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Dietary Education Provision Within a Cardiac Rehabilitation Programme in the UK: A Pilot Study Evaluating Nutritional Intakes Alongside Physical Activity Levels

Background/aims: The primary aim of this study was to evaluate the effectiveness of two 30-minute dietary education sessions, within cardiac rehabilitation (CR), as a means to optimise nutrient and energy intakes (EI). A secondary aim was to evaluate patients' habitual physical activity (PA) levels.

Methods: Thirty patients (males: n = 24, 61.8 ± 11.2 years; females: n = 6, 66.7 ± 8.5 years) attended a six-week early outpatient CR programme in the UK and received two 30-minute dietary education sessions emphasising Mediterranean diet principles. EI and nutrient intakes were measured through completion of three-day food diaries in weeks one and six (before and after the dietary education sessions) to assess the impact of these sessions on nutrient intakes. At the same time-points, a sub-group (n = 13) of patients had their PA levels assessed via accelerometery to assess the impact of the CR programme on PA.

Findings: Estimated energy requirements (EER) at week one (1988 ± 366 $kcal \cdot d^{-1}$) were not matched by actual EI (1785 ± 561 $kcal \cdot d^{-1}$) ($P = 0.047$, $d = -0.36$). EI reduced to 1655 ± 470 $kcal \cdot d^{-1}$ at week six ($P = 0.66$, $d = -0.33$) whereas EER increased as a function of increased activity (CR sessions). Nutrient intakes remained suboptimal, while no significant increases were observed in healthy fats and fibre, which consist core elements of a Mediterranean diet. Statistically significant increases were not observed in PA however patients decreased sedentary time by 11 ± 12% in week six compared to week one ($P = 0.009$; $d = -0.54$).

Conclusion: The present study findings suggest that two 30-minute dietary education sessions did not positively influence EI and nutrient intakes, while habitual PA levels were

not signifigantly increased as a result of the CR programme. Future research should explore means of optimising nutrition and habitual PA within UK CR.

Keywords

Cardiac rehabilitation, dietary education, habitual physical activity, coronary artery disease, Mediterranean diet

Introduction

Cardiac rehabilitation (CR) programmes are part of the multifaceted secondary prevention of cardiovascular disease (CVD). CR aims to address lifestyle risk factors of CVD and improve adherence to an active lifestyle (Dunn et al, 2014; Harrison and Doherty, 2018). Early outpatient (Phase III) CR in the UK usually involves exercise and education sessions, the latter of which include a variety of topics to address CVD risk factors in line with the British Association for Cardiac Prevention and Rehabilitation (BACPR) core components (BACPR, 2017). CR education sessions aim to foster an active role of patients in the management of their condition (Ghisi et al, 2014). Evidence suggests that the Mediterranean diet, which emphasises the intake of fruit and vegetables, high fibre foods and marine sources of omega-3 oils, can have a protective effect against cancer and CVD (Chapman et al, 2016). However, assessing adherence to a Mediterranean diet is usually monitored via subjective food frequency questionnaires and, therefore, accurate assessment of intake of single nutrients is not possible. According to the European Society for Clinical Nutrition and Metabolism (ESPEN guidelines), the recommended protein intakes for malnourished older adults or older adults at risk of malnutrition, such as in cases of acute or chronic illnesses, is 1-2-1.5 $g\cdot kg^{-1}BM\cdot d^{-1}$ (Bauer et al, 2013; Deutz et al, 2014); achieving such protein intakes is unlikely for those who follow Mediterranean diet like patterns, since recommendations for protein are relatively low (10-16% percentage of energy intake) (George et al, 2018) whilst emphasis is placed on eating plant-based protein sources which tend to contain lower quality and quantity of protein (Tosti et al, 2018; Berrazaga et al., 2019). Given this, little is known as to whether the dietary education sessions delivered as part of a comprehensive CR programme in the UK, influence patients' dietary habits and specifically protein intake.

Studies have shown significant improvements in self-reported nutritional intake following CR education sessions delivered in the USA, France and Turkey (Frame et al, 2003; Froger-Bompas et al, 2009; Irmak and Fesci, 2010; Eckman et al, 2012). However, the frequency of nutritional education sessions varies between CR programmes globally whilst also these studies (Frame et al, 2003; Froger-Bompas et al, 2009; Irmak and Fesci, 2010; Eckman et al, 2012) did not objectively assess dietary intakes using weighed food-diaries. Furthermore, limited evidence exists about the relationship between dietary intakes and PA levels in CR patients. As age and obesity are independent risk factors for CVD (Chia et al, 2018), and with older individuals at increased risk of sedentariness and suboptimal diets (Whittaker et al, 2018), there are several concerns about nutrition and PA in older CR attendees in particular. As nutritional needs change with age, the intake of some nutrients increases and energy requirements decrease (McNaughton et al, 2012). Moreover, sarcopenia, the decline of skeletal muscle mass, strength and function with age (Wannamethee et al, 2007), is closely linked to the development of chronic inflammation, hypertension and dyslipidaemia (Theodorakopoulos et al, 2017), all well-known risk factors for CVD. Therefore, nutritional strategies for the successful management of sarcopenia should focus on addressing protein and energy deficiencies whilst promoting an increase in PA levels and in particular, strength development activities (Robinson et al, 2018).

Taking into account that participants in cardiac rehabilitation programmes are older, with 30% of UK CR attendees over 75 years of age and from a broad patient population spectrum including heart failure (HF) National Audit of Cardiac Rehabilitation (NACR, 2019)), dietary education should be aiming to achieve nutritional balance in order to promote holistic health and should not only focus solely on the reduction of CVD risk factors. Adequate protein intake to promote anabolic health should be one of the aims of a balanced diet in this context. Energy intake (EI) is of equal importance to protein intake and achieving energy balance should be a minimum expectation unless weight reduction is recommended to patients who are overweight or obese.

CR in the UK encourages patients to accumulate 150-minutes of moderate intensity PA or 75-minutes of vigorous intensity PA per week (ACPICR, 2015; Davies et al, 2019). Some exercise-based CR interventions (Oliveira et al, 2008; Ribeiro et al, 2017) have been effective in increasing PA levels, whilst other studies have reported that CR does not influence habitual PA levels (Ayabe et al, 2004). However, there is limited research objectively assessing PA levels during UK exercise-based CR programmes. Discrepancies amongst research findings are likely due to differences in the CR provision (i.e. frequency, duration and type of exercise) and also methodological variations regarding PA assessment. The aim of this study was to evaluate the effectiveness of dietary education, delivered as part of a CR programme, on nutrient intakes and EI. A secondary aim, using a sub-group, was to evaluate patients' habitual PA levels.

Methods

Study design and patient group

An observational pre-post audit study was conducted in four demographically similar districts in West Yorkshire. Thirty patients with coronary artery disease who enrolled on a six-week community-based CR programme in Leeds UK, were recruited at their CR pre-assessment.

This was a convenience sample for a pilot (proof-of-concept) study. Participant key characteristics are presented in tables 1 and 2.

Patients were eligible if they were 30-80 years and had a previous myocardial infarction, Percutaneous Coronary Intervention or Coronary Artery Bypass Graft. Patients were excluded if they were pregnant or unable/unsuitable to attend exercise-based CR, if they had valvular disease or left main stem stenosis, significant co-morbidities, heart failure and non-cardiac surgery within the past six months. The Proportionate Review Sub-Committee of the Wales REC 6 reviewed our ethics submission and granted NHS ethical approval (number: 15/WA/0404). In addition, approval was granted by the Leeds Beckett University Research Ethics Committee. This project adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from all patients prior to any data collection. Various functional and clinical data were collected by the CR team prior to commencing CR to establish baseline values and patients were invited to a post-programme assessment on completion of CR. These included assessments of blood pressure, resting heart rate, age, height, weight, and body mass index. Patients' medication usage and dose were also established as well as details of their past medical history and associated CVD risk factors.

Cardiac rehabilitation programme

Patients enrolled on a six-week, early outpatient (Phase III), exercise-based CR programme which consisted of two exercise sessions and one education session per week, amounting to a total of 12 exercise sessions and six educational sessions. The exercise sessions consisted of a warm-up and cool-down with the main conditioning component being a circuit-training class where patients completed a total of 12 exercise stations (2min per station). At each station patients performed a cardiovascular exercise followed by active recovery exercise. The progression plan was for the patients to gradually reduce active recovery time in favour of cardiovascular time aiming to perform 24min of continuous cardiovascular exercise by the end of week six (ACPICR, 2015).

Nutritional education and dietary assessment

Patients received two 30-minute nutritional education sessions during their six-week CR programme. Each of these was delivered by an NHS registered dietician after the baseline data were collected. The focus of the educational sessions was to promote the Mediterranean diet (Sofi et al, 2010; Bo et al, 2016). Patients were asked to complete a three-day food diary in week one (prior to the first nutritional education session) and week six (after the second nutritional education session) of their CR programme with the instruction to include intake over two consecutive week days and one weekend day (Rossi et al, 2017).

Patient instructions included guidance on portion size accuracy with diagrams and pictures attached to the food diaries to accommodate this (Welsh et al, 2013). The diaries also prompted for information on food branding and supplement intake. Once completed, the diaries were then scrutinised for accuracy on portion sizes, accuracy on food branding and completeness (Dunbar et al, 2016). Food and drink intake were entered into the Nutritics dietary analysis software (Nutritics Ltd, Dublin, Ireland) to calculate mean EI in relation to estimated energy requirements (EER), mean absolute EI, mean macronutrient and specific nutrient intake. EER was calculated using the updated Henry Oxford Equations (Henry, 2005) within the Nutritics dietary analysis software. Age, body mass and PA levels were considered in this prediction. These were based on the estimation that patients were sedentary at baseline, giving a physical activity level (PAL) factor of 1.2, and increased PA levels as part of engagement in the CR programme, giving a PAL factor of 1.317. These PAL adjustment factors are based on values obtained from the Harris-Benedict equation (Harris and Benedict, 1918).

Assessment of physical activity

To obtain a reliable measure of the patients' PA levels and to assess whether current dietary intakes are appropriate for optimising PA levels, a sub-analysis was performed in 13 patients who had completed the food diaries and had valid five-day accelerometery data for both weeks one and six as recorded by an ActiGraph GT3X+ accelerometer (ActiGraph, LLC, Pensacola, FL, USA).

Patients were instructed to wear the device around the same hip during waking hours and remove whilst sleeping and when engaged in water-based activities (Gomersall et al, 2016). Patients were asked to complete a seven-day wear log which indicated when the device was worn and removed and subsequently was used for validating wear time. Wear time was validated as a minimum of five days consisting of ≥ 10 hours (Buman et al, 2010). This was calculated by subtracting non-wear time from 24 hours, with non-wear time consisting of ≥ 60 minutes of consecutive zero counts (Melin et al, 2016). To determine PA, filtered digital acceleration intervals were recorded in 60 second sampling periods known as epochs (Parsons et al, 2016). Each minute of activity was categorised using intensity thresholds (Prince et al, 2015) of counts per minute (sedentary: 0-99, light: 100-1799, moderate: 1800-3799, vigorous > 3800); these were predominately developed for older male adults.

Statistical analysis

Descriptive statistics and 95% confidence intervals are reported for patient characteristics pre- and post-CR. Normality of data distribution was assessed using the Kolmogorov-Smirnov (K-S) test. Given the test's propensity to give significant results (i.e. non-normal distribution), we also assessed the standardised (*z*) scores for skewness and kurtosis for each variable which did not appear normally distributed based on the K-S test. Data were deemed to be normally distributed if the *P*-value in the K-S test was >0.05 or when both of the *z* scores for skewness and kurtosis were within ± 1.96. Depending on normality, pairwise comparisons were performed by either paired *t*-tests or the Wilcoxon signed-rank test while associations were assessed by appropriate use of either Pearson's or Spearman's correlations. For all comparisons, Cohen's *d* effect sizes were calculated (as difference of the means divided by the mean of the two standard deviations) and interpreted using the following thresholds (ignoring the +/- sign): 0<d<0.2 (trivial), 0.2≤d<0.5 (small), 0.5≤d<0.8 (moderate), 0.8≤d<1.2 (large), d≥1.2 (very large). All statistical analyses were performed using SPSS version 26 (IBM, New York, US). Alpha-level was set at 0.05. Summary statistics of variables are reported as mean ± SD [95% CI] or median and interquartile range (IQR).

Results

Patient characteristics

Patients (n = 30) completed the study. Patients characteristics can be found in table 1 and table 2.

table 1

table 2

Dietary intake

At baseline, patients' average EI (1785 ± 561 $kcal \cdot d^{-1}$) was -8% (±26) below their EER (1988 ± 366 $kcal \cdot d^{-1}$) (P = 0.047, d = -0.36). At week six, patients' average EI (1655 ± 470 $kcal \cdot d^{-1}$) was -4.9 (±19.9) lower than week one (P = 0.66, d = -0.33, Figure 1) and 24% (±22) lower than their EER (2222 ± 403 $kcal \cdot d^{-1}$) (P < 0.001, d = -0.75).

figure 1

Figures 2, 3, and 4 show individual intakes of each macronutrient. In week one, patients consumed on average 1.0 ± 0.3, 2.8 ± 0.9, 0.8 ± 0.3 $g \cdot kg^{-1} \cdot d^{-1}$ of protein, carbohydrate (CHO) and fat respectively. On average, patients consumed lower quantities of macronutrients in week six compared to week one (1.0 ± 0.3, 2.4 ± 0.9, 0.7 ± 0.3 $g \cdot kg^{-1} \cdot d^{-1}$) with CHO intake statistically significantly lower, (P = 0.048). No other statistically significant pre-post differences were noted for other macronutrients, (P > 0.05), including alcohol consumption (Figure 5). The mean intakes expressed as a percentage (%) of the EER were 42.5 ± 13.0, 16.3 ± 4.2, 28.2 ± 10.6 in week one and 33.1 ± 11.6, 14.1 ± 4.7, 22.8 ± 9.0 in week six for CHO, protein, and fat respectively. The corresponding percentages for alcohol intake were 2.3 ± 3.7 and 1.9 ± 3.4 of EER for week one and six respectively.

figure 2

figure 3

figure 4

figure 5

Fat and fibre intake

Intakes of saturated, monounsaturated and polyunsaturated fat as well as omega-3, omega-6 fatty acids, and fibre in week six were not statistically significantly different than week one (all $P > 0.05$, Table 3).

table 3

Habitual physical activity levels

The change in average MVPA time outside and within the class between week one (173 ± 112min·wk^{-1}) and week six (178 ± 137min·wk^{-1}) was not statistically significant ($P = 0.85$; $d = 0.04$). There was a non-significant, moderate, inverse correlation between energy intake (kcal·d^{-1}) and time spent performing MVPA (min·wk^{-1}) during week one ($r = -0.42$, $P = 0.16$) and week six ($r = -0.44$, $P = 0.14$) of CR.

On average patients also spent 11 ± 12 % less time being sedentary in week six (2912 ± 691 min·wk^{-1}) compared to week one (3257 ± 576 min·wk^{-1}) of the CR programme ($P = 0.009$, $d = 0.54$). However, the times spent performing light, moderate and vigorous PA respectively in week six were not significantly different than week one (all $P > 0.05$).

Discussion

The primary aim of this study was to evaluate the effectiveness of dietary education, delivered as part of a CR programme on nutrient and energy intakes. The present findings indicate that two 30-minute dietary education sessions delivered within a comprehensive six-week CR programme did not optimise intakes of nutrients of interest and overall EI in patients undergoing exercise-based CR. In particular, patients in both weeks one and six of the intervention remained in negative energy balance, whilst no increases in protein, healthy fats, omega 3, 6 and fibre intakes were observed.

In this pilot study, lack of positive changes in nutrients of interest suggests that the existing dietary education provision does not effectively influence the dietary habits of all patients. The limited number and nature (group) of nutrition education sessions delivered during the programme, and the short duration of the CR programme, may be partly responsible for the lack of positive dietary changes, and therefore additional provision that can include both group and personalised educational sessions may be required for achieving changes in dietary behaviour, which is a complex phenomenon (Tapsell, 2017) and cannot be achieved by provision of information alone as it has been demonstrated in different settings (Black et al, 2014). Given that the majority of early outpatient CR programmes in the UK last for 8-weeks, the present study indicated a sub-optimal duration against national provision (Dalal et al, 2015). The BACPR guidelines nonetheless, offer no direction on the frequency and timing of dietary education patients are to receive (BACPR, 2017). Nutritional education in other countries, with substantially greater and of longer duration dietary provision, has positively influenced diet as Eckman et al. (2012) demonstrated that over a six-month period, significant improvements were observed in dietary intakes. Our data also suggests that primary emphasis should be on raising protein and healthy fat intakes since actual intakes were below Mediterranean diet recommendations (George et al, 2018) as well as research recommendations of CAD patients. Frame et al. (2003) demonstrated adherence to a regime that aimed to lower fat intake and increase intake of fruit and vegetables via a self-reported stage of change questionnaire following 12 weeks of CR. Differences in assessment of dietary intake may explain discrepancies given the lack of studies evaluating objective data.

Energy balance

Our patients appeared to be in negative energy balance at the start of the intervention by ~8% compared to calculated EER. This deficit is likely to be slightly lower, bearing in mind that underestimation of energy intakes is an inherent limitation of food diary records (Livingstone and Black, 2003). However, the even larger deficiencies in week six, partly due to an increase in energy expenditure as evidenced by participation in CR and by spending less time sedentary, corroborate our overall findings that patients were in negative energy balance. Further, it is also highly likely that dietary deficiencies for protein (Sauerwein and Strack Van Schijndel, 2007), at week six in particular contributed to this. Energy form alcohol was not increased further at week six and remained below the 5% recommendations (George et al., 2018) of total EI.

Protein

Whilst the benefits of the Mediterranean diet for CR patients are undeniable (Esposito et al, 2004) further dietary education is warranted by placing emphasis on raising protein and EI when physically active. Older adults, who were also the majority of our patients, require more dietary protein than their younger counterparts to satisfy the age-related changes in protein metabolism (Bauer et al, 2013). Intakes were at the lower end of the recommendations suggesting an intake of 1.0-1.2$g \cdot kg^{-1} \cdot d^{-1}$ for healthy older adults (Bauer et al, 2013; Deutz et al, 2014). According to ESPEN recommendations, protein intakes should be up to 1.5$g \cdot kg^{-1} \cdot d^{-1}$ for older adults at risk of malnutrition, and beyond 1.5$g \cdot kg^{-1} \cdot d^{-1}$ for older adults with severe illness (Deutz et al, 2014). Therefore, a higher protein intake may be warranted in cardiac rehabilitation attendees.

Essential fatty acids

In our study, subtle increases in saturated fatty acid and decreases in omega-3, omega-6, mono and polyunsaturated fat intakes are in contrast with other findings (Froger-Bompas et al, 2009). The Mediterranean diet promotes healthy fats such as monounsaturated fatty acids and polyunsaturated fatty acids (Rosato et al, 2019), and emphasises reduced intake of saturated fatty acids, alongside increased consumption of omega-3 and 6 fatty acids. Intake of such is evidenced to be vital in the reduction of inflammatory cytokines and adhesion molecules, which play a role in the early developmental stages of atherosclerosis at the endothelial cell level (Tuttolomondo et al, 2019). Lack of adherence in this study compared to others may be partly explained by variations in the definition of the Mediterranean diet between countries and time periods (Radd-Vagenas et al, 2017). Given the variations in educational material used in the dietary education sessions could be substantially different and the lack of specifics noted within the dietary education sessions received, it is unknown what information and advice patients were exposed to regarding consumption of fats. Future studies should aim to evaluate the specific topics that are covered as part of group dietary education within UK CR and determine consistency in the use of the term "Mediterranean diet."

Fibre

Patients consumed 69 ± 24 % of the reference nutrient intake (RNI) of fibre in week six or CR, which was lower in comparison to week one (71 ± 21%). The UK government recommends people consume 30g of fibre per day (O'Connor and Crosswaite, 2018). Patients were deficient by -23 (±30%) in week one of CR, which increased to -30 (±23) in week six. Evidence suggests that a recent intake of dietary fibre is more strongly associated with reduced risk of CAD (Streppel et al, 2008), it is therefore surprising that fibre intake reduced over the CR programme. Fruit, vegetables, legumes and grains are considered rich sources of fibre (Buil-Cosiales et al, 2016), all of which form the basis of the Mediterranean diet. Whilst studies (Irmak and Fesci, 2010; Eckman et al, 2012) indicated positive adherence to a

Mediterranean diet following dietary education, they did not directly assess fibre intake, highlighting the need to objectively evaluate nutrient intakes against RNI's.

Physical Activity

In week six of the programme, patients spent significantly less time being sedentary and increased MVPA levels by an average of 4 ± 75min·wk^{-1}. Despite no statistically significant changes in habitual PA levels, patients attained recommended MVPA levels set by the UK government (Davies et al, 2019) and emphasised by the BACPR (BACPR, 2017) by achieving a combination of both moderate (123 ± 100min·wk^{-1}) and vigorous PA (54 ± 76.5min·wk^{-1}) in week six of the programme. The lack of significant changes and wide dispersion around the PA data is likely due to a low sample size and differences in the exercise dose compared to other studies showing significant improvements in PA levels following completion of exercise-based CR (Oliveira et al, 2008; Ribeiro et al, 2017).

Conclusion

Two 30-minute dietary education sessions received as part of a comprehensive six-week UK CR programme may not be effective in improving patients' diet, particularly EI, protein, fats, omega 3, 6 and fibre given the breadth and depth of knowledge needed to cover all elements of the Mediterranean diet. The over-use of subjective methods to evaluate adherence and improvement may not be suitable to evaluate single nutrient intakes. There is a need for individualised dietary education within UK CR, that is sufficient enough to enhance patient knowledge on nutritional requirements when PA levels are expected to increase. Future research should look to evaluate dietary education in other UK CR centres.

Key points

- Dietary education within CR aims to educate patients on adherence to a Mediterranean diet like pattern.
- Objective weighed food-diaries were used to assess patient's nutrient intakes with specific emphasis on EI, protein, fats, omega 3, 6 and fibre before and after receiving two 30-minute dietary education sessions.
- Energy deficiencies were lower after receiving the dietary education sessions (~24% below EER, $P < 0.001$) compared to be before (~8% below EER, $P = 0.0047$).
- Protein, polyunsaturated, monounsaturated fat, omega 3, 6 and fibre intakes all decreased after receiving dietary education.
- Two 30-minute dietary education sessions delivered as part of a comprehensive CR programme may not be sufficient to elicit positive changes in nutrient intakes that match the energy requirements of patients that are engaging in more PA and emphasise a high intake of nutrients that are rich in the Mediterranean diet.
- CR encouraged patients to attain habitual PA levels with patients achieving 123 ± 100min·wk^{-1} of moderate and 54 ± 76.5min·wk^{-1} of vigorous PA in week six of the programme.

Reflective Questions

1. How might CR programmes incorporate other topics (EI for active patients) aswell as the Mediterranean diet into discussion within those dietary education sessions?

2. Is there a way to enhance the impact of dietary education within UK CR that is sufficient enough to enhance patient knowledge on a Mediterranean diet like pattern?

3. Is the Mediterranean diet adequate enough to allow patients to achieve recommended protein intakes, especially for those at risk of developing sarcopenia?

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