Published in final edited form as:

J Cardiopulm Rehabil Prev. 2018 November ; 38(6): 388–393. doi:10.1097/HCR.0000000000000331.

Dietary Micronutrient Intake of Participants in a “Partners Together in Health” Cardiac Rehabilitation Intervention

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Abstract

Purpose—Current guidelines for cardiovascular health emphasis a “dietary pattern” approach that could be expected to increase intakes of micronutrients in addition to altering the macronutrient profile. However, the effect of interventions such as cardiac rehabilitation (CR) on the micronutrient quality of the diet has not been evaluated. Therefore, the goal of this study was to investigate changes in micronutrient intake of CR participants over time.

Methods—This was a secondary analysis of data from a randomized clinical trial that assessed the effects of the Partners Together in Health (PaTH) Intervention on physical activity and healthy eating behaviors. The intake of 9 micronutrients important in cardiovascular health was assessed from 3-day food records. A Micronutrient Adequacy Score was evaluated at 3 time points (baseline, 3 and 6 months). Changes over time in micronutrient intake were assessed using a general linear model.

Results—68 participants who were enrolled in the PaTH interventional trial completed the study. There was no difference in the mean micronutrient score at any time point ($p=0.55$). Intake of individual micronutrients did not improve over the 6 month time frame with the exception of vitamin E, (8.7 mg vs. 6.5 mg for at 6 vs. 3 months, $p=0.02$). The proportion of participants with intakes meeting the Dietary Recommended Intake for each nutrient also remained the same over time.

Conclusion—Although CR programs may be effective in altering the macronutrient composition, improvements to overall diet quality may be tempered by a lack of improvement in intake of micronutrients.

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Conflict of interest: The authors declare no conflicts of interest.

Keywords

micronutrients; diet; cardiac rehabilitation

Introduction

Cardiovascular disease (CVD) remains the leading cause of morbidity and mortality for men and women in the United States and worldwide¹ and produces an immense health and economic burden. More than 2200 Americans die of CVD each day, and average of 1 death every 40 seconds.² For 2011–2012, the estimated annual costs for CVD were \$316.6 billion, making CVD the most costly of any diagnostic group.²

Nutrition and diet have long been recognized to play an important role in the development and progression of CVD. Suboptimal diet quality is a leading risk factor for death and disability in the U.S.² In 2010, an estimated 58,000 annual CVD deaths were attributable to sodium intake >2.0 g/d, representing 1 in 16 (6.3%) of all CVD deaths and 1 in 8 (13.1%) CVD deaths before age 70 years.² Currently, dietary strategies to manage CVD focus on a “dietary pattern” approach,³ such as the Dietary Approaches to Stop Hypertension (DASH) diet.⁴ One of the hallmarks of the DASH diet is the focus on nutrient dense foods such as fruits, vegetables, whole grains, low fat dairy, and nuts,^{3–5} therefore education regarding this type of diet pattern during CR programs could be expected to alter the intake of micronutrients in the program participants.

Often, the emphasis in cardiovascular disease is on the dietary composition of macronutrients, such as fats.^{3,6} Several investigators reported improvements in dietary fat and cholesterol intake as a result of intensive nutritional education, counseling, and behavioral interventions.^{7,8} While macronutrient composition is important, it is only part of the many factors in an optimal diet to prevent CVD. Micronutrients, including vitamin E and vitamin C, have been associated with improvements in atherosclerosis.^{9,10} Folate and B6 have been associated with nonfatal cardiac infarction and fatal heart disease,¹¹ and potassium intake has been shown to enhance the effects of a low sodium diet on hypertension.⁴ While micronutrients can be evaluated individually, scoring systems such as a “total micronutrient adequacy score” can be used in order to reflect changes in overall quality of the diet.¹²

Previous research has shown that couple-focused interventions during CR can offset the decline in dietary adherence often seen 6 months after CR in regards to macronutrient intakes,¹³ however; little is known about the impact of CR education on micronutrient intake. Current reports by the American Heart Association estimate that among U.S adults, the prevalence of healthy diet patterns is only 1.5%,² therefore educational programs such as CR that have the potential to improve measures of overall diet quality could have a profound impact. Therefore, the goal of this study was to investigate the micronutrient intake of patients during CR, and the impact of a strategy designed to increase adherence to dietary recommendations.

Methods

Study Population

This is a secondary analysis of micronutrient intake in participants who were enrolled in the Partners Together in Health (PaTH) Intervention on physical activity and healthy eating behaviors study.^{13,14} Briefly, the original study enrolled 34 patients and their partners, for a total of 68 individuals. Patients were enrolled in a CR program after coronary artery bypass graft (CABG) surgery. After IRB approval and informed consent, couples were randomly assigned to either the PaTH intervention group or a usual care (UC) group. The PaTH intervention group included spousal caregivers who joined their partner in CR, including exercise sessions and education classes to undertake comprehensive risk reduction for themselves. Caregivers in the control group were invited to attend the educational sessions with the patient. Further details on the methods of the parent study, including the conceptual base and randomization procedures, are described elsewhere.^{13,14} Although the initial study design was two treatment groups, all patients were combined into one group for this analysis of intakes of micronutrients.

CR program

Two clinical sites, a community hospital and an academic medical center, were the CR program sites for this study. Patients in both CR programs received similar CR elements in that they were provided with individualized counseling, education, goal setting in relation to life style changes (i.e., exercise regularly, eat low fat diet, lose weight, etc.), and feedback about progress towards goals at regular intervals. Both CR programs were nationally certified by the AACVPR (<https://www.aacvpr.org/Certification/>) indicating standardized program elements. Specific diet goals negotiated with CR participants were: 25–35% of total calories as fat; < 5–6% saturated fats; < 200 mg/d cholesterol; 20–25 g/day of soluble fiber, and < 2500 mg/day of sodium if normal blood pressure or < 1500 mg/d if hypertensive³.

Measures

3-day food record were used to assess intake and changes in eating behavior at three time points: baseline (the start of CR), 3 months (post-CR), and 6 months. Three day diet records are a well-accepted measure of dietary intake.^{15,16} The participant recorded all food and beverages consumed on 3 typical days including two weekdays and one weekend day. Participants were asked to describe in as much detail as possible their food intake, recording ingredients, name brands, and portion sizes. Portion sizes were estimated based on standard household measures and the use of food pictures depicting portion sizes was provided to each participant. Dietary intake data was then analyzed using Nutrition Data System for Research (NDSR) 2007 software, which provides a complete nutrient profile for all foods in the database.

A Micronutrient Adequacy Score,^{12,17} ranging from 0–9, was calculated for nine micronutrients that have been identified as important in the prevention and management of cardiovascular disease. Micronutrients of interest were chosen based on the literature and the Academy of Nutrition and Dietetics Evidence Analysis Library.^{18–24} These nutrients included vitamins C, E, A, B₁₂, B₆, folate, sodium, potassium and magnesium. The criteria

for assigning one point was meeting or exceeding the Dietary Recommended Intake (DRI); zero points were assigned if the participant did not meet the DRI for that nutrient. For sodium, one point was given for maintaining a level under the established Adequate Intake (AI) level, and zero points for exceeding the AI. The Recommended Dietary Allowance (RDA) was used when a nutrient level had been established; if no RDA had been established, the AI was used. Recommended Dietary Allowances are set to meet the needs of almost all (97 to 98 percent) individuals in a group, while the AI for life stage and gender groups is believed to cover the needs of all individuals in the group, but lack of data prevents the ability to specify with confidence the percentage of individuals covered by this intake. The baseline Micronutrient Adequacy Score was compared with the score at 3 and 6 months for both the control and intervention groups. Intakes of the 9 micronutrients were also evaluated individually, as well as the proportion of participants who met the DRI at each time point.

Statistical Analysis

Descriptive statistics were calculated for all variables. Both the micronutrient score and the components of the micronutrient score were compared by visit (baseline, 3 months, and 6 months) and group. A general linear mixed model was used to evaluate the change in mean micronutrient intakes and the change in proportion of participants achieving RDA over the three visits with random effects for both pairs and individuals. Participants were analyzed as individuals not as pairs, however the correlation between partners and the correlation between visits was accounted for in the modeling. If the overall p-value was significant, Tukey's method was used for pairwise comparisons. A general linear mixed model was also used to determine if the mean micronutrient adequacy score differed based on month of visit or group assignment. The model allowed the comparison of score between visit, group and the interaction of group and visit. A p-value of <0.05 was considered statistically significant. SAS version 9.4 (SAS, Cary, NC, USA) was used for all statistical analyses.

Results

Sixty-eight individuals (34 couples) completed the study. Patients were, on average, 61.7 ± 10.3 years of age; partners were 59.5 ± 11.6 (see Table 1). The majority of the couples were married, Caucasian, employed, had two years of college education, and an annual household income between \$30–70,000. In relation to CR, patients in both groups demonstrated very good adherence to both exercise (94.4%) and educational (81.6%) sessions. Partners in the PaTH group also demonstrated high adherence to the exercise sessions (89.4%). Across all partners, adherence to the educational sessions was lower for partners (73.6%) than for patients. The baseline characteristics of the patients and their partner is shown in Table 1.

Micronutrient Adequacy Score

The mean micronutrient adequacy scores at baseline for the control and experimental groups were $3.91 (\pm 1.31)$ and $4.41 (\pm 1.54)$, respectively, out of 9 possible points. At 3 months, the mean micronutrient score for the control was $4.09 (\pm 1.82)$ and for the experimental group was $4.03 (\pm 1.42)$. After 6 months, the mean score was $4.29 (\pm 1.77)$ for the control, and 4.26

(± 1.78) for the experimental group. There was no statistically significant interaction of visit time and group with respect to the mean micronutrient score ($p=0.32$). This implies that the change in mean micronutrient score over the 3 time points did not differ based on group. Overall, there was no difference in the mean micronutrient score based on group ($p=0.70$) or time of visit ($p=0.55$) (Figure 1). There was also no difference in micronutrient intake between patients and partners.

Intake of individual micronutrients

Although the initial study design was two treatment groups, because there were no statistically significant differences in changes over time between groups, all patients were combined into one group for the analysis of intakes of the 9 individual micronutrients included in the study. There was no difference in the mean intake of any of the 9 micronutrients evaluated at any time point (Table 2) with the exception of vitamin E, which was higher at the 6-month time point (8.7 mg) when compared to the 3 month time point (6.5 mg) ($p=0.02$). The proportion of participants who met the DRI for each nutrient evaluated also did not change over the course of the study (Table 3).

Discussion

This study showed no evidence of either CR or a couples focused intervention significantly influencing micronutrient intake in participants or their partners. There appears to be little difference in either micronutrient intake or the proportion of individuals meeting the RDA or AI during or after CR in a population with good adherence to the program.

We chose to focus exclusively on micronutrients in this study as the impact of CR on micronutrient intake of the participants has not previously been reported, yet the micronutrient profile of the participants could be hypothesized to improve if compliance with current CVD dietary guidelines increases. A Micronutrient Adequacy Score has previously been used as a measure of dietary quality. Murray et al. in Ireland used a similar score to assess diet quality in patients with type 2 diabetes in Ireland.¹² Using a scoring system of 1 point for meeting or exceeding the RDA and 0 for not meeting the RDA, 8 micronutrients were assessed. Their findings showed that patients with type 2 diabetes had significantly lower micronutrient intake scores compared to the non-diabetic control group.¹² Using the same scoring system, Sodjinou et al. assessed 14 micronutrients in the diets of people in the African country of Benin.²⁵ While there was no difference in Micronutrient Adequacy Score between those following a “traditional” rural African diet and the “transitional” or more urban diet, an association was found between increased vegetable intake and higher Micronutrient Adequacy Score.²⁵ In 2007, Desilets et al used a micronutrient adequacy score as a measure of diet quality of migrant Haitians living in Montreal, Canada.¹⁷

The 2013 Guideline on Lifestyle Management to Reduce Cardiovascular risk emphasizes dietary patterns rather than individual dietary components.³ Other organizations such as the Academy of Nutrition and Dietetics, support a “total diet” approach.²⁶ Interventional studies and population-based prospective cohorts suggest that there are healthier overall dietary patterns that are associated with lower risk of chronic disease. Two of these diet patterns, the

DASH diet and the Mediterranean diet, are both well-studied for their role in preventing heart disease.^{4,6} Both of these diet patterns emphasize intake of fruits, vegetables, and nuts. As the core components of these diet patterns are high in micronutrients, it could be hypothesized that increased compliance with a healthy dietary pattern during CR would be reflected in an increased intake of micronutrients.

One possible exception to the “total diet” approach may be sodium. While increasing intake of fruits, vegetables, fish, legumes, and low fat dairy products could result in a decreased sodium intake,³ at this time specific recommendations for sodium for the prevention of hypertension do exist. Unlike the other nutrients included in this study, restrictions of sodium intake are often necessary and can prove beneficial. Sodium restrictions to below the AI have been shown to reduce rates of high blood pressure and improve fluid balance. A well-conducted trial by Sacks et al demonstrated clinically meaningful lowering of blood pressure when sodium was reduced to 2,400 mg/d, with even lower blood pressures achieved when sodium intake was reduced to 1,500 mg/d.⁴ Regardless of overall intake, reductions in sodium intake of 1,000 mg/day have shown significant reductions in risk of hypertension.²⁷ This recommendation is relevant for participants in CR programs, for whom reducing sodium intake can prevent or improve control of hypertension and potentially reduce cardiovascular events. However, no reduction in sodium intake was seen in the participants in our study. The Adequate Intake value for sodium set by the Institute of Medicine is currently 2,300 mg/day, which differs slightly from the levels 2,400 mg/day reported to be beneficial in the Sacks study,⁴ however; the impact on behavior to support an intake of 2,300 mg a day vs. 2,400 mg a day may be minimal. Our findings taken in context with recent reports of excess sodium intake being the leading cause of diet-related cardiometabolic deaths²⁸ suggest that sodium should be a key target of CR programs.

An additional consideration is that dietary factors may be interrelated and modifiable by each other. For example, increasing intakes of potassium may increase or enhance the beneficial changes seen from decreasing sodium, possibly due to potassium’s role in increasing the excretion of sodium. In the DASH-sodium trial, the effects of the DASH dietary pattern and low sodium had significant, additive effects on blood pressure.⁴ It is concerning, therefore, that not only did potassium intake in our population remain steady over time, the mean intake of potassium was well below the DRI, with only 1–3% of the cohort meeting the AI level at any of the time points.

Three of the nutrients included in this study (vitamin A, vitamin E, and vitamin C) have powerful anti-oxidant properties. Although the research on the use of antioxidant vitamin supplements for the prevention of CVD is not uniformly positive, a substantial body of work suggests that diets high in anti-oxidants, such as vitamin A, C, and E, are all associated with decreased risk of coronary heart disease.^{9,10,29,30} Notably, a recent study reported that diets low in vitamin E may increase the harmful effects of tobacco smoke on cardiovascular disease.³¹ In our study, vitamin E intake was the only nutrient that demonstrated a change over time, with intakes at six months being significantly higher than intakes 3 months. The epidemiologic evidence relating fruit and vegetable intake to a reduction in CAD may be explained, at least in part, by the antioxidant content of these foods and the role of these antioxidants in preventing oxidative changes to low-density lipoproteins (LDL).³² A 2017

study estimated that when looking at 10 different dietary factors, low intake of nuts and seeds accounted for 59,374 (8.5%) of cardiometabolic deaths, second only to high sodium intake. Among cardiometabolic diseases, the largest number of heart disease deaths were due to low intake of nuts/seeds (54,591 deaths, 14.7% of total deaths).²⁸ As nuts and seeds are high in vitamin E,³³ it is possible that our cohort increased consumption of nuts/seeds during CR. This finding would be consistent with national trends that show that fewer diet-associated proportional deaths were related to insufficient nuts and seeds, however this is not seen in less-educated individuals.²⁸ It is also possible, however; that this increase in vitamin E intake seen in our cohort is accounted for by a switch to vegetable oils, which are higher in vitamin E than solid butter or margarines, and is a commonly recommended dietary change in CR. This would also be supported by an increase in vitamin E intake but not in magnesium intake in our cohort, as nuts, but not vegetable oils, are also high in magnesium.

Folate, vitamin B12, and vitamin B6 have been studied in regard to the primary prevention of CHD and heart failure.^{11,34} The mechanism behind these associations remains unclear. Early studies hypothesized that the benefit of these nutrients could be related to decreases in serum homocysteine levels, which has atherogenic properties.³⁵ More recent studies, however, have suggested that B-vitamins may influence CHD through more complex mechanisms involving both genetics and epigenetics.^{36,37} Folic acid and B6 supplementation has been shown to reduce a variety of risk factors in MI patients when used in combination with fish oil and oleic acid in men enrolled in a CR program,^{38,39} and population-based studies have shown a decrease in the overall birth prevalence of congenital heart abnormalities since the initiation of food fortification with folic acid,³⁶ providing some evidence of benefit of these nutrients.

Limitations

Our study does have several limitations, including the relatively small sample size, the predominantly Caucasian sample, and self-report of eating behavior. We know individuals tend to underestimate dietary intake; yet most current methods of measuring eating behavior are via self-report.

A substantial portion of CAD deaths are due to suboptimal diet and poor diet quality. Although CR programs may be effective in altering dietary macronutrient composition, improvements to overall diet quality may be tempered by the inability of these programs to increase intake of micronutrients. Further research on interventions improve intakes of foods high in vitamins and minerals during CR could significantly improve diet quality and cardiovascular health.

Acknowledgments

The authors have no conflicts of interest to disclose

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Figure 1. Micronutrient Adequacy Scores shown by visit and by intervention group. There was no difference in micronutrient adequacy score based on group ($p=0.70$) or time of visit ($p=0.55$).

Table 1Baseline Demographics of Participants^a

	Patients (n = 34)	Partners (n = 34)
Age, y	61.7 ± 10.3 (33–77)	59.5 ± 11.6 (29–76)
Education, y	14.6 ± 2.4 (9–17)	14.1 ± 2.3 (8–17)
CR, % adherence		
Exercise sessions	94.4 ± 14.2 (33–100)	89.4 ± 15.1 (50–100) ^b
Educational sessions	81.6 ± 3.7 (39–100)	73.6 ± 32.9 (0–100)
Number of bypass grafts	3.5 ± 1.1 (1–5)	n/a
Ejection fraction, %	55.9 ± 6.9 (37.5–67.5)	n/a
Sex		
Male	28 (82)	5 (15)
Female	6 (18)	29 (85)
Race		
White	32 (94)	32 (94)
Married	32 (94)	n/a
Employment status		
Working	24 (71)	20 (59)
Retired/not working	10 (29)	14 (41)
Household income		
<\$30,000 annually	3 (9)	
\$30–70,000 annually	18 (53)	n/a
>\$70,000 annually	13 (38)	

Abbreviations: CR, cardiac rehabilitation; n/a not applicable.

^aData reported as mean ± standard deviation (range) or number (%).

^bPercent adherence to exercise sessions only calculated in partners in PaTH intervention group.

Table 2Mean Micronutrient Intake of Participants at Each Time Point^a

	Baseline (n = 66)	3-mo Visit (n = 66)	6-mo Visit (n = 68)	P Value
Vitamin C, mg RDA: M: 90 mg; F: 75 mg	95.0 ± 55.9	82.5 ± 47.8	91.5 ± 62.1	.13
Vitamin E, mg RDA: 15 mg	7.2 ± 5.7	6.5 ± 3.3	8.7 ± 6.7	.02 ^c
Vitamin A, µg RAE RDA: M: 900 µg RAE; F: 700 µg RAE	694.5 ± 262.9	656.7 ± 297.5	674.1 ± 273.8	.66
Vitamin B12, mcg RDA: 2.4 mcg	5.7 ± 6.3	4.2 ± 1.6	4.6 ± 2.2	.08
Vitamin B6, mg RDA: M: 1.7 mg; F: 1.5 mg	1.9 ± 0.62	1.8 ± 0.5	2.1 ± 0.9	.07
Folate, mcg RDA: 400 mcg	509.7 ± 137.1	493.0 ± 205.5	527.7 ± 243.8	.53
Potassium, mg AI: 4700 mg ^b	2525.8 ± 705.3	2501.6 ± 689.3	2553.9 ± 822.2	.82
Sodium, mg AI: 2300 mg ^b	2715.1 ± 821.6	2778.0 ± 1001.6	2829.6 ± 1007.3	.59
Magnesium, mg RDA: M: 420 mg; F: 320 mg	265.2 ± 78.6	267.1 ± 73.5	272.3 ± 81.3	.70

Abbreviations: AI, adequate intake; F, females; M, males; RAE, retinol activity equivalents; RDA, Recommended Dietary Allowance.

^aData reported as mean ± standard deviation.^bNo RDA established; AI used instead.^cBased on comparison of 3-mo vs 6-mo visits.

Table 3Proportion of Participants Meeting the DRI for Each Nutrient at Each Time Point^a

	Baseline	3-mo Visit	6-mo Visit	<i>P</i> Value
Vitamin C RDA: M: 90 mg; F: 75 mg	47.0	42.4	42.7	.77
Vitamin E RDA: 15 mg	3.0	4.5	10.3	.18
Vitamin A RDA: M: 900 µg RAE; F: 700 µg RAE	31.8	27.3	30.9	.85
Vitamin B12 RDA: 2.4 mcg	83.3	90.9	88.2	.41
Vitamin B6 RDA: M: 1.7 mg; F: 1.5 mg	77.3	63.6	67.6	.18
Folate RDA: 400 mcg	62.1	63.6	70.6	.53
Potassium AI: 4700 mg ^b	1.5	1.5	2.9	n/a ^c
Sodium AI: 2300 mg ^b	100	100	100	n/a ^c
Magnesium RDA: M: 420 mg; F: 320 mg	10.6	13.6	17.6	.42

Abbreviations: AI, adequate intake; DRI, Dietary Recommended Intake; F, females; M, males; n/a, not available; RAE, retinol activity equivalents; RDA, Recommended Dietary Allowance.

^a All data reported as percentage.

^b No RDA established; AI used instead.

^c Too few individuals achieved the DRI to allow for calculation of a *P* value.