15,32] The weights were summed to yield the LIBRA score. The maximum range is −5.9 to +12.7. The 8-factor modified score ranged from −1.0 to +8.7. Higher scores indicate higher modifiable dementia risk or poorer LIBRA. Table 1 details the operationalisation of the LIBRA index.

2.4 | Covariates

Sociodemographic information was assessed based on a standardised questionnaire and included, among other variables, age in years, gender (men, women), level of education (reflecting the New Zealand educational system, ranging from no qualifications, secondary school qualification, post-secondary certificate or diploma to university degree) as well as ethnicity (self-identified; Māori and Non-Māori).[25]

2.5 | Statistical analysis

Sample characteristics were investigated by calculating means and *SD*s or proportions for the total sample and regarding cognitive impairment. Group differences between individuals with and without cognitive impairment were assessed using Chi-squared tests and independent samples *t*-tests, as appropriate. Average LIBRA scores were inspected according to sociodemographic characteristics with independent samples *t*-test or one-way analysis of variance (ANOVA).

Associations of LIBRA with cognitive functioning were assessed with linear regressions, unadjusted and adjusted for age, age squared, and gender; then adding education and finally ethnicity. Including a quadratic term for age accounted for the curvilinear relationship of age with cognitive functioning. Associations of LIBRA with cognitive impairment were based on logistic regressions, using the same adjustment approach. Linear mixed effects models with restricted maximum likelihood (REML) were used

TABLE 1 Operationalisation of the Lifestyle for Brain Health (LIBRA) index in the New Zealand Health, Work and Retirement (NZHWR) sub-study on cognitive functioning (n = 1001).

Factor	Assessment	Operationalisation and cutoffs	N (missings)	Weight
Coronary heart disease	Self-report	Responding 'Yes' to whether a health professional has diagnosed 'heart trouble' incl. heart attack	1001 (0)	+1.0
Diabetes mellitus	Self-report	Responding 'Yes' to whether a health professional has diagnosed 'diabetes'	1001 (0)	+1.3
Hypercholesterolaemia	*Not available in 2010 NZHWR wave*			
Hypertension	Self-report	Responding 'Yes' to whether a health professional has diagnosed 'high blood pressure or hypertension'	1001 (0)	+1.6
Depression	Short version of the Centre for Epidemiological Studies—Depression Scale (CES-D-10)[33]	CES-D-10 score ≥10	1001 (0)	+2.1
Obesity	*Not available in 2010 NZHWR wave*			
Smoking	Standardised self-report questionnaire on smoking.	Self-reported current smoker	988 (13)	+1.5
Low-to-moderate alcohol consumption	Alcohol Use Disorders Identification Test—Consumption Questions (AUDIT-C)[34]	Having drinks containing alcohol two to four times per month or less	993 (7)	−1.0
Physical inactivity	Standardised questionnaire adopted from the Health and Retirement Study (HRS)[35]	Being less than moderately active less than once a week	983 (18)	+1.1
High cognitive activity	*Not available in 2010 NZHWR wave*			
Healthy diet	*Not available in 2010 NZHWR wave*			
Chronic kidney disease	Self-report	Responding 'Yes' to having been diagnosed with a 'chronic renal disease or kidney condition'	983 (18)	+1.1
Total number of cases and LIBRA score range			974 (27)	−1.0–8.70

to assess whether LIBRA was longitudinally associated with cognitive functioning as well as cognitive decline over the 2 years of observation. The association between LIBRA and cognitive decline was estimated by including a two-way interaction term of time and LIBRA, which represents the rate of change in cognitive functioning as a function of LIBRA. The mixed models were initially unadjusted and then subsequently adjusted for age, age squared, and gender, plus education, and finally, plus ethnicity. Following likelihood ratio tests, the models included a random intercept and random slope with an unstructured covariance matrix. Finally, Cox regression was used to inspect whether LIBRA scores at baseline predicted incident cognitive impairment at follow-up, excluding individuals with prevalent cognitive impairment.

Since the analyses were based on a volunteer sample, we conducted a sensitivity analysis applying inverse probability weighting (IPW) to account for selection and response biases as well as for the oversampling of Māori descent to better reflect the demographics of the New Zealand electoral roll for observed birth years. IPW assigns weights to the individuals in the sample based on the inverse of their probability of being selected for the sample. Each weight is a propensity score obtained from regression analysis that predicted the likelihood of selection based on relevant characteristics (i.e., age, gender, ethnicity, and area-level socioeconomic status), informed by the Stats NZ 2006 census data.

A level of statistical significance of $p < 0.05$ was assumed. Analyses were performed with STATA/SE 17.0 (StataCorp, Texas).

3 | RESULTS

3.1 | Sample characteristics

Of 1001 participants of the subsample study, 881 were included in the analysis. Participants aged above 75 years were excluded as the LIBRA index does not have validity in older-old age groups (n = 79, 7.9%). Among the remaining 922 participants, further attrition was due to missing data on LIBRA factors (n = 18, 2.0%), cognitive functioning (n = 1, 0.1%) and sociodemographic covariates (n = 22,

2.4%). Since the proportion of missing data was low, no imputation was performed.

The analytical sample ($n = 881$) had a mean age of 63.1 ($SD = 6.5$, range = 49–75) years, 53.3% were female, and about a quarter were Māori (26.2%). The majority (61.7%) were highly educated, having obtained a post-secondary or university degree.

Individuals with cognitive impairment made up 7.8% ($n = 69$) of the sample. Their ACE-R scores were significantly lower across all five cognitive domains. Individuals with cognitive impairment tended to be older, were less educated and more frequently Māori, but did not significantly differ regarding the distribution of gender compared to individuals without cognitive impairment. More sample characteristics are detailed in Table 2.

3.2 | LIBRA scores

The observed LIBRA scores in the sample ranged from −1.0 to +7.4 with an overall mean score of 1.77 ($SD = 1.60$). Mean LIBRA scores were higher in early late-life compared to midlife ($M = 1.96$, $SD = 1.65$ vs. $M = 1.64$, $SD = 1.55$; $t(879) = -2.96$, $p = 0.003$), in men compared to women ($M = 1.96$, $SD = 1.65$ vs. $M = 1.60$,

TABLE 2 Characteristics of the study population for the total sample and according to cognitive impairment status.

	Total sample	Cognitive impairment	No cognitive impairment	Group difference
N	881	69 (7.8%)	812 (92.2%)	
Age, mean (*SD*)	63.1 (6.5)	66.7 (6.1)	62.6 (6.5)	$t(879) = -4.85$, $p < 0.001$
Gender, *N* (%)				
Women	470 (53.3%)	30 (43.5%)	440 (54.2%)	$Chi^2(1) = 2.93$, $p = 0.087$
Men	411 (46.7%)	39 (56.5%)	372 (45.8%)	
Education, *N* (%)				
No qualifications	140 (15.9%)	32 (46.4%)	108 (13.3%)	$Chi^2(3) = 53.16$, $p < 0.001$
Secondary school certificate	197 (22.4%)	8 (11.6%)	189 (23.3%)	
Post-secondary certificate or diploma	344 (39.0%)	21 (30.4%)	323 (39.8%)	
University degree	200 (22.7%)	8 (11.6%)	192 (23.6%)	
Ethnicity, *N* (%)				
Māori	231 (26.2%)	25 (36.2%)	206 (25.4%)	$Chi^2(1) = 3.88$, $p = 0.049$
Non-Māori	650 (73.8%)	44 (63.8%)	606 (74.6%)	
Cognitive functioning, mean (*SD*)	93.5 (5.0)	81.4 (5.3)	94.5 (3.4)	$t(879) = 29.41$, $p < 0.001$
Cognitive domains, mean (*SD*)				
Attention and orientation	17.8 (0.6)	17.4 (1.1)	17.9 (0.5)	$t(879) = 5.95$, $p < 0.001$
Memory	23.9 (2.6)	19.0 (4.0)	24.3 (2.0)	$t(879) = 19.20$, $p < 0.001$
Verbal fluency	11.4 (2.1)	8.0 (2.6)	11.7 (1.8)	$t(879) = 16.05$, $p < 0.001$
Language	25.0 (1.4)	22.6 (2.6)	25.2 (1.0)	$t(879) = 16.59$, $p < 0.001$
Visuospatial ability	15.3 (1.0)	14.4 (1.6)	15.4 (0.9)	$t(879) = 8.44$, $p < 0.001$
LIBRA score, mean (*SD*)	1.8 (1.6)	2.4 (1.7)	1.7 (1.6)	$t(879) = -3.36$, $p < 0.001$
LIBRA factors[a], *N* (%)				
Heart disease	120 (13.6%)	11 (15.9%)	109 (13.4%)	$Chi^2(1) = 0.34$, $p = 0.558$
Diabetes mellitus	81 (9.2%)	11 (15.9%)	70 (8.6%)	$Chi^2(1) = 4.08$, $p = 0.043$
Hypertension	319 (36.2%)	31 (44.9%)	288 (35.5%)	$Chi^2(1) = 2.46$, $p = 0.117$
Depression	156 (17.7%)	21 (30.4%)	135 (16.6%)	$Chi^2(1) = 8.32$, $p = 0.004$
Smoking (current smoker)	162 (18.4%)	22 (31.9%)	140 (17.2%)	$Chi^2(1) = 9.09$, $p = 0.003$
Low/moderate alcohol consumption	450 (51.1%)	41 (59.4%)	409 (50.4%)	$Chi^2(1) = 2.08$, $p = 0.149$
Physical inactivity	583 (66.2%)	44 (63.8%)	539 (66.4%)	$Chi^2(1) = 0.19$, $p = 0.660$
Chronic kidney disease	57 (6.5%)	5 (7.2%)	52 (6.4%)	$Chi^2(1) = 0.07$, $p = 0.785$

[a]8 of 12 factors were available in NZHWR.

SD = 1.54; $t(879) = 3.35$, $p < 0.001$), and in Māori compared to Non-Māori ($M = 2.00$, $SD = 1.70$ vs. $M = 1.69$, $SD = 1.56$; $t(879) = 2.52$, $p = 0.012$). Overall, LIBRA scores did not differ significantly according to level of education. Further details are provided in Table 3.

Individuals with cognitive impairment had a significantly higher LIBRA score than individuals without cognitive impairment ($M = 2.39$, $SD = 1.70$ vs. $M = 1.72$, $SD = 1.58$; $t(879) = -3.36$, $p < 0.001$).

3.3 | Cross-sectional associations of LIBRA and cognition

LIBRA scores were significantly associated with cognitive functioning, accounting for age, gender, education, and ethnicity ($B = -0.33$, 95% CI = −0.52; −0.15, $p < 0.001$), in that higher LIBRA scores indicated lower cognitive functioning. The association was also significant if individuals with cognitive impairment ($n = 69$) were excluded (adjusted: $B = -0.15$, 95% CI = −0.29; −0.01, $p = 0.031$; results not further shown).

LIBRA scores were associated with cognitive impairment, accounting for age, gender, education, and ethnicity. A one-unit increase in the LIBRA score was associated with a 22% higher likelihood of cognitive impairment (OR = 1.22, 95% CI = 1.04–1.42, $p = 0.013$). All results of the cross-sectional regression models are detailed in Table 4.

3.4 | Longitudinal associations of LIBRA and cognition

As in the cross-sectional linear regression analysis, higher LIBRA scores were significantly associated with lower cognitive functioning, adjusted for age, age^2, gender, education, and ethnicity ($B = -0.32$, 95% CI = −0.51; −0.14, $p = 0.001$). Average cognitive functioning was slightly lower at follow-up after 2 years than at baseline

TABLE 3 Mean Lifestyle for Brain Health (LIBRA) scores according to sociodemographic characteristics.

Factor	LIBRA score mean (*SD*)	Group difference
Age		
Midlife (49–64)	1.64 (1.55)	$t(879) = -2.96$, $p = 0.003$
Early late-life (65–75)	1.96 (1.65)	
Gender		
Women	1.60 (1.54)	$t(879) = 3.35$, $p < 0.001$
Men	1.96 (1.65)	
Education		
No qualifications	1.98 (1.68)	$t(878) = 2.47$, $p = 0.061$
Secondary school certificate	1.79 (1.58)	
Post-secondary certificate or diploma	1.82 (1.62)	
University degree	1.53 (1.52)	
Ethnicity		
Māori	2.00 (1.70)	$t(879) = 2.52$, $p = 0.012$
Non-Māori	1.69 (1.56)	

TABLE 4 Cross-sectional associations of LIBRA with cognitive functioning and cognitive impairment.

Outcome	Model	Estimates[a] (95% CI)	*SE*	*p*-value
Cognitive functioning	LIBRA	−0.52 (−0.72; −0.32)	0.10	<0.001
	LIBRA, adjusted for age, age^2, gender	−0.41 (−0.61; −0.21)	0.10	<0.001
	LIBRA, adjusted for age, age^2, gender, education	−0.35 (−0.54; −0.16)	0.10	<0.001
	LIBRA, adjusted for age, age^2, gender, education, ethnicity	−0.33 (−0.52; −0.15)	0.10	<0.001
Cognitive impairment	LIBRA	1.28 (1.10–1.48)	0.09	0.001
	LIBRA, adjusted for age, age^2, gender	1.22 (1.05–1.42)	0.09	0.008
	LIBRA, adjusted for age, age^2, gender, education	1.23 (1.05–1.43)	0.10	0.009
	LIBRA, adjusted for age, age^2, gender, education, ethnicity	1.22 (1.04–1.42)	0.10	0.013

[a]B for cognitive functioning, odds ratio for cognitive impairment.

TABLE 5 Longitudinal associations of LIBRA with cognitive functioning and cognitive decline.

Model	Factors	Estimates (95% CI)	*SE*	*p*-value
LIBRA	LIBRA	−0.52 (−0.72; −0.32)	0.10	<0.001
	Time	−0.89 (−1.33; −0.45)	0.22	<0.001
	LIBRA × time	−0.02 (−0.21; 0.16)	0.10	0.800
LIBRA, adjusted for age, age^2, gender	LIBRA	−0.40 (−0.60; −0.20)	0.10	<0.001
	Time	−0.89 (−1.32; −0.45)	0.22	<0.001
	LIBRA × time	−0.02 (−0.21; 0.17)	0.10	0.808
LIBRA, adjusted for age, age^2, gender, education	LIBRA	−0.34 (−0.53; −0.15)	0.10	<0.001
	Time	−0.88 (−1.32; −0.45)	0.22	<0.001
	LIBRA × time	−0.03 (−0.22; 0.16)	0.10	0.758
LIBRA, adjusted for age, age^2, gender, education, ethnicity	LIBRA	−0.32 (−0.51; −0.14)	0.10	0.001
	Time	−0.89 (−1.32; −0.45)	0.22	<0.001
	LIBRA × time	−0.03 (−0.22; 0.16)	0.10	0.766

assessment (B = −0.89, 95% CI = −1.33; −0.45, p < 0.001); however, cognitive decline was not significantly associated with LIBRA (B = −0.03, 95% CI = −0.22; 0.16, p = 0.766). Results are further detailed in Table 5. Excluding individuals with cognitive impairment at baseline (n = 69), LIBRA was still associated with cognitive functioning (adjusted: B = −0.15, 95% CI = −0.29; −0.02, p = 0.25); however, it did not predict incident cognitive impairment (adjusted HR = 1.03, 95% CI = 0.92; 1.15, p = 0.617; results not further shown).

3.5 | Sensitivity analysis

Applying weighting to better reflect the demographics of the NZ electoral roll for observed birth years provided similar results across modelling approaches. When weighted, higher LIBRA scores were associated with lower cognitive functioning (B = −0.49, 95% CI = −0.82; −0.15, p = 0.005) after adjustment for age, age squared, gender, education, and ethnicity. A one-unit increase in LIBRA scores was associated with a 36% higher likelihood for cognitive impairment (OR = 1.36, 95% CI = 1.06–1.74, p = 0.014) in the weighted, adjusted analysis. Weighted longitudinally, LIBRA was associated with cognitive functioning (B = −0.33, 95% CI = −0.54; −0.11, p = 0.003), but not cognitive decline (B = −0.02, 95% CI = −0.22; 0.19, p = 0.884) after adjustment for age, age squared, gender, education, and ethnicity. Results are not further shown.

4 | DISCUSSION

We investigated the LIBRA index in relation to cognitive functioning in a midlife to early late-life sample of New Zealanders. In the sample of 881 adults aged 49–75 years, the LIBRA index was significantly associated with cognitive outcomes. Cross-sectionally, higher LIBRA scores, reflecting a poorer lifestyle and greater modifiable dementia risk, yielded lower cognitive functioning and a higher likelihood of cognitive impairment. Moreover, LIBRA scores were longitudinally associated with cognitive functioning, however, did not predict cognitive decline over 2 years. Given the short follow-up period and the rather high level of stability observed in cognitive functioning across the two waves,[20] the latter result may not surprise and requires re-inspection covering a longer period. Results were comparable for the unweighted and weighted sample, suggesting that the LIBRA score is a useful tool for assessing lifestyle-related brain health in relation to cognitive functioning in midlife to early late-life New Zealanders. Our study corroborates and expands findings of the Dunedin Study, a population-representative New Zealand-based birth cohort followed to midlife, which found that the LIBRA index performed well in identifying gradients of risk for Alzheimer's disease and related dementias among a cross-sectional sample of New Zealanders at the age of 45 years[36] Specifically, Dunedin Study members with higher LIBRA scores had lower midlife cognitive functioning, including lower IQ scores and higher everyday cognitive problems. They also showed lower structural brain integrity, evident by higher white matter hyperintensities.[36]

Our results add to the growing international body of literature that demonstrated the utility of the LIBRA index in quantifying room for brain health improvement based on individual-level modifiable dementia risk and protective factors in midlife and early late-life populations. For example, the LIBRA index showed good predictive validity for incident dementia in the DESCRIPA project, a multicentre study of eight harmonised European population-based cohorts: Among 9387 individuals without dementia at baseline, higher LIBRA scores predicted incident dementia after a mean follow-up time of 7.2 years in midlife and late-life participants, but not oldest-old age (80–97 years).[16] Higher midlife LIBRA scores were related to increased risk for MCI and dementia up to 30 years later in the Finnish CAIDE population-based study.[12] In cognitively unimpaired late-midlife individuals from the Wisconsin Registry for Alzheimer's Prevention, a higher LIBRA score was related to lower cognitive functioning, but not amyloid beta plaque accumulation.[37]

The LIBRA index demonstrated utility in relation to cognitive functioning in a clinical sample of help-seeking individuals, including those with MCI.[17] LIBRA correlated with global cognition in a sample of older Italians with subjective cognitive decline (SCD).[38] Moreover, results from the Maastricht Study suggested, that white matter hyperintensities and cerebrospinal fluid volume mediated the significant association between LIBRA scores and cognitive functioning.[20] In addition, the LIBRA index has usefulness as a surrogate outcome and monitoring tool in trials against cognitive decline and dementia.[39] For example, in the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER), higher LIBRA scores at baseline indicated less cognitive improvement over time.[22] Moreover, the multidomain intervention led to a decrease in LIBRA scores irrespective of cognitive functioning at baseline. A post-hoc analysis using the LIBRA index as a surrogate outcome in the Prevention of Dementia by Intensive Vascular Care (preDIVA) trial corroborated primary findings that the intervention was not effective in preventing cognitive decline or dementia.[40] Overall, and adding our results, there is good evidence for the applicability of the LIBRA index regarding a diverse range of populations, settings, and outcomes. Notably, in the above-named studies, the operationalisation of the LIBRA factors varied, and there were different numbers and combinations of available factors. This flexibility can be viewed as an asset of the LIBRA index.

Nevertheless, there is an ongoing debate on how to improve the LIBRA index and similar modelling approaches.[41] It has been suggested, for example, that the LIBRA score may underestimate dementia risk and that scores with a greater range of modifiable risk factors could be more informative.[42] Notably, a recent revision suggested the addition of three more factors (hearing impairment, social contact, and sleep) to the LIBRA index, which is currently undergoing validation studies.[43] Brett et al. demonstrated that incorporating concussion history into the LIBRA index improved the model fit and the explained variance in MCI and cognitive functioning, respectively, in a U.S. sample of former National Football League players.[44] This suggests considering a dynamic indexing approach to address different circumstances: which factors to include at which life stage with what weights for specific target populations. Region-, cultural- or population-specific aspects might moderate the weight of each factor in an index.[45] Social and economic deprivation are drivers of adverse lifestyles for brain health.[23,46] Moreover, systemically disadvantaged populations are at greater risk for chronic diseases, including dementia risk-related conditions like diabetes, cardiovascular disease, and obesity, which also tend to occur at much younger ages in deprived groups.[24] The varying prevalence of modifiable dementia risk factors between Aotearoa New Zealand's main ethnic populations,[13] which show strong clustering with socioeconomic conditions, may point to differential relative risks at different stages in life. It would be worthwhile to investigate whether tailoring the LIBRA index to the unique context of Aotearoa New Zealand's ethnic populations would outperform the uniform index, which nevertheless demonstrated utility in relation to cognitive functioning in midlife to early late-life New Zealanders.

4.1 | Strengths and limitations

Strengths of the study include the large sample size, cross-sectional and longitudinal insights, as well as the use of reliable measures that have been adapted and validated for culturally appropriate use in Aotearoa New Zealand.

Concerning limitations, the LIBRA index computed for this study was based on information for 8 out of 12 modifiable health and lifestyle factors for dementia due to limited data availability in the 2010 NZHWR wave. The subsequent narrower range of the LIBRA scores likely led to an underestimation of the strength of associations with cognitive outcomes. This assumption is supported by studies that suggested including more modifiable risk factors for dementia leads to more informative results.[42] Moreover, the operationalisation of risk and protective factors differed from other studies; importantly, relying on self-reported outcomes as opposed to objective measures (e.g., self-reported hypertension as opposed to blood pressure measures). This may compromise comparability with other studies.

The findings of the study may not be easily generalised to New Zealand's midlife and early late-life population. The volunteer sample was not representative in that the participants' characteristics deviated from sociodemographic distributions among the general population. However, a sensitivity analysis, that applied a weighting strategy to better reflect the demographic characteristics of the general population for the demographic of interest, suggested similar results. Since the volunteer sample was disproportionately highly educated and likely failed to include individuals with more severe cognitive impairment,[47] weighting may not rule out bias entirely and may even introduce other biases, such as the violation of the positivity assumption, that is, when individuals with a very low estimated probability of selection receive extremely large weights. Thus, unweighted and weighted findings are presented.

Lastly, findings of the predictive value of the LIBRA index regarding cognitive decline are limited by a short observation period. Since cognitive changes occur slowly, a longer follow-up period may provide better insights. It is planned to re-assess the 2010 NZHWR face-to-face subsample, which will allow for modelling cognitive trajectories over a substantial observation period, supplemented with the biennial NZHWR postal survey data spanning 2010–2024.

5 | CONCLUSION

The LIBRA index showed a relation to cognitive functioning and cognitive impairment in a sample of midlife and early late-life New Zealanders, indicating promising utility for quantifying modifiable dementia risk and thus room for brain health improvement in this population. Further investigations, ideally with a LIBRA index containing a wider range of risk and protective factors and with regards to cognitive decline and incident dementia spanning over a longer observation time, will help to improve its applicability in the context

of Aotearoa New Zealand. For local use, refinement of the LIBRA index should also consider cultural differences in health and lifestyle risk factors, which may impact factor weights.

AUTHOR CONTRIBUTION

SR designed the study, conducted the statistical analysis, and wrote the paper. CS and FA acquired funding, designed the cohort study, oversaw data collection, supported data interpretation, and provided important intellectual content. All authors have reviewed and agreed with the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

DATA AVAILABILITY STATEMENT

Data used in this study is available upon reasonable request to the corresponding author.

ETHICS STATEMENT

The study has been approved by the Human Ethics Committee (HEC Southern B; 09/70, 10/43) of Massey University and adheres to the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All participants provided written informed consent.

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