THE RELATIONSHIP BETWEEN MARKERS OF MALNUTRITION AND MUSCLE WASTING WITH FRAILTY AND PHYSICAL FUNCTION IN OLDER CARE HOME RESIDENTS

A. Slee¹, T. Ahmed², L. Storey², L. Wilkinson², G. Wilson², G. Garden³

Abstract: Background: Older care home residents may suffer from malnutrition and muscle wasting within a background of varying degrees of frailty, comorbidity and disability. Hence, malnutrition is complicated by co-presence of sarcopenia, cachexia and inactivity-induced muscle atrophy. Objectives: (1) to assess the prevalence of malnutrition in care home residents using different methodologies. (2) To examine the relationship between measurements of nutritional status and muscle mass with frailty and physical function; Design: initial pilot study. Setting: care homes for older people. Participants: 73 participants, 46 female and 27 male; Intervention: observational study. Measurements: height (m), weight (kg), body mass index (BMI) (kg), bioelectrical impedance assessment (BIA) of fat free mass index (FFMI) (kg/m²), mid upper arm muscle circumference (MUAMC) (cm), Edmonton Frailty Scale (EFS) and Barthel Index (BI). Results: There was a relatively high prevalence of malnutrition depending on measure used. MNA-SF 0-7 score was 30% for females and 28% males. Low MUAMC was found in 41% females and 53% males; low BIA FFMI in 37% females and 52% males. Good correlation (P<0.001) was found for most measures including against EFS and BI for MNA-SF and MUAMC. Conclusions: Malnutrition prevalence was relatively high. MNA-SF and MUAMC correlated well with functional status and frailty EFS measures. FFMI by BIA correlated well with MNA-SF and MUAMC. This range of practical techniques should be explored further for determining malnutrition risk and muscle wasting in relation to functionality and frailty in care home residents

Key words: Malnutrition, sarcopenia, cachexia, frailty, muscle wasting.

Introduction

Older people in care homes have varying degrees of comorbidity, frailty and impaired functional ability which may be associated with clinical outcomes (1). Malnutrition, a serious concern for this population group, is a component of the frailty cycle, and may be linked to worse outcomes (2, 3), therefore screening for malnutrition with simple tools has high clinical value (4, 5). There is debate however, regarding which methods to use and specific cut-off points (e.g. body mass index, BMI) (6). Furthermore, differentiating the different states of cachexia, sarcopenia and disuse atrophy is complex (7-10). Older people with varying degrees of frailty, comorbidity (and associated inflammation etc.) and poor physical function may suffer from a combination of states and be difficult to assess. Regardless of origin, these states lead to skeletal muscle mass (SMM) loss and a reduction in nutritional status making an older person more susceptible to malnutrition and risk of morbidity and mortality. Recently, the term ‘muscle wasting disease’ has been suggested as an umbrella term to encompass all forms of muscle loss (11).

Regarding techniques of assessment for malnutrition risk, the mini nutritional assessment (MNA) and abbreviated short-form (MNA-SF) have been validated and suggested for use in older people (4) and uses BMI with significant weight loss and other specific questions. Previous studies in older people have also utilised bioelectrical impedance assessment (BIA) to estimate nutritional status, measuring fat free mass (FFM) and FFM index (FFMI in kg/m²) (5, 12-14). Recently, an ESPEN consensus statement, produced for the assessment of malnutrition discussed specific cut-off points for BMI, weight loss and use of FFMI. Muscle wasting can be estimated by FFMI as an indicator of SMM. It can also be measured practically by the mid upper arm muscle circumference (MUAMC). The MUAMC was used in a large Italian study (n = 357) by Landi et al (ILSIRENTE Study) which investigated the relationship between MUAMC in community-dwelling older people with

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physical performance and mortality (15).

One area of research has been the development of tools and measures for frailty status and the relationship with health and specific aspects such as muscle loss in ageing, sarcopenia. The Edmonton Frailty Scale (EFS) was developed as a brief, valid and reliable tool which can be used to identify multi-domain frailty by clinical staff without training in geriatric medicine (16). The usefulness of the EFS in care homes and relationship with markers of nutritional status, malnutrition and muscle wasting has yet to be ascertained. Furthermore, the relationship between these different markers with measurements of the Activities of Daily Living (ADLs) is also of high interest. The Barthel Index (BI) is commonly used by geriatricians to indicate functional ability/disability (17).

This study aimed to (1) investigate malnutrition prevalence in care home residents using different methods and (2) investigate the relationship between markers of nutritional status, frailty and physical function.

Methods

Participants and study design

This study was undertaken between October 2015 and May 2016 and is part of an ongoing care home service evaluation, the Frailty and Nutrition Study in Lincoln (FANS). Study was cleared through NHS research ethics committee in September 2015. Care home residents underwent Comprehensive Geriatric Assessment (CGA) in four care homes in Lincoln, United Kingdom. Patients were diagnosed with different levels of frailty and with a range of comorbidities including; cardiovascular disease, chronic heart failure, chronic kidney disease, chronic obstructive pulmonary disorder, cancer, diabetes, arthritis, and dementia. Most residents were being treated with multiple drugs. The aim was to recruit 100 to 150 patients in line with other similar studies; however the designated study time restraints dictated the current number. Measurements were collected by members of a multidisciplinary care team.

Anthropometric measurements

Height (in m) was estimated using ulnar length and conversion tables (BAPEN, UK). Weight (in kg) was measured and body mass index (BMI in kg/m²) calculated. Mid upper arm circumference (MUAC) was measured using a tape measure around the mid-point of the upper arm. Measurements were taken on the right side of the participant’s body unless affected by disability or disease.

Bioelectrical impedance assessment measurements

BIA measurements were taken using a single-frequency (50 kHz) Maltron 916 S, bioelectrical impedance analyser (Maltron International Ltd., Rayleigh, Essex, UK). Measurements were taken using a standard hand-to-foot tetra-polar technique with participants in the supine position, in accordance with the manufacturer’s guidelines. Raw impedance measurements of resistance (R) and reactance (Xc) in ohms and PA were recorded.

The BIA estimation of FFM was completed using the following BIA equation (Kyle equation (18)):

\[
FFM = -4.104 + (0.518 \times \text{height}^2 / R) + (0.231 \times \text{weight}) + (0.130 \times Xc) + (4.229 \times \text{sex}: \text{men} = 1, \text{women} = 0).
\]

Height is in cm and weight in kg.

Nutritional assessment: MNA-SF screening

MNA-SF screening was undertaken by clinical staff according to instructions and scores recorded. Scores were converted into categories for nutritional status using MNA scoring criteria either low risk/normal (12–14), medium risk/at risk (8–11) and high risk/malnourished (0–7).

Mid-upper arm muscle circumference calculation

The MUAMC was calculated using the formula:

\[
\text{MUAMC} = \text{mid-upper arm circumference} - (3.14 \times \text{triceps skinfold thickness})
\]

Measurement of triceps skinfold thickness (to the nearest 0.2 mm) was made using Harpenden skinfold calliper (range: 0.00–50.00 mm; minimum graduation: 0.20 mm).

Using reference data from Landi et al, the lowest tertiles for males (< 21.1 cm) and for females (< 19.2 cm) were used as cut-off points to indicate low muscle mass.

Malnutrition prevalence

Prevalence of malnutrition was assessed by BMI, MNA-SF score and FFMI. A BMI of < 20 kg/m² was used as the population is older and high presence of comorbid chronic conditions. E.g. in the cachexia definition by Evans et al. a BMI < 20 kg/m² is used as a cut-off point when there is presence of a chronic disease (7).

Edmonton frailty scale

The EFS was undertaken by clinical staff as part of routine CGA in participants. The EFS 10 domain test as described by Rolfson et al with maximum score of 17 was undertaken (16). Higher scoring indicates increasing frailty.
Barthel index

The BI was undertaken by clinical staff as part of routine CGA in participants. A standard 10 question BI with a maximum of 20 point scoring was undertaken (17). Lower scoring indicates increasing disability.

Statistical analysis

Data was analysed as a group and individually for males and females. Cut-off points were assigned for malnutrition risk and low MUAMC. Number of residents and percentage (%) was calculated for prevalence. Correlations were performed on all variables using Pearson test and Spearman for nonparametric data. All statistical tests were performed using IBM SPSS Statistics Version 21.

Results

There were 73 resident participants recruited over 4 separate care homes. The characteristics of the older care home residents can be seen in Table 1. MNA-SF and BIA was completed in all residents, MUAMC in 58, EFS in 49 and BI in 52.

Table 1
Participant characteristics and variables. Mean +/- standard deviation, median [ ], minimum and maximum ( )

<table>
<thead>
<tr>
<th>Variable</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>73 (46 females, 27 males)</td>
</tr>
<tr>
<td>Age, years</td>
<td>86.0 +/- 6.5 years of age [87] (70-97)</td>
</tr>
<tr>
<td>Height, m</td>
<td>1.65 +/- 0.09 m [1.65] (1.47-1.91)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>66.1 +/- 16.9 kg [63.5] (38.7-117.7)</td>
</tr>
<tr>
<td>Body mass index (BMI), kg/m2</td>
<td>24.3 +/- 6.2 kg/m2 [23.0] (15.3-49.0)</td>
</tr>
<tr>
<td>Mini nutritional assessment (MNA) score (0-14)</td>
<td>9.0 +/- -3.0 [9.5] (3-14)</td>
</tr>
<tr>
<td>Edmonton frail scale (EFS) (0-17)</td>
<td>11.2 +/- -2.8 [11] (5-16)</td>
</tr>
<tr>
<td>Barthel index (0-20)</td>
<td>10.3 +/- -6.6 [11] (0-20)</td>
</tr>
<tr>
<td>Fat Free Mass Index, kg/m2</td>
<td>16.2 +/- -2.5 [16.0] (11.4-24.2)</td>
</tr>
<tr>
<td>Mid-upper arm muscle circumference (MUAMC), cm</td>
<td>20.0 +/- -4.2 cm [20.9] (9.0-26.6)</td>
</tr>
</tbody>
</table>

All residents had gait speed and grip strength below the cut-off points for the European Working Group on Sarcopenia in Older Persons (EWGSOP) definition for sarcopenia (9).

Prevalence of malnutrition was assessed by BMI and MNA-SF score (see Table 2). Prevalence of low MUAMC indicative of muscle wasting can be found in Table 2 along with low FFMI.

Table 2
Prevalence of malnutrition, low MUAMC and low FFMI

<table>
<thead>
<tr>
<th>Variable</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malnutrition &lt;20 kg/m2</td>
<td>11/46 (24%)</td>
<td>6/27 (22%)</td>
</tr>
<tr>
<td>Malnutrition 0-7 MNA-SF</td>
<td>13/43 (30%)</td>
<td>7/25 (28%)</td>
</tr>
<tr>
<td>Malnutrition risk 8-11 MNA-SF</td>
<td>15/43 (35%)</td>
<td>12/25 (48%)</td>
</tr>
<tr>
<td>Low MUAMC*</td>
<td>14/34 (41%)</td>
<td>10/19 (53%)</td>
</tr>
<tr>
<td>Low FFMI†</td>
<td>17/46 (37%)</td>
<td>13/25 (52%)</td>
</tr>
</tbody>
</table>

*Low MUAMC: <19.2 cm for females and <21.1 cm for males. †Low FFMI: <15 kg/m2 for females and <17 kg/m2 males.

Correlations

There was good correlation between most measures (Table 3). However, there was no significant correlation between FFMI with Edmonton EFS or Barthel Index BI. Figures 1-3 depicts key correlations for (1) MNA-SF score, (2) MUAMC and (3) FFMI.

Table 3
Correlations between variables with correlation coefficient, r and significance, P values shown

<table>
<thead>
<tr>
<th>Variables</th>
<th>Correlation coefficient, r value</th>
<th>Significance, P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNA-SF vs BMI</td>
<td>0.68</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MNA-SF vs EFS</td>
<td>-0.75</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MNA-SF vs BI</td>
<td>0.58</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MUAMC vs BMI</td>
<td>0.64</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MUAMC vs MNA-SF</td>
<td>0.49</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MUAMC vs EFS</td>
<td>-0.61</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MUAMC vs BI</td>
<td>0.43</td>
<td>0.01</td>
</tr>
<tr>
<td>FFMI vs BMI</td>
<td>0.72</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FFMI vs MUAMC</td>
<td>0.51</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FFMI vs MNA-SF</td>
<td>0.43</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BMI vs EFS</td>
<td>-0.53</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BMI vs BI</td>
<td>0.27</td>
<td>0.063</td>
</tr>
<tr>
<td>EFS vs BI</td>
<td>-0.71</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Discussion

In this study, 73 care home residents were screened for malnutrition using BMI, the MNA-SF and BIA estimation of FFMI (Table 2). Malnutrition by BMI was 24% in females and 22% in males. A BMI cut-off point of 20 kg/m2 was used to indicate malnutrition rather than 18.5 kg/m2. This was due to the age of the participants (86 +/- 6.5 years) with similar studies using a higher cut-off point for older people, as does the MNA-SF tool. Furthermore, the cachexia definition by Evans et al, utilises a cut-off point of 20 kg/m2 in the presence of a chronic condition,
e.g. heart failure or cancer etc. (7). The population group that were assessed in this study had a high prevalence of comorbidity and chronic disease conditions. An ESPEN consensus paper recently suggested using 18.5 kg/m² OR significant unintentional weight loss (>10% indefinite of time, or >5% over the last 3 months) combined with either BMI (<20 kg/m² if <70 years of age, or <22 kg/m² if ≥70 years of age) or FFMI (<15 kg/m² and 17 kg/m² in women and men, respectively) (6). In this participant group, weight loss was difficult to assess accurately as it was highly dependent on robust records being kept within the care home itself (e.g., previous carers etc.). Weight loss is a component of frailty, a strong predictor of outcomes and in particular, the presence of cachexia wasting. As described above, due to high comorbidity and chronic disease prevalence it is likely that cachexia prevalence was relatively high despite not having the weight loss data to confirm this.

**Figure 1**
Graphs to show the relationship between MNA-SF score and (a) BMI, (b) EFS and (c) BI. Closed circles indicates female residents and triangles, males. Correlation results can be found within Table 3

Identifying malnutrition by MNA-SF found that 30% females and 28% males were classified as malnourished (0-7 score) and 35% females and 48% males as ‘at risk’ (score 8-11). This was a higher prevalence than using BMI. Based upon the nature of the MNA-SF and the questions it contains, it may be suggested that a person who has greater frailty, comorbidity and physical disability will score worse with a greater risk of malnutrition. Interestingly, the correlation results tend to confirm this relationship with BMI (r = 0.68, P < 0.001), EFS (r = -0.75, P< 0.001) and BI (r = 0.58, P < 0.001) (Figure 1).

**Figure 2**
Graphs to show the relationship between MUAMC and (a) BMI, (b) MNA-SF score and (c) EFS and (d) BI. Closed circles indicates female residents and triangles, males. Correlation results can be found within Table 3

BIA estimation of FFMI identified that 37% females and 52% males had a low FFMI. Cut-off points of <15 kg/m² for females and <17 kg/m² males were utilised as suggested from the ESPEN consensus paper to indicate a low FFMI (6). BIA estimations of FFMI prove to be useful in this study similar to previous work (5). In the previous study, BIA estimation of FFMI was used alongside MNA-SF to better categorise malnutrition risk compared to using the standard UK Malnutrition Universal Screening Tool (MUST). With regards to accuracy of BIA, dual energy x-ray absorptiometry is the gold standard technique for measuring FFMI, but is difficult to use in the older population group in long term care and is also expensive. BIA is inexpensive and
portable and can be used at the bed side (e.g. bed-bound residents). Drawbacks to its use however, include errors due to hydration abnormalities leading to false FFM estimations. In this study, 2 residents were omitted from FFMI estimation due to hydration abnormalities. Also, the presence of an electronic cardiac pacemaker is contraindicated for BIA use, and which is more likely to be prevalent in this population. Within the ESPEN consensus paper it was suggested that FFMI should be used as a possible measure of nutritional status, alongside weight loss (6). It may also be suggested however that FFMI alone may be useful in situations when it is impossible to gather accurate weight loss information.

In terms of skeletal muscle mass (SMM) the FFMI is a useful predictor of both nutritional status and an indicator of overall SMM. FFM consists of all mass other than fat mass and obviously the large body compartment of SMM makes up a high proportion of FFM. Therefore, we may assume under normal circumstances that a low FFMI and FFMI may be indicative of a poor nutritional status and also low SMM. The FFMI was positively correlated with BMI (r = 0.72, P < 0.001), MNA-SF (r = 0.43, P < 0.001) and MUAMC (r = 0.51, P < 0.001) in residents. MUAMC was measured as a practical means of estimating SMM and muscle wasting. Using the lower tertiles in a study by Landi et al as cut-off points, the relative muscle mass and number of people with a lower MUAMC was determined. The number of participants with a low MUAMC was 41% females and 53% males. In particular, interestingly the prevalence rates were quite similar to the low FFMI levels (37% females and 52% males). Hence, this data may support the concept of MUAMC as an estimation of SMM and muscle wasting. Using the lower tertiles in a study by Landi et al as cut-off points, the relative muscle mass and number of people with a lower MUAMC was determined. The number of participants with a low MUAMC was 41% females and 53% males. For example, considering the MUAMC, the prevalence was 37% females and 52% males. Hence, this data may support the concept of MUAMC as an estimation of SMM and muscle wasting. Using the lower tertiles in a study by Landi et al as cut-off points, the relative muscle mass and number of people with a lower MUAMC was determined. The number of participants with a low MUAMC was 41% females and 53% males. In particular, interestingly the prevalence rates were quite similar to the low FFMI levels (37% females and 52% males). Hence, this data may support the concept of MUAMC as an estimation of SMM and muscle wasting. Using the lower tertiles in a study by Landi et al as cut-off points, the relative muscle mass and number of people with a lower MUAMC was determined. The number of participants with a low MUAMC was 41% females and 53% males. In particular, interestingly the prevalence rates were quite similar to the low FFMI levels (37% females and 52% males). Hence, this data may support the concept of MUAMC as an estimation of SMM and muscle wasting. Using the lower tertiles in a study by Landi et al as cut-off points, the relative muscle mass and number of people with a lower MUAMC was determined. The number of participants with a low MUAMC was 41% females and 53% males. However, the prevalence rates were quite similar to the low FFMI levels (37% females and 52% males). Hence, this data may support the concept of MUAMC as an estimation of SMM and muscle wasting. Using the lower tertiles in a study by Landi et al as cut-off points, the relative muscle mass and number of people with a lower MUAMC was determined. The number of participants with a low MUAMC was 41% females and 53% males. Interestingly, in this study there was no correlation with FFMI which was perhaps unexpected. This may be due to low study participant numbers. The EFS was evaluated in a recent study by Perna et al with 366 hospitalised older patients (20). EFS scores were associated with cognition, functional independence, medications, nutritional status by MNA, functional performance by BI and hand grip strength. They also found a significant difference in female patients with sarcopenia (SMM Index by DEXA). They concluded that the EFS may be a helpful tool for stratifying the state of fragility in this population group.

Frailty and sarcopenia increases the risk of disability (1,3). In this study the BI was taken as a method of measuring ADLs and hence physical functional status. The mean score of the participants was 10.3 +/- 6.6 which may indicate a moderately impaired level of functional ability, but there was also a high level of variance between participants. EFS score highly correlated (negatively) with BI (r = -0.71, P < 0.001) (Table 3), such that increasing frailty was associated with worsening of physical function. As stated earlier, significant correlations were found between BI and MNA-SF and with MUAMC. Furthermore, a significant positive correlation was found between BMI and EFS (r = 0.53, P < 0.001) (Table 3). This data fits well with the concept of the frailty cycle. Fried et al, describe this relationship in detail in (3). Nutritional status and malnutrition risk are key components of frailty due to the impact of a variety of factors including, the dysregulation of energy balance with ageing (anorexia of ageing) and illness (inflammation driven changes in appetite and metabolism). Furthermore, sarcopenia is also a major component. Interestingly, in this study there was no correlation with FFMI which was perhaps unexpected. This may be due to low study participant numbers. The EFS was evaluated in a recent study by Perna et al with 366 hospitalised older patients (20). EFS scores were associated with cognition, functional independence, medications, nutritional status by MNA, functional performance by BI and hand grip strength. They also found a significant difference in female patients with sarcopenia (SMM Index by DEXA). They concluded that the EFS may be a helpful tool for stratifying the state of fragility in this population group.

The reduced muscle mass may be the result of a combination of age-related sarcopenia, chronic disease, e.g. cachexia, and physical inactivity/disability (7-11). Practically however, this is difficult to untangle and the overarching term of muscle wasting disease which has recently been suggested by Von Haehling et al may be important here (11). Dupuy et al, found in a large cohort of older women (n=3025) that sarcopenia prevalence can vary greatly depending on the method used (19). Hence, there needs to be a standardisation in the terminologies and methods used in measuring sarcopenia and overall muscle loss.

The EFS was measured in participants to assess frailty. The EFS is a simple tool which can be used by non-geriatrician staff to assess multi-domain frailty which includes sections on cognition, mood, medications and functional status. The mean score of the participants was 11.2 +/- 2.8, which indicates a moderate level of frailty. As stated earlier, significant correlations were found between EFS and MNA-SF and with MUAMC. Furthermore, a significant negative correlation was found between BMI and EFS (r = -0.53, P < 0.001) (Table 3). This data fits well with the concept of the frailty cycle. Fried et al, describe this relationship in detail in (3). Nutritional status and malnutrition risk are key components of frailty due to the impact of a variety of factors including, the dysregulation of energy balance with ageing (anorexia of ageing) and illness (inflammation driven changes in appetite and metabolism). Furthermore, sarcopenia is also a major component. Interestingly, in this study there was no correlation with FFMI which was perhaps unexpected. This may be due to low study participant numbers. The EFS was evaluated in a recent study by Perna et al with 366 hospitalised older patients (20). EFS scores were associated with cognition, functional independence, medications, nutritional status by MNA, functional performance by BI and hand grip strength. They also found a significant difference in female patients with sarcopenia (SMM Index by DEXA). They concluded that the EFS may be a helpful tool for stratifying the state of fragility in this population group.

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The EFS was measured in participants to assess frailty. The EFS is a simple tool which can be used by non-
(r = 0.55, P < 0.0001) and a poorer functional status was associated with low BMI, low MUAMC and reduced oral intake. Hence, this data corroborates findings from our study. This study suggests that multi-domain screening for nutritional status, muscle mass, frailty and functionality is important in this population group. Regular screening may improve diagnosis and guide treatment opportunities, e.g. nutritional and protein supplementation. Further studies are required to confirm this and to evaluate specific methods e.g. determination of malnutrition prevalence.

Conclusion

This pilot study found that prevalence of malnutrition was dependent on the method used to determine. There was a high prevalence of malnutrition by MNA-SF and FFMI and high levels of muscle wasting by MUAMC and FFMI. Those residents with poor nutritional status (by BMI, MNA-SF and FFMI) had lower muscle mass, greater frailty (by EFS) and worse physical function (by BI). Future studies should be performed to confirm or refute these relationships and their meaning.

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Conflict of interest: The authors declare that they have no conflicts of interest.

Statement of Authorship: AS is the lead author and designated study Chief Investigator. GG and TA played key roles in the design and development of the study and in writing of the paper. LS, LW and GW were co-investigators primarily involved in data acquisition.

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Ethical standards: Full UK NHS research ethics guidelines were followed in this study.

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