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NUTRITION, DAILY WALKING AND RESILIENCE ARE ASSOCIATED WITH PHYSICAL FUNCTION IN THE OLDEST OLD MEN

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Abstract: *Background:* Maintaining good physical functioning in old age is of utmost importance for healthy and active aging. We examined physical function and associated factors in the oldest-old men. *Subjects and methods:* The participants of this cross sectional analysis of a longitudinal study were the oldest old men(n=394, mean age 88 years, range 82-97 years) from the Helsinki Business Men cohort who responded to a postal health and nutrition survey in 2016. Physical function was defined using the respective subscale (Physical Function, PF) in the RAND-36 health-related quality of life (HRQoL) instrument. Resilience was measured with validated Finnish version of Resilience scale. Diet quality was assessed using Mediterranean diet adherence score (MeDi) and Diet quality index (DQI) which is designed to show adherence to Finnish dietary recommendations. Food and dietary intakes were retrieved using 3-day food records (obtained from a sub-group of the respondents). The participants were divided into quartiles corresponding to their PF scores and health and nutrition indicators were calculated into these PF quartiles. Furthermore, a linear regression model was used to determine factors associated with PF. *Results:* PF quartiles were positively associated with lower age, daily walking habit, cognition, diet quality, resilience, alcohol use and negatively associated with blood glucose levels, weight loss, body weight (BW) and falls. Polyunsaturated to saturated fat ratio and berry intake were also associated with PF. In a linear regression model PF was positively associated ($p < .001$, adjusted $R2 = .560$) with MeDi, cognition, resilience, vitality (RAND-36), and negatively with age and BW. *Conclusion:* MeDi, exercise, resilience, cognition, use of alcohol, fat quality and lower age were positively associated with PF in the oldest-old men. Weight loss, falls and interestingly BW were negatively associated with PF.

Key words: Physical function, RAND-36, diet quality, Mediterranean diet adherence score, oldest old men.

Introduction

In longitudinal studies many risk factors of poor physical functioning have been identified. They include, for example, comorbidities, low physical activity, poor nutrition, in particular energy-protein malnutrition, low psychosocial health, social circumstances and lifestyle factors (1-4).

Both obesity in mid-life, low body weight in old age and especially unintentional weight-loss have been associated with frailty and loss of physical function (3-5). While many studies have shown that poor nutritional status, insufficient energy, protein and nutrient intakes along with nutritional deficiencies have been linked to loss of muscle mass and increased risk of frailty, fewer studies have shown how diet quality is associated with physical functioning (4, 6-8). In the oldest old men diet quality in relation to physical functioning has not been thoroughly studied.

The population examined in this study differs in many ways from normal population of older people. The participants were the oldest old surviving men from Helsinki Business Men (HBS) cohort which included men from the highest socio-economic class. The objective of this study was to examine their unique characteristics and to identify factors associated with RAND physical function subscale (PF). We also present a model of the determinants of PF, which considers physical, nutritional and psycho-social factors.

Methods

The participants of this cross-sectional analysis of a longitudinal study are the surviving oldest old home-dwelling men from The Helsinki Businessmen Study (HBS). It was originally a convenience cohort of executives and businessmen (n = 3490) who participated in health check-ups during the 1960s, but since the beginning of the 1970s it has developed into a clinical-epidemiological, longitudinal study (9). No systematic dietary surveys of this cohort have been performed earlier, but in 2016 a postal Health and Nutrition survey was sent to the surviving participants (n= 715).

Health survey

The postal survey included various validated instruments such as RAND-36 Health Related Quality of Life (HRQoL) questionnaire consisting of eight subscales: Physical function (PF), Role limitations caused by physical health problems (Role physical, RP), Role limitations caused by emotional problems (Role emotional, RE), Vitality (VT), Mental health (MH), Social functioning (SF), Bodily pain (BP), and General health (GH) (10). A score of each sub-scale of RAND-36 HRQoL was calculated and compared with the Finnish population data of somewhat younger older men (11). The survey also included validated Finnish version of resilience score (RS-SF), which consists of 14 items from the original Resilience-scale (12).

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The resilience score was calculated summing the 14 items and forming an over-all score (12). Furthermore, the survey included the Clinical Dementia Rating (CDR), of which sum of boxes was calculated, along with various health related questions such as falls, self-reported weight, blood pressure, glucose and cholesterol levels and background information questions (12).

Nutrition

The nutrition part of the survey included two validated diet quality questionnaires: Mediterranean diet adherence score (MeDi) (14) and Diet Quality Index (DQI) that was originally designed to evaluate the adherence to the Finnish Nutrition Recommendations (15). In addition, the participants received 3-day food diaries and instructions how to complete them. Once the food diaries and diet quality questionnaires were returned, they were checked by a nutritionist and follow-up calls were made in order to verify the quantities and type of food items consumed when necessary. The dietary intake data was analyzed using Nutrica 3.11 program developed for this purpose (16).

Statistical analysis

The participants were divided into quartiles corresponding to their RAND-36 PF scores and health and nutrition indicators as well as dietary food and nutrition intakes were classified according to the PF quartiles. The statistical significance for hypotheses of linearity was evaluated for a trend with ANOVA for continuous variables or the Mantel-Haenszel test for categorical variables. Furthermore, a linear regression model for associative factors of PF was performed. The statistical analyses were performed, using the SPSS statistical program, version 22 (SPSS IBM, Armonk, NY, USA).

Ethics

All participants have signed an informed consent to participate in this study. The study protocol was approved by the Helsinki University Central Hospital Ethics Committee.

Results

Of the surviving participants 476 (response rate 67%) returned the survey. Of those four participants reported being unable to fill the survey due dementia, nine surveys were returned by respondent's spouse stating that the respondent had recently died, and 69 had other reasons for not filling the survey or they had only partially filled the survey. Finally, 394 of the participants were included in the final analysis, of those 338 filled the diet quality indices and a subgroup of 142 returned 3-day food records, of which 130 responded both RAND PF-subscale questions and returned food records.

Table 1
RAND-36 HRQoL questionnaire results in HBS cohort compared to general population

RAND- 36 HRQoL subscales	HBS Age: 82-97 years n = 394	General Finnish population values (13) Age: 75-79 years n = 39
Physical Function (SD)	59.3 (23.6)	54.5 (28.2)
General Health (SD)	54.8 (16.8)	44.7 (21.8)
Mental Health (SD)	79.9 (16.4)	72.8 (24.2)
Vitality (SD)	74.5 (19.8)	55.1 (26.8)
Bodily Pain (SD)	69.4 (27.5)	59.7 (27.4)
Social Functioning (SD)	79.5 (23.9)	69.4 (29.6)
Role limitations caused by physical health problems (SD)	57.2 (39.9)	42.1 (40.8)
Role limitations caused by emotional problems (SD)	69.1 (37.9)	50.4 (38.9)

HRQoL = Health Related Quality of Life; HBS = Helsinki Business Men; SD = standard deviation

The mean age of the participants was 88 years (range 82-97 years). Mean RAND-36 HRQoL scores of the eight subscales are presented in table 1 together with Finnish population based data (13). The scores of our study participants were higher than population means in somewhat younger men (aged 75-79). PF quartiles were positively associated with lower age ($p < 0.001$), daily walking habit ($p < 0.001$), cognition according to CDR sum of boxes ($p < 0.001$), both MeDi ($p = 0.009$) and DQI ($p = 0.004$), lower blood glucose levels ($p = 0.005$), alcohol use ($p = 0.012$) and negatively associated with weight loss ($p < 0.001$), body weight (BW) ($p = 0.001$) and falls ($p < 0.001$) (Table 2).

In a linear regression model (Model 1) PF was associated ($p < 0.001$, adjusted $R2 = 0.56$) with MeDi, resilience, vitality subscale of RAND-36, cognition (CDR sum of boxes) and negatively with age and BW (Table 3). In model 2 we used the same coefficients but changed MeDi for DQI. In this model DQI did not reach statistical significance ($p = 0.08$) and the overall model's significance and R decreased ($p = 0.001$, adjusted $R2 = 0.55$).

In a subgroup returning both RAND and dietary records, fat quality (PUFA: SFA-ratio) and berry intake were associated with PF (Table 4). Other foods, energy and nutrient intakes were not associated with PF, although there was a trend of higher intakes of vegetables, legumes, protein, fiber, folate, and vitamin E with higher PF status.

Discussion

PF of the oldest old men was linearly associated with diet quality, cognition, daily walking habit, resilience and alcohol use whereas age, blood glucose levels, BW, weight loss and

Table 2
Characteristics of the oldest old men in HBS cohort according to RAND-36 HRQoL subscale physical function (PF) quartiles (Q)

Physical function (PF) quartiles (Q) / Characteristics	Q1 PF n = 94	Q2 PF n = 94	Q3 PF n = 97	Q4 PF n = 98	p- value[1,2]
PF score	22.5 (10.6)	52.3 (6.9)	70.8 (4.2)	85.9 (5.4)	< .001
Age, mean (SD)	89.0 (3.8)	87.4 (3.5)	86.5 (3.2)	87.1 (3.6)	< .001
Weight loss in last three months, %					
1. > 3 kg	11	3	3	3	< .001
2. Don't know	9	7	4	3	
3. 1-3 kg	21	21	11	11	
4. No weight loss	60	68	82	83	
Walks every day, %					
1. Not at all	21	1	0	0	<.001
2. < 1 km	63	45	26	11	
3. 1-3 km	16	50	63	60	
4. > 3 km	0	4	11	30	
Have you fallen during last year?,%					
1. Several	9	4	1	2	<.001
2. 1-2 times	50	31	23	16	
3. I have not fallen	41	64	76	82	
Use of alcohol, %					
1. No alcohol	24	25	25	18	.012
2. Have used before, but stopped	31	17	15	12	
3. Use alcohol	45	59	60	71	
CDR, sum of boxes	2.3 (2.3)	1.4 (1.4)	0.7 (0.9)	0.5 (1.0)	<.001
Blood glucose	6.4 (1.4)	6.0 (.9)	6.1 (1.1)	5.7 (.6)	.005
Cholesterol, mmol/l	4.3 (1.0)	4.1 (1.0)	4.5 (.9)	4.5 (1.0)	.240
Weight, kg	79.0 (15.2)	79.1 (10.5)	77.6 (10.0)	73.6 (9.0)	.001
Mediterranean diet score (SD)	3.9 (1.2)	4.5 (1.4)	4.4 (1.5)	4.7 (2.0)	.009
Diet quality index score (SD)	9.5 (1.9)	9.6 (1.8)	10.0 (1.9)	10.3 (1.6)	.004
Resilience (RS-14) (SD)	72.2 (13.1)	75.1 (10.1)	78.7 (7.1)	81.6 (10.6)	< .001

1. Statistical significance of linearity was tested by ANOVA; 2. statistical significance linearity was tested by Mantel-Haenszel test; HRQoL = Health related quality of life; HBS = Helsinki business men; Q = quartile; SD = standard deviation; CDR = Clinical dementia rating (13), RS-14 = Resilience short-form score (12); PF = physical function according to RAND-36 Health Related Quality of Life instrument.

falls were inversely associated with PF. In linear regression model PF was positively associated with MeDi, age, cognition, RAND-36 vitality part, resilience and negatively with BW.

Our population differs in many ways from the general population. They had higher mean scores of the RAND-36 HRQoL subscales than those of somewhat younger people of the general population (13), which may be explained by their higher socio-economic status (9). Thus, the present participants are a selected group of older men because of survivorship and because the frailest men or ones with poor cognition may have been unable to take part of the survey.

Diet quality, according to MeDi was associated with higher PF scores. Mediterranean diet has been associated with various health benefits in numerous studies and inversely with frailty (17-18). In our population, MeDi scores in general were quite low, however significantly associated to PF. On the other hand DQI scores were higher which is understandable since DQI is designed to measure adherence to Finnish dietary recommendations and it thus emphasizes foods typically consumed in Finland (bread, milk). However, although this population had low scores on MeDi, in regression model, MeDi but not DQI was associated with PF showing that the MeDi score is relevant even in this population. This data is consistent with other studies that good nutrition and diet quality play a

Table 3
Linear regression modes of associative covariates of RAND-36 subscale of physical function (PF)

Model 1	**β [95% CI] unstandardized**	**β standardized coefficents**	**t- value**	**Significance**
Constant				
	143.21 [71.55, 233.79]		3.72	< .001
CDR (sum of boxes)	-4.75 [-7.07, -2.62]	-0.28	-4.30	< .001
Resilience	0.31 [0.03, 0.59]	0.13	2.17	.032
MeDi adherence score	2.77 [1.22, 4.31]	0.20	3.54	.001
Body weight, kg	-0.53 [-0.76, -0.29]	-0.26	-4.45	< .001
Vitality (RAND-36 HRQoL)	0.48 [0.32, 0.63]	0.39	5.97	< .001
Exercise, hours per week	0.54 [- 0.12, 1.19]	0.09	1.63	.106
Age	-1.37 [-2.19, -0.56]	-0.20	-3.34	.001
R2	0.58			
Adjusted R2	0.56			
F-test	26.56			< .001
Std error of the estimate	14.86			
Model 2	**β [95% CI] unstandardized**	**β standardized coefficents**	**t- value**	**Significance**
Constant	79.56 [51.92, 216.25]		2.55	.012
CDR (sum of boxes)	-4.78 [-6.88, -2.32]	-0.28	-4.13	< .001
Resilience (RS-14)	0.39 [1.88, 9.80]	0.17	2.71	.01
DQI	1.37 [-0.15, 2.89]	0.11	1.78	.08
Body Weight	-0.53 [-0.76, -0.28]	-0.26	-4.29	< .001
Vitality (RAND-36)	0.46 [0.30, 0.63]	0.37	5.52	< .001
Exercise hours per week	0.63 [-0.41, 1.31]	0.11	1.86	.07
Age	-1.35 [-2.17, -0.53]	-0.20	-3.26	.01
R^2	0.55			
Adjusted R2	0.53			
F-test	23.76			< .001
Std error of the estimate	15.33			

CDR = Clinical dementia rating; MeDi = Mediterranean adherence score; CI = confidence interval; DQI = Diet quality Index; Std = standard; HRQoL = Health related quality of life.

central role in healthy aging and may protect against frailty (17-18). Berry intake and fat quality, measured as polyunsaturated to saturated fat-ratio (PUFA:SFA), were associated with higher PF. Cardiovascular disease (CVD) is known to increase frailty and CVD is associated with decline in physical functioning (19). Thus, one could speculate that better fat quality in the oldest-old men may have been a long-term habit which has attributed to lower CVD prevalence. Other dietary food intakes were not associated with PF. There was, however, a trend of higher intake of vegetable, legume, fiber as well as higher protein, folate, and vitamin E in those with higher PF, which is consistent with earlier studies (6, 17-18).

Alcohol use was associated with higher PF scores in this study. This so called alcohol paradox has also been observed in a prior longitudinal study in this population (20). While high consumption of alcohol has many harmful effects on health, benefits associated with moderate consumption in old age have also been reported (21-22). Especially Mediterranean drinking pattern as well as drinking only with meals have been associated with lower risk of frailty in older adults (22). It has been suggested that moderate alcohol consumption may decrease inflammation associated with frailty (21), but reverse causality cannot be excluded (23).

Surprisingly, lower BW of the participants was associated with higher PF, whereas weight loss was associated with lower PF. In many studies older people have benefitted from higher BMI. However, in a prior study of the same population, constant normal weight was associated with better survival

Table 4
Dietary intakes of foods and nutrients presented as means according to RAND- subscale physical function (PF) quartiles

Physical function (PF) quartiles / Foods	Q1 PF n = 22	Q2 PF n = 33	Q3 PF n = 38	Q4 PF n = 37	p- value[1]
Total fruits and vegetables, g (SD)	250 (210)	242 (122)	245 (181)	295 (171)	.266
Vegetables	111 (113)	123 (87)	140 (128)	154 (97)	.106
Fruits	131 (121)	97 (84)	87 (98)	113 (101)	.631
Berries	8 (17)	22 (33)	17 (24)	28 (41)	.044
100% juice	64 (161)	53 (89)	30 (73)	48 (83)	.446
Whole grain, g (SD)	86 (55)	82 (45)	94 (58)	91 (57)	.512
Nuts, g (SD)	3 (8)	12 (36)	7 (13)	11 (25)	.361
Legumes, g (SD)	5 (13)	7 (16)	12 (29)	15 (68)	.284
Fish, g (SD)	32 (35)	50 (49)	40 (49)	56 (54)	.141
Chicken, g (SD)	24 (34)	24 (37)	14 (26)	17 (29)	.230
Red meat, g (SD)	58 (54)	55 (62)	67 (57)	46 (49)	.533
Processed meat, g (SD)	21 (26)	26 (29)	32 (26)	23 (20)	.733
Milk products, g (SD)	322 (168)	343 (196)	306 (232)	303 (193)	.106
Egg, g (SD)	15 (30)	19 (27)	7 (15)	13 (24)	.315
Dietary intake of nutrients					
Vitality, kcal (SD)	1459 (418)	1519 (374)	1578 (456)	1457 (349)	.985
Protein, g BW/d (SD)	0.78 (0.32)	0.89 (0.20)	0.89 (0.32)	0.93 (0.27)	.085
Total fat, g (SD)	60 (21)	65 (23)	67 (28)	59 (19)	.717
SFA (SD)	22 (9)	23 (9)	23 (10)	19 (7)	.200
MUFA (SD)	23 (8)	23 (9)	26 (13)	22 (9)	.920
PUFA (SD)	10 (3)	12 (6)	12 (6)	12 (5)	.463
PUFA/SFA ratio	0.52 (0.16)	0.56 (0.30)	0.58 (0.23)	0.65 (0.23)	.039
Carbohydrates, g (SD)	161 (27)	161 (24)	164 (25)	158 (22)	.879
Sugar, g (SD)	27 (15)	24 (17)	26 (14)	22 (13)	.346
Fiber, g (SD)	19 (7)	19 (5)	21 (9)	21 (9)	.090
Vitamin D, μg (SD)	7 (6)	9 (6)	7 (9)	9 (8)	.435
Vitamin E, mg (SD)	9 (3)	10 (4)	11 (5)	11 (5)	.100
Vitamin C, mg (SD)	75 (66)	79 (41)	71 (51)	82 (49)	.737
Folate μg (SD)	208 (66)	228 (68)	239 (83)	233 (71)	.203
Thiamine, mg (SD)	1.0 (0.4)	1.0 (0.3)	1.0 (0.3)	1.1 (0.4)	.599
Iron, mg (SD)	9 (4)	10 (3)	10 (3)	10 (3)	.327
Zinc, mg (SD)	9 (3)	10 (2)	11 (3)	10 (3)	.344
Calcium, mg (SD)	731 (323)	848 (275)	808 (386)	744 (310)	.774
Magnesium, gm (SD)	273 (76)	285 (63)	305 (90)	301 (82)	.137

PF = Physical function; SD = Standard deviation; PUFA = polyunsaturated fatty acids; SFA = saturated fatty acids; 1Statistical significance of linearity was tested by ANOVA

and less frailty and disability, whereas weight loss increased all the risks (24). It seems though that constant normal weight throughout life course may be the most beneficial for the PF in this population (24).

In line with prior studies, daily walking was associated with higher PF (25). Frailty increases risk of falls and loss of PF, which was also seen in our data as falls were inversely associated with PF. It is well known that poor cognition increases frailty and loss of physical functioning (26). This is logical since people with poor cognition are often frail and

declining cognition is linked to depression and poor quality of life compared to people who are cognitively intact (26). Resilience is a relatively less studied health related factor in older people (12). The relationship between resilience and well-being has been suggested to be intermediated through positive view of the self, the world and the future (27). In a recent study resilience in older adults was associated with health behaviors such as healthy eating and exercise (28). Furthermore, self-rated successful aging was associated with resilience in another recent study in older people (29). Thus, resilience and attitude of overcoming obstacles in later life may also play a factor in avoiding loss of PF.

Strengths and limitations

The strength of this study was a relatively high participation of the oldest old men. There are very few studies with such old participants who actively take part in these types of surveys. The same participants have returned surveys many times before, thus this allows us to link this study to earlier findings of the longitudinal data that been gathered for decades of these participants, which increases the reliability of the results. The strength of the nutrition data was that it was gathered using two diet quality indices along with 3-day food records. The nutrition data was checked and verified by a nutritionist and follow-up calls were made in order to check quantities and kind of food items used by the participants in order to ensure the correctness of nutritional data. A major limitation of the study is its' cross-sectional design which prevents any conclusions about causal relationships to be drawn. Unfortunately not all participants returned food records. They were only received of a sub-group, thus the number of the food records remained relatively low, which prevented their use in the same analysis with the rest of the data.

Conclusions

Diet quality, keeping healthy body weight, cognition, resilience, consuming moderate amounts of alcohol, daily walking habit, and avoiding weight loss seem to be very important factors in maintaining good PF in the oldest old men in this study. Even though our population is unique in their characteristics, interventions planned to increase healthy diet, exercise and resilience may promote healthy aging also in general population of older people.

Key points

- The oldest old men in HBS cohort had higher RAND-36 HRQoL scores than somewhat younger men of general population.
- Diet quality, especially Mediterranean diet adherence score, daily walking, moderate alcohol use, and fat quality were positively associated with RAND-36 HRQoL subscale Physical function (PF) in the oldest old men.
- Body weight, age, blood glucose levels and falls were inversely associated with PF.
- Cognition and resilience were associated with PF

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Conflict of Interest: SKJ: reports no conflict of interest; AU: reports no conflict of interest; KHP: reports no conflict of interest; TES: reports having various educational and consultative cooperation with several companies, including Nutricia, Abbott, Amgen, Merck, Pfizer, Novartis, and Novo-Nordisk; a minor amount of stock in Orion Pharma; and is a board member and former president of executive board of European Union Geriatric Medicine Society which has cooperation also with the nutrition industry.

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