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Review

Overcoming protein-energy malnutrition in older adults in the residential care setting: A narrative review of causes and interventions

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ABSTRACT

Malnutrition, in particular protein-energy malnutrition, is a highly prevalent condition in older adults, and is associated with low muscle mass and function, and increased prevalence of physical frailty. Malnutrition is often exacerbated in the residential care setting due to factors including lack of dentition and appetite, and increased prevalence of dementia and dysphagia. This review aims to provide an overview of the available literature in older adults in the residential care setting regarding the following: links between sarcopenia, frailty, and malnutrition (in particular, protein-energy malnutrition (PEM)), recognition and diagnosis of malnutrition, factors contributing to PEM, and the effectiveness of different forms of protein supplementation (in particular, oral nutritional supplementation (ONS) and protein-fortified foods (PFF)) to target PEM. This review found a lack of consensus on effective malnutrition diagnostic tools and lack of universal requirement for malnutrition screening in the residential care setting, making identifying and treating malnutrition in this population a challenge. When assessing the use of protein supplementation in the residential care setting, the two primary forms of supplementation were ONS and PFF. There is evidence that ONS and PFF increase protein and energy intakes in residential care setting, yet compliance with supplementation and their impact on functional status is unclear and conflicting. Further research comparing the use of ONS and PFF is needed to fully determine feasibility and efficacy of protein supplementation in the residential care setting.

1. Introduction

Malnutrition is an increasing problem in older adults, particularly those over 65 years of age (Elia and Russell, 2009) and residing in residential living facilities (British Dietetic Association, 2017). Despite the increasing prevalence of malnutrition and the known detrimental effects on health, the effectiveness of malnutrition screening procedures are unclear, resulting in it remaining undetected and untreated (Elia and Russell, 2009). Individuals with malnutrition often suffer from muscle weakness, altered immune function, decreased functionality, and increased risk of infection (Agarwal et al., 2013), which can lead to increased mortality risk (Sullivan and Walls, 1998). In particular, protein-energy malnutrition (PEM), resulting from a decrease in protein and energy intake, has been associated with a number of health outcomes, disease states, and illnesses (Corish and Kennedy, 2000; Correia and Waitzberg, 2003). It has been reported that under-nutrition is a prominent issue in older adults in the residential care setting (Care Quality Commission, 2017; "NHS New Care Models: The framework for enhanced health in care homes," 2016; Russell and Elia, 2015; Shepherd et al., 2017). This highlights the need to assess the most effective methods of increasing protein and energy intake in this setting in order to decrease malnutrition prevalence, in particular PEM. Therefore, this review aims to provide an overview of the available literature in older adults in the residential care setting regarding the following: links

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between sarcopenia, frailty, and malnutrition (in particular, PEM), recognition and diagnosis of malnutrition, factors contributing to PEM, and the effectiveness of different forms of protein supplementation (in particular, oral nutritional supplementation (ONS) and protein-fortified foods (PFF)) to target PEM.

2. Sarcopenia, frailty, and malnutrition

The current phenomenon of an ageing population has placed considerable interest in geriatric syndromes such as sarcopenia. Sarcopenia, the established multifactorial condition associated with a progressive loss of skeletal muscle mass, quality, and physical function (Cruz-Jentoft et al., 2019; Lees et al., 2019; Rosenberg, 1997), has been shown to be highly prevalent in the residential care setting (Rodríguez-Rejón et al., 2019). Indeed, in this setting the prevalence of sarcopenia has been reported to be up to 6 times greater than community dwelling older individuals (Mayhew et al., 2019; Rodríguez-Rejón et al., 2019). The process of sarcopenia begins around the 4th decade of life (Walston, 2012), and proceeds at a rate of approximately 0.7–1.2 % muscle mass lost per year, with up to 50 % of muscle mass being lost by the 8th decade of life (Metter et al., 1997; Mitchell et al., 2012).

Sarcopenia is most commonly defined as an age-associated decrease in muscle mass and function, following the European Working Group on Sarcopenia in Older People (EWGSOP) guidelines for definition and diagnosis (Cruz-Jentoft et al., 2019). However, sarcopenia is not an inevitable condition in all older adults, evident from the disparity of its progression rates and prevalence across the population (Dodds et al., 2014). Using the EWGSOP definition of sarcopenia, a recent meta-analyses indicated the prevalence of sarcopenia in community-dwelling older adults to be approximately 13 % (Mayhew et al., 2019). However, it can reach a significantly higher prevalence of up to 73 % in long-term care homes and between 22–87 % in assisted-living facilities (Rodríguez-Rejón et al., 2019). Diet and physical activity are key modifiable behavioural factors associated with sarcopenia development (Cruz-Jentoft et al., 2014) and may be the largest contributors to the reported differences in sarcopenia prevalence between community-dwelling and older adults in the residential care setting.

Frailty is a whole-body geriatric syndrome associated with impairments in physiological systems and decreased homeostatic reserve with increasing age (Fried et al., 2001). Frailty results in an increased risk of negative health-related outcomes such as falls, fractures, and hospitalisation (Morley et al., 2013; Rodríguez-Mañas et al., 2013). Despite the organ-specific nature of sarcopenia and the whole-body nature of frailty, there is overlap with respect to their definitions and diagnosis. For example, sarcopenia is reported to be associated with muscle loss (Cruz-Jentoft et al., 2019), whilst frailty is more commonly reported to be associated with weight loss (Fried et al., 2001); which may consist of muscle and/or fat loss. However, both sarcopenia and frailty include characterisation of loss of functional mobility and strength, often measured by gait speed and handgrip strength when identifying a frail or sarcopenic individual (Cederholm, 2015). Importantly, malnutrition is considered to be a key contributor development of both of these conditions (Artaza-Artabe et al., 2016).

There are a number of definitions of malnutrition, with one of the most universally accepted definitions describing malnutrition as "a state of energy, protein, or nutrient excess or deficiency, resulting in adverse effects on body composition and function, and clinical outcomes" (Elia, 2003). Malnutrition is one of the most commonly unrecognised and under-treated health conditions worldwide, and an abundance of reports and research have recently identified under-nutrition as a prominent issue in care homes (Care Quality Commission, 2017; "NHS New Care Models: The framework for enhanced health in care homes," 2016; Russell and Elia, 2015; Shepherd et al., 2017). It has been reported by The British Association for Parenteral and Enteral Nutrition (BAPEN) that 34 % of older care home residents experience undernutrition (Cruz-Jentoft et al., 2014), and results from a systematic review identified that 12–54 % of care home residents experience under-nutrition (Russell and Elia, 2015). Furthermore, a recent policy statement published by The British Dietetic Association acknowledged the issue of increasing prevalence of under-nutrition in older adults living in residential care (British Dietetic Association, 2017).

The European Society for Parenteral and Enteral Nutrition (ESPEN) have proposed terminologies to support a better understanding of malnutrition. In this attempt to afford enhanced understanding, ESPEN categorise undernutrition as i) disease-related malnutrition (DRM) with or without inflammation, and ii) non-DRM. Furthermore, ESPEN identify sarcopenia, frailty, micronutrient deficiency, and obesity as different forms of malnutrition (Cederholm et al., 2017). Unsurprisingly, due to the overlapping nature of differing types of malnutrition, ageing contributes to many aspects of these conditions. For instance, undernutrition has been identified as a risk factor for both sarcopenia and frailty (Cruz-Jentoft et al., 2017; Welch, 2014) in older individuals, increasing the risk of comorbidity development and adverse outcomes, and impairing quality of life (Morley, 2012). The different forms of malnutrition, as proposed by ESPEN, are summarised in Fig. 1.

PEM, which is classified as non-DRM, is one of the most common forms of malnutrition in older adults, resulting when protein and/or energy intake fails to meet the nutritional requirements of the body (Hoffer, 2001). This impairs the ability to recover from illness and predisposes individuals to disease-related outcomes (McWilliams, 2008). Furthermore, PEM has a significant negative impact on mental and physical well-being of older adults in the residential care settings (Stow et al., 2015). For example, PEM has been shown to decrease quality of life, increase risk of depression, infection and pressure ulcer development, and adversely impact clinical outcome development (Arvanitakis et al., 2009; Cowan et al., 2004; Crogan and Pasvogel, 2003). Clear evidence demonstrates the need for an increase in protein intake in older individuals due to the pivotal role PEM has been shown to play in sarcopenia and frailty onset and development (Beaudart et al., 2019). Older adults in the residential care setting are often the frailest older individuals most vulnerable to comorbidity and sarcopenia development, however, malnourishment is a common issue in care facilities (Bunn et al., 2018).

A wealth of evidence based on the assessment of diet quality has established a relationship between a 'healthier' diet and an increase in muscle mass, along with a lower risk of decline of physical performance (Bloom et al., 2018). To exemplify, observational research in community-dwelling older adults has demonstrated a significant relationship between a greater protein intake and a reduced percentage of lean muscle mass loss over a 3-year period (Houston et al., 2008). Similarly, interventional research has demonstrated that increasing protein intake from 0.8 to 1.6 $g.kg^{-1}.day^{-1}$ over a 10-week period can produce significant improvements in lean body mass and knee-extensor peak power (Mitchell et al., 2017). These findings highlight the option of using protein supplementation to maintain skeletal muscle protein anabolism and function in older adults. Older adults living with frailty are often in the residential care setting, presenting with the most extreme cases of sarcopenia and thus most in need of interventions to limit the decline of muscle mass and function. However, despite evidence presenting the effectiveness of physical activity and exercise training as anabolic stimuli for skeletal muscle (Kirk et al., 2019), the high prevalence of frailty in the residential care setting with limited functional mobility may limit its widespread use in this 'at-risk' group (Corcoran et al., 2017).

There is currently no difference in the recommended daily allowance (RDA) or estimated average requirement (EAR) of protein intake for young and older adults. The current RDA and EAR for protein is 0.8 $g.kg^{-1}.day^{-1}$ and 0.66 $g.kg^{-1}.day^{-1}$ respectively. However, it has been suggested that to maintain optimal health in older adults, higher dietary protein intakes may be necessary (Bauer et al., 2013). The current recommendation for protein from the PROT-AGE group is 1.0-1.2 g.

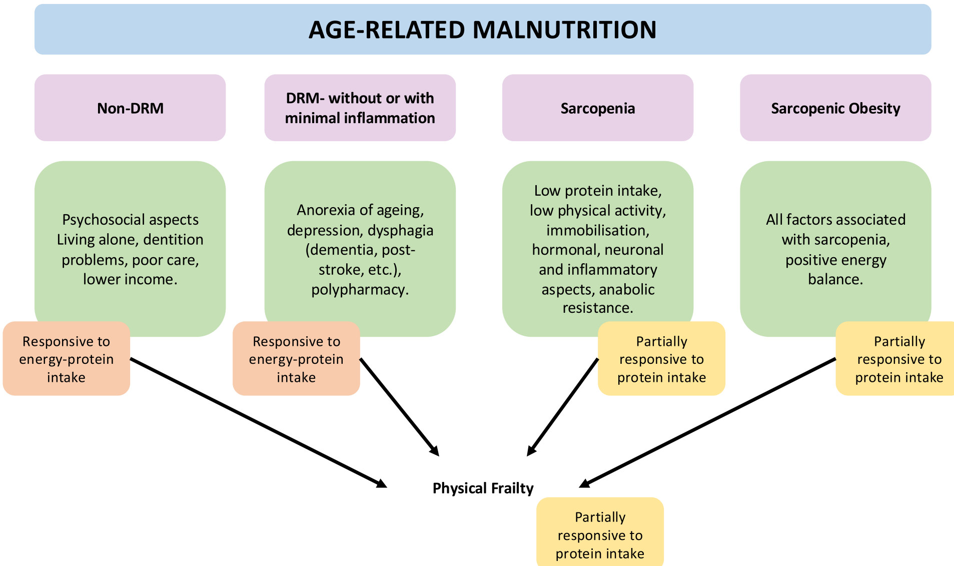

Fig. 1. Summary of age-related malnutrition. DRM: disease-related malnutrition. Illustrated is the definition of distinct age-related nutritional diagnosis, the causes of each condition, and their responses to nutritional therapy. All malnutrition conditions have the potential to contribute to the progression of physical frailty. Conditions in which the central mechanism is the low intake of nutrients (Non-DRM, DRM without or with minimal inflammation) are well responsive to nutritional therapy. However, if other metabolic components are involved, as in sarcopenia and sarcopenic obesity, energy and or protein intake alone are not enough. This figure is adapted from Cederholm et al. (2017).

$kg^{-1}.day^{-1}$ for healthy older individuals, 1.2–1.5 $g.kg^{-1}.day^{-1}$ for individuals with chronic disease or acute injury, and up to 2.0 $g.kg^{-1}.day^{-1}$ for individuals experiencing severe malnutrition (Bauer et al., 2013). Evidence has demonstrated an association between low protein intake and frailty in older adults (Coelho-Júnior et al., 2018), highlighting the need to increase protein intake in older adults in the residential care setting who are at increasing risk of malnutrition. Data obtained from care homes has demonstrated that up to 35 % of residents do not consume an adequate amount of protein, markedly below the EAR (Cruz-Jentoft et al., 2017; Tieland et al., 2012). It must however be noted that beyond protein provision, several factors contribute to a decrease in protein consumption with advancing age, particularly in the residential care setting, including a decrease in appetite, and increased prevalence of dementia, dysphagia, and dentition issues (Gaspareto et al., 2017; Hildebrandt et al., 1997; Pilgrim and Sayer, 2015). Related to these additional challenges of achieving optimal protein intake in older adults, there is a growing interest in protein supplementation for these individuals, and in particular in the residential care setting, where older adults are more susceptible to the adverse outcomes associated with low protein consumption, including sarcopenia and frailty.

This susceptibility is evident in the high, yet variable, reported prevalence of sarcopenia, frailty, and PEM in the residential care setting, with the reported prevalence of sarcopenia, for example, in nursing home residents ranging between 14–85 % (Bahat et al., 2010; Landi et al., 2012; Senior et al., 2015; Zhang et al., 2018). Differences in reported prevalence are likely explained by the variety of diagnostic tools used and their cut-off points for muscle mass, and the age and clinical status of the participants. Similarly, despite the prevalence of frailty being identified as higher in those in the residential care setting compared to community-dwelling individuals at 15–84 % (Buckinx et al., 2017; Collard et al., 2012; Fried et al., 2001; Kojima, 2015), the reported presence of frailty is also largely determined by the diagnostic tool used. When considering the prevalence of PEM in the residential care setting, a number cannot be presented reflecting a lack of knowledge on the prevalence of specifically PEM in this population (as the prevalence of general malnutrition is more commonly reported) (Damo et al., 2018). These figures are demonstrative that despite the growing interest, there is limited available research in this topic area, and the available research highlights the need to develop universal methods of determining sarcopenia, frailty, and PEM in this vulnerable population.

Currently 425,000 older people in the UK live in residential care homes (Gordon et al., 2014). This is three times more people than are in hospital at any one time, and this number is set to increase further (Goodman et al., 2016). Care home residents experience greater multi-morbidity and polypharmacy than age-matched community dwellers (Gordon et al., 2014), and malnutrition is a prevalent contributory factor. As such, there is a clear need to explore and establish how much protein elderly adults in the residential care setting are currently receiving and consuming, which factors are influencing protein consumption in these individuals, and the effectiveness of protein supplementation to slow the rate of sarcopenia onset and development.

3. Recognition and diagnosis of malnutrition

Early recognition and diagnosis of malnutrition has been identified as one of the most pivotal factors to prevent or slow the malnutrition trajectory (Ferguson et al., 1999), yet there is no universal malnutrition screening or assessment in place in UK care homes. This has proven to be a problem in determining how many individuals in the residential care setting are at risk of, or are diagnosed with, malnutrition, in particular PEM. This is evident in the disparity of reported malnutrition prevalence when using different diagnostic tools (Gaskill et al., 2008; Pauly et al., 2007). The Department of Health's Minimum Standards for Care Homes for Older People state that on admission to care homes, individuals must be weighed and that their diet preferences should be noted, however there is no universally accepted malnutrition assessment tool required for use in this setting. Established malnutrition assessment tools used in the healthcare setting include the Mini Nutritional Assessment (MNA) (Guigoz et al., 2002), Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening (NRS-2002), and Subjective Global Assessment (SGA) (Detsky et al., 1987). Specific to the residential care setting, the MNA short-form (MNA-SF), which includes an assessment of functional, psychological, and cognitive parameters, has shown good predictive value for survival in nursing homes (Donini et al., 2016).

The discrepancies between tools used to evaluate malnutrition and PEM do not allow the precise identification of PEM in the residential care setting. These discrepancies often lie in the design of malnutrition screening tools, and their specificity to different populations. For example, the MUST is a broader malnutrition screening tool, designed for use in hospitals, community and other care settings, whereas the SGA is primarily a clinical malnutrition screening tool, designed for adult surgical populations to predict surgical outcome (Van Bokhorst-de van der Schueren et al., 2014). Due to differences in the criteria used to assess malnutrition across screening methods, the reported prevalence of malnutrition in elderly individuals in the residential care setting is broad at 5%–70% (Bauer et al., 2008; Pauly et al., 2007). Diekmann and colleagues investigated these discrepancies in a comparative analysis of the MNA, NRS-2002, and MUST in nursing home residents (Diekmann et al., 2013). Their participants included individuals with cognitive impairment to ensure a true reflection of the care home population, however the complexity of the MNA as a malnutrition screening tool highlighted a low applicability rate in this population compared with the MUST and NRS-2002 (Diekmann et al., 2013). Similarly, low applicability of the MNA in comparison to the SGA and NRS-2002 has also been previously reported in hospital in-patients on geriatric wards (Bauer et al., 2005). Furthermore, one of the key differences in the design of these malnutrition tools is the body mass index (BMI) and weight-loss cut-offs. The NRS-2002 and MUST do not adjust their BMI cut-off values for older people and use the World Health Organisation recommendations, which are based on research in young and middle-aged, as opposed to older individuals (Diekmann et al., 2013). In contrast, the MNA uses BMI cut-offs adapted for older people, which often results in more sensitive, lower scores, indicating a higher malnutrition risk in comparison to the MUST and NRS-2002 (Diekmann et al., 2013).

The breadth of research comparing methods of malnutrition assessment lacks a clear consensus. However, upon evaluating the available literature, it may be perceived that the present problem is not just the form of malnutrition assessment being used, but the lack of universal requirement for malnutrition screening to take place in older adults on admission to care homes and nursing homes. It is recommended that care homes screen individuals for malnutrition every 3 months, yet there is no requirement for this or policy-based implication if this is not carried out (Van Bokhorst-de van der Schueren et al., 2014; Volkert et al., 2019). These discrepancies can make identifying those at risk of malnutrition, in particular PEM, challenging. In the case of malnourishment not being diagnosed or treated in a malnourished individual, this may result in exacerbation of existing, or development of new comorbidities.

4. Factors affecting protein consumption in older individuals

PEM is a complex process of grave concern in older age due to the associated negative consequences related to quality of life, physical functioning, and overall health (Hung et al., 2019). However, PEM is not simply a result of increasing age. There are many contributing physiological and psychosocial factors to PEM in elderly individuals, some of which may explain the higher proportion of individuals in the residential care setting with PEM compared to their community-dwelling counterparts. These factors are summarised in Fig. 2.

Appetite influences not only protein intake, but also total energy intake in older individuals. This has resulted in appetite often being studied in parallel to PEM (Agarwal et al., 2013; Bunn et al., 2018; Gaskill et al., 2008). An association has been previously reported between low protein intake and appetite in community-dwelling older adults (van der Meij et al., 2017), however, this association has been reported as more common in nursing home residents (Malafarina et al., 2013). In older adults' poor appetite is associated with low total energy intake (Shahar et al., 2003, 2009), lower diet quality (Shahar et al., 2009), and decreased diet variety (Dean et al., 2009). A key factor in older adults in the residential care setting which may impact upon appetite is the presence of dementia. It is widely reported that individuals suffering from dementia may experience increased difficulty eating and drinking, thereby requiring more assistance with these everyday tasks. Dementia is a known predictor of entry to residential care facilities (Andersson et al., 2012; Gnjidic et al., 2012), and it is reported that up to 75 % of older individuals in the residential care setting suffer from dementia (Matthews and Dening, 2002; Stewart et al., 2014). This population group are therefore a high-risk group for PEM due to increases in eating and drinking and associated declines in appetite.

Dysphagia, the difficulty in swallowing, is a prevalent factor contributing towards a decline in appetite and energy and protein (Gaspareto et al., 2017; Payne and Morley, 2018) intake in older adults, and has been reported in 13–57 % of older adults suffering from dementia (Volkert et al., 2015). It has been reported that up to 60 % of nursing home residents in the United States suffer from dysphagia (Tanner, 2010), highlighting the prevalence of this problem in the residential care setting as well as in individuals suffering from dementia. Furthermore, research investigating appetite and protein intake has identified a relationship between declining oral health, or tooth loss, with increasing age and decreased protein consumption (de Abreu et al., 2008; Hung et al., 2019). Often occurring hand-in-hand with dysphagia, many older adults in the residential care setting experience dentition issues and poor oral hygiene (Saunders et al., 2008). This largely impacts individual protein and energy intake and can lead to PEM due to

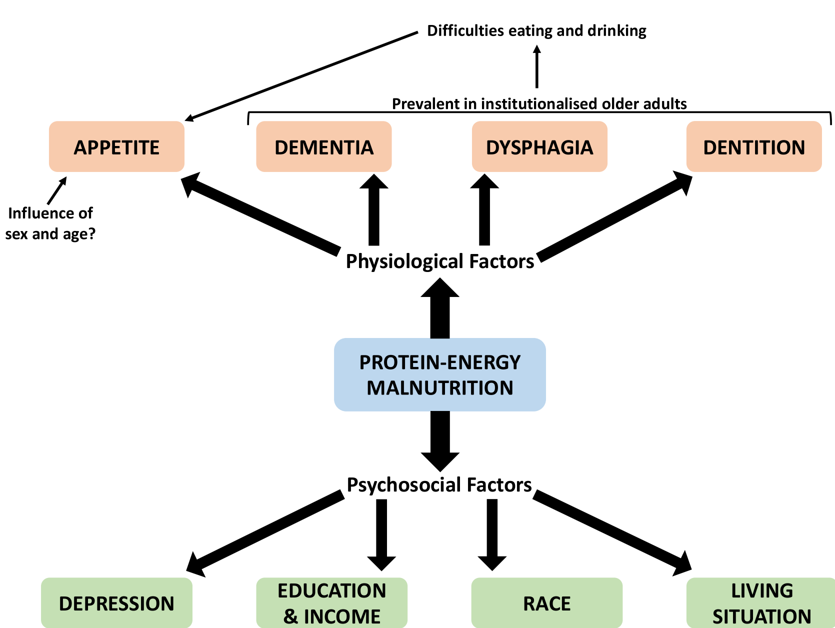

Fig. 2. Summary of factors influencing protein-energy malnutrition in older adults. Several physiological and psychosocial factors influence protein-energy malnutrition in older adults. The primary physiological factor influencing not only protein intake, but also total energy intake, is decreased appetite (Shahar et al., 2003, 2009), with research on the influence of sex and chronological age on appetite yielding conflicting data (Gaspareto et al., 2017; Gray-Donald et al., 2014; Tieland et al., 2015; Volkert et al., 2004). Other physiological factors contributing to protein energy malnutrition, common in elderly adults in the residential care setting, are dementia, dysphagia, and dentition (Corcoran et al., 2017; Matthews and Dening, 2002; Stewart et al., 2014), which can also contribute to decreased appetite. Several psychosocial factors are also known to influence protein energy malnutrition in older individuals, including those in the residential care setting. These include depression, education and income, ethnicity, and living situation (Beasley et al., 2010; McDougall et al., 2007; Pilgrim and Sayer, 2015).

Table 1
Studies investigating the effects of protein supplementation in older adults in the residential care setting.

First author, year	Setting (Country)	Study design	Study participants	Age (yrs) Mean (SD)	Percent female	Intervention duration	Intervention protein content goal (g/d)	Intervention energy content goal (kcal/d)
Oral Nutritional Supplementation								
de Luis, 2018	Nursing homes and community-based (Spain)	Prospective Observational	N = 148 IG 1 (CD): 97 IG 2 (RE): 51	80 (8)	66	12-weeks	NS	NS
Parsons, 2017	Care homes (Hampshire, England, UK)	RCT	N = 104 IG: 53 CG: 51	89 (8)	86	12-weeks	16	600
Jobse, 2015 Stange, 2013	Nursing homes (Nurnberg and Furth, Germany)	RCT	N = 87 IG: 45 CG: 42	86 (6)	91	12-weeks	24	600
Allen, 2013	Hospital and nursing home environments (UK)	Crossover design study	N = 26 (n = 18 nursing home residents, n = 8 hospitalised patients)	84 (8)	69	1-week (ONS given 3xday on alternate days)	~ 42	~ 849
Carlsson, 2011	Residential care facilities (Umeå, Sweden)	RCT	N = 177 IG 1 (ENS): 42 IG 2 (EX + PL): 41 IG 3 (ONS): 47 IG 4 (PL): 47	85 (6)	74	3-months	7.4	~ 816
Manders, 2009	Institutes for chronic care (The Netherlands)	RCT	N = 176 IG: 119 CG: 57	81	74	24-weeks	8.75	250
Cruz-Jentoft, 2008	Nursing homes (Spain)	Prospective observational	N/ IG = 358 No control group	84 (7)	71	12-weeks	NS. State 200 mL ONS, 20% protein.	NS
Wouters-Wesseling, 2006	Nursing homes (Wageningen, The Netherlands)	RCT	N = 34 IG: 18 CG: 16	83 (7)	85	5-weeks	11.2 g	309
Lauque, 2000	Nursing homes (Toulouse)	RCT	N = 88 CG 1: 19 CG 2: 22 IG 1: 19 IG 2: 28	CG 1: 84 (8) CG 2: 85 (6) IG 1: 85 (6) IG 2: 88 (4)	84	60-days	NS	300−500
Johnson, 1993	Nursing homes (USA)	Retrospective case control	N = 109 IG: 56 CG: 53	IG: 88 (6) CG: 85 (8)	IG: 86 CG: 85	Up to 72-months	NS	NS
Protein-fortified foods								
Beelen, 2017	Care facilities (The Netherlands)	Interventional	N/ IG = 22 No control group	83 (9)	59	10-days	Varying- aim to increase overall protein intake to 1.2 g/kg/d	NS
Van Wymelbeke, 2016	Nursing homes (Burgundy, France)	RCT	N = 68 IG 1 (PFF): 29 IG 2 (ONS): 17 CG: 22	IG 1: 84 (8) IG 2: 90 (7) CG: 87 (8)	79	12-weeks	IG 1: 12.8 IG 2: 14	IG 1: 180 IG 2: 200
Pouyssegur, 2015	Nursing homes (Nice, France)	RCT	N = 175 IG: 88 CG: 87	86 (8)	80	6-weeks	11.5	244
Iuliano, 2013				87 (6)	78	4-weeks		NS

(*continued on next page*)

Table 1 (*continued*)

First author, year	Setting (Country)	Study design	Study participants	Age (yrs) Mean (SD)	Percent female	Intervention duration	Intervention protein content goal (g/d)	Intervention energy content goal (kcal/d)
	Low-level aged care facilities (Melbourne, Australia)	Prospective intervention	N = 130 IG: 62 CG: 68				Varying- modified diets to contain at least 2 additional serves of dairy food/day	
Leslie, 2013	Care homes (UK)	RCT	N = 41 IG: 22 CG: 19	91 (7)	88	12-weeks	NS	Maximum potential increase of ~400
Smoliner, 2008	Nursing homes (Germany)	RCT	N = 65 IG: 22 CG: 30	IG: 82.2 (9.5) CG: 84 (9.5)	IG: 77 CG: 75	12-weeks	NS. Protein added per meal on top of standard diet.	NS

Abbreviations: ONS, Oral Nutritional Supplement; PFF, Protein-fortified food; RCT, Randomised Controlled Trial; IG, Intervention Group; CG, Control Group; CD, Community-dwelling; RE, Residential; NS, Not Stated; Ex, Exercise; ENS, Exercise and Nutritional Supplement; Pl, Placebo.

individuals struggling to chew and swallow whole foods (Hildebrandt et al., 1997).

To date, the effects of sex and age on appetite and protein consumption are unclear. Recent research investigating the factors associated with protein consumption in older adults reported a significant difference in protein consumption (g, g/kg) between male and female participants (Gaspareto et al., 2017). However, this contradicts previously published data, which reported no difference in protein intake between males and females when expressed in g/kg as opposed to g (Gray-Donald et al., 2014; Tieland et al., 2015; Volkert et al., 2004). The well-reported decline in appetite in older individuals was first termed the 'anorexia of ageing' (Morley and Silver, 1988), however evidence shows no difference between older men and women in appetite nor protein consumption (Gaspareto et al., 2017; Tieland et al., 2015, 2012; Volkert et al., 2004), with these results suggestive that other factors are present, such as comorbidities and declining oral health, that have a greater influence on protein intake in older individuals.

Recent evidence highlights the role of psychosocial factors affecting appetite and protein consumption in older adults, due to the strong influence of environment and mood on appetite regulation (Pilgrim and Sayer, 2015). Depression is a known psychological factor related to an impairment of appetite (Engel et al., 2011) and has been reported to be present in 27 % of individuals living in care homes in the UK (McDougall et al., 2007). Research investigating protein consumption and its relationship with several psychosocial factors in 90,000 women aged 50–79 demonstrated an association between low depression scores and a higher protein consumption (Beasley et al., 2010). This study also identified several psychosocial factors associated with a greater protein intake. These include a higher level of education and income, not smoking, being younger and white ethnicity and co-habitation. Together, a combination of the described physiological and psychosocial factors can result in PEM, particularly in older adults in the residential care setting at greater risk of adverse health outcomes and comorbidity development.

5. Evidence of protein supplementation in older adults in the residential care setting

Literature investigating protein supplementation techniques in older adults in the residential care setting is sparse. Despite often being the individuals most vulnerable to malnutrition, in particular PEM, there is a lack of consensus of the feasibility and efficacy of protein supplementation in this population. Often due increasing participant frailty and decreased mobility, existing methods used to assess outcome measures including musculoskeletal 'health', functional ability, and basic anthropometric measures, are not feasible for use in the residential care setting. Furthermore, complications may lie in commonly used methods of supplementation due to a breadth of factors affecting protein consumption, as previously described. Making outcome measure adaptations and determining what interventions are feasible for use in the residential care setting is vital to progress research in this sector.

The most commonly used methods of supplementing protein are oral nutritional supplements (ONS), and protein-fortified foods (PFF). An ONS is a source of energy and protein, often in liquid form, commonly used in malnourished individuals in the residential care setting when experiencing difficulty obtaining nutrients from whole foods (Collins et al., 2019). Previous research has demonstrated the benefits of ONS prescription, with individuals prescribed ONS for 6-months following hospitalisation showing a marked improvement in functional capacity and increased independence (Volkert et al., 1996). However, evidence investigating ONS compliance and effectiveness is conflicting. Alternatively, PFF is a form of supplementing protein in the form of energy- and protein-dense meals or snacks; increasing protein intake without any dramatic change to the quantity of food an individual is consuming (Mills et al., 2018). Again, as with ONS, data on the compliance and effectiveness of PFF is largely equivocal.

Table 2
Oral nutritional supplementation and protein-fortified foods study outcomes.

First author, year	Protocol Overview	Study Outcomes
Oral Nutritional Supplementation		
De Luis, 2018	12-weeks ONS supplementation, Nursing homes and community-based	•Significant increases observed in weight and BMI in comparison to baseline •Decrease in NRS-2002 scores in ONS group (decreased malnutrition score) •Significant improvements in functionality measures (Katz ADL scores) and quality of life (EQ-5D-3 L scores) in comparison to baseline
Parsons, 2017	12-weeks ONS supplementation vs dietary advice, Care homes.	•Higher QoL in ONS group compared to dietary advice at 6- and 12-weeks •Significant body weight increases in ONS group (at 12-weeks, not seen in dietary advice group). No significant differences between groups. •ONS group demonstrated increased total energy and protein intake (not accounted for by discrepancies in voluntary food intakes) •Majority of macronutrient intakes higher in ONS compared to dietary advice group at 6- and 12-weeks
Jobse, 2015		•ONS compliance high in 35.7 % and low in 28.6 % of participants •Those with higher compliance showed positive associations with body weight increases, BMI, upper-arm circumference, and MNA-SF scores •Higher compliance in malnourished individuals with chewing difficulties •Lowe compliance in those who were immobile, depressed, had gastrointestinal complaints, or consumed more than 4 daily drugs
	12- weeks ONS supplementation, Nursing homes	•Several outcome measures could not be assessed in a number of participants due to mobility issues and cognitive impairment (geriatric depression scale, 46 %; handgrip strength, 38 %, gait speed, 49 %)
Stange, 2013		•In those that could complete all assessments, there were no changes in functionality in the CG or IG, excluding ADL scores, which decreased in both groups •When assessing QoL, there was a trend for "positive self-perception" to decrease in the CG and increase in IG. There was a significant reduction in "being busy" in the CG
Allen, 2013	1-week ONS supplementation (given 3x on alternate days), Hospital and nursing home environments	•When ONS was consumed, individuals were more likely to achieve their daily energy and protein requirements. This did not impact their habitual food consumption. •ONS supplementation increased energy, macronutrient, vitamin, and mineral intake (excluding Vitamin A)
Manders, 2009	24-weeks ONS supplementation, Chronic care institutes	•Body weight increased in the ONS group and decreased in the control group, however this was not significant •Several blood biomarkers demonstrated significant changes in favour of the IG (albumin, pre-albumin, Vitamin D, Hcy, folate, Vitamin B_{12}, and Vitamin B_6) •High compliance of ONS supplementation (97.46 % at 6-weeks, 96 % at 12-weeks)
Cruz-Jentoft, 2008	12-weeks ONS supplementation, Nursing homes	•No significant change in BMI •Significant improvements observed in MNA score and body weight
Wouters-Wesseling, 2006	5-weeks ONS supplementation, Nursing homes	•Significant differences in weight change were observed between the standard (-0.4 kg) and supplementation (+0.8 kg) groups •No differences in anthropometric measurements •No differences were observed in energy intakes nor macronutrient intakes between groups
Lauque, 2000	60-days ONS supplementation, Nursing homes	•Higher energy intake after 60-days ONS supplementation •Improvements in MNA score and body weight in the most malnourished and those at risk of malnutrition receiving ONS •No improvements in MNA score nor weight in those at risk of malnutrition receiving ONS
Johnson, 1993	Varying supplementation period (Up to 72-months), Nursing homes	•Many patients receiving ONS supplementation were below the age-adjusted body weight values upon admission, and until ONS supplementation began, an average decrease in body weight was observed •Participants consuming ONS gained weight over 9−10 months to approximate admission weight •Average age of ONS participants higher than control patients. More likely to be wheelchair- or bed-bound, require assistance eating, and eat a modified diet.
Protein-fortified foods		
Beelen, 2017	10-days PFF supplementation, Care facilities	•Consuming PFF increased protein intake but did not result in any changes in energy, fat, or carbohydrate intake •All participants reached a protein intake of 0.8 g/kg/day, and a higher proportion of individuals reached the recommended protein intake of 1.2 g/kg/d (n = 9/22) as opposed to baseline (n = 4/22) •PFF supplementation resulted in a significant increase in protein intake at breakfast and during the evening
Van Wymelbeke, 2016	12-weeks PFF vs ONS supplementation, Nursing homes	•Higher total energy intake in PFF group compared to CG and ONS at day 30 and 90 •Following intervention, a larger number of the PFF group participants (72 %) reached the recommended protein intake of 0.8 g/kg/day in comparison to the ONS (53 %) and CG (36 %) •Blood biomarker assessment demonstrated an increase in blood levels of Vitamins B_9, B_2, D, B_6, B_{12} following PFF intervention. Decreases were observed in plasma homocysteine •High reported PFF compliance (83 % consuming all of brioche). This was lower for the ONS group (74 % consuming all ONS). •No significantly different BMI, handgrip strength, or MNA scores between or within groups
Pouyssegur, 2015	6-weeks PFF supplementation, Nursing homes	•Increased average weight in PFF compared to IG. This persisted for 1-month and 3-months post-PFF supplementation. •Diarrhoea reduction was observed in PFF group in comparison to the IG post- nutritional intervention
Iuliano, 2013	4- weeks PFF supplementation, Low-level aged care facilities	•PFF demonstrated a steady increase in mean appetite throughout the intervention period •Increases in mean energy and protein intake, proportion of energy from protein, and proportion of estimated energy requirements in PFF group. Decrease in proportion of energy from fat in PFF group.

(*continued on next page*)

Table 2 (*continued*)

First author, year	Protocol Overview	Study Outcomes
		•Increases in nutrients including calcium, Vitamin D, phosphorus, and zinc in PFF group only •Prior to intervention, mean phosphorus and zinc intakes were below recommended levels. With PFF intervention, the recommended levels were attained.
Leslie, 2013	12-weeks PFF supplementation, Care homes	•Increase in mean energy intake and weight gain in PFF group only •A small number of PFF participants (n = 6/16) demonstrated an increase in BMI > 18.5 kg m^{-2}
Smoliner, 2008	12-weeks PFF supplementation, Nursing homes	•Higher protein intake in PFF group compared to CG. No difference in total energy intake. •Improvements in nutrition and body composition parameters (including BMI, MNA score, fat free mass) throughout intervention in PFF group and IG •No improvements were observed in muscle function following nutritional intervention •Decline in the Barthel Index and the physical functioning component of the Short Form-36 questionnaire observed in all participants following the intervention period

Abbreviations: QoL, Quality of Life; ONS, Oral Nutritional Supplement; BMI, Body Mass Index; MNA-SF, Mini Nutritional Assessment- Short Form; CG, Control Group; IG, Intervention Group; ADL, Activities of Daily Living; PFF, Protein Fortified Food.

This literature review aimed to identify articles supplementing ONS or PFF in residential care settings and provide a scoping overview of the outcomes of these studies, in particular those impacting malnutrition state. A scoping review was chosen as opposed to other review formats, such as a systematic review, due to the review aim of providing an overview of the current knowledge base regarding protein supplementation in older adults in the residential care setting based on published guidelines (Munn et al., 2018). This meant that extensive inclusion criteria were not necessary, and studies of different protocols and study designs having a wide range of primary outcome measures were included. This is necessary in effectively summarising the evidence available regarding protein supplementation in the residential care setting. Scoping literature searches were performed by two researchers independently (S.L.M, P.S.A.) on PubMed and Google Scholar databases, and abstracts of relevant articles were examined. Further, a literature search using the PubMed MeSH only tool was used including the search terms “Protein” AND “Nursing Homes” or “Care Homes” or “Housing for the elderly” or “Geriatric nursing” or “Homes for the Aged”. 553 manuscripts were identified and screened for those mentioning protein supplementation, protein enriched diet (liquids, solids), dietary supplementation, or any other form of protein supplementation. Articles deemed to fit the aim of the present review were included. Inclusion criteria included articles available in English with full text available investigating the effects of ONS supplementation and/or PFF on older adults living in residential care settings. Following this literature search, 17 relevant protein supplementation studies in older adults based in residential care facilities were identified. Of these, 11 used ONS and 6 used PFF. Following identification of these studies, relevant information regarding study setting, design, participant number, participant age, percentage of female participants, intervention duration, intervention protein content goal (g.day^{-1}), and intervention energy content goal (kcal.day^{-1}) was extracted for comparison. These variables are displayed in Table 1. A summary of all study outcomes is displayed in Table 2. Further comparisons were made to assess the effectiveness of protein supplementation, the differences in outcome measures used, and the implications these may have had on supplement efficacy. These comparisons were made to provide a scoping overview of the available research in this topic area and identify gaps in the knowledge base to be further addressed.

6. Protein supplementation in older adults the residential care setting: A summary of findings

6.1. Oral nutritional supplementation

The use of dietary advice has been suggested to aid protein intake, yet its use in older adults in the residential care setting is not commonly reported. However, an identified study from Parsons et al. (2017) aimed to compare the effects of dietary advice (DA) vs. ONS supplementation in n = 104 malnourished care home residents (identified using MUST, mean age 88.5(7.9)yrs) without obvious dementia (no direct measure, determined via medical notes and care home staff input) (Parsons et al., 2017). Following 12-weeks of ONS supplementation (goal of 16 g protein, 600 kcal per day), results demonstrated a significantly higher QoL rating (measured using EuroQol 5 Domain Health Questionnaire) in the ONS group compared to the DA group. ONS increased total energy, protein, and majority of micronutrient intakes. However, no differences were found in appetite sensations (following resident interview) between the two groups, excluding fullness, which was identified to be significantly lower in ONS group compared to DA group. However, this study did not include individuals with dementia and therefore the results may not be generalisable to all older adults in the residential care setting as it has previously been reported that up to 75 % of individuals in the residential care setting suffer with dementia (Matthews and Dening, 2002; Stewart et al., 2014). This was the only identified ONS study comparing ONS with DA but does show that in this particular group of care home residents ONS may be more effective than DA at improving energy and protein intake, and that protein supplementation in the form of ONS may benefit quality of life and dietary intake.

A previous systematic review identified a positive effect of ONS containing at least 20 % of calories from protein on handgrip strength (Cawood et al., 2012). However, limited ONS studies investigate the effect of protein supplementation on functional status in older adults in the residential care setting. This is often due to the difficulties associated with taking these measurements in this patient population. However, Stange et al. (2013) investigated the effects of a low-volume, nutrient- and energy-dense ONS (24 g protein, 600 kcal) on functional status, along with nutritional status and QoL in n = 77 nursing homes residents (mean age 87(6)yrs) (Stange et al., 2013). Results demonstrated significant differences in several nutritional parameters and QoL in favour of the intervention group (see Table 1 for details). Regarding physical functioning, Stange et al. (2013) also reported that hand grip strength and gait speed could not be assessed in 38 % and 49 % of participants, respectively, primarily due to mobility issues and cognitive impairment. Stange et al. (2013) further identified a lack of compliance of functional testing in the residential care population, highlighting a knowledge gap that needs to be explored further. These results are suggestive that ONS may be used to increase energy and protein intake and improve nutritional parameters in older adults in the residential care setting. However, the true effects of ONS on functional status remain unknown due to problems identified in conducting functional tests in this population.

Several studies were identified that assessed the compliance and acceptability of ONS in the residential care setting to increase protein and energy intake (Cruz-Jentoft et al., 2008; Jobse et al., 2015; Lauque et al., 2000). Specifically, the most recent of these studies assessed compliance with an ONS intervention, and identified the specific characteristics associated with low compliance in n = 87 nursing home residents (mean age 87(6)yrs) (Jobse et al., 2015) (data taken as part of previously reported RCT (Stange et al., 2013)). Following 12-weeks ONS supplementation, with the goal to provide 24 g protein (600 kcal) per day, a wide range of compliance (determined by estimates of ONS consumption from nursing home staff) was observed (high compliance in 36 % and low compliance in 29 %). However, it was observed that positive changes in body weight, BMI, upper-arm circumference, and MNA-SF score were significantly higher in participants with a higher compliance. Similarly, an earlier study aimed to determine the acceptability of ONS in n = 88 nursing home residents (age range 84–88 yrs), and its effect on the nutritional status of malnourished residents (Lauque et al., 2000). Average daily ONS intake in malnourished individuals or those at risk of malnourishment averaged at ~400 kcal, with good observed compliance (determined via a survey). Despite using a different method of measuring compliance, a similar relationship was observed between compliance, MNA score, and weight. Most participants identified as malnourished or at risk of malnourishment demonstrated weight gain and improvement in MNA score, with no reported improvements in participants not receiving ONS supplementation (see Table 2 for details). A comparable study published had similar study aims: to evaluate adherence to 12-weeks ONS in nursing home residents identified as suffering from or at risk of malnourishment and to study changes in defecation following ONS supplementation (Cruz-Jentoft et al., 2008). High ONS compliance was observed (determined by number and quantity of ONS consumed) and resulted in significant changes in nutritional status, mirroring previously reported findings (Lauque et al., 2000; see Table 2 for more information). Despite not stating the full composition of the ONS, Cruz-Jentoft et al. (2008) stated that the ONS contained 20 % protein, which resulted in positive outcome measures (Cruz-Jentoft et al., 2008). Cruz-Jentoft et al. (2008) reported the highest compliance levels of all 3 studies, with Lauque et al. (2000) reporting good compliance (ONS protein content not stated, 300−500 kcal), and Jobse et al. (2015) reporting a wide range of compliance levels (24 g protein, 600 kcal). Due to the lack of information regarding the ONS composition and other factors affecting compliance in these studies, the relationship cannot be attributed solely to number of calories as protein. However, compliance with ONS was reported as high, suggesting that ONS may be a feasible method of increasing protein and energy intake in this setting. Further in-depth analysis and research is needed to fully explore ONS compliance and the factors which may influence this.

The final group of selected ONS studies for review investigated whether consumption of ONS influenced energy and protein intake from participants' regular diet. One of the earliest studies investigating the use of ONS in malnourished older adults examined the effect of ONS in elderly nursing home residents and investigated the nutritional assessment, if any, received by elderly nursing home residents (Johnson et al., 1993). This study provided an early perspective of malnutrition in the residential care setting, noting an average decrease in body weight in residents upon nursing home admission followed by an average weight gain over an average of 9−10 months back to admission weight. Interestingly, it was reported that ONS residents were older than control residents, and more likely to be wheelchair- or bed-bound, require assistance eating, and eat a modified diet. Incidentally, many of these factors, such as an increase in dependency and dentition issues are now known factors contributing to progression and diagnosis of malnutrition (Agarwal et al., 2013). Furthermore, Johnson and colleagues identified weight loss and poor appetite as the most common reasons for starting ONS supplementation, key factors which are now part of malnutrition screening tools such as the MNA. Despite not providing the total protein and energy content of the provided ONS or the average duration of ONS supplementation, this study reports beneficial effects of a high-protein oral supplement on factors such as body weight, which are now well-known factors associated with PEM. However, without information regarding the composition of the supplemented ONS, the true effect of ONS on outcome measures cannot be determined. Similarly, Wouters-Wesseling et al. (2006) investigated the effect of ONS on preventing weight loss in elderly psychogeriatric nursing home residents following acute illness from infection (Wouters-Wesseling et al., 2006). Specifically, this study included 2 groups: residents receiving early ONS supplementation (200 mL ONS daily; 209 kcal, 11.2 g protein) prior to acute illness onset, and residents receiving standard treatment (dietary intervention occurring once a physician had observed weight loss, loss of appetite and/or low intake). Results demonstrated significant differences in weight changes between the standard (-0.4 kg) and supplementation (+0.8 kg) groups, yet these differences were not reciprocated in anthropometric measurements. As reported by Johnson and colleagues, the reported results state that ONS may facilitate weight gain in nursing home residents. However, no malnutrition screening tool was used. Despite weight loss influencing malnutrition development and assessment, using a screening tool such as the MNA which takes into consideration body weight and BMI among other factors such as appetite, mobility, protein intake, and prescription medication, may provide a more reliable assessment of malnutrition in a nursing home setting.

Later published work from Manders et al. (2009) completed a randomised controlled trial with a 24-week supplementation period in n = 176 individuals in chronic care institutes (Manders et al., 2009). They aimed to determine whether ONS had a positive effect on dietary intake and nutritional status and had a secondary aim of investigating the effect ONS supplementation would have on their habitual food consumption. Favourable effects of ONS were seen, with a higher number of individuals reaching their energy and protein requirements and beneficial effects observed on body weight in the ONS group (see Table 2). Interestingly, both ONS and placebo groups displayed small decreases in energy intake from food (-0.5 MJ/day), suggesting that this is not a compensatory effect of ONS supplementation. Similarly, a study from de Luis et al. (2018) investigated the effects of supplementing a high calorie and protein, β-hydroxy-β-methylbutyrate (HP-HMB-ONS) containing ONS on nutritional status, ADL, and QoL in older malnourished adults (community-dwelling outpatients and older adults in residential care settings) (de Luis et al., 2018). Beneficial effects were observed in malnutrition and nutritional status and measures of QoL and functionality (see Table 2). However, this study did not report the amount of protein or energy in the supplementing ONS, and no statistical comparisons were made between the adults in the community and those in residential living facilities. The lack of statistical comparison in this study is a challenge to determining the efficacy to of the HP-HMB-ONS in adults in the residential care setting.

Another study also looking at the addition of ONS to participants regular diet, albeit over a much shorter time period is Allen et al. (2013). Specifically, they investigated whether in older adults in the residential care setting with dementia, a 1-week ONS supplementation would decrease energy and protein intake from their regular diet (Allen et al., 2013). Their secondary aim was to determine whether irrespective of changes in their regular diet, whether ONS can aid achievement of adequate protein and energy intakes (see Table 1 for full details). As previously reported (de Luis et al., 2018; Manders et al., 2009), ONS supplementation provided favourable results. Results demonstrated a higher number of individuals met their energy and protein requirements, a weak but significant correlation between ONS consumption and body weight, and no changes in protein consumption (g) consumed in food on intervention compared to control days (see Table 2). As previously mentioned, the energy and protein content of the ONS supplement has been suggested to be a key factor to consider when investigating the effectiveness of ONS in the residential care setting. When comparing the above studies, the composition of the provided ONS was unclear in 2/5 studies (de Luis et al., 2018; Johnson et al., 1993), despite de Luis et al. (2018) reporting the use of a high-protein ONS. In the remaining 3/5 studies protein content ranged from 8.75 g protein (250 kcal) to 42 g protein (849 kcal) (Allen et al., 2013; Manders et al., 2009; Wouters-Wesseling et al., 2006). All the above studies found a positive effect of ONS on outcome measures; strikingly, Allen and colleagues reported a statistically significant correlation between ONS consumption and body weight after only 1-week of supplementation. Thus, this high protein and energy content (42 g protein, 849 kcal) ONS may not be realistic as a long-term ONS supplementation in the residential care setting due to factors such as appetite (Shahar et al., 2003, 2009), yet the importance of high ONS protein content has been demonstrated.

Declining muscle mass in older age is a key contributor to sarcopenia development, with exercise often prescribed to older individuals as an adjuvant to protein nutrition to aid muscle mass maintenance. Yet, this is not always feasible in the residential care setting due to declining physical function. The effect of nutritional supplementation on muscle mass and function specifically in older adults in the residential care setting is not widely reported in the literature, yet, a study was identified that investigated the effects of an exercise programme and ONS on muscle mass in residential care facilities. Despite the focus of this review not being on exercise interventions in the residential care setting, this study has been included due to the presence of an ONS only supplementation group (n = 47, mean age 83(6)yrs) and a placebo group (placebo drink, no exercise intervention; n = 47, mean age 85(7)yrs) (Carlsson et al., 2011). Carlsson et al. (2011) used ONS containing 7.4 g protein and 10.8 g carbohydrate, and placebo containing 0.2 g protein and 10.8 g carbohydrate, ensuring that differences between groups could not be attributed to differences in carbohydrate content. No differences were observed in muscle mass or body weight between the ONS and CG. This study provides contrasting results to the majority of other ONS studies, possibly as protein supplementation was not the primary focus of this study, meaning protein content (g) in ONS supplements were markedly lower compared with the other reported ONS supplementation studies. Of note, although out with the scope of this review to be discussed in detail, ONS combined with 3-months high intensity exercise did not result in any differences in muscle mass or body weight, with no beneficial effect of ONS supplementation.

6.2. Protein fortification

An alternative approach to increase protein consumption in older individuals is the use of PFF. In the present review, 6 PFF studies in older adults in the residential care setting were identified. The majority of these studies aimed to investigate the effect of different forms of PFF on the nutritional status of older individuals in residential care facilities. However, Iuliano et al., (2013) conducted a 4-week feasibility intervention study in n = 130 low-level aged-care residents (older individuals in the residential care setting requiring some assistance with daily activities, age range 87–88 yrs) to investigate compliance with consumption of 2 additional serves of dairy (specific protein and energy intakes not stated) to increase protein and calcium intake to recommended levels (Iuliano et al., 2013b). This proved effective in increasing mean energy and protein intake, and proportion of energy from protein as well as several nutritional parameters (see Table 2 for full study outcomes). An earlier study conducted by Leslie et al. (2013) used PFF to increase protein intake of food without increasing meal sizes over 12-weeks (Leslie et al., 2013). Their method adding dairy-based foods, such as double cream and butter, to resident's usual meals. This study was conducted in n = 41 (mean (SD) age 91(7)yrs) UK care home residents, and demonstrated an increase in mean energy intake and body weight in the intervention group, supporting previously reported results (Iuliano et al., 2013b) and further highlighting the potential for use of dairy-based products to increase protein and energy intake in older adults in the residential care setting.

A common method of PFF supplementation to increase protein and energy intake involves using regular diet items, such as bread and soup, to increase palatability of the supplemented food, and to keep the supplementation in line with the regular diet of the individual. Of the 6 PFF studies identified in this review, 2 used this form of PFF in a residential care setting (Beelen et al., 2017; Smoliner et al., 2008). Beelen et al. (2017) developed various protein-enriched foods such as bread, soups, and mashed potatoes to substitute into the residents normal diet, with protein-enriched fruit juices offered as additional choices (Beelen et al., 2017). Similarly, Smoliner et al. (2008) used energy-enriched soups and sauces, with the addition of 2 snacks high in protein and energy served between meals (Smoliner et al., 2008). Both studies aimed to determine the effect the supplementation would have on individual nutritional status, with Beelen et al. (2017) specifically aiming to increase protein intake to 1.2 $g.kg^{-1}.day^{-1}$; the recommended protein intake for older adults from the PROT-AGE group (Bauer et al., 2013). Both studies observed an increase in protein intake in the PFF group compared to CGs, with no changes observed in energy intake. Furthermore, Beelen et al. (2017) observed a higher proportion of individuals reaching the recommended protein intake of 1.2 $g.kg^{-1}.day^{-1}$ following PFF intervention. However, Smoliner et al. (2008) also investigated the effect of PFF on muscle function (determined using hand grip strength) and observed no significant differences between the PFF and the CG. The above studies demonstrate the effectiveness of using foods familiar to the individual to increase protein intake, however, the role of PFF on muscle function cannot be concluded and is yet to be fully elucidated.

The final 2 of the 6 identified PFF studies selected for the current scoping review include supplementation of protein-fortified snacks, specifically brioche and cookies, to increase protein intake in the residential care setting (Pouyssegur et al., 2015; Van Wymelbeke et al., 2016). Specifically, Van Wymelbeke et al. (2016) investigated the effect of providing protein-enriched brioche compared to ONS or usual breakfast to n = 68 nursing home residents over a 12-week period on various measures of nutritional intake and status and blood biochemistry measures (see Table 2 for full outcome measures) (Van Wymelbeke et al., 2016). Per portion, the brioche (65 g) contained 180 kcal energy and 12.8 g protein, and the ONS (200 mL) contained 200 kcal energy and 14 g protein. Results reported a higher total energy intake in the brioche group at day 30 and 90 in comparison to the CG, and a higher proportion of individuals reaching the recommended minimum protein intake of 0.8 $g.kg^{-1}.day^{-1}$ (72 %) compared to the ONS (53 %) and CGs (36 %). Furthermore, blood biochemical analysis demonstrated an increase in blood levels of vitamins B9, B2, D, B6, and B12, and a decrease in plasma homocysteine in the brioche group. Pouyssegur et al. (2015) focussed on the effect of 6 weeks protein-fortified cookie supplementation on weight gain in n = 175 malnourished older adults in the residential care setting (Pouyssegur et al., 2015). Results reported an increase in average weight in the PFF group compared to control, which was maintained 1-month and 3-months after the supplementation period. Further analysis identified a positive impact of protein fortified cookie supplementation on several secondary outcome measures, including body weight, appetite, and presence of pressure ulcers (see Table 2 for full outcome measures). Together, these studies imply beneficial effects of providing protein fortified snacks with which older adults are familiar as a means to increase protein and energy intake, yet, due to the nature of the current review, further research and statistical analysis is needed to determine this.

6.3. ONS vs PFF: which is more effective in older adults in the residential care setting?

To our knowledge, this is the first narrative review of the effects of ONS and PFF supplementation in the residential care setting. The selected studies used a wide range of outcome measures; however, it is important to compare the efficacy of these supplements in increasing protein and energy consumption in older adults in this setting. Several of the included studies did not explicitly report the change in protein (g) and energy (kcal) intake from baseline to post-supplementation period (Carlsson et al., 2011; Cruz-Jentoft et al., 2008; de Luis et al., 2018; Jobse et al., 2015; Johnson et al., 1993; Pouyssegur et al., 2015; Smoliner et al., 2008). This may be due to the primary aim being the assessment of compliance with the supplementation protocol as opposed to other outcome measures in some studies (Cruz-Jentoft et al., 2008; Jobse et al., 2015). However, of the studies reporting protein (g) and energy (kcal) intake, there appears to be a negligible difference with respect to increasing protein and energy intake between ONS and PFF supplementation. Despite many PFF studies not stating an explicit amount of protein supplemented in the prescribed foods (Iuliano et al., 2013a; Leslie et al., 2013; Smoliner et al., 2008; Van Wymelbeke et al., 2016), observationally there appears to be a higher protein and energy content in ONS compared to PFF diets and supplements. However, this does not deem ONS as more effective than PFF, and all outcome measures need to be considered prior to advising what is more effective in older adults in the residential care setting.

6.4. Limitations and future research

This narrative review highlights the importance of dietary protein and the benefits of protein supplementation in the residential care setting. However, it is not without limitations. A systematic review or meta-analysis would provide more information regarding the effectiveness of the different methods of protein supplementation in this setting, but this is not yet feasible. There is limited research on protein supplementation specifically in the residential care setting, although there is lack of harmonisation between study aims and outcome measures. There are also problems in evaluating the research. These problems include a lack of information across all studies regarding the energy and protein content of the supplemented protein, lack of universal nutritional assessment tool use, lack of compliance of testing functional status in this population, and a lack of true representation of this population (many studies do not include individuals living with dementia, despite up to 75 % of individuals in the residential care setting being diagnosed with cognitive deficits). Further research in this area needs to tackle these problems to offer robust evidence of protein supplementation in the residential care setting. Despite this review not including studies not in the English language, not being of a systematic nature and not performing meta-analyses, it has clearly highlighted the problems that need to be addressed so further research can fully determine the true influence of protein supplementation in this population, and the most effective method of doing so.

7. Conclusions

It is widely reported in the literature that the prevalence of malnutrition is higher in older adults in the residential care setting compared with community dwelling adults. In particular, PEM is highly prevalent in the residential care setting and can result in the development and exacerbation of adverse health conditions. Despite this, the exact prevalence of different types of malnutrition in residential care settings cannot be fully determined due to discrepancies between malnutrition assessment tools and a lack of universal requirement for malnutrition screening. The most effective methods of targeting PEM in older adults are undoubtedly through increasing energy and protein intake, yet, due to factors such as appetite and dentition, interventions are not straightforward to develop or deliver. The most common forms of protein supplementation to target PEM in the residential care setting include ONS and PFF, yet studies yield differing results, such that the most effective method cannot yet be identified. Regarding sarcopenia prevention and treatment, there is limited evidence of how much protein or energy should be prescribed in this unique population. Further research comparing the use of ONS and PFF is needed to fully determine feasibility and efficacy in the residential care setting.

Author contributions

S.L.M. conducted the literature search, writing, reviewing, and editing of the manuscript. P.S.A. assisted with the literature search and manuscript writing. S.L.M., P.S.A., A.L.G., B.E.P., and C.A.G. reviewed, edited, and approved the final manuscript.

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Declaration of Competing Interest

The authors report no declarations of competing interest.

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