Nutrition clinique et métabolisme 33 (2019) 190–198

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Basic study

Nutritional support for enhanced recovery programs in orthopedics: Future perspectives for implementing clinical practice

Soutien nutritionnel pour programmes de récupération améliorée en orthopédie : perspectives d'application dans la pratique clinique

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ARTICLE INFO

Article history:
Received 30 March 2019
Received in revised form 26 April 2019
Accepted 29 April 2019
Available online 12 August 2019

Keywords:
Orthopedic
Nutritional support
Enhanced recovery after surgery
Fast-track

Mots clés :
Orthopédique
Soutien nutritionnel
Récupération améliorée après chirurgie
Fast-track

ABSTRACT

Over the last 15 years, orthopedic departments have begun to consider a multidisciplinary approach in the management of hip/knee arthroplasty and spine surgery. However, much misperception persists on the founding concepts of rapid-recovery approaches, and most of the programs in orthopedics lacks nutritional support. Despite the complexities of nutritional parameters prognostic potentials, associated interventions mainly focused on using dietary supplements. Nevertheless, an effective integrative nutritional support program for enhancing recovery after surgery should comprehensively account for pre-operative nutritional counseling and optimization, shortening fasting time, early postoperative feeding and integration, and follow-up dietary management after discharge.

RÉSUMÉ

Au cours des 15 dernières années, les départements d'orthopédie ont commencé à envisager une approche multidisciplinaire dans la prise en charge de l'arthroplastie de la hanche/du genou et de la chirurgie de la colonne vertébrale. Cependant, de nombreuses idées fausses persistent sur les concepts fondateurs des approches de récupération rapide et, la plupart des programmes d'orthopédie manquent de soutien nutritionnel. Malgré la complexité des potentiels pronostiques des paramètres nutritionnels, les interventions associées ont principalement porté sur l'utilisation de compléments alimentaires. Néanmoins, un programme efficace de soutien nutritionnel intégratif visant à améliorer la récupération après une chirurgie

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https://doi.org/10.1016/j.nupar.2019.04.002

devrait prendre en compte les conseils et l'optimisation nutritionnels préopératoires, la réduction du temps de jeûne, l'alimentation et l'intégration postopératoires précoces, ainsi que la gestion diététique après la sortie.

1. Introduction

A challenge in the care of an orthopedic patient lies with the journey he makes from the outpatient ambulatory to the pre-operative unit, operating room, and post-operative intensive unit or rehabilitation facility. Often, each stage has its own hospital staff that aims to manage the immediate clinical situation with little strategic thinking. The need for a holistic approach that could optimize the peri-operative care was suggested in 1995 by Bartram and Kehlet [1], when they investigated the combined effect of a minimally invasive surgery, continuous epidural anesthesia, and early oral nutrition and mobilization in older adults undergoing elective colonic resection for tumours, thus highlighting the importance of collaborative working between physicians, nurses, and physical therapists. Two years later, Kehlet theorized that pre-operative malnutrition and post-operative muscle loss could be treated with pre-operative nutrition and post-operative early oral feeding, respectively [2], further introducing another player of care: the dietitian nutritionist. This dedication to nutritional practice evolved in the following years, resulting in the recent Enhanced Recovery After Surgery (ERAS) program by different European experts, whose protocol can definitely be applied to non-orthopedic surgeries. Conversely, the multidisciplinary approach in orthopedics acquired notoriety only in the late 2000s, when Berend from United States of America outlined the specific elements comprising the rapid-recovery program for total hip arthroplasty (THA) and total knee arthroplasty (TKA) [3]. In orthopedics, ERAS protocols are often named "fast-track" pathways in response to the high demand for THA or TKA interventions, which counted 23049 THA (88.4% elective, 11.6% trauma) and 20656 TKA (84.4% of primary knee procedures) in Italy during 2017 [4], with orthopedic surgeons being subjected to a considerable pressure to attain the best results while minimizing days of hospitalization. However, misperceptions still exist about the concepts upon which ERAS and other pathways should be based [5]. Both the burdening economic climate and misinformation have detracted from the ability of each orthopedic centre to assimilate the cardinal principles of ERAS, with the incorporation of a dietitian nutritionists often being omitted. Many THA and TKA fast-track programs, although providing positive results, may need a further nutritional integration [6]. Wainwright from United Kingdom, who was the first to suggest the introduction of ERAS principles in spine surgery, recently stated that some current integrative programs for THA and TKA do not properly adhere to the ERAS indications [7]. A malnutritional status prior to orthopedic surgery is known to be associated with worse outcomes. The primary criteria for addressing malnutrition in clinical settings appear to be well recognized, being three factors termed "phenotypic" criteria (non-volitional weight loss, low body mass index (BMI), reduced lean mass) and two factors being "etiologic" in nature (low food intake, disease burden) [8]. However, also laboratory markers, such as total lymphocyte count (TLC), albumin, pre-albumin, iron metabolism, and vitamin D, could be used as a complement to the abovementioned nutritional examination, even if they might be unreliable by themselves [9,10]. The aim of our review is to address the current evidences concerning the nutritional support in orthopedics, thus recapitulating the complexities of peri-operative care and discussing future perspectives for clinical practice.

1.1. *Methodology of the review*

Data from PubMed and Google Scholar were reviewed, focusing on English publications regarding nutritional parameters associated to worse outcomes in THA, TKA, or spine surgery, and corrective nutritional interventions associated with better prognosis. The search considered observational and interventional clinical studies with no publication date restriction. For a more intelligible reading, we narratively categorized the results of our literature search into those concerning the pre-surgery and post-surgery phase.

2. Discussion

2.1. *Nutritional considerations prior to orthopedic surgery*

2.1.1. *Laboratory markers*

Since 1991, it was reported that a pre-operative malnutritional status, characterized by TLC less than 1500 cells/mm^3 and albumin less than 3.5 g/dL, was associated with higher rates of wound complications in THA and TKA [11]. Serum albumin level of less than 3.9 g/dL was associated with prolonged recovery in THA [12]. Both low (< 3.4 g/dL) serum albumin and low (< 1200 cells/mm^3) TLC correlated with greater resource consumption, longer length of stay, and greater operative time in patients undergoing joint replacement surgery [13], thus finally suggesting that these parameters could be improved with dietary supplements before surgery. Similar results concerning the negative prognostic value of hypoalbuminemia, but also low pre-albumin, were suggested in more recent papers that were facilitated by nationwide surgical registries [14,15]. Blood nutritional markers, such as total proteins, albumin, pre-albumin, and TLC undergo a relevant 48-h drop after major surgeries even in well-nourished subjects [16].

The pre-operative serum transferrin levels were significantly lower for patients who developed wound complications after THA [17]. Serum ferritin was said to be the most sensitive and specific test to diagnose anemia and iron deficiency in surgical patients [18], but levels of hemoglobin less than 13 g/dL for both genders are widely used. Eventually, the surgical procedure *per se* may cause anemia, but patients with low pre-operative hemoglobin may be more likely to suffer post-operative drops in serum levels and adverse outcomes, such as higher rates of 90-day readmissions and transfusions [6,19]. Certainly, more invasive surgical procedures may involve greater blood losses, such as spinal osteotomies, which often require longer lengths of hospital stay [20]. THA and TKA may conversely rely on minimally invasive procedures with reduced blood losses compared to spine surgery. However, data from six European countries showed that the mean decrease in hemoglobin levels presented no significant differences between hip, knee, or spine procedures [21].

Vitamin D levels were shown to be involved not only in the well-known calcium homeostasis and bone mineral density, but they were also positively associated with handgrip strength after hip fracture [22]. After TKA, subjects with vitamin D deficiency (25(OH)D less than 12 ng/mL) performed significantly worse than non-deficient patients in the American Knee society Score, Alternative Step Test, and Six-Meter walk Test [23]. A positive association between vitamin D levels and Harris Hip Score was also reported [24]. Among orthopedic patients, insufficient levels of vitamin D can be found in 80–90% of cases [25,26]. Patients with low pre-operative concentrations of vitamin D may be more prone to longer hospitalization [27], acute periprosthetic infections [28], and 90-day complications [29].

2.1.2. Anthropometry

In the early 1990s, Bostman showed that patients undergoing elective orthopedic surgery had higher body weight than matched subjects from the general population [30]. Subsequent studies investigating the prognostic factor of body weight used standard BMI categories: undernutrition (< 18 kg/m^2), normal weight (18–24.9 kg/m^2), overweight (25–29.9 kg/m^2), obesity (> 30 kg/m^2), and morbid obesity (> 45 kg/m^2). Higher BMI is known to increase the risk for mechanical implant failure, component malposition, prosthesis dislocation [31], and to be therefore associated with slower gain of function [32]. However, there are several limitations in using BMI for stratifying the risk for implant failure. First, BMI does not distinguish between muscle mass and fat mass. Body composition assessed routinely through bioelectrical impedance analysis (BIA) may prove to be more useful than BMI in predicting clinical outcomes [33], with older people usually tending to have more body fat than younger people. Another paper reported that not the BMI, but a higher fat mass, was associated with higher rates of any medical or surgical complication after total joint arthroplasty [34]. Increased body fat with concomitant muscle weakness and low muscle mass (i.e. sarcopenic obesity) was suggested to be a risk for adverse events in orthopedic surgery [35]. Strength-based measures (e.g. handgrip or knee extensor force) may be useful parameter to assess muscle function [36,37]. Second, BMI is not suitable for some elderly or spine patients who often present a deformity of the column that affects their height and therefore the calculation. Third, the predefined standard BMI groupings may not be useful for older adults, as an overweight or non-morbid obesity status was shown to be protective against all-cause mortality [38]. Conversely, morbidly obese patients encounter higher risk of surgical and medical 30-day post-operative complications after THA or TKA than non-obese patients [39].

2.1.3. Dietary habits

About 50% of Italian older adults undergoing THA or TKA were reported to usually follow a Western dietary pattern, which is characterized by higher content of sugar, salt, processed meats, saturated fats, refined grains, and lesser consumption of fruits and vegetables [40]. Conversely, the Mediterranean dietary pattern was associated to reduced joint degeneration and subchondral bone deterioration [41] that certainly contribute to accelerate the progression of osteoarthritis (i.e. the main clinical indication for which arthroplastic procedures are performed – the 91.0% and 94.9% of THA and TKA cases, respectively, in Italy during 2017) [4]. On the other hand, the Mediterranean diet is characterized by a high consumption of fruit and vegetables, cereals, olive oil, seafood, pulses, and nuts. Low adherence to this diet may expose the patients to nutritional deficits or insufficient dietary intakes, as was observed for protein, vitamins C and E, and omega-3 fatty acids consumption in THA/TKA patients [36].

2.2. Nutritional interventions prior to orthopedic surgery

2.2.1. Dietary supplementation

A halved length of hospital stay and a significant reduced C-reactive protein was observed in THA patients supplemented with arginine, fish oil, and nucleotides (600 mL/die of Impact, Nestlé) for five days before surgery [42], conceivably suggesting immunosupplements to be effecting to reduce the acute immune response. Concerning pre-operative anemia, oral ferrous sulphate supplementation was suggested in 1997 to protect against post-operative drops in hemoglobin levels and to reduce excessive rates of transfusion [43]. In 2017, an international consensus statement proposed oral iron supplementation to be given to patients with iron deficiency with or without anemia [18]. A supplementation plan of sucrosomial iron (Sideral Forte, Pharmanutra) may reduce hospitalisation and surgery-related costs in THA if started at least 4 weeks prior to elective surgery [44]. Giving the fact that cardiac diseases are one of the major risk factors for post-operative complications in THA or TKA, authors supplemented orthopedic patients with calcifediol (i.e. 25(OH)D, starting dose of 50 μg/day for months) and observed a cardiac gain of function [26], ultimately suggesting to initiate the supplementation protocol weeks before surgery. The sole supplementation of vitamin D2 (base dose of 2000 UI daily for months) was showed to promote spinal fusion even if started after surgery [45]. Other authors reported to plan a more comprehensive pre-admission supplementation programs that provided vitamin D (daily 1000 IU of vitamin D3 in tablets), proteins, and β-hydroxy β-methylbutyrate (HMB) supplementation through the consumption of 1-2 Ensure Enlive by Abbott (350 kcal, 20 g of proteins, 1.5 g of HMB, vitamins, minerals) [46]. A more specific and tailored pre-admission dietitian nutritionist review [47] or coaching intervention [46] was suggested to be useful prior to surgery, possibly identifying any motivational or physical deficit that could invalidate the clinical outcome. Concerning immediate pre-operative interventions, a shortened duration of hospital stay in THA/TKA was achieved through the integration of a nutritional intervention into the ERAS protocol, which included minimal pre-operative fasting with clear oral fluids up to 2 hours before surgery and the addition of oral carbohydrate loading [47]. Earlier discharges were also observed for orthopedic patients undergoing an ERAS protocol that comprised the consumption of three sachets of Build-up (Nestlé) in 150 mL of water 2 days before surgery and two sachets 1 day before surgery [48]. Moreover, admitted patients were given two sachets of the high carbohydrate drink Preload (Vitaflo, Nestlé) to be dissolved in 400 mL of water at 8 p.m. in the evening prior to surgery and the other sachet few hours before surgery. In another study, a small sample of spine patients were randomized to study the effects of a pre-operative prehabilitation program plus the consumption of 200 mL protein drink (Fortimel, Nutricia) to integrate the usual diet: shorter hospital stay and better patient satisfaction were the only significant improvements found [49].

2.2.2. Structured behavioral programs

Not all authors feel confident in recommending that obese patients should lose weight before THA or TKA [50]. In fact, "recent weight loss" was found to be a predictor for "non-home discharge" in surgery for adult spinal deformity [20]. The Malnutrition Universal Screening Tool, which is used to identify patients at risk of malnutrition, comprises the investigation of non-volitional weight loss in the past 3–6 months in its five-step screening. A non-volitional body weight reduction, especially in the geriatric population, may indeed affect the muscle mass reservoir, and this event should be avoided especially if facing a surgical operation. A loss of muscle mass might also be the result of a poorly planned weight loss program if it did not focus on the maintenance of lean mass, which could definitely be favored by a physical activity program. However, increasing physical activity or participating in an exercise program may be difficult for some patients because of the pain associated with advanced hip or knee osteoarthritis. Considering that most patients undergoing total joint replacement are willing to lose weight before surgery [51], authors suggested that best results could came from a dietitian nutritionist-supervised weight loss intervention [50]. Nonspecific healthy eating advices were reported to be useless to achieve weight loss prior to

Table 1
Nutritional parameters associated to worse outcomes in total hip arthroplasty, total knee arthroplasty, or spine surgery, and corrective nutritional interventions associated with better prognosis.

Nutritional parameters associated with worse outcomes	References	Worse outcomes associated with nutritional parameters	Nutritional interventions associated with better prognosis	References	Better prognoses associated with nutritional interventions
Before surgery					
Laboratory markers					
Low levels of pre-albumin, albumin, total protein, and total lymphocyte count	(Greene et al. 1991) [11] (Del Savio et al., 1996) [12] (Lavernia et al. 1999) [13] (Bohl et al. 2016) [14] (Zajonz et al. 2018) [28] (Lalueza et al. 2005) [16] (Stone et al. 2018) [15]	Higher wound complications, prolonged recovery time, higher resource consumption and operative time	Protein supplementation, immuno-nutrition	(Negm et al. 2018) [46] (Alito et al. 2016) [42]	Suggested improvement of frailty and mobility, decreased length of hospital stay, reduced C-reactive protein
Low levels of hemoglobin, transferrin, ferritin, and iron	(Jans et al. 2018) [6] (Lavernia et al. 1999) [13] (Gherini et al. 1993) [17] (Lasocki et al. 2015) [21]	Higher 90-day readmissions, transfusions, and wound complications	Iron supplementation	(Andrews et al. 1997) [43] (Scardino et al. 2018) [44]	Reduced transfusion rates, decreased length of hospital stay
Low vitamin D	(Jans et al. 2018) [6] (Zajonz et al. 2018) [28] (Gumieiro et al. 2015) [22] (Shin et al. 2017) [23] (Nawabi et al. 2010) [24] (Maier et al. 2016) [27] (Traven et al. 2017) [29]	Longer hospitalization, acute periprosthetic infections, lower handgrip strength and physical performance, higher 90-day complications	Vitamin D supplementation	(Briguglio et al. 2018) [26] (Negm et al. 2018) [46] (Plehwe et al. 2002) [45]	Gain of cardiac function, suggested improvement of frailty and mobility, promotion of spinal fusion
Anthropometry					
High body mass index	(Bostman 1994) [30] (Adhikary et al. 2016) [39] (AAHKS 2013) [31] (Li et al. 2017) [32]	Higher 30-day complications, increased risk for mechanical implant failure, component malposition, and prosthesis dislocation, slower gain of function	Planned weight loss program	(Pellegrini et al. 2017) [51] (Gandler et al. 2016) [52]	Suggested improvement of knee symptoms and no delays of knee replacement, improved physical health scores after surgery
Altered fat mass/muscle mass ratio	(Ledford et al. 2016) [34] (Godziuk et al. 2018) [35]	Higher complications and adverse events	Exercise and dietary supplements	(Negm et al. 2018) [46]	Suggested improvement of frailty and mobility
Dietary habits					
Western diet, unhealthy eating behaviors	(Purcell et al. 2016) [36] (Briguglio 2016) [40] (Morales-Ivorra et al. 2018) [41]	Suggested nutritional deficiencies and risk for joint degeneration and subchondral bone deterioration	Nutritional counseling or *ad hoc* diet	(Proudfoot et al. 2017) [62] (Christelis et al. 2015) [47] (Negm et al. 2018) [46]	Decreased length of hospital stay, suggested improvement of frailty and mobility
Fasting	(Soffin et al. 2016) [5] (Greene et al. 1991) [11]	Metabolically 'fed' state with more nitrogen and protein loss	Carbohydrate or mixed nutrient loading	(Christelis et al. 2015) [47] (Dwyer et al. 2012) [48] (Nielsen et al. 2010) [49] (Alito et al. 2016) [42]	Decreased length of hospital stay, reduced C-reactive protein
After surgery					
Short-term weight loss and reduced food intake	(Briguglio 2016) [40] (Keller et al. 2015) [56]	Suggested increased hospital stay and reduced gain of muscle performance	Supplementation with a combination of carbohydrates, proteins, amino acids, β-hydroxy β-methylbutyrate, or vitamin D	(Christelis et al. 2015) [47] (Nielsen et al. 2010) [49] (Dwyer et al. 2012) [48] (Nishizaki et al. 2015) [59] (Dreyer et al. 2018) [60] (Ekinci et al. 2016) [61]	Decreased length of hospital stay, maintenance of lower limbs strength, preservation of quadriceps muscle volume, acceleration of wound healing
Unhealthy eating behaviors	(Pellegrini et al. 2018) [51]	Suggested overeating and alteration of the nutritional status	General nutritional counseling or *ad hoc* diet	No references	Expected healthy eating behaviors and adherence to nutritional prescriptions

surgery compared to a structured intervention by a dietitian nutritionist [52].

2.3. Nutritional considerations after orthopedic surgery

There is a lack of data about nutritional status alterations after orthopedic surgery. If no nutritional support program was present, post-operative TLC and albumin levels would return to concentrations before surgery only after 10 days [11], and it is reasonable to say that it could be the same for other laboratory markers. An internal survey showed that about 66% of THA or TKA Italian older adults lost weight during the immediate 15 post-operative days, and that food intake was insufficient for both energy and proteins during hospitalization [40]. Conversely, other authors reported that most of their patients maintained their body mass [53]. However they considered weight change over two-years, overlooking short-term weight loss, and relied on patients-reported measures, which may convey a high risk of bias. In fact, a reduction of body weight after surgery may compromise the overall recovery in turn causing hospital-associated deconditioning, with activity-related, nutrition-related, and disease-related sarcopenia onset. After surgery, patients may be subjected to weight loss for several reasons, such as low energy and protein intakes and higher resting metabolic expenditures. Low food intake was reported to be influenced by the so-called geriatric anorexia [54], but was also showed to be caused by the poor palatability of hospital diets, the excessive culinary expectations of in-patients, and the lack of nutritional monitoring that prevents patients to leave food in their tray [55]. Other factors influencing food intake during hospitalization were reported to be some organizational barriers, such as interruptions at meals, lack of help when needed, receiving food not ordered [56]. Whether the discharge was shorter for fast-track programs or longer for in-patient rehabilitation, post-hospital syndrome is likely to occur, with higher risks of post-operative complications, such as infections, within 30 days after discharge [57]. Alterations of the nutritional status are possible even after patients return home, because they are often overcome by unhealthy food choices, possibly overcompensating for days of the strict hospital diets [58].

2.4. Nutritional interventions after surgery

Despite the suggestion made by Bartram and Kehlet [2] about the concept of early oral nutrition in 1995, uncertainties still persist. Normal oral food intake, enriched by enteral protein solution (daily intake of about 1000 kcal and 80 g of protein), may be allowed from the first post-operative day, with the concomitant monitoring of oral fluid and food intake [1]. Generally, early post-operative nutrition is promoted in fast-track programs for orthopedic surgery patients, but nutritional interventions may vary, or may not be detailed enough. One Australian study on THA/TKA preferred a carbohydrate supplementation [47], and another study from Denmark on spine patients chose a 150 mL protein-drink (Fortimel, Nutricia) to be consumed in the evening on the day of surgery and to continue to consume 4×150 mL a day in addition to the hospital standard diet [49]. Some authors reported encouraging patients to sit up, eat, and drink almost immediately after THA, with an emphasis on oral protein and carbohydrate intake rather than intravenous fluid administration. Additionally, patients were given two sachets of Build-up drink on the evening after surgery and three sachets for 3 consecutive days thereafter [48]. If food and meal services were undervalued and nutritional monitoring was not provided, patient's dissatisfaction would more likely to be associated with low food intake and an increased length of hospital stay [56]. In order to counteract the hospital-associated deconditioning, authors provided TKA patients a daily dose of 2.4 g of HMB, 14 g of L-glutamine, and 14 g of L-arginine, thus observing a maintenance of lower limb strength [59]. This nutritional support program was sustained peri-operatively, beginning 5 days before surgery and continued for 28 days after surgery. Quadriceps muscle volume was preserved by consuming 20 g of essential amino acids twice a day for 7 days before TKA and for 6 weeks after surgery [60]. In addition to standard nutrition after surgery, authors from Turkey supplemented fractured patients with 3 g Calcium HMB, 1000 IU of vitamin D, and 36 g protein, and observed an increased muscle strength and an acceleration of wound healing compared to control group [61]. Despite great potential advantages of nutritional support programs in counterbalancing abovementioned sarcopenia, it should be noted that the combination of both nutritional therapy and physical exercise appears to be the most effective treatment, as it was for the structured behavioural program before surgery, and one cannot be dissociated from the other [54]. No studies reported a nutritional counseling or *ad hoc* diet to be continued after the discharge.

In Table 1, all abovementioned nutritional parameters that were showed to influence clinical outcomes were reported. Accordingly, nutritional interventions were categorized for biochemical, anthropometric, and dietary data before and after surgery.

3. Conclusion

This study narratively reviewed the current state of knowledge about nutritional considerations and interventions in various orthopedic settings, mainly focusing on THA, TKA, and spine surgery. Few evidences concerning spine surgery were found, probably because of later suggestions of its implications by ERAS professionals. While nutritional parameters that are known to predict clinical outcomes in orthopedics seem to be well categorized, conversely the interventions aimed at correcting these biochemical, functional, or eating behavior alterations are much more difficult to identify. The demographic and pathological differences between clinical cases prevent the standardization of any nutritional support program and few prospective studies on orthopedic patients have investigated nutritional support interventions with a randomized controlled design. Moreover, pre-admission nutritional support programs, which should be applied at least 1 month prior surgery, can be integrated for elective orthopedics, but traumatic surgeries lack of time for the optimization process, and immediate pre-operative/post-operative nutritional interventions should acquire more emphasis [62].

3.1. Pre-admission remarks

Both phenotypic and etiologic criteria for malnutrition, together with concomitant laboratory markers, should be assessed before scheduling a patient for an orthopedic procedure. Reliable screening tools may be used, but they should be selected according to the specific setting and disease population, as each tool has its own pros and cons and different cut-points for severity grading [8,10]. Blood markers of protein, iron, and vitamin D metabolism were found to predict clinical outcomes, with relative supplementations possibly being useful in correcting serum levels. Low TLC and post-operative acute immune response may be addressed through the so-called immuno-nutrition. Weight loss programs appeared to lack of evidence, but they should be accounted and customized on patients' conditions and preferences, with the dietitian nutritionist and physical therapists dynamically working together. The preservation of muscle strength during body weight reduction may be monitored through handgrip and guaranteed by a concomitant protein and vitamin D supplementation [22], the latter being associated mainly with functional outcomes. A general nutritional education by a dietitian nutritionist, together with the eventual psychological support by a clinical psychologist, may be useful in patients who are anxious for the imminent surgical procedure. Of note, diagnosis of depression or anxiety were associated with adverse outcomes after THA or TKA [63]. A more specific nutritional optimization through an *ad hoc* diet may help malnourished or frail individuals to attain the best possible fitness before surgery. For instance, patients suffering from spine deformities may normally experience digestive concerns, such as gastroesophageal reflux [64], thus possibly compromising their dietary habits long before elective surgery.

3.2. Peri-operative remarks

Immediately prior to surgery, patients should be educated to eat prescribed hospital diets after surgery in order to prevent weight loss or excessive muscle catabolism. If the nutritional counseling focused on the establishment of achievable goals for post-operative oral intake, orthopedic patients would be more likely to eat adequately after surgery. In fact, oral intake is frequently limited after surgery even if bowel movements are present, and feeding is often provided as a diet progression from liquids to soft and then to solid foods. Nevertheless, no scientific bases for such practice exist. The nutritional support should avoid fasting possibly through carbohydrate loading [5], and focus on the peri-operative education in order to convey the importance of early feeding and to establish achievable goals for food/liquid intakes. Pre-operative carbohydrate loading [65] and peri-operative amino acids or HMB may be useful in counteracting hospital-associated deconditioning in turn ameliorating post-operative hunger, muscle volume and strength, respectively. Stool impaction, which may delay recovery, and swallowing disorders, which are a strong risk factor for aspirations pneumonia, were among the more frequently reported events in a geriatric orthopedic population, with peri-operative nutritional surveillance being extremely important to avoid these clinical exacerbations [66]. A decreased level of physical activity with unhealthy eating may contribute to shifts in body compositions that may be veiled if changes in BMI are used as predictors instead of fat mass/muscle mass percentages. Post-operative pain, desire for high-fat/high-calorie foods, overeating, mood alterations, and many other factors may interfere with dietary habits. In order to increase the dietary intake after surgery, either carbohydrate or protein supplementation may be effective, with any dietary supplementation always being decided by mutual agreement between dietitian nutritionists, hospital pharmacists, anesthesiologists, and orthopedic surgeons. It should be noted that any dietary supplement should be investigated for possible interactions with drugs prescribed during and after hospitalization [67,68]. The overall scope for providing sufficient energy and proteins after orthopedic surgeries should be the avoidance of excessive muscle catabolism and loss of strength, which may delay early mobilization and discharge.

3.3. Post-discharge remarks

Nutritional support programs after discharge should aim to increase and maintain healthy habits in order to avoid readmissions and complications. Therefore, it is necessary to guarantee the highest pre-operative serum values of blood markers in order to raise baseline levels before the inevitable serum drops after surgery. Indeed, a tailored nutritional education and follow-ups through phone calls or scheduled visits should be planned for first post-operative weeks in order to ensure that the prescribed nutritional intervention is being followed after discharge. In fact, one of the main limitations of nutritional interventions in older adults has been reported to be the lack of long-term adherence [54], and therefore a strict monitoring possibly provided by administrative assistants should help avoiding a high rate of withdrawal from treatment. Supplementation with iron, proteins, or vitamin D may be continued after discharge if deficits persist, but they are not intended to replace a regular dietary intake through natural sources.

4. Future perspectives for implementing clinical practice

An attentive peri-operative program could take years to be integrated in a specific setting [62], but would certainly guarantee the optimal medical model. The low risk profile compared to the great potential benefits warrant the consideration of incorporating a comprehensive nutritional support program in orthopedic surgery. Future researchers should investigate each nutritional intervention in their own setting, initially considering each single component showed in Table 1, and successively integrating multiple interventions and multidisciplinary approaches. Peri-operative dietitian nutritionists are invited to observe, investigate, and report their results with the highest level of detail, especially for the following items.

4.1. Decision-making algorithms

As mentioned previously, pre-admission nutritional support interventions may be conceivable for elective procedures, but are not relevant for trauma patients. Conversely, immediate pre-operative and post-operative support programs are applicable for both sets of patients. Possibly, a distinction between the two types of programs should be accounted. Some authors described a so-called optimization clinic for elective orthopedic surgery, but only a selection of patients with a poor nutritional status may be included in such programs. Conversely, dedicated peri-operative units may be integrated for trauma patients [69].

4.2. Details about what, when, and how

Each nutritional intervention should be justified according to previous evidence. The supplement or molecule used, the dosage, and the administration schedule should be specified. The amount of time needed to fulfil the optimization process or correct the nutritional deficit should also be stated. For example, 4 weeks for iron [44], at least 1 month for vitamin D [26], and at least 6 months for weight loss programs [51]. For the latter, details about the program's focus, goal setting, duration, timeline, coaching delivery, and social support should be reported in order to identify effective strategies to lose, control, or maintain weight peri-operatively.

4.3. Patient education as well as staff education: who does what

The support and understanding of the patients is an essential part of health care delivery and to maximize the benefits of the enhanced recovery program. Despite dietitian nutritionists being the core part of all clinical nutrition teams, each staff member has its own role: dietitian nutritionists and pharmacists should always be involved for dietary supplement choices before and after surgery. Peri-operative orthopedic surgeons, anesthesiologists, and nurses should always supervise decisions concerning clinical choices, with all staff members being actively committed to working together. The structured behavioral program planning should involve physical therapists, psychologists, and administrative assistants who can

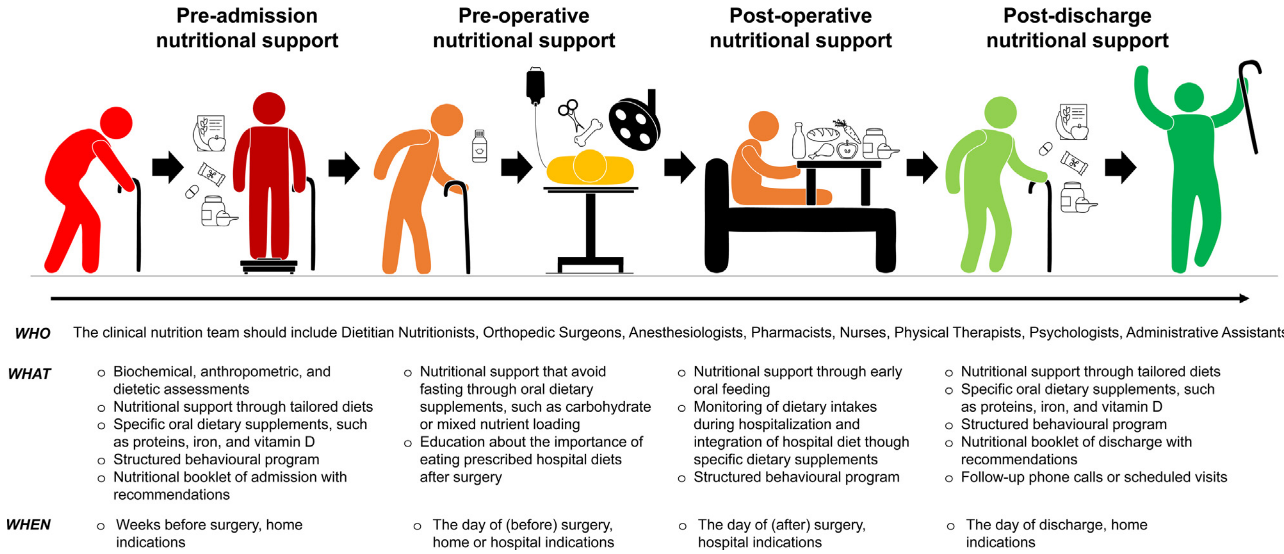

Fig. 1. A proposed peri-operative nutritional support program for Orthopedics.

support follow-up surgical registries. Furthermore, each specialized player has the primary responsibility of reviewing the literature and integrating the multimodal program [5]. Lectures, workshops, meetings, and written instructions may be organized [47].

4.4. Cost analysis

Peri-operative nutritional programs can produce better clinical outcomes at lower costs [69,70]. Cost-effectiveness is the ratio between costs and clinical benefits: the lesser the ratio the higher the value. Economic data about the integration of a multimodal approach in orthopedics were rarely reported, with these authors considering not only the new benefits in terms of mortality and morbidity associated with decreased length of stay or number of readmissions, but also considering many other cost items [69]. The increasing number of orthopedic surgeries performed worldwide, together with the constant concern to minimize costs, make it paramount for both the success of specific interventions and their associated cost-effectiveness to be evaluated. This approach would guide the clinicians through multiple nutritional approaches, in order to follow both evidence-based procedures and alternative solutions according to single patient needs.

In Fig. 1, a suggestive proposal regarding how a peri-operative nutritional support program in orthopedics could be planned and aligned with recent literature is shown. The graphics shows who should do what and when. All health professionals involved in the clinical nutrition team should be properly trained for evaluate and intervene during all phases of ERAS protocol, by knowing strengths and limitations of biochemical values, BMI, BIA, malnutrition screening tools, strength-based measures, and dietary supplements for orthopedic populations. Overall, these findings provide the evidence necessary to develop a feasible integrative nutritional support program for ERAS protocols in orthopedics, thus accounting for pre-operative nutritional counseling and optimization, shortening fasting time, early postoperative feeding and integration, follow-up dietary management after discharge.

Ethical approval

This article does not contain any studies with human participants or animals.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgement

Authors kindly thank Rachel Applefield for language editing.

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