The effectiveness of a targeted education intervention to increase protein intake in people with CHD: a pilot feasibility randomised controlled trial

JAMES, Emily <http://orcid.org/0000-0002-3032-9662>, DAS, Rajiv, BROWNSON-SMITH, Rosiered, RICKELTON, Estelle, GOODALL, Stuart, NICHOLS, Simon <http://orcid.org/0000-0003-0377-6982> and O'DOHERTY, Alasdair F.

British Journal of Nutrition

cambridge.org/bjn

The effectiveness of a targeted education intervention to increase protein intake in people with CHD: a pilot feasibility randomised controlled trial

Emily James[1,2,3], Rajiv Das[4], Rosiered Brownson-Smith[3,5], Estelle Rickelton[4], Stuart Goodall[3], Simon Nichols[6,7] and Alasdair F. O'Doherty[3,8]

[1]Diabetes Research Centre, University of Leicester College of Life Sciences, UK; [2]NIHR Leicester Biomedical Research Centre, UK; [3]School of Sport Exercise and Rehabilitation, University of Northumbria at Newcastle, UK; [4]Freeman Hospital, Newcastle upon Tyne Hospitals NHS Foundation Trust, UK; [5]Newcastle University, Faculty of Medical Sciences, UK; [6]Centre for Cardiovascular Health, Edinburgh Napier University, UK; [7]Advanced Wellbeing Research Centre, Sheffield Hallam University, UK and [8]Department of Sport and Exercise Sciences, Durham University, UK

Research Article

Cite this article: James E, Das R, Brownson-Smith R, Rickelton E, Goodall S, Nichols S, and O'Doherty AF (2026). The effectiveness of a targeted education intervention to increase protein intake in people with CHD: a pilot feasibility randomised controlled trial. *British Journal of Nutrition*, page 1 of 9. doi: 10.1017/S0007114526107235

Received: 27 May 2025
Revised: 20 March 2026
Accepted: 10 April 2026

Keywords:
Cardiac rehabilitation; CHD; Dietary education; Dietary intake; Protein

Abbreviations:
CG, control group; CR, cardiac rehabilitation; PG, protein group

Corresponding author:
Emily James; Email: e.james@leicester.ac.uk

Abstract

Low protein intake is prevalent in people with CHD and is inadequately addressed in UK-based cardiac rehabilitation. This pilot feasibility study aimed to identify whether targeted education increases protein intake in patients with CHD and low protein intake, compared with standard cardiac rehabilitation dietary education. People referred to cardiac rehabilitation with CHD (≥ 50 years) underwent anthropometric assessment and completed a food diary, sit-to-stand test and three questionnaires (physical activity, sarcopenia screening and nutrition knowledge). Participants with low protein intake (≤ 1·2 g/kg per d) were randomised to receive either extra protein education (intervention; protein group) or standard education (control; control group), embedded within their usual 6-week cardiac rehabilitation programme. At 6 and 12 weeks, outcome measures were repeated; thirty-four participants provided baseline data. Protein intake was inversely associated with waist circumference ($r = -0{\cdot}348$). Twenty-seven participants (79 %) with low protein intake were randomised to the protein group (n 15) or control group (n 12). At week 6, the median (interquartile range) change in protein intake was 0·0 (−0·0–0·3) and 0·4 (0·2–0·5) g/kg per d in the protein group and control group, respectively (effect size 0·5). At week 12, the change in protein intake was 0·0 (−0·0–0·1) and −0·0 (−0·2–0·2) g/kg per d in the protein group and control group, respectively (effect size 0·3). Effect sizes for all other variables were ≤ 0·4. The intervention appeared well-received by those who completed the study; however, changes to primary and secondary outcomes were minimal. Uptake of the study was low, and attrition was high, limiting the interpretation of efficacy and the implementation of a definitive trial.

Dietary education in UK-based cardiac rehabilitation (CR) is most frequently delivered in two group-based or individual classes and largely reflects the current consensus of the cardioprotective diet[1]. The Mediterranean-style diet and dietary approaches for the management of overweight and obesity, dyslipidaemia and hypertension are strongly advocated in the educational content of UK-based CR[1]. Education of this nature can elicit positive dietary modification in people with CHD. Dietary education as part of, or in addition to, core CR has been shown to increase participants' intake of fruits, vegetables and fish and successfully modify fat and/or carbohydrate intake in accordance with the education given[2–4].

Few studies have investigated the effect of targeted dietary education on modifying protein intake in people with CHD. Adequate protein intake (> 1·2 g/kg body mass, for people with a chronic long-term condition[5,6]) supports preservation of lean mass and physical function[7]. This is particularly important in cohorts, such as those with CHD, where weight loss is often encouraged, but is caveated with the need to minimise loss of lean, as opposed to adipose tissue[8]. Low lean mass[9] and related pathologies (e.g. frailty[10] and sarcopenia[11]) are common and worsen prognosis in people with CHD. We recently showed that education concerning the importance of dietary protein intake is a low priority in UK-based CR and warrants increased focus[1]. Given that targeted education interventions can initiate favourable changes to dietary intake[2–4], evidence-based interventions designed to increase protein intake could be useful adjuncts to standard CR.

This pilot randomised controlled trial was primarily aimed at assessing whether a targeted education intervention, designed to increase protein intake in people with CHD, can be implemented as an adjunct to a standard 6-week CR programme. Secondary aims were to (1) identify the prevalence of low protein intake in CR attendees with CHD, (2) identify whether

protein intake was different based on poor physical function and (3) identify the intervention effect on sit-to-stand ability and risk of sarcopenia. The findings of this pilot study are intended to inform a definitive, adequately powered study.

Methods

Study design

This single-centre, parallel-group, two-arm pilot randomised controlled trial was implemented as an adjunct to a standard CR programme, using a pragmatic study design. The trial is conducted and reported in accordance with the Consolidated Standards of Reporting Trials 2021 statement: extension to randomised pilot and feasibility trials[12]. Volunteers provided baseline data at the start of their 6-week CR programme. Those with protein intake < 1·2 g/kg per d were randomised to an intervention protein group (PG) or a control group (CG). Intervention endpoint and follow-up data were collected post-6 and 12 weeks. Study activities were predominantly undertaken in person, with remote options available if participants preferred.

Patient and public involvement

Feedback on the study design and study documents was provided by members of the Public Involvement in Research Group at the Sheffield Hallam University Advanced Wellbeing Research Centre prior to submission for Research Ethics Committee (REC) review. Feedback from the public involvement group was considered, and the study was amended as appropriate. For example, some sections of the patient-facing documents were reworded to ensure that they were easily understood by a lay audience.

Cardiac rehabilitation

Study participants were recruited from three community-based CR programmes in Newcastle-upon-Tyne, UK, after referral from primary care. The CR programme involved twelve core sessions, ideally attended twice per week over 6 weeks or over a longer time as needed. All sessions involved supervised, circuit-based exercise (45 min), combining both aerobic and resistance exercises. Six of twelve sessions were supplemented with 1 h of education about CHD secondary prevention, including one dietitian-led nutritional education session based around the Eatwell Guide[13]. The six education sessions were delivered cyclically by relevant healthcare professionals. New patients attended the CR centres weekly to start their 6-week programme due to a rolling referral process from primary care. Accordingly, each patient received their standardised dietitian-led nutritional education session at a different point in their 6-week course.

Intervention

Eligible participants were assigned an alphanumeric code and randomised (1:1) to the PG or CG. The allocation sequence was generated a priori by a member of the research team using RAND, ROUNDUP and RANK spreadsheet functions (MS Excel).

The intervention consisted of one pre-recorded dietary education session lasting ~20 min, in addition to (and mimicking the current embedded delivery of) the dietary education session received as part of the standard CR programme. The intervention either summarised the information provided in core CR dietary education (CG) or contained targeted information designed to educate participants on how to increase and improve the quality of their dietary protein intake (PG). The PG intervention explained the advantages of increasing protein intake, presented target protein intake by body weight and provided example daily menus. The content was aligned with UK Government dietary guidance[13] and our understanding of the cardioprotective diet, with emphasis on incorporating sufficient and varied sources of high-quality protein (defined as having a Digestible Indispensable Amino Acid Score of ≥ 75 %[14]). The format of delivery replicated how the core dietary education session was delivered, in terms of being instructor led with an opportunity for the participant to ask questions about their learning. However, the educational content was pre-recorded to ensure intervention consistency between participants. In accordance with the pragmatic study design, the intervention length was kept to approximately 20 min to avoid excessive participant burden and allow the intervention to be embedded within the current CR resource (i.e. delivered at the location of the existing CR sessions and during a time that clinical CR staff were present).

Creation of the education sessions was multistage. We collaboratively updated the currently used dietary education material in accordance with the British Association for Cardiovascular Prevention and Rehabilitation's recommended practices. Using this material as a template, new educational material for the PG was created. Several iterations of the material were reviewed by members of the research team, an National Health Service (NHS) dietitian and CR co-ordinators before final approval of all co-authors. Participants watched their assigned pre-recorded education session via a laptop at their usual CR session or were emailed a web link to access the video remotely during their first week of the CR programme. This was intended to give the participants the greatest opportunity possible to make behavioural changes. Where the participant accessed the video remotely, verbal confirmation was requested that this had been completed. The participant was also asked to briefly summarise their learning to a researcher.

Participants

We included people, ≥ 50 years, enrolled in standard CR with a dietary education component, following a recent clinical diagnosis of CHD or related cardiac event. Pronounced declines in muscle mass (1–2 % per year) and strength/function (1–5 % per year) occur after 50 years of age[15]; accordingly, this cohort was considered to be likely to attain the greatest benefit from an intervention designed to increase protein intake. All participants provided written informed consent. Potentially eligible participants were initially identified by the existing cardiac care team before being provided with study information. After at least 24 h, participants provided their informed consent to participate and began recording their dietary intake in a 3-d food diary at home. Those with protein intake < 1·2 g/kg per d at baseline assessment were eligible for the intervention, chosen as expert groups recommend a target protein intake of at least 1·2 g/kg per d for older adults with chronic diseases[5,6]. Exclusion criteria included a contraindication to light exercise, being medically unable to alter their diet and known stage 4 or 5 chronic kidney disease.

Study procedures

Baseline data were collected at the start of the CR programme. Initial follow-up was completed ideally 6 weeks from baseline assessments; this was adjusted as needed to align with the participant finishing their core CR programme. Additional follow-up

assessments were conducted 6 weeks after completion of the CR programme (12 weeks).

Anthropometry

Stature (m), body mass (kg) and waist circumference (cm) were measured by an exercise instructor or cardiac nurse during the standard induction of people joining the CR programme.

Dietary intake

A 3-d food diary (two weekdays and one weekend day) was completed at home, while participants maintained their usual diet. Written instructions and an example food diary entry were provided, including instructions to specify the volume, frequency and brand names of all food and drinks consumed. A researcher obtained any missing details from the food diary during discussions with participants. Analysis of energy and macronutrient content of common foods is similar between researcher-led weighed portion analysis and participant-reported estimated food diaries (CV for protein content: 10·7 %)[16]. Reliable quantification of macronutrient consumption can be obtained with 3 d of food diary data ($r = 0{\cdot}8$)[17]. Based on a within-person CV of 12 % for daily protein intake based on weighed 3-d dietary records[18], to detect a 15 % change in an individual's protein intake between repeated diaries with 95 % confidence, 2–3 d of diet reporting are sufficient[19].

Questionnaires

The Physical Activity Vital Signs questionnaire asks: (1) How many days during the past week have you performed physical activity where your heart beats faster and your breathing is harder than normal for 30 min or more? And (2) How many days in a typical week do you perform activities like this?[20] The SARC-F + EBM uses self-reported signs of indicative sarcopenia, age and BMI to generate a sarcopenia risk score, where ≥ 12 points indicates risk of sarcopenia[21].

Participants completed a researcher-developed questionnaire (online Supplementary Material 1), comprising a five-point Likert scale response to the statement 'I feel like I have a good understanding of how the food I eat can affect my health' and a list of thirteen foods from which to identify good protein sources. Feedback on the intervention was requested at week 6.

Sit-to-stand test

Participants completed five successive chair stands as quickly as possible using a chair with a standard seat height and a straight back. Inability to complete five repetitions in ≤ 15 s indicates probable sarcopenia[22].

Statistical analyses and justification of sample size

Food diary data were inputted into dietary analysis software (Nutritics Professional Plus v5·81, 2022) by one researcher. Total energy (kcal/d), macronutrient and micronutrient values collected over 3 d are presented as average intake per d. Macronutrient intakes were corrected for body mass. RMR was estimated using the Mifflin-St Jeor equation[23].

Statistical analyses were performed using SPSS (SPSS IBM Corp, Version 27.0). Given the modest sample size, non-parametric methods were used for all analyses. Variables are reported as frequency (percentage) or median (25th, 75th percentile). Demographic characteristics are stratified by baseline protein intake (≥ 1·2 or < 1·2 g/kg per d). Associations between protein intake and variables of interest were calculated using Spearman's rank correlations. Due to missing data, descriptive statistics are reported with the number of participants for individual variables. The median change between timepoints is reported for the PG and CG (complete cases) for dietary intake, sit-to-stand performance and sarcopenia risk score. Effect sizes are reported, defined as small (0·2), medium (0·5) and large (0·8) effects[24]. Due to a lack of statistical power and consistent with the Consolidated Standards of Reporting Trials guidance for reporting pilot trials, *P*-values are not reported[25].

Pilot studies require a minimum of twenty-four participants[26]. Anticipating 20 % attrition at follow-up, we aimed to recruit thirty participants with low protein intake (fifteen per group) over 12 months. We previously identified protein intakes < 1·2 g/kg per d in 70 % of people with CHD (James *et al.*, unpublished data). Accordingly, we estimated that screening approximately forty-three patients at baseline would be sufficient to meet the intended sample size.

Missing data

To facilitate the calculation of the primary outcome (protein intake (g/kg per d)), we used the last observation carried forward for the missing follow-up body mass values. For transparency, we also present absolute changes in protein intake without data imputation. All other variables underwent complete case analysis.

Results

Between February 2022 and July 2023, ninety-five people were approached to participate in this study (Figure 1). Baseline data were provided by thirty-four consenting participants (35·7 % uptake); twenty-seven (79·4 %) had low protein intake and were randomised to the PG (*n* 15) or CG (*n* 12). One participant chose to view the educational video remotely. No other study activities were completed remotely.

Baseline demographics

Table 1 shows baseline characteristics. Baseline protein intake (g/kg per d) was associated with waist circumference ($r = -0{\cdot}348$, $P = 0{\cdot}044$; *n* 34) but not sit-to-stand time ($r = 0{\cdot}029$, $P = 0{\cdot}878$; *n* 31) or age ($r = 0{\cdot}189$, $P = 0{\cdot}285$; *n* 34).

Four participants (three in the low protein group (PG)) were unable to complete the sit-to-stand test unaided (median protein intake 0·87 g/kg per d). Twenty-nine participants who completed the test did so in < 15 s. Three (8·8 %) participants scored ≥ 12 points on the SARC-F + EBM questionnaire, of which one had a protein intake < 1·2 g/kg per d.

Intervention effect and evaluation

Table 2 shows a complete case analysis of the intervention effect. Variables of interest for all cases are presented in online Supplementary Table S1. Baseline median dietary protein intake was lower in the CG (0·7 (0·5–0·8) g/kg per d) than the PG (0·9 (0·7–1·1) g/kg per d). Individual data points are shown in Figure 2.

At week 6, the median change in protein intake was 0·0 (−0·0–0·3) and 0·4 (0·2–0·5) g/kg per d in the PG and CG, respectively (medium effect size: 0·5). At week 12, there was no change in protein intake in either group Figure 2(a) and (b). Effect sizes between groups for all other variables were small to medium. Participants considered the educational information to be new to them (38 %), helpful (100 %),

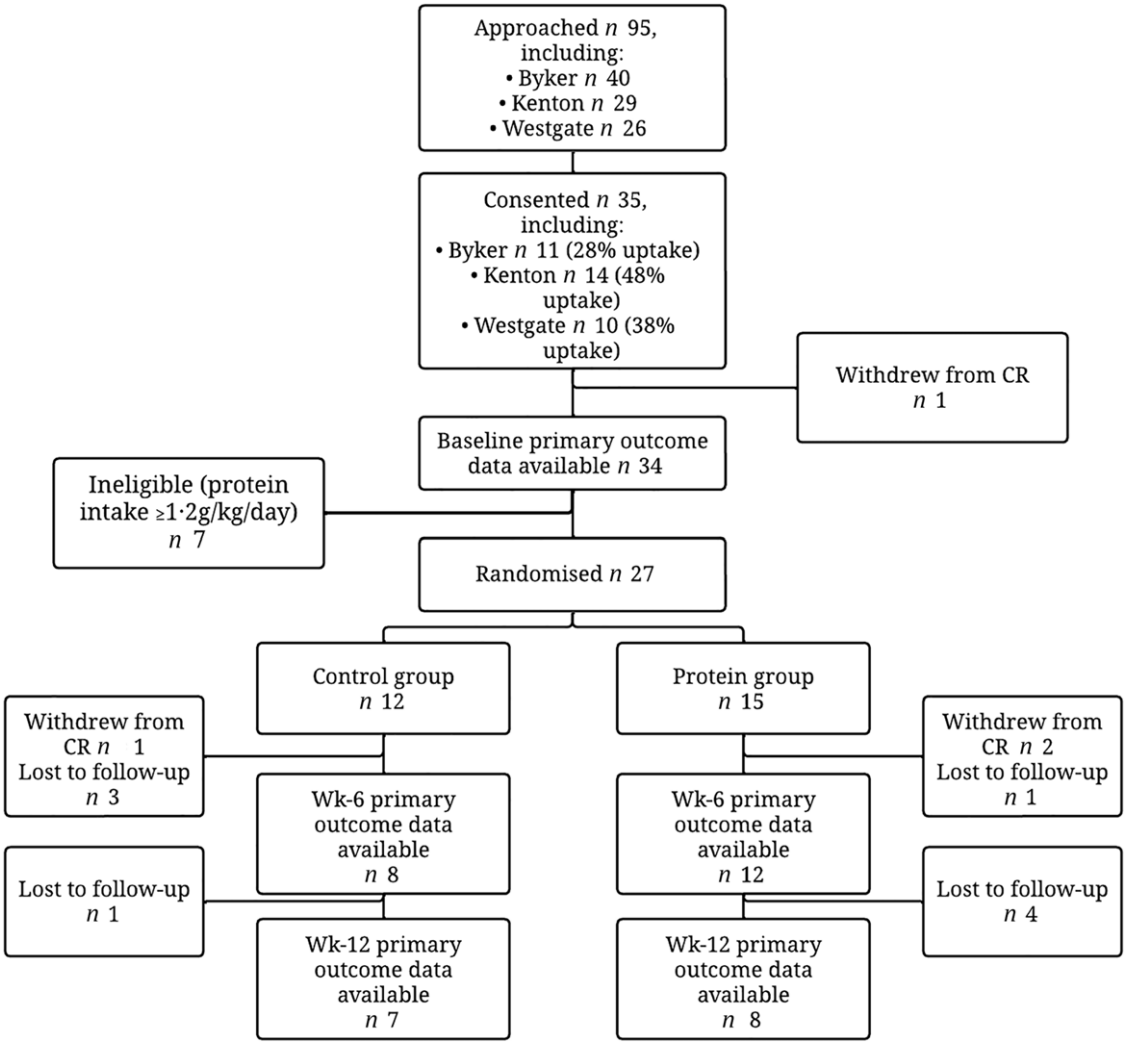

Figure 1. Study recruitment (February 2022–July 2023). CR, cardiac rehabilitation.

easy to understand (100 %) and inspiring dietary changes (78 %; online Supplementary Table S2 and Material 2).

Discussion

This pilot randomised controlled trial aimed to identify whether a targeted educational intervention to increase dietary protein intake in people with CHD and low protein intake could be implemented as an adjunct to standard CR dietary education. This information was intended to inform the implementation of a definitive trial. Low protein intake was prevalent in CR attendees (79·4 %). Changes to primary and secondary outcomes were minimal. The intervention appeared well-received by those who completed the study; however, uptake of the study was low, and attrition was high, suggesting that recruitment to a larger trial in a timely manner would be unfeasible.

Protein and other dietary intake

A high prevalence of low protein intake in older adults is reported in the present study (79·4 %) and by others (70·8 %)[27], potentially explained by a limited understanding of the importance of protein intake in this cohort[28]. Although people attending structured CR programmes are uniquely positioned to receive targeted protein education, current dietary education in UK-based CR programmes contains minimal focus on increasing protein intake[1]. Older people with chronic diseases need 1·2–1·5 g/kg per d of dietary protein[5,6]; this is higher than recommended for healthy younger adults[29] to compensate for age-related anabolic resistance, insulin resistance, physical inactivity and inflammatory status[5,30,31]. We report that protein intake was inversely associated with waist circumference ($r = -0{\cdot}348$). Elevated waist circumference increases cardiometabolic risk independently of BMI[32]. The association between higher protein intake and lower adiposity is likely due to the satiety and thermogenic response-promoting properties of protein compared with other macronutrients[33]. Weight management is a core focus of dietary education in one-quarter of the UK CR programme[1]; one way to support this could be through dietary interventions promoting adequate protein intake as part of CR.

Previously, two 30-min education sessions based on the Mediterranean diet, incorporated into a 6-week CR programme, did not influence protein intake[34]. Our study extends these findings, demonstrating that targeted protein-specific education was not more effective than standard dietary education at increasing protein intake. The increase in protein intake was

Table 1. Baseline characteristics. Median (IQR) or frequency (%)

	< 1·2 g protein/kg/d (*n* 27)		≥ 1·2 g protein/kg/d (*n* 7)	
	Median/frequency	IQR/%	Median/frequency	IQR/%
Age (years)	68·0	58·0–75·0	71·0	60·0–77·0
Male	22	81·5	7	100·0
BMI (kg/m^2)	28·2	27·1–30·5	25·7	24·3–30·3
Waist circumference (cm)	104·5	99·0–111·5	96·5	87·0–109·0
Medical history				
Myocardial infarction	22	81·5	3	42·9
Angina	11	40·7	2	28·6
Percutaneous coronary intervention	23	85·2	4	57·1
Coronary artery bypass graft	5	18·5	3	42·9
Hypertension	18	66·7	5	71·4
Cardiac failure	2	7·4	0	0·0
Peripheral vascular disease	3	11·1	0	0·0
Stroke/transient ischaemic attack	2	7·4	1	14·3
Dietary intake				
Energy (kcal/d)	1677·4	1192·0–1861·0	2148·6	1462·4–2395·2
Estimated RMR (kcal/d)	1600·8	1429·7–1757·3	1524·3	1425·6–1675·3
Protein (g/d)	69·1	55·8–79·2	116·9	90·9–140·7
(g/kg per d)	0·8	0·7–0·9	1·2	1·2–1·6
Carbohydrate (g/d)	202·3	157·0–227·6	193·9	177·9–292·2
(g/kg per d)	2·4	1·6–2·8	2·4	1·9–3·7
Total fat (g/d)	44·2	36·0–73·5	76·6	45·8–134·3
(g/kg per d)	0·6	0·4–0·8	1·1	0·5–1·4
Saturated fat (g/d)	15·6	12·5–27·7	20·1	16·6–35·6
Fibre (g/d)	20·3	15·0–23·7	23·0	17·8–31·6
PAVS Question 1	4·0	2·0–4·0	2·0	2·0–4·0
PAVS Question 2	4·0	1·0–6·0	3·0	2·0–5·0
SARC-F + EBM score	4·0	0·0–10·0	10·0	0·0–12·0
'I feel like I have a good understanding of how the food I eat affects my health'				
Strongly agree	11	40·7	1	14·3
Agree	16	59·3	6	85·7
High protein foods correctly identified (out of 13)	11·0	10·0–12·0	11·0	10·0–13·0
Sit-to-stand (s)	10·3	8·4–11·1*	10·0	8·0–12·7†

IQR, interquartile range; PAVS, Physical Activity Vital Signs.
n 24, †*n* 6.

greater in the CG at week 6 (compared with the PG), possibly attributed to the higher median protein intake at baseline in the PG (median 0·9 g/kg per d, *v.* 0·7 g/kg per d in the CG). The 'ceiling effect' determines that the magnitude of dietary change following intervention is smaller in people with higher baseline adherence to a favourable dietary pattern[35]. That is, those with a lower protein intake at baseline in the present study had greater room for improvement following intervention. Alternatively, participants who have inadvertently become aware that they were allocated to the control group may be motivated to change their behaviour to improve their protein intake[36,37].

We acknowledge that the 'dose' of the intervention in the present study was minimal. To the best of our knowledge, the effect of targeted education sessions to increase protein intake has not previously been assessed in CR. We, therefore, did not have a reference point for the most effective intervention dose. Instead, we used a pragmatic intervention design intended to mimic the current embedded delivery of dietary education practices in the UK-based CR. This avoided introducing an additional independent variable by changing the education methods as well as the content. That the currently used dietary education dose for CR was not sufficient to elicit meaningful changes in dietary intake is, in

Table 2. Change in outcome variables between timepoints (complete cases)

	PG		CG			PG		CG		
	Median Δ (6 weeks)	IQR	Median Δ (6 weeks)	IQR	Effect size	Median Δ (12 weeks)	IQR	Median Δ (12 weeks)	IQR	Effect size
Dietary intake										
n	12		8			8		7		
Energy (kcal/d)	51·6	−95·4–583·5	605·4	−187·6–819·1	0·2	31·4	−264·8–333·2	101·5	−602·9–168·7	0·1
Protein (g/d)	3·1	−4·8–26·3	32·4	17·6–38·8	0·6	4·6	−0·7–13·2	−1·7	−16·6–13·7	0·3
(g/kg per d)	0·0	−0·0–0·3	0·4	0·2–0·5	0·5	0·0	−0·0–0·1	−0·0	−0·2–0·2	0·3
Carbohydrate (g/d)	2·2	−27·4–23·5	11·2	−56·9–119·5	0·1	14·0	−52·9–84·2	21·9	−151·2–57·1	0·0
(g/kg per d)	0·0	−0·4–0·3	0·1	−0·6–1·4	0·1	0·2	−0·4–0·8	0·2	−1·7–0·7	0·0
Total fat (g/d)	9·9	−11·0–33·2	13·6	−8·1–35·7	0·1	−4·6	−14·3–8·5	9·3	−39·7–17·8	0·1
(g/kg per d)	0·1	−0·1–0·3	0·2	−0·1–0·4	0·1	−0·0	−0·2–0·1	0·1	−0·4–0·2	0·1
Saturated fat (g/d)	−1·2	−10·7–7·5	7·9	−2·7–13·2	0·2	−2·5	−6·9–3·2	−0·8	−9·9 6·4	0·1
Fibre (g/d)	2·9	−0·3–8·5	5·4	−1·7–13·8	0·2	−2·1	−3·2–1·7	−4·0	−11·6–9·8	0·1
(Cholesterol) mg/d	60·7	−123·0–211·2	33·9	−101·0–148·4	0·0	7·3	−125·5–127·6	6·1	−41·6–125·2	0·1
Na (mg/d)	−231·0	−630·8–787·6	275·1	−247·6–810·5	0·2	192·2	−720·9–542·3	−224·2	−495·4–282·2	0·1
n	8		9			3		3		
Sit-to-stand (s)	−1·3	−2·4–0·3	−0·4	−1·2–0·8	0·4	0·5	−0·2–0·6*	1·0	0·2–2·3*	0·4
n	9		8			3		3		
SARC-F + EBM (total score)	0·0	0·0–0·5	0·0	0·0–1·0	0·1	0·0	−1·0–0·0*	0·0	−1·0–0·0*	0·0

*Median (range).

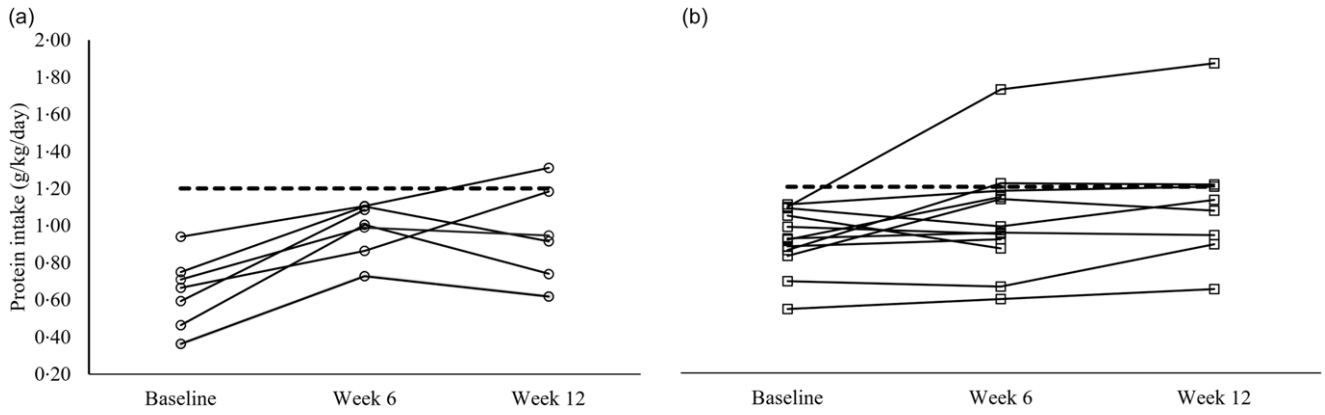

Figure 2. Individual change in protein intake in the (a) control and (b) intervention groups. Median (interquartile range) protein intake was 0·7 (0·5–0·8), 1·0 (0·9–1·1) and 0·9 (0·7–1·2) g/kg per d in the control group and 0·9 (0·7–1·1), 1·0 (0·9–1·2) and 1·1 (0·9–1·2) g/kg per d in the intervention group at baseline, week 6 and week 12, respectively. The dashed line indicates target protein intake.

itself, an important finding of this feasibility study. Furthermore, median values for self-reported moderate-to-vigorous physical activity already met or exceeded the exercise guidelines recommended by the Association of Chartered Physiotherapists in Cardiovascular Rehabilitation at baseline in both groups[38] and increased further in the intervention group over the course of the study (online Supplementary Table 1). An increased exercise training stimulus increases protein intake requirements, further highlighting the need for effective dietary support in those attending exercise-based CR.

The change in most nutritional components, excluding protein, was similar across groups at both time points (effect sizes ≤ 0·3). Three nutrition-focused sessions were suggested as the minimum required to positively influence dietary intake during CR[39], with empirical support for up to six dietary education sessions over 3 weeks favourably altering fat, fruit and vegetable intake[40]. Conversely, the same dietary components were successfully altered following one dietary education session during a 4-week CR programme[2]. The addition of behaviour change techniques in the latter study is notable[2], highlighting a potential avenue to influence dietary intake in shorter CR programmes. The rationale for the two sessions in the present study was that we wanted to replicate standard care identified in our previously published national survey, thereby using a 'real-world' approach[1].

Physical function and sarcopenia risk

Similar to others[41], we found no association between sit-to-stand time and protein intake at baseline. Sit-to-stand time and other measures of physical function improve following CR completion[42,43]. Participants in the PG completed the sit-to-stand test more quickly after the intervention (−0·9 s). Given the lack of change in protein intake in the PG, the protein intervention is unlikely to be causal. The CG saw a smaller improvement in sit-to-stand performance (−0·4 s), coinciding with a median reduction in physical activity (Physical Activity Vital Signs response; −0·5 d per week) between baseline and week 12. Together, these might signify either deconditioning or the presence of a new injury that would preclude physical activity and worsen sit-to-stand performance. Alternatively, as participants in the CG had a higher SARC-F + EBM score at baseline compared with those in the PG, it could be speculated that standard CR is not adequately tailored to improve physical function in participants at a higher risk of sarcopenia. Of the three participants identified as being at risk of sarcopenia via the SARC-F + EBM questionnaire, only one had a low protein intake. Due to our small sample size, it is difficult to form a conclusion about this finding. Additionally, objective measures of body composition and muscle function and quality have greater utility to detect sarcopenia and should be prioritised over risk-based questionnaire scores where available for laboratory-based studies.

Acceptability of the intervention

Encouragingly, all participants reported the information in the educational sessions to be helpful. The high proportion of participants who reportedly planned to change their diet based on the information given to them (88·9 and 65·2 % in the PG and CG groups, respectively) is likely influenced by self-selection of the participant group (i.e. people attending CR are actively addressing their long-term health). Despite most participants newly planning to adjust their diet, half reported that the educational information given was already known to them, and overall, we saw minimal change in dietary intake at either time point. This suggests that lack of information is not the main barrier to healthful dietary choices, as, ultimately, many did not appear to act on their intention to change. This potentially strengthens the argument for incorporating behaviour change techniques into CR delivery.

Uptake of the intervention from invited participants (36·7 %) was lower than for previous similar trials (≥ 48 %; 3, 4). Furthermore, attrition at 12 weeks for randomised participants, although similar between groups, was more than double the anticipated level (44 %), likely precluding implementation of a full-scale trial. In practice, our findings suggest that additional support might be needed to increase protein intake in people with CHD. Strategies could include increasing the number of education sessions, incorporating behaviour change techniques or providing protein supplementation.

Strengths and limitations

We evaluated a novel educational intervention designed to increase protein intake using a pragmatic study design to determine real-world feasibility. Additionally, we report the effectiveness of standard CR dietary education to increase protein intake in people with CHD. Protein intake is a comparatively under-reported outcome, evidenced by previous similar studies that evaluated the

effectiveness of CR dietary education on intake of fruits, vegetables, fish, fats and carbohydrates.

Limitations of this study include the small sample size and differences in baseline protein intakes between the randomly assigned PG and CG. We used food diaries to estimate dietary intake. Although self-reported dietary intake is widely collected in nutrition research, under-reporting of dietary intake is common when using this approach.

Summary

Low protein intake was prevalent in people with CHD; however, it did not appear to be associated with sarcopenia risk or sit-to-stand time. The findings of this pilot study were intended to inform a larger randomised controlled trial. Although the intervention effect cannot be definitively reported due to the present study being underpowered, it appears that protein intake was not altered following a targeted protein education intervention. Additionally, despite the intervention being well-received by study completers, the low recruitment rate and high attrition substantially limit both the implementation of a definitive trial and the interpretation of efficacy. New interventions to increase protein intake should be developed using patient involvement for assessment in future research and using methods beyond the constraints of current CR delivery methods.

Implications for practice

The education content was reviewed favourably by participants, who largely reported subsequent intent to alter their diet. Therefore, the lack of knowledge of a healthy diet among participants does not appear to be a limiting factor in eliciting behaviour change. Dietary education as part of CR should be reviewed and steps taken to improve its effectiveness.

Supplementary material. For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114526107235.

Acknowledgements. We would like to thank the participants for their time and commitment. We would also like to thank the CR teams at each of our study sites, including cardiac nurses, dietitians and exercise practitioners, for their help and support, which made this study possible.

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

E. J.: conceptualisation, data curation, formal analysis, methodology, project administration, writing – original draft, writing – review & editing; R. D.: methodology, writing – review & editing; R. B-S.: data curation, writing – review & editing; E. R.: methodology, writing – review & editing; S. G.: conceptualisation, methodology, supervision, writing – review & editing; S. N.: conceptualisation, methodology, supervision, writing – review & editing; A. F. O.: conceptualisation, methodology, supervision, writing – review & editing.

The authors declare no conflicts of interest.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Health Research Authority Northeast-Tyne and Wear South Research Ethics Committee; 21/NE/0117. Written informed consent was obtained from all subjects. The trial was registered at ClinicalTrials.gov on 10 August 2021 (identifier NCT04999358).

References

1. James E, Butler T, Nichols S, *et al.* (2024) Provision of dietary education in UK-based cardiac rehabilitation: a cross-sectional survey conducted in conjunction with the British Association for Cardiovascular Prevention and Rehabilitation. *Br J Nutr* **131**, 880–893.
2. Laursen UB, Johansen MN, Joensen AM, *et al.* (2021) Is cardiac rehabilitation equally effective in improving dietary intake in all patients with ischemic heart disease? *J Am Coll Nutr* **40**, 33–40.
3. Leslie WS, Hankey CR, Matthews D, *et al.* (2004) A transferable programme of nutritional counselling for rehabilitation following myocardial infarction: a randomised controlled study. *Eur J Clin Nutr* **58**, 778–786.
4. Zwisler A-DO, Soja AMB, Rasmussen S, *et al.* (2008) Hospital-based comprehensive cardiac rehabilitation *v.* usual care among patients with congestive heart failure, ischemic heart disease, or high risk of ischemic heart disease: 12-month results of a randomized clinical trial. *Am Heart J* **155**, 1106–1113.
5. Bauer J, Biolo G, Cederholm T, *et al.* (2013) Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. *J Am Med Dir Assoc* **14**, 542–559.
6. Deutz NE, Bauer JM, Barazzoni R, *et al.* (2014) Protein intake and exercise for optimal muscle function with aging: recommendations from the ESPEN Expert Group. *Clin Nutr* **33**, 929–936.
7. Campbell WW, Deutz NEP, Volpi E, *et al.* (2023) Nutritional interventions: dietary protein needs and influences on skeletal muscle of older adults. *J Gerontol: Series A* **78**, 67–72.
8. Cava E, Yeat NC & Mittendorfer B (2017) Preserving healthy muscle during weight loss. *Adv Nutr* **8**, 511–519.
9. Nichols S, O'doherty AF, Taylor C, *et al.* (2019) Low skeletal muscle mass is associated with low aerobic capacity and increased mortality risk in patients with coronary heart disease–a CARE CR study. *Clin Physiol Funct Imaging* **39**, 93–102.
10. Purser JL, Kuchibhatla MN, Fillenbaum GG, *et al.* (2006) Identifying frailty in hospitalized older adults with significant coronary artery disease. *J Am Geriatrics Soc* **54**, 1674–1681.
11. Zhang N, Zhu WL, Liu XH, *et al.* (2019) Prevalence and prognostic implications of sarcopenia in older patients with coronary heart disease. *J Geriatr Cardiol* **16**, 756–763.
12. Eldridge SM, Chan CL, Campbell MJ, *et al.* (2016) CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *Pilot Feasibility Stud* **2**, 64.
13. Public Health England (2016) The Eatwell Guide: Public Health England (updated 25 September 2018). https://www.gov.uk/government/publications/the-eatwell-guide (accessed May 2023).
14. Food and Agricultural Organization (2011) Dietary protein quality evaluation in human nutrition. *FAO Food Nutr Pap* **92**, 1–66.
15. Keller K & Engelhardt M (2013) Strength and muscle mass loss with aging process. Age and strength loss. *Muscles Ligaments Tendons J* **3**, 346–350.
16. Curtis C, Hills SP, Arjomandkhah N, *et al.* (2024) The test–retest reliability and validity of food photography and food diary analyses. *Nutr Diet* **81**, 563–572.
17. Singh R, Verest MTE & Salathé M (2025) Minimum days estimation for reliable dietary intake information: findings from a digital cohort. *Eur J Clin Nutr* **79**, 1007–1017.
18. dos Santos Vaz J, Bittencourt M, Almeida JC, *et al.* (2008) Protein intake estimated by weighed diet records in patients with type 2 diabetes: misreporting and intra-individual variability using 24-hour nitrogen output as criterion standard. *J Am Dietetic Assoc* **108**, 867–872.
19. Willett W (2013) *Nutritional Epidemiology*. New York: American Chemical Society.
20. Greenwood JL, Joy EA & Stanford JB (2010) The physical activity vital sign: a primary care tool to guide counseling for obesity. *J Physical Activity Health* **7**, 571–576.
21. Kurita N, Wakita T, Kamitani T, *et al.* (2019) SARC-F validation and SARC-F+ EBM derivation in musculoskeletal disease: the SPSS-OK Study. *J Nutr Health Aging* **23**, 732–738.
22. Cruz-Jentoft AJ, Bahat G, Bauer J, *et al.* (2019) Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing* **48**, 16–31.
23. Mifflin MD, St Jeor ST, Hill LA, *et al.* (1990) A new predictive equation for resting energy expenditure in healthy individuals. *Am J Clin Nutr* **51**, 241–247.
24. Coolican H (2017) *Research Methods and Statistics in Psychology*. London: Psychology Press.
25. Eldridge SM, Chan CL, Campbell MJ, *et al.* (2016) CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ* **355**, i5239.
26. Julious SA (2005) Sample size of 12 per group rule of thumb for a pilot study. *Pharm Stat* **4**, 287–291.

27. Hengeveld LM, Boer JMA, Gaudreau P, *et al.* (2020) Prevalence of protein intake below recommended in community-dwelling older adults: a meta-analysis across cohorts from the PROMISS consortium. *J Cachexia, Sarcopenia Muscle* **11**, 1212–1222.
28. Carrillo E, Chaya C, Viadel A, *et al.* (2023) Early changes in elderly food habits related to reduced protein intake. *Food Qual Preference* **108**, 104862.
29. Trumbo P, Schlicker S, Yates AA, *et al.* (2002) Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *J Am Diet Assoc* **102**, 1621–1630.
30. Guillet C, Prod'homme M, Balage M, *et al.* (2004) Impaired anabolic response of muscle protein synthesis is associated with S6K1 dysregulation in elderly humans. *Faseb J* **18**, 1586–1587.
31. Volpi E, Mittendorfer B, Rasmussen BB, *et al.* (2000) The response of muscle protein anabolism to combined hyperaminoacidemia and glucose-induced hyperinsulinemia is impaired in the elderly. *J Clin Endocrinol Metab* **85**, 4481–4490.
32. Powell-Wiley TM, Poirier P, Burke LE, *et al.* (2021) Obesity and cardiovascular disease: a scientific statement from the American Heart Association. *Circulation* **143**, e984–e1010.
33. Drummen M, Tischmann L, Gatta-Cherifi B, *et al.* (2018) Dietary protein and energy balance in relation to obesity and co-morbidities. *Front Endocrinol* **9**, 443.
34. Moore CE, Tsakirides C, Rutherford Z, *et al.* (2020) Dietary education provision within a cardiac rehabilitation programme in the UK: a pilot study. *Br J Cardiac Nursing* **15**, 1–12.
35. Fernandez-Lazaro CI, Toledo E, Buil-Cosiales P, *et al.* (2022) Factors associated with successful dietary changes in an energy-reduced Mediterranean diet intervention: a longitudinal analysis in the PREDIMED-Plus trial. *Eur J Nutr* **61**, 1457–1475.
36. Hébert JR, Frongillo EA, Adams SA, *et al.* (2016) Perspective: randomized controlled trials are not a panacea for diet-related research. *Adv Nutr* **7**, 423–432.
37. McCambridge J, Kypri K & Elbourne D (2014) In randomization we trust? There are overlooked problems in experimenting with people in behavioral intervention trials. *J Clin Epidemiol* **67**, 247–253.
38. Association of Chartered Physiotherapists in Cardiovascular Rehabilitation (2023) *Standards for Physical Activity and Exercise in the Cardiovascular Population*, 4th ed. London: Association of Chartered Physiotherapists in Cardiovascular Rehabilitation.
39. Lara-Breitinger K, Lynch M & Kopecky S (2021) Nutrition intervention in cardiac rehabilitation: a review of the literature and strategies for the future. *J Cardiopulmonary Rehabil Prev* **41**, 383–388.
40. Froger-Bompas C, Laviolle B, Guillo P, *et al.* (2009) Sustained positive impact of a coronary rehabilitation programme on adherence to dietary recommendations. *Arch Cardiovasc Dis* **102**, 97–104.
41. Coelho-Júnior HJ, Milano-Teixeira L, Rodrigues B, *et al.* (2018) Relative protein intake and physical function in older adults: a systematic review and meta-analysis of observational studies. *Nutrients* (Internet) **10**, 1330.
42. Rengo JL, Savage PD, Shaw JC, *et al.* (2017) Directly measured physical function in cardiac rehabilitation. *J Cardiopulm Rehabil Prev* **37**, 175–181.
43. Marzuca-Nassr GN, Seron P, Román C, *et al.* (2022) A hybrid exercise-based cardiac rehabilitation program is an effective strategy to improve muscle strength and functional exercise capacity in adults and older people with coronary artery disease. *Front Physiol* **13**, 948273.