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Research

Which cardiovascular risk factors are associated with cardiovascular disease and predict future events in advanced age in New Zealand?

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Aim: *To examine the relationship between cardiovascular risk factors, cardiovascular health at baseline and predictors of cardiovascular disease (CVD) events at 28 months in advanced age.*
Methods: *A total of 108 adults in advanced age were recruited. A standardised questionnaire, comprehensive physical assessments, physical activity and fasting blood samples were analysed. CVD events at follow-up were ascertained from hospital records.*
Results: *Sixty-seven per cent of participants had CVD at baseline. Physical activity (OR (95% CI): 0.99 (0.98–1.0);* P = *0.04) and high-density lipoprotein (HDL) (OR (95% CI): 0.3 (0.09–1.0);* P = *0.046) were independently associated with CVD. The 28-month incidence rate of CVD was 6 cases/100 person-years. Baseline diastolic BP (OR (95% CI): 0.9 (0.9–1.0);* P = *0.03) and waist circumference (OR (95% CI): 1.06 (1.01–1.1);* P = *0.01) were independently associated with subsequent CVD events at follow-up.*
Conclusion: *Physical activity and HDL levels were inversely associated with CVD at baseline but were not predictive of future CVD events. CVD in advanced age warrants further investigation.*

Key words: *aged, cardiovascular disease, HDL, physical activity.*

Introduction

One potential impact of population ageing is increased health-care costs particularly devoted to cardiovascular disease (CVD). In New Zealand, between 2001 and 2003, 53% of deaths of those aged 85 years and older (also known as advanced age) were attributable to CVD [1]. Māori, indigenous to New Zealand, record a higher mortality from circulatory diseases at a younger age [2]; the average age of first stroke for Māori and non-Māori New Zealanders was 61 and 76 years old, respectively [3].

Cigarette smoking, obesity, diabetes, hypertension and hyperlipidaemia are established cardiovascular risk factors used in the Framingham risk equation. However, this equation is limited to adults up to age 75 years. The Leiden 85+ Study reported that the Framingham risk equation did not predict CVD mortality in people of advanced age [4]. One explanation is that total cholesterol (TC) [5] and body weight [6] increase with age up to the sixth and seventh decade, and then decline. Diastolic blood pressure (DBP) rises only until 50 years and decreases thereafter but systolic blood pressure (SBP) continues to increase with age [7]. Isolated systolic hypertension (ISH), the predominant hypertension subtype in older adults [8], was associated with increased risk of heart failure (HF). However, the Cardiovascular Health Study found that the adverse relationship between ISH and HF was observed in adults younger but not older than 78 years old [9]. These studies suggest individuals living past the average life expectancy may have a different mechanism of accumulation of CVD risk than younger individuals and the relationship between these conventional risk factors and CVD risk may change over time.

Most studies of CVD have involved very few people of advanced age. This study aimed to examine risk factors associated with CVD, to determine the incidence rate of CVD and to explore predictors of CVD events over a follow-up period of 28 months in people of advanced age. These findings will help to understand the pathophysiology of CVD in advanced age which will illuminate the changing mechanisms of CVD risk and guide appropriate intervention. Findings from this study will add to the limited body of evidence of CVD risk in advanced age.

Material and method

Study design and participants

As part of a larger cohort study (Life and Living to Advanced Age – a cohort study in New Zealand, LILACS NZ), we conducted a feasibility study that collected comprehensive baseline information and hospital records over a 28-month

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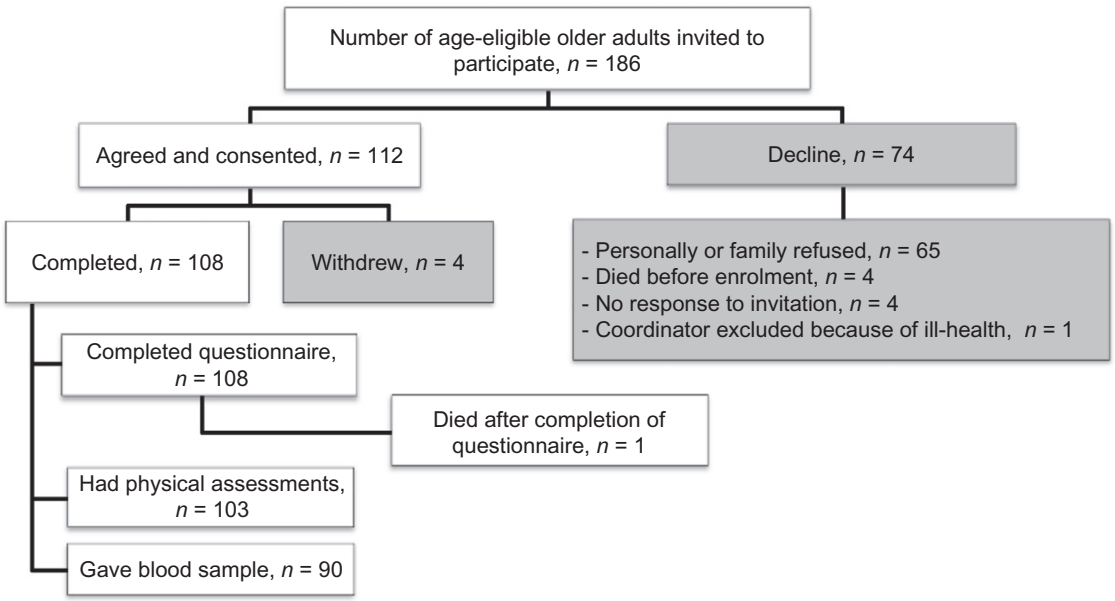
Figure 1: Diagram for recruitment, response and completion rate.



period. The LILACS NZ study is a prospective cohort study aiming to examine a broad range of health, socioeconomic and environmental factors related to independence in advanced age.

In the feasibility study, 186 eligible older adults were identified from three North Island locations (rural and urban) in New Zealand through local general practitioners and personal contact of local health services personnel. Of these, 112 (60%) respondents (33 Māori aged 75–79 years and 79 non-Māori aged 85 years) were recruited between January and August 2008; four withdrew consent (Figure 1). The sample size was based on available funding. We recruited younger Māori because of an 8-year disparity in longevity [2] and the likelihood of death in the subsequent year being equivalent for all participants (P90 from 2001 census STATS NZ) considering the excess level of disability at younger age for Māori [2]. The Multi-Region Ethics Committee, Ministry of Health New Zealand approved the study in June 2007. All study participants provided written informed consent.

Measures

Data collection was completed in three phases. First, interviewers administered face-to-face standardised questionnaires that collected sociodemographic, health behaviours, medical history and physical activity determined using the validated Physical Activity Scale for the Elderly (PASE) [10]. A higher PASE score indicates an increased level of physical activity. Medications were viewed and recorded by trained interviewers. Financial situation was gauged with specific questions: 'Thinking of your money situation right now, would you say that you are comfortable; have just enough to get along on; cannot make ends meet?'

Second, a standardised physical assessment was performed, including anthropometric measures, blood pressure (BP), electrocardiogram (ECG) and echocardiographic assessment of the left ventricular mass (LVM). Third, fasting blood samples were collected.

All echocardiographic images were digitally obtained using a portable echocardiography machine (Sonosite Micro Maxx, USA) according to a standardised protocol by trained research sonographers. Transthoracic echocardiographic images were acquired in standard planes according to the American Society of Echocardiography (ASE) guidelines. LVM was calculated according to the ASE formula [11] and was indexed to height to the power of 2.7 ($Ht^{2.7}$) [12].

Clinically manifest CVD was defined as the presence of myocardial infarction, stroke, coronary artery bypass grafting, peripheral artery bypass grafting, congestive heart failure, percutaneous coronary intervention, angina, intermittent claudication, or hospital admission due to CVD up to and including the time of recruitment. This information was ascertained by self-report through face-to-face interviews and from review of hospitalisation records supplied by a nationally held register of all hospitalisations. A similar process was carried out to ascertain the presence of hypertension; verified from medication records, self-report and sitting assessments of BP (an average of three readings of ≥140/90 mmHg or ISH SBP ≥ 140 mmHg, DBP < 90 mmHg); type 2 diabetes, fasting serum glucose ≥7.0 mmol; and dyslipidaemia, abnormal fasting serum lipids according to the NZ Heart Founda-

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tion recommendation [13]. Subsequent CVD events were ascertained from hospitalisation records from September 2008 to December 2010.

Statistical analysis

Descriptive statistics are presented for all variables. Continuous data with a normal distribution (as determined using histogram and box-plots) are presented as means and standard deviations (SD); with medians and interquartile ranges for variables with a non-normal distribution. Age and ethnicity were linked by the sampling design; the Māori participants' age varied whereas non-Māori were all aged 85 years. Logistic regression models were constructed to determine the association between CVD and CVD risk factors (i.e. physical activity levels, body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), SBP and DBP, serum glucose, TC, triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), TC/HDL ratio and LVM/$Ht^{2.7}$) adjusting for sex, age-ethnicity, smoking status and potential confounders (i.e. relevant medications to the variables of interest: BP-lowering, glucose-lowering and lipid-lowering medications); 13 models were constructed. An interaction term (variable of interest × age-ethnicity) was added to the pertinent regression model to determine the effect of age-ethnicity on the association between CVD and the variable of interest. The analyses found that the associations between CVD and variables of interest were the same for both age-ethnic groups. Variables associated with CVD at $P \leq 0.2$ from the 13 individual models were selected for inclusion in the final regression model. Inclusions of independent variables in the models are kept within the criterion of 10 : 1 ratio of outcome events-to-independent variables. A P-value of <0.05 was considered statistically significant. The incidence rate of CVD over a follow-up period of 28 months was calculated as the ratio of new cases to the number of participants who did not have CVD at baseline. Logistic regression models were used to examine determinants of subsequent CVD events including all risk factors adjusting for age-ethnicity, baseline CVD and relevant medications to the variables of interest as described above. Variables associated with subsequent CVD events at $P \leq 0.2$ were selected for inclusion in the final regression model. Statistical analyses were performed with SPSS 18.0 for Windows.

Results

Participants

One hundred and twelve participants were recruited (response rate 60%): 33 Māori (mean age 76.6, SD = 1.8) and 79 non-Māori (mean age 85.2, SD = 0.6); 56% were women. More than half (53%) were widowed, 38% were married/partnered, 6% were divorced/separated, and 3% had never married. Most participants lived in a private residence (86%), the remainder living in a retirement village (6%), rest home (low level dependency long-term residential care) (4%) or on a marae (tribal based housing) (4%). Three-quarters had received secondary (38%) or tertiary (36%) education. Most participants were financially 'comfortable' (86%), 11% 'just have enough to get along', and 3% 'could not make ends meet'.

Cardiovascular risk factors and CVD

Half of the participants (n = 55, 51%) had never smoked cigarettes, 92 (85%) had dyslipidaemia, 91 (84%) had hypertension, 22 (20%) had type 2 diabetes, and 27% had a BMI ≥30.0 kg/m^2. Seventy-two (67%) participants had CVD at baseline. The breakdowns of baseline CVD events are shown in Figure 2. Table 1 reports the clinical characteristics in relation to cardiovascular risk factors. In univariate analyses, no variables differed between those with and without CVD except for WC which was lower (P = 0.02) and HDL higher (P = 0.04) in those without than with CVD. Physical activity levels were higher in those without CVD and not on any prescribed medications than those with CVD and on prescribed medication (Figure 3).

Risk factors associated with CVD

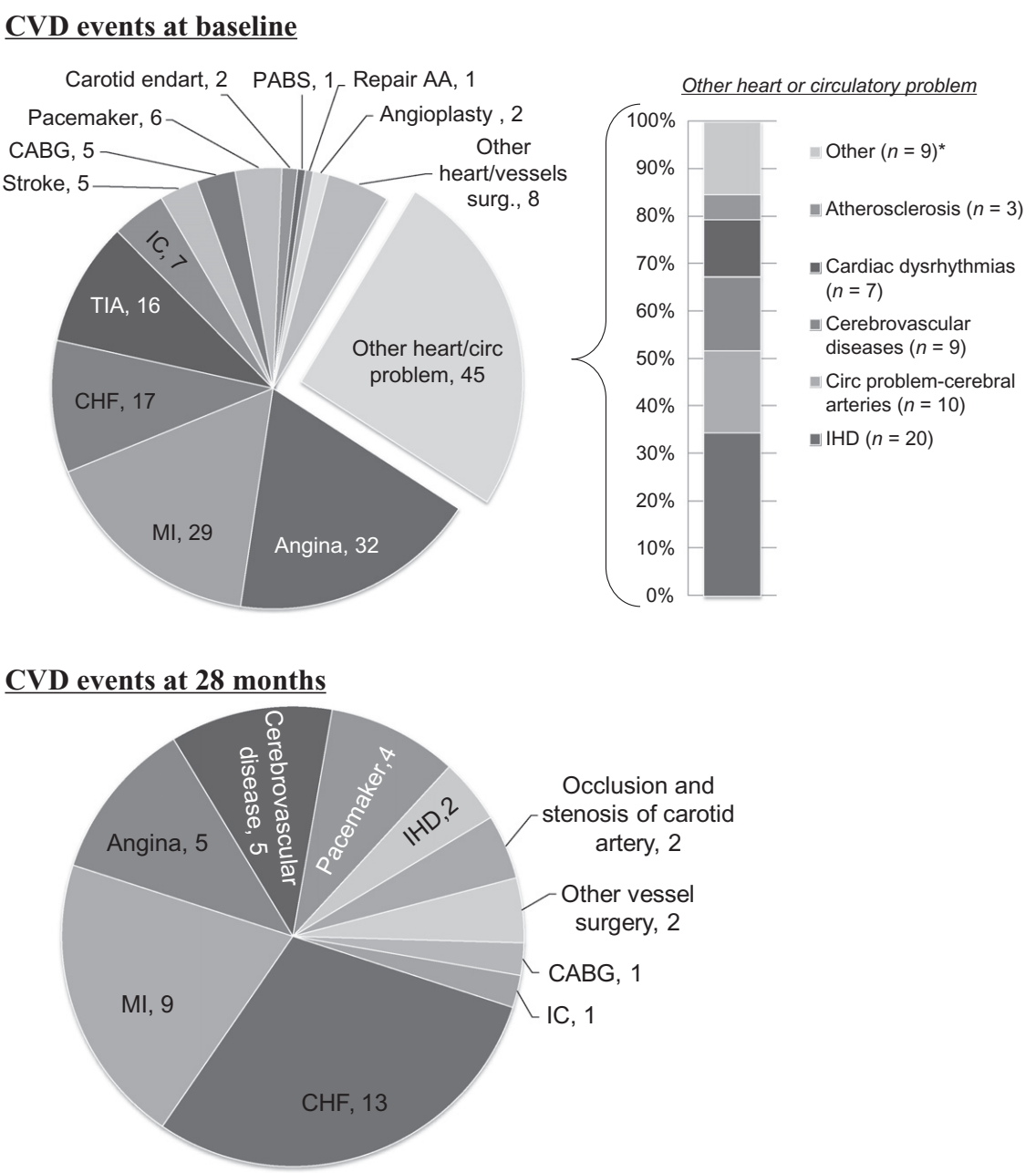
Variables associated with CVD at $P \leq 0.2$ were physical activity (PASE score), HDL, BMI, WC and LVM (LVM/$Ht^{2.7}$). A final regression model was constructed from these variables to examine independent association of relevant risk factors with CVD, controlling for sex, age-ethnicity and smoking status. Owing to the strong correlations between BMI, WC and HDL (P < 0.001), they were entered into separate models (Table 2). The first three models in Table 2 show that physical activity level was associated with CVD after controlling for sex, age-ethnicity, smoking status, LVM, and HDL (Model 1), BMI (Model 2) and WC (Model 3).

Limiting the covariate list to conventional cardiovascular risk factors associated with CVD at $P \leq 0.2$ (HDL, BMI and WC) and controlling for sex, age-ethnicity and smoking status, we found that HDL was independently associated with CVD (OR (95% CI): 0.3 (0.1–1.0); P = 0.04) but not BMI (OR (95% CI): 1.08 (1.0–1.2); P = 0.1) or WC (OR (95% CI): 1.03 (1.0–1.06); P = 0.1). Although SBP was not associated with CVD at $P \leq 0.2$, it is an important CVD risk factor, so the association between HDL and CVD was further controlled for SBP. HDL remained associated with CVD independent of sex, age-ethnicity, smoking status and SBP (Table 2, Model 4).

CVD events during follow-up

During the follow-up period, 12 (17%) participants with CVD at baseline had recurrent events, five (14%) participants who did not have CVD at baseline had new events; 31 participants remained CVD-free and 60 participants did not have a recurrent CVD event. The breakdowns of baseline CVD events at 28 months are shown in Figure 2. The 28-month incidence rate of CVD was 6 cases per 100 person-years. No association was found between baseline CVD and CVD events during follow-up period (Table 2). Baseline risk factors associated with CVD events during follow-up period

Figure 2: The breakdown of CVD events at baseline and at 28 months.



*Others include cardiomegaly ($n = 1$), aortic aneurysm ($n = 1$), unspecified peripheral vascular disease ($n = 1$) and personal history of other vascular diseases ($n = 6$).*Notes:* A total of 44 CVD events occurred during the 28 months follow-up involving 17 participants. The number of CVD events range between 1 ($n = 6$) and 6 ($n = 2$) events. CHF was the most common CVD during the follow-up period. The five 'New CVD' cases are CHF ($n = 2$), cerebrovascular disease ($n = 1$), IC ($n = 1$) and pacemaker implantation ($n = 1$).
AA, aortic aneurysm; CABG, coronary artery bypass surgery; Carotid endart, carotid endarterectomy; CHF, congestive heart failure; circ, circulatory; IC, intermittent claudication; IHD, ischemic heart disease; MI, myocardial infarction; TIA, transient ischemic attack; PABS, peripheral artery bypass surgery; surg, surgery.

at $P \leq 0.2$ were PASE score, DBP, BMI, WC, WHR, HDL, TG and TC/HDL ratio. A final regression model was constructed from these variables to examine independent association between baseline risk factors and subsequent CVD, controlling for age-ethnicity and baseline CVD. DBP was inversely and WC was positively associated with subsequent CVD events (Table 2, Model 6). Physical activity level (Model 7) and HDL (Model 8) demonstrated an inverse but not statistically significant relationship with subsequent CVD. Table 3 shows the baseline cardiovascular risk factors for each of the four groups of participants.

Discussion

In this study of people in advanced age, two-thirds of the participants had clinically manifest CVD at the time of the baseline assessment. Controlling for conventional CVD risk factors and LVM, we found that physical activity was inversely associated with CVD. Habitual physical activity is

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Table 1: Clinical characteristics in relation to cardiovascular risk factors of study participants

	All ($n = 108$)	No CVD ($n = 36$)	Yes CVD ($n = 72$)
Age-ethnicity			
Māori (75–79 years)	33 (31%)	10 (28%)	23 (68%)
Non-Māori (85 years)	75 (69%)	26 (72%)	49 (32%)
Sex: Men	48 (44%)	13 (36%)	35 (49%)
PASE†, median (IQR)	84 (86)	96 (111)	80 (63)
BMI, median (IQR)	27.1 (7.1)	24.7 (5.6)	27.4 (8.4)
Waist circumference (cm), mean (SD)	95 (15)	91 (14)	97 (16)*
Waist-to-hip ratio, mean (SD)	0.9 (0.08)	0.9 (0.09)	0.9 (0.08)
Fasting serum glucose (mmol/L), median (IQR)	5.2 (0.9)	5.3 (1.1)	5.2 (0.8)
SBP (mmHg), mean (SD)	151 (21)	153 (18)	150 (23)
DBP (mmHg), mean (SD)	83 (12)	84 (12)	82 (12)
TC (mmol/L), mean (SD)	5.0 (1.1)	5.3 (1.0)	4.9 (1.1)
Triglycerides (mmol/L), median (IQR)	1.2 (0.6)	1.3 (0.7)	1.2 (0.6)
HDL (mmol/L), mean (SD)	1.5 (0.4)	1.6 (0.4)	1.4 (0.7)*
LDL (mmol/L), mean (SD)	2.9 (0.9)	3.1 (1.0)	2.8 (0.9)
TC/HDL ratio, median (IQR)	3.5 (1.3)	3.6 (1.4)	3.6 (1.3)
Normal ECG‡, *n* (%)	54 (53)	18 (53)	36 (54)
LVM/Ht2.7 (g/m2.7), median (IQR)	40.1 (28.5)	36.9 (17.3)	43.0 (31.2)
On pharmacotherapy in relation to the cardiovascular system§	88 (81%)	22 (61%)	66 (92%)
Number of medication indicated for the cardiovascular system:			
None	20	14	6¶
1	24	7	17
2	14	3	11
3	22	7	15
4	15	4	11
5	9	1	8
6	3	–	3
7	1	–	1

*$P < 0.05$. †Seven participants had a score of zero: three were wheelchair-bound, and four were in a rest home. Excluding these seven participants, the median (IQR) was 100 (85), ranges 22–282. Since it is possible to have a zero score for this instrument (questionnaire), the seven participants (6% of the total study sample) with a PASE score of zero were kept in the analysis. ‡The most common abnormality on the ECG was bundle branch block ($n = 17$), LV hypertrophy ($n = 13$), atrial fibrillation ($n = 12$; there were another 22 self-reported atrial fibrillation), old myocardial infarction ($n = 8$). Note: two participants had two abnormalities on the ECG and one participant had three abnormalities on the ECG. §The most commonly-prescribed medication indicated for the cardiovascular system was aspirin ($n = 53$; No CVD = 12, Yes CVD = 41), followed by beta blocking agents ($n = 40$) and ACE inhibitors/angiotensin II antagonists ($n = 40$), diuretics ($n = 30$) and lipid-lowering medications ($n = 29$; No CVD = 8, Yes CVD = 21), cardiac therapy (i.e. organic nitrates, digitalis glycosides, antiarrhythmics; $n = 20$), calcium channel blockers ($n = 19$) and warfarin ($n = 13$). ¶Of these 6 participants, 2 self-reported CVD and not being on prescribed medication. The remaining 4 had confirmed CVD from hospital records, 2 did not have medication listed in the questionnaire and 2 were taking medications (metformin, allopurinol, omeprazole and lucozade) not indicated for a heart condition. BMI, body mass index; CVD, cardiovascular disease; DBP, diastolic blood pressure; HDL, high density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein; LVM, left ventricular mass; PASE, Physical Activity Scale for the Elderly; SBP, systolic blood pressure; SD, standard deviation; TC, total cholesterol.

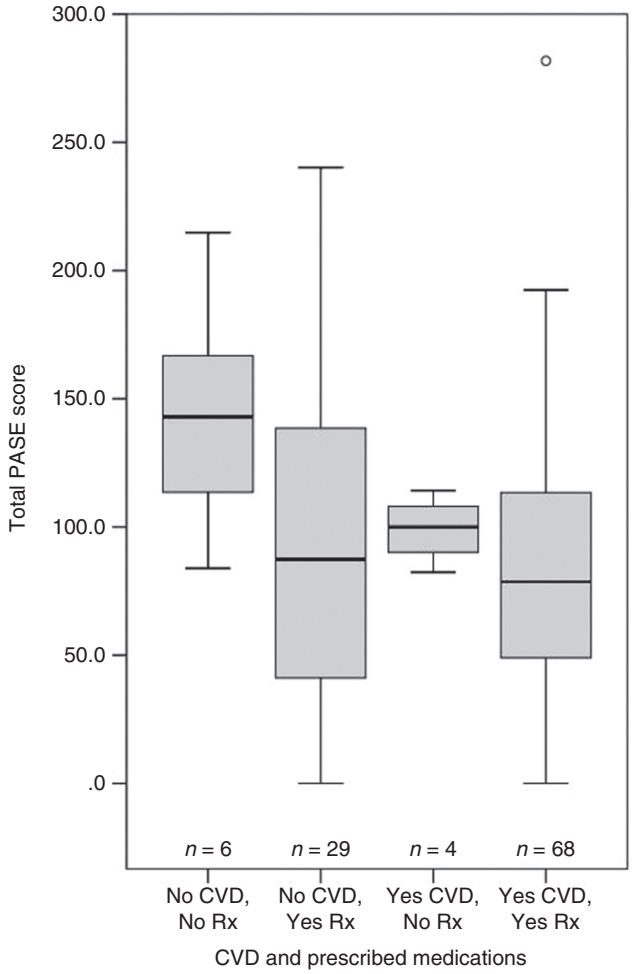
associated with reduced CVD risk [15,16]; however, the presence of CVD may in turn affect the level of physical activity achieved. Heart failure and stroke limit physical function and cause disability [17,18]. Comorbidities restrict physical function leading to functional decline in older adults [19]. Participants who had CVD and were on five or more prescribed medications (a reasonable indication for presence of comorbidities) performed less physical activity. The cause and effect relationship between physical activity and CVD could not be determined in this study but is likely to operate in both directions.

In examining the lipid profile, this study found HDL was inversely associated with CVD. This finding differs from the current evidence that TC/HDL ratio best predicts cardiovascular outcomes in adults [20]. One reason why HDL is more important than other lipid parameters in advanced age may be that the relationship between cholesterol levels and nutritional status differs in old age. In older patients (mean age 68 years) with stable chronic heart failure, cholesterol levels were positively correlated with pre-albumin levels, suggesting that cholesterol levels indicate nutritional status [21]. In our study sample, we found risk of undernutrition was prevalent [22]. Longitudinal studies have shown that cholesterol levels decline after age 65 years [23]. The chain effect of ageing and poorer nutritional status leading to declining cholesterol levels may suggest that the predictive value of the TC/HDL ratio observed in younger adults is not as good a predictor of CVD risk in advanced age. HDL may be more useful.

Other studies have shown a positive relationship between HDL and functional performance in community-dwelling older people [24,25]. HDL has been suggested to be a well-being index [25]. Our study found that physical activity was associated with CVD, but HDL did not moderate this association. Physical activity is closely related to health status in older adults [19]. However, life-time habitual physical activity protects against CVD risk [15,16] by raising HDL levels. At advanced age, where comorbidities are common, is decreased HDL a cause or consequence of reduced physical activity? The vicious cycle between physical activity, HDL and CVD in advanced age remains under-explored.

In our study, a lower DBP and a higher WC at baseline were associated with CVD events during the follow-up period; baseline CVD was not associated with subsequent CVD events. Our finding of a positive association between WC and CVD risk is in line with other epidemiological studies [26]

Figure 3: PASE score in four different groups of CVD status and medications.



The median of PASE score is greater in participants without CVD and not on any prescribed medication than the group of participants who had CVD and were on prescribed medications (median (IQR) 143 (73) vs 79 (66), $P = 0.02$).

CVD, cardiovascular disease; IQR, interquartile range; PASE, Physical Activity Scale for the Elderly.

Table 2: Logistic regression models examining cardiovascular risk factors associated with CVD in advanced age

Dependent variable: Baseline CVD			
Model†	List of independent variables	Odds ratio (95% CI)	*P*-value
1	PASE score (change of 10-unit)	0.90 (0.80–1.00)	0.03
	LVM	1.03 (1.00–1.07)	0.2
	HDL§	0.50 (0.10–2.06)	0.3
2	PASE score (change of 10-unit)	0.90 (0.80–1.00)	0.01
	LVM	1.02 (1.00–1.06)	0.2
	BMI	1.07 (0.90–1.20)	0.3
3	PASE score (change of 10-unit)	0.90 (0.80–1.00)	0.01
	LVM	1.03 (1.00–1.06)	0.2
	WC	1.02 (1.00–1.07)	0.4
4	HDL§	0.30 (0.09–1.00)	0.046
	SBP	1.00 (1.00–1.01)	0.1
Dependent variable: CVD events at 28-month follow-up			
Model††	List of independent variables	Odds ratio (95% CI)	*P*-value
5	Baseline CVD	1.20 (0.30–4.50)	0.8
	DBP	0.90 (0.90–1.00)	0.04
	BMI	1.08 (1.00–1.20)	0.1
6	Baseline CVD	1.05 (0.30–4.00)	0.9
	DBP	0.90 (0.90–1.00)	0.03
	WC	1.06 (1.01–1.10)	0.01
7	Baseline CVD	1.30 (0.40–4.50)	0.7
	DBP	0.90 (0.90–1.00)	0.04
	PASE score (change of 10-unit)	0.90 (0.80–1.04)	0.172
8	Baseline CVD	0.70 (0.20–2.80)	0.6
	DBP	0.90 (0.90–1.00)	0.03
	HDL§	0.20 (0.02–1.20)	0.08
	PASE score (change of 10-unit)	0.90 (0.80–1.04)	0.1

†All models controlled for sex, age-ethnicity and smoking status. ††All models controlled for age-ethnicity and baseline CVD. BP-lowering medication was not included in the models because all participants with CVD events at follow-up were on BP-lowering medication. §Lipid-lowering medication was not included in the model because it was found to have no apparent association with HDL levels. Lipid-lowering medications are generally indicated for hyperlipidaemia with limited effect on HLD levels [14]. BMI, body mass index; CVD, cardiovascular disease; DBP, diastolic blood HDL, high density lipoprotein; LVM, left ventricular mass; PASE, Physical Activity Scale for the Elderly; SBP, systolic blood pressure; WC, waist circumference.

suggesting indices of abdominal obesity are more appropriate in predicting CVD risk than BMI. In the Atherosclerosis Risk in Communities (ARIC) study of more than 760 adults (mean age 57 years), hypertension, hyperlipidaemia, diabetes, smoking, physical inactivity and ECG established left ventricular hypertrophy were associated with increased risk of recurrent CVD [27]. We do not have a precise explanation for the inverse association between DBP and CVD risk. In the Leiden 85+ Study, low DBP and SBP are associated with a low cardiac index and a low stroke volume index [28]. There is evidence that low BP may be a stronger predictor of poor CVD and other adverse outcomes than high BP [29]. With regards to physical activity, there may be a trend towards lower physical activity levels among those with recurrent CVD than with those who remain CVD-free during the follow-up period (Table 3). HDL levels are in the direction of conferring protection from subsequent CVD. Nevertheless, our study did not have enough power to be certain if low levels of physical activity and HDL predict subsequent CVD events.

Seventeen participants had at least one CVD event during the follow-up period; five new cases and 12 recurrent cases. Participants who had CVD during the follow-up period appear to have a less favourable baseline cardiovascular health profile. The 28-month incidence rate of CVD was 6/100 person-years. In the Cardiovascular Health Study, the 5-year incidence rates of coronary heart disease for Caucasian men and women aged 85 and over were 63/1000 and 19/1000 person-years respectively [30]. Owing to the small number, we did not compare baseline CVD risk factors between the four different CVD groups at follow-up and we did not calculate a sex-specific incidence rate of CVD. A larger prospective

Table 3: Baseline cardiovascular risk factors of study participants with and without a CVD event during the follow-up period

	Remain CVD free ($n = 31$)	No recurrent CVD ($n = 60$)	Yes recurrent CVD ($n = 12$)	New CVD ($n = 5$)
Age-ethnicity, *n*				
Māori (75–79 years)	9	20	3	1
Non-Māori (85 years)	22	40	9	4
PASE, median (IQR)	111 (111)	84 (62)	55 (46)	88 (80)
Glucose, median (IQR)	5.3 (1.2)	5.2 (0.9)	5.3 (0.9)	5.9 (2.8)
SBP, mean (SD)	151 (17)	151 (23)	147 (23)	172 (10)
DBP, mean (SD)	86 (11)	83 (12)	77 (12)	74 (17)
BMI, median (IQR)	24.7 (5.6)	27.0 (9.0)	28.3 (8.5)	27.8 (12.7)
WC, mean (SD)	89.6 (12.1)	95.7 (15.6)	104.4 (14.8)	101.7 (22.6)
WHR, mean (SD)	0.9 (0.1)	0.9 (0.1)	0.9 (0.09)	0.9 (0.2)
TC, mean (SD)	5.3 (1.03)	5.0 (1.1)	4.4 (1.0)	5.6 (0.7)
TG, median (IQR)	1.3 (0.7)	1.2 (0.5)	1.3 (0.9)	2.0 (0.4)
HDL, mean (SD)	1.6 (0.4)	1.4 (0.4)	1.3 (0.3)	1.3 (0.4)
LDL, mean(SD)	3.1 (1.0)	2.9 (0.9)	2.4 (0.8)	3.4 (0.9)
TC/HDL ratio, median (IQR)	3.3 (1.2)	3.6 (1.3)	3.1 (2.3)	4.2 (3.7)
LVM/ht$^{2.7}$, median (IQR)	36.5 (18.1)	40.2 (29.0)	46.3 (35.2)	40.4 (-)
Atrial fibrillation, *n* (column %)	5 (16%)	19 (32%)	8 (67%)	2 (40%)

BMI, body mass index; CVD, cardiovascular disease; DBP, diastolic blood pressure; HDL, high density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein; LVM, left ventricular mass; PASE, Physical Activity Scale for the Elderly; SBP, systolic blood pressure; SD, standard deviation; TC, total cholesterol; TG, triglyceride; WC, waist circumference; WHR, waist-to-hip ratio.

cohort study will allow a sex- and ethnic-specific incidence rate of CVD and reveal determinants for subsequent CVD in advanced age.

Interestingly, our study did not find an association between SBP and CVD. Two-thirds of the participants were on medications affecting the BP. The pharmacotherapy could have controlled their BP, alleviating the impact of SBP on CVD risk. Those with low BP may represent a group with low cardiac output and thus be at increased mortality risk because of their cardiac disease; they may have died and therefore not be in the study. Conversely, studies of people in advanced age have shown a non-linear relationship between BP and all-cause mortality [31]. The lowest hazard ratio for adverse outcomes was at SBP 140 mmHg [32], suggesting the optimal BP for these people may be higher than currently recommended.

It is somewhat surprising we did not find an association between LVM and CVD or subsequent CVD events. We speculate this may be because increasing LVM with ageing is part of the compensatory mechanism, in conjunction with increased BP, to overcome arterial stiffness.

The current observational study has limitations. It did not allow causal attribution of CVD to physical activity or HDL. The small sample could not be stratified by CVD status and use of prescribed medications. Additionally, the healthy survivor effect may apply in this study as frailer older people probably did not survive to an advanced age. Since our follow-up information was constrained by being limited to hospitalisation records only, we might have missed CVD cases not leading to hospitalisation, such as episodes of angina. This, however, will lead to under-reporting rather than over-reporting of CVD. We did not include sociodemographic factors, which are potential confounders, in our analyses. With limited data, findings from this observational study cannot be generalised to those of advanced age in NZ; cautious interpretation of the findings is needed.

The LILACS NZ, a prospective cohort study initiated in March 2010, has recruited 937 participants at baseline and will attempt to follow the sample every year for up to 15 years. The larger sample size will minimise type I error and the prospective nature will allow a snapshot of the cause and effect relationship between risk factors and CVD outcome in advanced age.

Conclusion

In this sample of people in advanced age, two-thirds had clinical evidence of CVD. Of the conventional cardiovascular risk factors examined, HDL was inversely associated with CVD. The inverse association between level of physical activity and CVD risk may persist into advanced age but reverse-causality may be present. The LILACS NZ study will confirm these findings.

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Key Points

- Two-thirds of people in advanced age had clinically manifest CVD.
- Physical activity and HDL were inversely associated with CVD risk.
- The 28-month incidence rate of CVD was 6 per 100 person-years.
- Baseline DBP and WC were independently associated with subsequent CVD events at 28 months.

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