J Nutr Health Aging. 2019;

ARE HEALTH BEHAVIORS AND SELF-RATED HEALTH RELATED TO CARDIOVASCULAR HEALTH AND FUNCTIONAL PERFORMANCE? RESULTS FROM THE LOOKUP 7+ CROSS-SECTIONAL SURVEY AMONG PERSONS AGED 65+

H.M. REMPE[1], R. CALVANI[2,3], E. MARZETTI[3], A. PICCA[2,3], C.C. SIEBER[1,4], E. FREIBERGER[1], F. LANDI[3]

1. Friedrich-Alexander-University of Erlangen-Nürnberg, Institute for Biomedicine of Aging, Nürnberg, Germany; 2. Università Cattolica del Sacro Cuore, Institute of Internal Medicine and Geriatrics, Rome, Italy; 3. Fondazione Policlinico Universitario "Agostino Gemelli" IRCCS, Rome, Italy 4. Department of Medicine, Kantonsspital Winterthur, Winterthur, Switzerland. Corresponding author: Hanna M. Rempe, Kobergerstraße 60, 90408 Nürnberg, Germany, E-mail: hanna.rempe@fau.de

Abstract: *Objectives:* Cardiovascular health (CVH) and physical performance (PP) are key factors of successful ageing. This study investigated whether self-reported CVH behaviours and self-rated health (SRH) are related to ideal CVH and PP. *Design:* Cross-sectional survey. *Setting:* Public places in Italy (e.g. exhibitions, malls, health promotion campaigns), outside of conventional healthcare settings. *Participants:* 1415 community-living persons aged 65+ years (mean age 72.2 ± 5.4; 58.4% female). *Measurements:* Three ideal CVH behaviors [regular physical activity (PA), healthy diet, no smoking] and SRH (1 excellent – 4 poor) were assessed through a brief questionnaire. Four ideal CVH factors [iBMI ≤ 25 kg/m2, untreated random total blood cholesterol ≤200 mg/dl, absence of diabetes (untreated random blood glucose ≤200 mg/dl), untreated blood pressure (iBP) <140/90mmHg] and two ideal PP factors [grip strength (iGrip), 5-repetition chair-stand test <10 seconds (iStand)] were measured. *Results:* Adjusted for age and gender, regular PA was positively related to CVH factor score (β = 0.1; p = < .001), iBMI (OR = 1.8; 95% CI = 1.5-2.3), iBP (OR = 1.3; 95% CI = 1.1-1.6) and iStand (OR = 1.6; 95% CI = 1.3-2.1). Healthy diet was positively related to CVH factor score (β = 0.1; p = < .05) and iGrip (OR = 1.4; 95% CI = 1.1-1.8). Participants rating SRH as "good" (OR = 2.0; 95% CI = 1.1-3.9) and "not so good" (OR = 2.3; 95% CI = 1.2-4.5) met iDiabetes more often than those with poor SRH. Moreover, iStand (OR = 3.2; 95% CI = 1.6-6.6) and iGrip (OR = 4.2; 95% = CI 2.0-8.8) were more prevalent among participants with excellent SRH compared with those with poor SRH. *Conclusions:* Physical activity, diet and self-rated health may provide quick and easy-to-assess metrics to identify persons aged 65+ years at risk of cardiovascular events and functional impairment, who could particularly benefit from engaging in health promotion programs.

Key words: Cardiovascular health, lifestyle behavior, physical performance, subjective health, Lookup 7+.

Introduction

The accrual of cardiovascular risk factors and declining physical performance is associated with the development of cardiovascular disease (CVD), loss of independence, disability and mortality, especially with advancing age (1). Studies have shown that lifestyle factors, particularly health behaviors, play a major role in the development of both CVD and functional impairment (2, 3). In order to promote cardiovascular health at the population level, the American Heart Association (AHA) established seven cardiovascular health (CVH) metrics, encompassing four health behaviors (diet, physical activity, smoking, body mass index) and three physiological health factors (blood pressure, blood glucose, total blood cholesterol) (4). Previous studies showed that a higher number of CVH metrics at an ideal level was associated with lower prevalence of CVD-related outcomes (5), lower odds for non CVD-related outcomes (6), reduced health care costs (7), and better overall health (8). The few studies that investigated the association of AHA's CVH metrics and physical performance level highlights the importance of CVH behaviors (9), particularly physical activity (2, 10-12), which is recognized as a key factor in counteracting the decline of physical function (13).

The evaluation of AHA's CVH factors and the assessment of physical performance (PP) require specific equipment, trained personnel, and are time-consuming, especially among older persons. In contrast, the evaluation of CVH behaviors is mostly based on self-report and can easily be done during a lifestyle interview. To the best of our knowledge, no study has investigated to what extent multiple, self-reported CVH behaviors provide information about objectively measured CVH factors and PP. Another easy-to-survey health parameter, self-rated health (SRH), has been more frequently examined in relation to AHA's CVH metrics and PP. Better SRH is associated with a higher prevalence of ideal CVH metrics (iCVH), especially for those categorized as CVH behaviors (14, 15). Notably, poor SRH is associated with decline in PP (16-18). For instance, Brenowitz et al. (17) identified SRH lower than excellent as predictive for a reduction in physical function in terms of walking speed, upper and lower extremity muscle strength, and balance ability.

Prior research justifies the assumption that combining CVH behaviors and SRH may provide an informative and cost-effective appraisal of health factors relevant in older age.

Received September 21, 2019
Accepted for publication October 11, 2019

Hence, the purpose of the present study was to explore the extent to which CVH behaviors and SRH are related to ideal CVH and PP factors in a large and relatively unselected sample of older community-living persons.

Methods

Study design and participants

The sample comprises participants of the Longevity Check-up 7+ study, which is an ongoing initiative by the Department of Geriatrics of the Università Cattolica del Sacro Cuore (Rome, Italy). The project was designed to raise awareness in the general population on major lifestyle behaviors and cardiovascular risk factors. To accomplish this overarching objective, participants were recruited in unconventional settings, including public events, shopping malls, supermarkets, etc.

The sample of this sub-study consists of 1415 community-dwellers aged 65 years and older, for whom information on SRH was available. Participants were enrolled between March 2017 and May 2018 in the following settings: Health Ministry Women´s Day (Rome, April 2017), CamBio Vita (Catania, May 2017), COOP shopping centers (Bologna, Modena, Genoa, Rimini, and Grosseto, May-June 2017), Conad supermarkets (Rome, Anzio, Terni, Perugia, Viterbo; November 2017), Tennis & Friends (Rome, October 2017), and Mese del Cuore (Rome, Milan, Naples, 2017 and 2018). Depending on the setting, the initiative was advertised in newspapers, magazines, and TV-broadcasting. Visitors were also invited to participate through direct contact by study personnel. Detailed descriptions of sampling methods and the objectives of the Lookup 7+ project are provided elsewhere (2,19-21).

Ethics, Consent and Permissions

The study protocol was approved by the Ethics Committee of the Università Cattolica del Sacro Cuore (protocol #A.1220/CE/2011). Written informed consent was obtained from every participant prior to the enrolment. The manuscript was prepared in accordance with the "Strengthening the Reporting of Observational studies in Epidemiology" (STROBE) reporting guidelines (22).

Measures

In the Lookup 7+ study, adapted versions of the ideal cardiovascular health (iCVH) metrics originally defined by Lloyd et al. (4) were used to assess CVH behaviors and CVH factors. People who agreed to be screened underwent individual assessments in a consistent order: informed consent acquisition, lifestyle interview, collection of SRH, measurement of blood pressure, body weight and standing height, blood glucose and blood cholesterol, handgrip strength test and 5-repetition chair stand test. Procedures of assessments are described in more detail elsewhere (2, 19).

Ideal cardiovascular health (iCVH) behavior and self-rated health (SRH)

Ideal cardiovascular health (iCVH) behaviors (no smoking, regular physical activity, healthy diet) were assessed through a lifestyle interview with closed questions. Smoking status was defined as follows: current smoker (has smoked 100+ cigarettes in lifetime and currently smoked cigarettes), never smoker (has never smoked or has smoked <100 cigarettes in lifetime) and former smoker (has smoked at least 100 cigarettes in lifetime, but had quit at least 28 days before interview). In this study, never smokers or former smokers were combined as ideal smoking status (iSmoking). To meet the ideal physical activity criterion (iPA), participants had to be involved in leisure time activity at least twice a week during the past year. The following activities were considered: light walking for at least 30 min per session, cycling, swimming, running, or practicing resistance training for at least 20 min per session, respectively. Ideal dietary behavior (iDiet) was defined as the consumption of at least three portions of fruit and/or vegetables per day. Reference tables from the Italian Society of Nutrition (SINU) were used to calculate daily intake of fruit and vegetables (http://www.sinu.it/html/cnt/larn.asp).

Based on prior research, SRH was assessed with a question on general health status ("How would you rate your health in general?"). Responses were given on a 4-point scale graded 1 "excellent", 2 "good", 3 "not so good", 4 "poor".

Cardiovascular health and functional performance

Ideal Cardiovascular Health (iCVH) factors

Body height was measured through a standard stadiometer, while an analogue medical scale was used to measure body weight. In contrast to the original AHA definition of CVH metrics (4), BMI was classified as a CVH factor because it must be measured and can be seen as a consequence of lifestyle behaviors. BMI was calculated as the weight (kg) divided by the square of height (m). Ideal BMI (iBMI) corresponds to normal BMI defined by WHO (<25.0 kg/m^2), whereas the other categories were considered as not meeting iBMI (25.0-29.9 overweight, ≥30 obesity) (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html). Systolic and diastolic blood pressure was measured with a clinically validated Omron M6 electronic sphygmomanometer (Omron, Kyoto, Japan). In addition, participants were asked whether they received blood pressure therapy. Among these older participants, an untreated blood pressure of <140/<90mmHg was considered as iBP (23). Total cholesterol was measured from capillary blood samples using disposable strips based on a reflectometric system with a portable devise (MultiCare-In, Biomedical Systems International srl, Florence Italy) (24). Lipid-lowering drug use, defined as cholesterol treatment, was also recorded. Participants with untreated total blood cholesterol <200 mg/dl met the criterion for ideal Cholesterol (iCholesterol). Finally, ideal blood glucose criteria (iDiabetes) was defined as the absence of diabetes without accordance to AHA´s definition

Table 1
Main characteristics of the study population as a whole and according to gender

	Total (N=1415)	Women (n=826)	Men (n=589)
	N/M (SD/P)	N/M (SD/P)	N/M (SD/P)
Age**	72.2 ± 5.4	71.9 ± 5.3	72.7 ± 5.4
iCVH behaviors			
iSmoking	1249 (88.3%)	735 (89%)	514 (87.3%)
iDiet*	1093 (77.2%)	655 (79.3%)	438 (74.4%)
iPA	660 (46.6%)	386 (46.7%)	274 (46.5%)
SRH (1 excellent – 4 poor)***	2.4 ± 0.7	2.5 ± 0.7	2.3 ± 0.6
excellent	72 (5.1%)	37 (4.5%)	35 (5.9%)
good***	741 (52.4%)	389 (47.1%)	352 (59.8%)
not so good***	511 (36.1%)	330 (40%)	181 (30.7%)
poor***	91 (6.4%)	70 (8.4%)	21 (3.6%)
BMI (kg/m^2)***	26.5 ± 4.1	26.2 ± 4.5	27.0 ± 3.5
Systolic BP (mmHg)*	129.8 ± 16.0	129 ± 16.7	130.9 ± 14.9
Diastolic BP (mmHg)	75.1 ± 9.6	74.8 ± 9.7	75.6 ± 9.3
Cholesterol (mg/dl)[a]***	211.5 ± 32.3	215 ± 31.4	206.7 ± 32.8
Glucose (mg/dl)[b]**	103.1 ± 24.8	101.6 ± 19.8	105.2 ± 30.3
Grip strength (kg)***	26.5 ± 10.0	20.3 ± 5.8	35.2 ± 8.0
Chair stand test (s)***	9.4 ± 2.9	9.6 ± 3.3	9.0 ± 2.4
iCVH factors score**	1.8 ± 0.9	1.9 ± 0.9	1.7 ± 0.9
0	63 (4.5%)	20 (2.4%)	43 (7.3%)
1	512 (36.2%)	289 (35.0%)	223 (37.9%)
2	532 (37.6%)	318 (38.5%)	214 (36.3%)
3	261 (18.4%)	174 (21.1%)	87 (14.8%)
4	47 (3.3%)	25 (3%)	22 (3.7%)
iCVH factors			
iBMI***	530 (37.5%)	354 (42.9%)	176 (29.9%)
iBP**	452 (31.9%)	288 (34.9%)	164 (27.8%)
iCholesterol***	300 (21.2%)	133 (16.1%)	167 (28.4%)
iDiabetes***	1265 (89.4%)	772 (93.5%)	493 (83.7%)
iPP factors			
iGrip*	946 (66.9%)	530 (64.2%)	416 (70.6%)
iSittostand**	979 (69.2%)	547 (66.2%)	432 (73.3%)

Abbreviations: N, number; M, mean; SD, standard deviation; P, percentage; SRH, self-rated health; iBMI, ideal body mass index; iBP, ideal blood pressure; iCVH, ideal cardiovascular health; iPP, ideal functional performance; Note: *p < .05, **p <0.01, ***p < 0.001, chi-square-test or t-test, [a] n=1407 (f=824; m=583), [b] n=1414 (f=826; m=588)

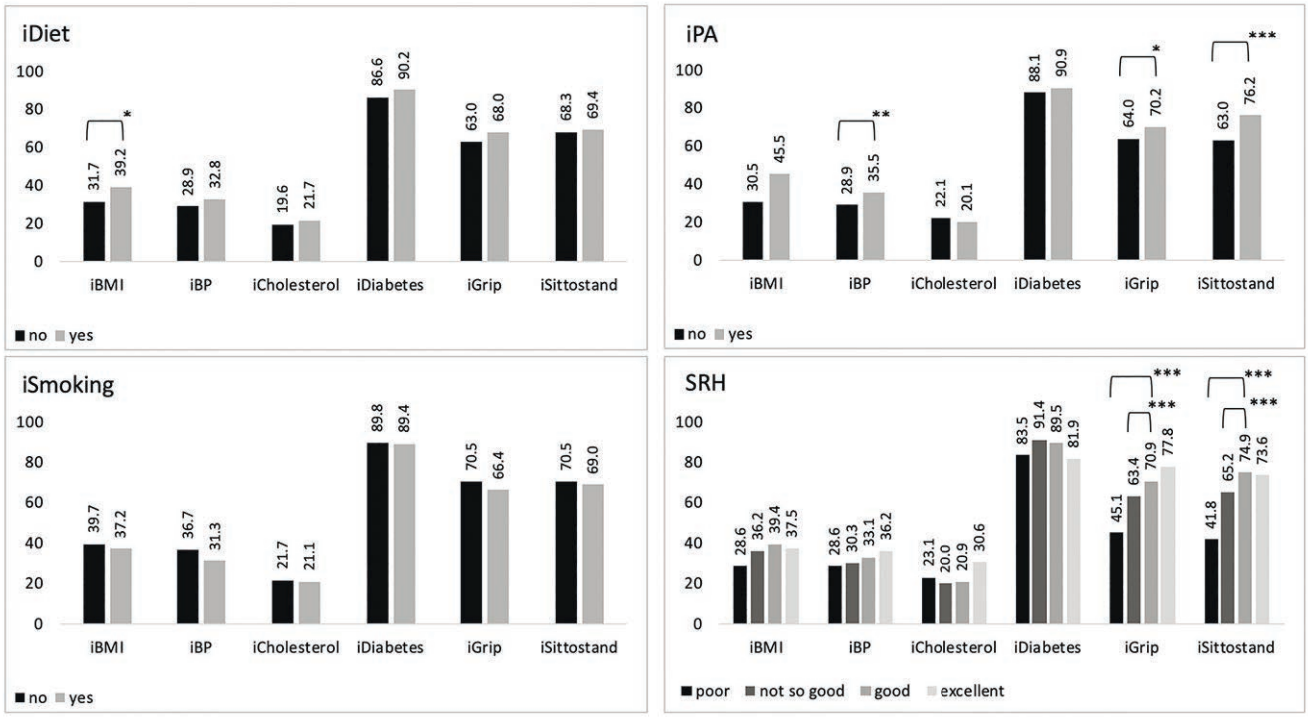
(fasting plasma glucose <100mg/dL), because glycaemia was determined in random capillary blood samples (using disposable strips based on an amperometric system with a MultiCare-In portable device). Therefore, those without self-reported diabetes, no antidiabetic treatment, and those with a measured random blood glucose level ≤200mg/dl were considered to meet iDiabetes. In addition, the iCVH factors score represents the sum of the single iCVH factors.

Ideal Physical Performance (iPP) factors

PP of lower extremities was assessed via the 5-repitition chair stand test, a sub-task of the well-validated Short Physical Performance Battery (SPPB) (25). For detailed test procedure descriptions see Landi et al. (2018c). Briefly, participants were instructed to stand up from a chair five times in a row as quickly as possible, with arms folded across the chest. Participants completing the test in <10s were considered as meeting the criterion for iSittostand (26).

Figure 1

Percentage of participants having iCVH and iPP factors according to compliance with iCVH behaviors and SRH- categories



Note: *p < .05, **p <0.01, ***p < 0.001, chi-square-test

Handgrip strength as an indicator of upper extremity performance was evaluated by using a North Coast handheld hydraulic dynamometer (North Coast Medical, Morgan Hill, CA), as described previously (2). Gender- and BMI-adjusted cut-offs for ideal grip strength (iGrip) were defined according to Fried et al. (27).

Statistical analysis

Demographics, main clinical characteristics, iCVH metrics and iPP factors are reported as mean and standard deviation for continuous variables or absolute numbers and percentages for dichotomous and categorical variables. T-tests or χ^2-statistics were used to assess differences between genders.

Linear and logistic regression analysis were used to examine the association of CVH behaviors and SRH with iCVH factors score, single iCVH factors, and iPP factors as dependent variables, respectively. Pearson correlation coefficients (r) of independent variables < .21 (see supplementary material)) and VIF with a range of 1.01 - 1.07 indicate a very low level of multicollinearity. First, univariate models were calculated to identify whether CVH behaviors and SRH were independently associated with the main variables of interests. In a second step, multivariable models were estimated including all CVH behaviors variables and SRH. Finally, model 3 was adjusted for age and gender as possible confounding factors.

All statistical analyses were performed using IBM SPSS 25. Results were considered statistically significant at a p-value of < 0.05 and two-sided tests were applied.

Results

Sample characteristics and prevalence of iCVH and iPP factors

The main characteristics of the study participants are listed in Table 1. Mean age of participants was 72 ± 5.4 years (range 65-97) with 58.1% women. Less than half of enrollees demonstrated iPA, with no differences between women and men. The vast majority of participants met the ideal criterion for smoking status and more than three quarters followed a healthy diet, with a higher prevalence among women. More than half of participants rated their health as excellent or good (57.6%), with better rates in men than in women.

The average iCVH factors score (iBMI, iBP, iCholesterol, iDiabetes) was 1.8, with women having slightly but significantly higher scores than men. The most prevalent iCVH factor was iDiabetes (89.4%), while the least prevalent was iCholesterol (21.2%). Analysis of gender differences revealed that women more frequently had iBMI, iBP and iDiabetes, whereas men met more often the iCholesterol criterion. Finally, more than half of the participants showed iPP in their upper and lower extremities (iGrip, iSittostand), with a larger proportion in men.

Table 2

Estimated linear and logistic regression models for iCVH factors sumcsore, single iCVH factors and single iPP factors (N=1415)

Variables	Model 1		Model 2[a]		Model 3[b]	
	β- coefficient	p	β- coefficient	p	β- coefficient	p
iCVH factors						
iDiet	0.08	**	0.07	**	0.07	**
iPA	0.12	***	0.12	***	0.11	***
iSmoking	-0.03		-0.04		-0.04	
SRH	-0.05		-0.02		-0.04	
	Model 1		**Model 2[a]**		**Model 3[b]**	
	OR (95%CI)	**p**	**OR (95%CI)**	**p**	**OR (95%CI)**	**p**
Single iCVH factors						
iBMI						
iDiet	1.39 (1.07-1.81)	*	1.30 (0.99-1.70)		1.25 (0.95-1.64)	
iPA	1.90 (1.53-2.37)	***	1.84 (1.47-2.31)	***	1.83 (1.46-2.30)	***
iSmoking	0.92 (0.66-1.28)		0.84 (0.60-1.18)		0.82 (0.58-1.16)	
SRH – poor [Ref.]						
excellent	1.50 (0.78-2.90)		1.11 (0.56-2.17)		1.29 (0.65-2.56)	
good	1.63 (1.01-2.62)	*	1.23 (0.75-2.01)		1.43 (0.87-2.36)	
not so good	1.42 (0.87-2.31)		1.17 (0.71-1.93)		1.27 (0.77-2.10)	
iBP						
iDiet	1.20 (0.92-1.58)		1.19 (0.90-1.56)		1.23 (0.93-1.63)	
iPA	1.35 (1.08-1.69)	**	1.33 (1.05-1.67)	*	1.29 (1.02-1.64)	*
iSmoking	0.78 (0.56-1.10)		0.75 (0.53-1.05)		0.79 (0.56-1.13)	
SRH – poor [Ref.]						
excellent	1.41 (0.73-2.74)		1.21 (0.62-2.37)		1.35 (0.68-2.68)	
good	1.23 (0.76-2.00)		1.08 (0.66-1.76)		1.20 (0.73-1.98)	
not so good	1.09 (0.67-1.78)		0.99 (0.60-1.63)		1.05 (0.63-1.74)	
iDiabetes						
iDiet	1.42 (0.97-2.07)		1.35 (0.92-1.98)		1.31 (0.89-1.94)	
iPA	1.35 (1.96-1.91)		1.34 (0.93-1.91)		1.27 (0.88-1.83)	
iSmoking	0.96 (0.56-1.63)		0.89 (0.52-1.52)		0.90 (0.52-1.56)	
SRH – poor [Ref.]		*				*
excellent	0.90 (0.40-2.03)		0.76 (0.33-1.76)		1.03 (0.44-2.42)	
good	1.68 (0.92-3.06)		1.43 (0.77-2.66)		2.02 (1.06-3.85)	*
not so good	2.09 (1.11-3.95)	*	1.88 (0.99-3.57)		2.31 (1.19-4.47)	*
iCholesterol						
iDiet	1.14 (0.83-1.55)		1.17 (0.86-1.61)		1.21 (0.88-1.67)	
iPA	0.89 (0.69-1.15)		0.87 (0.66-1.13)		0.89 (0.68-1.17)	
iSmoking	0.97 (0.65-1.43)		0.98 (0.66-1.45)		0.97 (0.65-1.45)	
SRH – poor [Ref.]						
excellent	1.47 (0.73-2.95)		1.54 (0.76-3.13)		1.26 (0.61-2.59)	
good	0.88 (0.52-1.48)		0.91 (0.54-1.55)		0.73 (0.42-1.25)	
not so good	0.83 (0.49-1.42)		0.84 (0.49-1.45)		0.74 (0.43-1.29)	

Table 2 (continued)
Estimated linear and logistic regression models for iCVH factors sumcsore, single iCVH factors and single iPP factors (N=1415)

	Model 1		Model 2[a]		Model 3[b]	
	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p
iPP factors						
iSittostand						
iDiet	1.05 (0.81-1.38)		0.93 (0.70-1.23)		1.02 (0.77-1.37)	
iPA	1.88 (1.49-2.37)	***	1.65 (1.30-2.10)	***	1.63 (1.27-2.10)	***
iSmoking	0.93 (0.65-1.33)		0.88 (0.61-1.27)		1.02 (0.70-1.48)	
SRH – poor						
excellent	3.89 (1.99-7.60)	***	3.17 (1.61-6.26)	**	3.24 (1.60-6.56)	**
good	4.16 (2.66-6.52)	***	3.52 (2.22-5.56)	***	3.69 (2.28-5.98)	***
not so good	2.61 (1.66-4.11)	***	2.34 (1.48-3.71)	***	2.45 (1.51-3.95)	***
iGrip						
iDiet	1.24 (0.96-1.61)		1.18 (0.91-1.54)		1.37 (1.03-1.81)	*
iPA	1.32 (1.06-1.65)	*	1.16 (0.92-1.47)		1.11 (0.87-1.42)	
iSmoking	0.93 (0.65-1.33)		0.79 (0.55-1.14)		0.92 (0.64-1.35)	
SRH – poor [Ref.]						
excellent	4.27 (2.14-8.53)	***	3.91 (1.94-7.88)	***	4.21 (2.01-8.79)	***
good	2.96 (1.90-4.61)	***	2.74 (1.74-4.31)	***	2.91 (1.80-4.71)	***
not so good	2.11 (1.35-3.32)	**	1.99 (1.26-3.15)	**	2.11 (1.30-3.41)	**

Abbreviations: β, standardized coefficient; OR, odds ratio; CI, confidence interval; Note: *p < .05, **p <0.01, ***p < 0.001, [a] adjusted for CVH behaviors, SRH, [b] adjusted for CVH behaviors, SRH, age, gender

Relation of iCVH behaviors and SRH with iCVH and iPP factors

Figure 1 depict the prevalence of iCVH and iPP factors according to iCVH behaviors and SRH-categories, respectively. Associations between iCVH behaviors, SRH, and iCVH and iPP factors are presented in Table 2. More detailed values of the regression analysis with indication of the exact p-values are shown in the supplementary material.

A positive correlation between iDiet and iCVH factors score was determined, indicating that participants meeting the iDiet criterion had higher means of iCVH factors compared with those not meeting iDiet criterion. Furthermore, participants with iDiet had higher odds of iBMI in the crude model 1; however, this association was no longer evident in adjusted models 2 and 3. Regarding iPP factors, participants with an iDiet were more likely to meet the iGrip criterion in adjusted model 3.

Consistent with findings on iDiet, iPA was positively related to iCVH factors score. Furthermore, participants with iPA were more likely to meet iBMI than those who did not meet iPA. In addition, participants with iPA demonstrated higher odds of having iBP. In terms of iPP factors, fulfilling iPA criterion was linked to higher odds of iSittostand and iGrip in crude model 1. For iSmoking, no association with any variable of interest was observed.

Participants who rated their SRH as "good" and "not so good" were more likely to meet iDiabetes criterion compared with those with poor SRH in crude model 1 and adjusted model 3. Stronger and almost linear graded associations were found between SRH and iPP factors. For instance, participants with excellent SRH were more than 3-fold and 4-fold likely to meet iSittostand and iGrip criteria, respectively, than those with poor SRH.

Discussion

The results of our study show that iCVH behaviors and SRH provide information on objectively measured cardiovascular and functional health factors in a relatively unselected, community-dwelling study sample outside of conventional health care settings. Although all participants are mobile and independently-living, this "real world" sample cover a broad range of older age (65-97 years) and represent heterogeneity in terms of cardiovascular health and functional status. With 73.8% of the participants meeting only one or two favourable CVH factors and with half of the participants having at least one limitation in physical function, our results underline the importance of identifying these health risk factors as easily as possible to prevent cardiovascular events and to counteract functional decline. The higher prevalence of CVH factors such as BMI, cholesterol and blood pressure at non-ideal levels compared with younger samples (19) might be explained by age-related changes in body composition with an increase

in visceral body fat as well as shifts in hormone regulation effecting glucose and lipid metabolism (28). The gender-specific differences in the prevalence of CVH factors could be explained by the fact that these changes occur differently between men and women (29). Of special interest is the relatively high prevalence of poor physical performance metrics in our community-dwelling older participants. This finding is a "call to action", as declining physical function is clearly associated with frailty and a high risk for mobility disability (30, 31).

Our results provide evidence that two of the considered CVH behaviors, regular exercise and healthy diet, are related to higher iCVH factors score and therefore to a lower overall cardiovascular risk profile. Regular physical activity was revealed as an indicator for favorable, untreated blood pressure in accordance to evidence of regular exercise as blood pressure-lowering factor (32). Furthermore, consistent with prior findings including longitudinal studies (33), regular physical activity was associated with a higher likelihood of having a BMI in the normal range compared to inactive participants. Besides that, only few associations between iCVH behaviors and single iCVH factors were revealed. Healthy diet was identified as an indicator for a BMI in the normal range, in line with previous findings indicating a possible inverse association between the amount of fruit/vegetable intake and weight (34, 35). However, this association diminishes in adjusted models, which may be related to changes in dietary requirements with increasing age (36).

The value of evaluating CVH behaviors as indicators for objectively measurable health factors was particularly evident with regard to physical performance level. As expected, engagement in regular physical activity was associated with good muscle strength and muscle function in lower and upper extremities. Regular fruit/vegetable consumption, on the other hand, was associated with better strength in upper extremities when gender and age effects were kept constant. This is consistent with previous studies showing that the consumption of plant foods may be associated with better physical performance (37). Especially in this sample, which is still mobile but already shows a relatively high prevalence of limitations in functional domains, nutrition and exercise behavior serve as early indicators for the necessity of prevention and intervention approaches (38).

Surprisingly, no significant association of smoking status with iCVH and iPP factors was revealed. From a methodological perspective, the low prevalence of smokers in this sample could obscure statistically significant differences between smokers and non-smokers. On the other hand, although smoking is a well-established detrimental factor of cardiovascular health (39,40), this pathway may be masked by the fact that smoking in prior studies was related to better single iCVH factors, for instance lower blood pressure (41) and BMI among adults (42).

Despite the high prevalence of CVH risk factors, limitations in physical performance, and physical inactivity, SRH were mainly rated as good. This seemingly contradictory finding supports the assumption that SRH represents far more than objectively measurable health states. SRH may be generated by a variety of other factors such as personal traits, peer-comparisons, social environment, knowledge of one´s own health, and emotional states (43,44). This might also explain why, in comparison to other studies (45,46), relatively few associations between SRH and CVH factors occur. First, advancing age seems to be accompanied by a decoupling and increasing discrepancy between SRH and objectively measurable health factors. People tend to evaluate their health better than might be expected, despite suffering from clinically-relevant diseases/chronic diseases (47). Second, most studies to date treated health behaviors as dependent variables in the investigation of SRH-CVH metrics score relation, which could have strengthened the superficially apparent link between them (8,15). In a similar vein, when Boehm et al. (48) used behavioral factors as explanatory variables, the association of SRH with cholesterol, glucose and blood pressure at ideal levels was attenuated. Third, only those health determinants may be included in the assessment of SRH that cause restrictions in everyday activities or pain and thus directly affect well-being. In support of this assumption, our investigation revealed the only link between SRH and CVH factors in terms of diabetes criterion. Participants reporting poor SRH were less likely to meet the ideal diabetes criterion (absence of diabetes) than those rating SRH as "not so good" or "good". Poor SRH level may be accompanied by low capacities and resources to compensate for diabetes related burden in daily living such as dietary restrictions and medication use. In contrast, as high blood pressure and high cholesterol levels do not provoke directly remarkable symptoms or restrictions in daily living, they seem not to be perceived as health-impairing conditions even if they are known.

In line with our view of SRH being mainly associated with health factors that have a noticeable impact on everyday life, SRH was revealed as a powerful indicator of physical performance in both lower and upper extremities. This easily assessable parameter may enable the identification of functional losses at an early stage and provide a possible starting point for tailored interventions to counteract further decline. Especially lower extremity dysfunction represents an early stage in the disablement process preceding loss of physical function and independence (49,50). Taken together, our results contribute to a growing body of literature revealing an association of SRH with physical function parameters (18).

Limitations

Several limitations apply to this study. Due to the cross-sectional design, no causal relations between health relevant behaviors, SRH, and cardiovascular as well as functional health factors can be determined. Furthermore, as the assessment of health behaviors is based on self-report, potential information

bias of participants must be considered. Although the easy collection of modified AHA-CVH-metrics is a considerable advantage for the largest possible population-based recruitment in the Lookup 7+ project, this also risks a loss of information. With regard to the recording of nutrition, fruit/vegetable consumption is an important part of the "Dietary Approaches to Stop Hypertension (DASH)" diet (51), but also other factors such as the consumption of red meat, salt or saturated fat consumption play a role for nutrition-effected cardiovascular health. Although the procedure of cholesterol and glucose levels evaluation was previously validated (24), portable devices are more prone to measurement error than stationary equipment. Furthermore, the study setting with random cholesterol and glucose level determination could cause an overestimation of both parameters. Similarly, the setting may have influenced the measurement of blood pressure and physical performance level, because evaluations were performed throughout the day, so some participants may have walked or eaten before the assessments. To limit this potential bias, participants were allowed to rest until they felt comfortable with the performance tests. Another limitation of the study design is that no information about cardiovascular conditions such as stroke, myocardial infarct, or heart failure was collected. However, due to the recruitment in public places, it can be assumed that no acute illnesses were present at the time of the assessment.

Conclusion

In this Longevity 7+ sample aged 65+, three major conclusions can be drawn. First, the assessment of CVH health behaviors (diet and physical activity) provides information on physiological CVH risk factor profile, highlighting regular physical activity as an indicator for blood pressure and BMI in a health-promoting range. Second, the survey of self-rated health, physical activity and diet allows a rapid screening for physical performance level in older persons. Third, since CVH factors do not appear to be identifiable by self-reported health behaviors, particular attention should be paid to the evaluation of these factors by performing objective measurement, regardless of good CVH behavior profile and good SRH.

In order to obtain a cost-effective, yet comprehensive picture of cardiovascular and functional health factors in a population aged 65 years and older, it is therefore advisable to evaluate exercise and dietary behavior as well as self-rated health.

Acknowledgements: The Lookup 7+ Study Group is composed as follows: Steering Committee: F. Landi, R. Bernabei. Coordination: E. Marzetti, R. Calvani, L. Mariotti

Writing Panel: A.M. Martone, M. D'Angelo, E. Serafini, A. Picca, V. Palmieri, M. Tosato, P. Abete, A. Cherubini, F. Corica, S. Salini, E. Freiberger, H. M. Rempe

Field investigators: M. Bianco, D. Biscotti, V. Brandi, M. Broccatelli, L. Catalano, F. Ciciarello, M. D'Elia, M.T. Fuga, E. Ortolani, G. Savera, M. B. Zazzera. Participants: A. Almohani, F. Benvenuto, M. Bianchi, G. Bramato, R. Capitani, C. Celesti, G. Colloca, F. Cuccaro, L. Damato, E. Di Murru, S. Fabrizi, D. Fusco, A. Galliani, V. Galluzzo, S. Gervasi, R. Quarta, G. Modica, R. Monti, S. Orvieto, C. Pais, C. Pantanelli, S. Rocchi, D. Ronconi, E. Rota, F. Sollazzo, M. Tritto. The authors thank Norbert T. Rempe for linguistic revision of the manuscript.

Author Contributions: E.M. and F.L. conceived and designed the experiments. A.P. and E.M. performed the experiments. H.M.R., R.C., E.M. and F.L. conceptualized the manuscript, analyzed and interpreted the data. H.M.R. wrote the paper, and R.C., E.M., A.P., C.C.S., E.F. and F.L. revised it critically. All authors have read and approved the final version of the article. The present work was performed in fulfillment of the requirements for obtaining the degree Dr. rer. biol. hum (Doctoral Degree in Human Biology) for H.M.R.

Conflicts of Interests: R.C., E.M., E.F., C.S., and F.L. are partners of the SPRINTT Consortium, which is partly funded by the European Federation of Pharmaceutical Industries and Associations (EFPIA). All other authors declare no conflict of interest.

Financial Disclosure: The Lookup 7+ project was supported by Italia Longeva; Marche Region; Ferrarini, Tedaldi, Fileni, and Elanco; Danone Italia; and Merck Sharp & Dohme Italia. The study was also partly supported by intramural research grants from the Catholic University of the Sacred Heart (D3.2 2013 and D3.2 2015) and by the non-profit research foundation 'Centro Studi Achille e Linda Lorenzon.

Sponsor´s Role: The sponsors played no role in the design, methods, participant recruitment, data collections, analysis, or preparation of the paper.

Ethical Standards: The study protocol was approved by the Ethics Committee of the Università Cattolica del Sacro Cuore (protocol #A.1220/CE/2011). Written informed consent was obtained from every participant prior to the enrolment. The manuscript was prepared in accordance with the "Strengthening the Reporting of Observational studies in Epidemiology" (STROBE) reporting guidelines (22).

References

1. Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. J Am Coll Cardiol. 2017;70:1-25.
2. Landi F, Calvani R, Picca A, Tosato M, D'Angelo E, Martone AM, Serafini E, Ortolani E, Savera G, Salini S, Acampora N, Bernabei R, Marzetti E. Relationship between cardiovascular health metrics and physical performance in community-living people: Results from the Longevity check-up (Lookup) 7+ project. Scientific Reports. 2018;8:16353.
3. Lachman S, Peters RJ, Lentjes MA, Mulligan AA, Luben RN, Wareham NJ, Khaw K-T, Boekholdt SM. Ideal cardiovascular health and risk of cardiovascular events in the EPIC-Norfolk prospective population study. Eur J Prev Cardiol. 2016;23:986-994.
4. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. Circulation. 2010;121:586-613.
5. Shah AM, Claggett B, Folsom AR, Lutsey PL, Ballantyne CM, Heiss G, Solomon SD. Ideal cardiovascular health during adult life and cardiovascular structure and function among the elderly. Circulation. 2015;132:1979-1989.
6. Ogunmoroti O, Allen NB, Cushman M, Michos ED, Rundek T, Rana JS, Blankstein R, Blumenthal RS, Blaha MJ, Veledar E, Nasir K. Association Between Life's Simple 7 and Noncardiovascular Disease: The Multi-Ethnic Study of Atherosclerosis. J Am Heart Assoc. 2016;5:e003954.
7. Willis BL, DeFina LF, Bachmann JM, Franzini L, Shay CM, Gao A, Leonard D, Berry JD. Association of Ideal Cardiovascular Health and Long-term Healthcare Costs. Am J Prev Med. 2015;49:678-685.
8. Allen NB, Badon S, Greenlund KJ, Huffman M, Hong Y, Lloyd-Jones DM. The association between cardiovascular health and health-related quality of life and health status measures among U.S. adults: A cross-sectional study of the National Health and Nutrition Examination Surveys, 2001-2010. Health Qual Life Outcomes. 2015;13.
9. Windham BG, Harrison KL, Lirette ST, Lutsey PL, Pompeii LA, Gabriel KP, Koton S, Steffen LM, Griswold ME, Mosley TH. Relationship Between Midlife Cardiovascular Health and Late-Life Physical Performance: The ARIC Study. J Am Geriatr Soc. 2017;65:1012-1018.
10. Graciani A, García-Esquinas E, López-García E, Banegas JR, Rodríguez-Artalejo F. Ideal cardiovascular health and risk of frailty in older adults. Circ Cardiovasc Qual Outcomes. 2016;9:239-245.
11. Garcia-Hermoso A, Ramirez-Velez R, Ramirez-Campillo R, Izquierdo M. Relationship Between Ideal Cardiovascular Health and Disability in Older Adults: The Chilean National Health Survey (2009-10). J Am Geriatr Soc. 2017;65:2727-2732.
12. Jin Y, Tanaka T, Ma Y, Bandinelli S, Ferrucci L, Talegawkar SA. Cardiovascular Health Is Associated with Physical Function among Older Community Dwelling Men and Women. J Gerontol A Biol Sci Med Sci. 2017;72:1710-1716.
13. Paterson DH, Warburton DE. Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. Int J Behav Nutr Phys Act. 2010;7:38.
14. Ogunmoroti O, Utuama OA, Salami JA, Valero-Elizondo J, Spatz ES, Rouseff M,

Parris D, Das S, Guzman H, Agatston A, Feldman T, Veledar E, Maziak W, Nasir K. Association between self-rated health and ideal cardiovascular health: The Baptist Health South Florida Employee Study. J Public Health (Oxf). 2017;40:e456-e463.
15. Veromaa V, Kautiainen H, Juonala M, Rantanen A, Korhonen PE. Self-rated health as an indicator of ideal cardiovascular health among working-aged women. Scand J Prim Health Care. 2017;35:322-328.
16. Hirosaki M, Okumiya K, Wada T, Ishine M, Sakamoto R, Ishimoto Y, Kasahara Y, Kimura Y, Fukutomi E, Chen WL, Nakatsuka M, Fujisawa M, Otsuka K, Matsubayashi K. Self-rated health is associated with subsequent functional decline among older adults in Japan. Int Psychogeriatr. 2017;29:1475-1483.
17. Brenowitz WD, Hubbard RA, Crane PK, Gray SL, Zaslavsky O, Larson EB. Longitudinal associations between self-rated health and performance-based physical function in a population-based cohort of older adults. PLoS One. 2014;9:e111761.
18. Martinez DJ, Kasl SV, Gill TM, Barry LC. Longitudinal association between self-rated health and timed gait among older persons. J Gerontol B Psychol Sci Soc Sci. 2010;65:715-719.
19. Landi F, Calvani R, Picca A, Tosato M, Martone AM, Ortolani E, Salini S, Pafundi T, Savera G, Pantanelli C, Bernabei R, Marzetti E. Cardiovascular health metrics, muscle mass and function among Italian community-dwellers: the Lookup 7+ project. Eur J Public Health. 2018;28:766-772.
20. Marzetti E, Calvani R, Picca A, Sisto A, Tosato M, Martone AM, Ortolani E, Salini S, Pafundi T, Santoliquido A, Santoro L, Bernabei R, Landi F. Prevalence of dyslipidaemia and awareness of blood cholesterol levels among community-living people: results from the Longevity check-up 7+ (Lookup 7+) cross-sectional survey. BMJ Open. 2018;8:e021627.
21. Landi F, Calvani R, Picca A, Tosato M, Martone A, Ortolani E, Sisto A, D'Angelo E, Serafini E, Desideri G, Fuga M, Marzetti E. Body Mass Index is Strongly Associated with Hypertension: Results from the Longevity Check-Up 7+ Study. Nutrients. 2018;10:1976.
22. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61:344-349.
23. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J. 2018;39:3021-3104.
24. Rapi S, Bazzini C, Tozzetti C, Sbolci V, Modesti PA. Point-of-care testing of cholesterol and triglycerides for epidemiologic studies: evaluation of the multicare-in system. Transl Res. 2009;153:71-76.
25. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol A Biol Sci Med Sci. 1994;49:85-94.
26. Makizako H, Shimada H, Doi T, Tsutsumimoto K, Nakakubo S, Hotta R, Suzuki T. Predictive Cutoff Values of the Five-Times Sit-to-Stand Test and the Timed "Up & Go" Test for Disability Incidence in Older People Dwelling in the Community. Phys Ther. 2017;97:417-424.
27. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56:M146-156.
28. Zamboni M, Zoico E, Scartezzini T, Mazzali G, Tosoni P, Zivelonghi A, Gallagher D, De Pergola G, Di Francesco V, Bosello O. Body composition changes in stable-weight elderly subjects: the effect of sex. Aging Clin Exp Res. 2003;15:321-327.
29. Palmisano BT, Zhu L, Eckel RH, Stafford JM. Sex differences in lipid and lipoprotein metabolism. MOL METAB. 2018;15:45-55.
30. Landi F, Calvani R, Tosato M, Martone AM, Fusco D, Sisto A, Ortolani E, Savera G, Salini S, Marzetti E. Age-Related Variations of Muscle Mass, Strength, and Physical Performance in Community-Dwellers: Results From the Milan EXPO Survey. J Am Med Dir Assoc. 2017;18(1):88.e17-88.e24.
31. Morley JE, Vellas B, Kan GA, Anker SD, Bauer JM, Bernabei R, et al. Frailty consensus: a call to action. J Am Med Dir Assoc. 2013;14(6):392-397.
32. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Ann Intern Med. 2002;136:493-503.
33. Cárdenas Fuentes G, Bawaked RA, Schröder H, Tur Marí JA, Babio N, Serra-Majem L, et al. Association of physical activity with body mass index, waist circumference and incidence of obesity in older adults. Eur J Public Health. 2018;28:944-950.
34. Alinia S, Hels O, Tetens I. The potential association between fruit intake and body weight-a review. Obes Rev. 2009;10:639-647.
35. Nour M, Lutze SA, Grech A, Allman-Farinelli M. The Relationship between Vegetable Intake and Weight Outcomes: A Systematic Review of Cohort Studies. Nutrients. 2018;10:E1626.
36. Levine ME, Suarez JA, Brandhorst S, Balasubramanian P, Cheng CW, Madia F, et al. Low protein intake is associated with a major reduction in IGF-1, cancer, and overall mortality in the 65 and younger but not older population. Cell Metab. 2014;19:407-417.
37. Fougere B, Mazzuco S, Spagnolo P, Guyonnet S, Vellas B, Cesari M, Gallucci M. Association between the Mediterranean-style Dietary Pattern Score and Physical Performance: Results from TRELONG Study. J Nutr Health Aging. 2016;20(4):415-419.
38. Inzitari M, Doets E, Bartali B, Benetou V, Di Bari M, Visser M, Volpato S, Gambassi G, Topinkova E, De Groot L, Salva A. Nutrition in the age-related disablement process. J Nutr Health Aging. 2011;15(8):599-604.
39. Aune D, Schlesinger S, Norat T, Riboli E. Tobacco smoking and the risk of heart failure: A systematic review and meta-analysis of prospective studies. Eur J Prev Cardiol. 2019;26(3):279-288.
40. Pirie K, Peto R, Reeves GK, Green J, Beral V. The 21st century hazards of smoking and benefits of stopping: a prospective study of one million women in the UK. Lancet. 2013;381:133-141.
41. Leone A. Does Smoking Act as a Friend or Enemy of Blood Pressure? Let Release Pandora`s Box. Cardiol Res Pract. 2011;2011(264894).
42. Plurphanswat N, Rodu B. The association of smoking and demographic characteristics on body mass index and obesity among adults in the U.S., 1999–2012. BMC Obesity. 2014;1(18).
43. Jylha M. What is self-rated health and why does it predict mortality? Towards a unified conceptual model. Soc Sci Med. 2009;69:307-316.
44. Zajacova A, Huzurbazar S, Todd M. Gender and the structure of self-rated health across the adult life span. Soc Sci Med. 2017;187:58-66.
45. Manczuk M, Vaidean G, Dehghan M, Vedanthan R, Boffetta P, Zatonski WA. Ideal cardiovascular health is associated with self-rated health status. The Polish Norwegian Study (PONS). Int J Cardiol. 2017;230:549-555.
46. Liu Y, Ozodiegwu ID, Nickel JC, Wang K, Iwasaki LR. Self-reported health and behavioral factors are associated with metabolic syndrome in Americans aged 40 and over. Prev Med Rep. 2017;7:193-197.
47. Idler E, Cartwright K. What Do We Rate When We Rate Our Health? Decomposing Age-related Contributions to Self-rated Health. J Health Soc Behav. 2018;59:74-93.
48. Boehm JK, Chen Y, Williams DR, Ryff CD, Kubzansky LD. Subjective well-being and cardiometabolic health: An 8-11year study of midlife adults. J Psychosom Res. 2016;85:1-8.
49. Verbrugge LM, Jette AM. The disablement process. Soc Sci Med. 1994;38:1-14.
50. Pavasini R, Guralnik J, Brown JC, di Bari M, Cesari M, Landi F, et al. Short Physical Performance Battery and all-cause mortality: systematic review and meta-analysis. BMC Medicine. 2016;14:215-224.
51. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino G, Hu FB. Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. Arch Intern Med. 2008;168:713-720.