Opinion

Disease-specific Nutritional Physical Therapy: A Position Paper by the Japanese Association of Rehabilitation Nutrition (Secondary Publication)

Tatsuro Inoue1, Izumi Takeuchi2, Yuki Iida3, Kohei Takahashi4, Fumihiko Nagano5, Shinjiro Miyazaki6, Kengo Shirado7, Yoshihiro Yoshimura8, Ryo Momosaki9, Keisuke Maeda10, and Hidetaka Wakabayashi11

Abstract:
Nutritional disorders diminish the effectiveness of physical therapy. The pathogenesis of nutritional disorders, such as sarcopenia, frailty, and cachexia, differs from disease to disease. Disease-specific nutrition can maximize the function, activity, participation, and quality of life for patients undergoing physical therapy, a practice known as nutritional physical therapy. Understanding and practicing disease-specific nutritional physical therapy is essential to meet patients’ diverse needs and goals with any disease. Thus, the physical therapist division of the Japanese Association of Rehabilitation Nutrition, with advice from the Japanese Society of Nutrition and Swallowing Physical Therapy, developed this review. It discusses the impact of disease-specific nutritional physical therapy on sarcopenia and frailty in community-dwelling older adults, obesity and metabolic syndrome, critical illness, musculoskeletal diseases, stroke, respiratory diseases, cardiovascular diseases, diabetes, renal disease, cancer, and sports.

Key Words:
Exercise, Nutritional disorders, Nutritional therapy, Resistance training

1. Introduction
Malnutrition, sarcopenia, frailty, and cachexia impair the health status and reduce the effectiveness of physical therapy. It is necessary to deal with nutritional disorders according to their pathogenesis as they differ from disease to disease. Skeletal muscle atrophy occurs early in the disease in patients with critical illness due to increased muscle breakdown caused by severe invasion. In stroke patients, dysphagia and motor paralysis lead to malnutrition and sarcopenia. Osteoarthritis and osteoporotic fractures indicate different nutritional disorders in patients with musculoskeletal diseases. Chronic heart failure, chronic obstructive pulmonary disease, and cancer cause cachexia by pathogenic mechanisms characteristic of each disease and lead to a poor prognosis. Therefore, it is necessary to understand disease-specific nutritional physical therapy to deal with these nutritional disorders. We aim to provide a basis for practicing disease-specific nutritional physiotherapy through this review.

2. Disease-specific Nutritional Physical Therapy (Table 1)
Sarcopenia and frailty in the community-dwelling older adults
Sarcopenia and frailty are geriatric syndromes that should not be ignored during physical therapy. Sarcopenia is a skeletal muscle disease that causes age-related loss of muscle mass, muscle weakness, and decreased physical function, leading to falls, hospitalization, and death (1). Sarcopenia is categorized as primary and secondary sarcopenia. Primary sarcopenia indicates sarcopenia with no apparent cause other than aging. Secondary sarcopenia indicates the presence of causes other than aging. It is caused by disease, inactivity, inadequate intake of energy or protein (2). The prevalence of sarcopenia in community-dwelling older adults is approximately 10%-20% in Japan.
Table 1. Disease-specific Nutritional Physical Therapy.

| Disease | Disease-specific nutritional physical therapy |
|---------|------------------------------------------------|
| Sarcopenia and frailty in the community-dwelling older adults | Physical therapy for older people with sarcopenia and frailty includes a combination of resistance training, aerobic and balance exercises, and nutrition. Amino acid (EAA), and leucine metabolites such as β-hydroxy-β-methylbutyrate (HMB) and creatine, is effective for muscle protein synthesis (16). |
| Obesity and metabolic syndrome | Nutritional therapy for obesity and metabolic syndrome aims to increase muscle mass and decrease body fat mass simultaneously (20). To reduce 1 kg of stored fat, 7,500 kcal must be consumed. To increase muscle mass, protein should be unrestricted, and resistance training and protein intake should be combined. Aerobic exercise is effective for reduction of fat mass (19)(20). |
| Critically ill | Prevention of ICU-AW is an important intervention. Within 3-5 days after ICU admission, avoid over-feeding and gradually increase protein intake to 3.3 g/kg/day and calories to 70% of predicted levels (20). Start early mobilization with adequate protein intake and moderate energy expenditure by exercise, as muscle protein degradation increases due to hypercatabolism. After 5 days, nutrition should be maintained at a protein intake of at least 1.2 g/kg/day to induce muscle protein anabolism in exercise stimulation. The exercise load should be 40% of the maximum load. |
| Musculoskeletal diseases | Emphasizing protein intake throughout the entire surgical process (pre- and postsurgical periods) reduces muscle atrophy and loss of function due to increased muscle protein catabolism and immobilization after orthopedic surgery (10). Protein intake of 1.2-2.0 g/kg/day is considered for the rehabilitation period following major surgery. For obese osteoarthritics patients, a combination of energy restriction (estimated energy expenditure –300-1000 kcal), meal replacement supplements with protein, resistance training, and aerobic exercise improves function and relieves pain (10). |
| Stroke | Nutritional interventions include adjusting food texture and initiating oral intake early in patients with mild dysphagia. Tube feedings early and percutaneous endoscopic gastrostomy are recommended for patients who require enteral feedings for more than 28 days (20) in patients with severe dysphagia. Rehabilitation includes early mobilization, swallowing training, and assessment of eating posture. Administration of fortified nutritional supplements, a combination of leucine-enriched amino acid intake, and rehabilitation effectively improve sarcopenia and ADL (9)(10). |
| Respiratory diseases | Nutritional therapy such as dietary advice and fat and/or protein-enriched supplementation for stable COPD patients increases body weight, muscle mass, 6-min walk distance, and health-related QOL (21). Small and frequent oral intake is effective in avoiding dyspnea. The combination of exercise therapy such as resistance training and walking exercises and nutrition therapy effectively increases body weight and muscle mass and improves exercise tolerance, especially in patients with malnutrition (22). |
| Cardiovascular diseases | In the therapeutic strategies for cardiac cachexia, comprehensive cardiac rehabilitation is useful, including appropriate heart failure medications, nutrition therapy, and exercise. Aerobic exercise training counteracts skeletal muscle wasting in addition to improving exercise tolerance. Resistance training is also recommended for cardiovascular disease patients with frailty and sarcopenia. In patients with chronic heart failure, protein intake of 1.2-1.5 g/kg and caloric supplementation based on 25-30 kcal/kg depending on the degree of stress (10) should be combined with exercise therapy. |
| Diabetes | Aerobic exercise and resistance training or a combined approach reduce the risk of developing type 2 diabetes and improve cardiovascular disease risk factors (23). Nutritional therapy optimizes total energy intake (25-35 kcal/target body weight/day) and corrects nutrient imbalances such as limiting saturated fatty acids. |
| Kidney disease | Aerobic exercise and resistance training are recommended to improve exercise tolerance and QOL. In nondialysis patients with severe renal dysfunction, exercise intensity is adjusted according to age and physical function (10). Energy and protein intake according to the severity of kidney disease and sarcopenia. In patients with low L-carnitine levels, the administration of L-carnitine maintains and improves exercise tolerance and muscle mass (10). |
| Liver disease | Nutritional therapy (energy: 35-40 kcal/kg/day, protein: 1.3-1.5 g/kg/day) such as BCAA supplementation and late evening snacks are recommended (10). Aerobic exercise, resistance training, or a combined approach is effective, but it needs to be careful with decreasing hepatic blood flow during and after exercise. |
| Cancer | A multidisciplinary approach, including physical and nutritional therapy, is recommended to improve the response to treatment, prognosis, and QOL (24). The combination of aerobic exercise and resistance training effectively improves fatigue and QOL. Nutritional physical therapy needs to be considered based on cancer treatment or palliative care. |
| Sports | Athletes’ physical activity decreases immediately after injury or surgery, while rehabilitation and training for returning to competition often involve high-intensity exercise (10). Therefore, exercise energy expenditure and energy stores need to be considered in terms of energy needs (10). Because female athletes are prone to low energy availability (LEA), physical therapists should conduct nutritional screening including LEA (weight, eating disorder, bone density/damage, amenorrhea, etc.) (10)(19), when conducting rehabilitation. |
| Anorexia | The American Psychiatric Association guidelines recommend starting at 30-40 kcal/kg/day and increasing 70-100 kcal/kg/day during the weight gain phase (10). The National Institute for Clinical Excellence guidelines for anorexia nervosa set a weekly weight gain goal of 0.5-1 kg for inpatients and 0.5 kg for outpatients, adding approximately 3,500-7,000 kcal/week (10). Controlled physical activity (10) and low-intensity resistance training (10) are safe and beneficial for restoring body composition, maintaining bone density, and decreasing anxiety (10). |
| Depression | The Mediterranean diet is associated with a lower risk of depression (10). Eicosapentaenoic acid and docosahexaenoic acid are effective in treating mood disorders, impulse control disorders, and psychotic disorders (10). Both aerobic and resistance exercise are beneficial for depression, and the higher the intensity and volume of exercise, the more effective (10)(13). |

pan (9)(10), and it is a risk factor for disability and death (10). The Asian Working Group for Sarcopenia criteria (9) and its 2019 version (10) have been widely used in Japan. Frailty is a comprehensive concept that indicates the physical, psychological, and social aspects of aging (7)(9). The Fried criteria (7) evaluate physical frailty, and the prevalence of physical frailty is approximately 10% in Japan (9)(10)(11). The diagnostic criteria of social frailty are not standardized, but it is a risk factor for disability (12), depression (13), and death (12). Thus, comprehensive interventions based on understanding the multiple aspects of frailty are needed.

Resistance training (RT) combined with nutritional thera-
In critically ill patients, such as those with sepsis, a state of systemic hypercatabolism exists, causing various biological reactions, including the production of inflammatory cytokines and increased immune activity. Skeletal muscle proteins break down into amino acids used for endogenous energy supply in the form of protein synthesis and glucose regeneration. As a result of the degradation of skeletal muscle, which accounts for most of the protein stored in the body, muscle mass and bodyweight decrease. Myofibrillar proteins (actin and myosin), accounting for 60%-70% of the muscle proteins, are degraded. In critically ill patients, the amount of muscle proteins lost per day is 250 g, equivalent to 750-1,000 g of muscle mass. This amount can be translated into approximately four times the daily loss of skeletal muscle mass due to short periods of fasting. Skeletal muscle dysfunction in critically ill patients admitted to the intensive care unit (ICU) is called ICU-acquired weakness (ICU-AW). It worsens the patient’s prognosis and health-related QOL even if they are eligible for discharge. ICU-AW complicates about half of all critically ill patients with sepsis, multiple organ failure, or prolonged mechanical ventilation management. In addition, the development and progression of ICU-AW is caused by the combined and synergistic effect of invasive medication, hypovolemia, and malnutrition. Therefore, it is extremely important to reduce these factors as countermeasures for ICU-AW.

Other factors contributing to skeletal muscle dysfunction in critically ill patients include inactivity and malnutrition. Inactivity causes a decrease in muscle protein synthesis and an increase in protein degradation, leading to skeletal muscle atrophy. The decrease in muscle protein synthesis is observed early in the inactive period (6-24 h) and is prolonged. Bed rest for 5 days decreases the size of muscle fibers by 3.5%-10% and muscle strength by 9%-13%. In patients with severe disease, inadequate energy intake leads to a worse prognosis. Insufficient energy causes increased catabolism, which leads to further weight loss as protein and fat are broken down and consumed. In a study of the relationship between cumulative energy balance and prognosis, survival was poor in patients with multiple organ failure at levels of less than 10,000 kcal.

An appropriate combination of nutrition and exercise therapy should be used to reduce catabolic effects and promote recovery. A recovery program with a focus on physical therapy and nutrition is recommended in the early stages of ICU admission. In the early stages of the disease, the patient should receive enteral nutrition with high protein and leucine-containing amino acids, early mobilization and exercise therapy, and neuromuscular electrical stimulation therapy. It is important to correct the imbalance between catabolic and anabolic effects in the acute phase through rehabilitation nutrition intervention to promote the recovery of physical functions.

Musculoskeletal diseases

Patients with musculoskeletal diseases often suffer from malnutrition and sarcopenia. In hip fracture patients, the prevalence of malnutrition and sarcopenia was 7%-26% and 11%-76.4%, respectively. Malnutrition and sarcopenia diminish functional recovery and increase mortality and morbidity. Sarcopenic obesity is due to age-associated loss of muscle mass and increased fat mass, obesity-associated inflammation, and pain-associated inactivity. The development and progression of sarcopenic obesity lead to the development and progression of osteoarthritis. Sarcopenic obesity delays functional recovery in patients after hip arthroplasty.

Nutritional physical therapy is effective in patients with musculoskeletal diseases and coexisting nutritional disorders. Nutritional therapy for older patients with hip fracture undergoing rehabilitation reduces mortality and improves muscle strength and ADL. The updated clinical practice guidelines for rehabilitation nutrition recommended enhanced nutritional therapy in patients with hip fractures undergoing rehabilitation. It is especially useful to combine physical therapy and nutrition therapy, such as oral nutritional supplements and individual nutritional counseling. In obese patients...
with osteoarthritis, a combination of diet and exercise therapy is useful for weight loss, functional improvement, and pain relief \(^{(43)}\) \(^{(44)}\). Furthermore, energy restriction (estimated energy expenditure of \(-300\text{-}1000\) kcal) combined with meal replacement supplements, RT, and aerobic exercise is useful \(^{(45)}\) \(^{(46)}\).

**Stroke**

Stroke patients suffer from malnourishment, mainly due to impaired consciousness and dysphagia. The prevalence of malnutrition in patients with stroke ranges from 6.1% to 62% \(^{(48)}\), and is associated with an increased incidence of infections, pressure ulcers, gastrointestinal bleeding, longer hospital stays, and mortality during hospitalization. In recovery-phase stroke patients, malnutrition diminishes ADL improvement \(^{(49)}\).

Stroke-related sarcopenia is caused by denervation, muscle atrophy, and dysphagia \(^{(50)}\). The prevalence of sarcopenia in patients with stroke is 53.6% \(^{(51)}\) \(^{(52)}\) and sarcopenia leads to reduced ADL recovery, dysphagia, and a lower rate of home discharge \(^{(33)}\) compared with nonsarcopenia. Decreased muscle cross-sectional area \(^{(53)}\) \(^{(54)}\) \(^{(55)}\) and increased subcutaneous and intramuscular fat mass \(^{(56)}\) caused by paralysis is characteristic of strokes.

In the case of nutritional problems in patients with stroke, the combined intervention of exercise and nutrition therapy effectively improves clinical outcomes. The updated clinical practice guidelines for rehabilitation nutrition recommend enhanced nutrition therapy for patients with stroke undergoing rehabilitation \(^{(46)}\). The combination of leucine-enriched amino acid intake and rehabilitation effectively increases skeletal muscle mass and improves ADL in stroke patients with sarcopenia in the convalescent rehabilitation wards \(^{(57)}\) \(^{(58)}\).

**Respiratory Diseases**

Chronic respiratory disease, mainly chronic obstructive pulmonary disease (COPD), is associated with a higher incidence of weight loss and sarcopenia, which leads to exacerbations and death. The prevalence of malnutrition in COPD patients is 24.6% and 45.0%, according to the European Society for Clinical Nutrition and Metabolism \(^{(59)}\) and the Global Leadership Initiative on Malnutrition criteria \(^{(60)}\), respectively, which is associated with increased hospitalization and mortality. Unintentional progressive weight loss is the strongest independent risk for mortality \(^{(41)}\). The prevalence of sarcopenia in patients with COPD was 15.5% \(^{(62)}\) \(21.6%\) \(^{(63)}\), which is associated with a decreased predicted forced expiratory volume in the first second, exercise tolerance, and QOL compared with nonsarcopenic patients \(^{(62)}\). In addition, reduced muscle strength \(^{(64)}\) and fat-free mass \(^{(65)}\) are independent predictors of mortality in patients with COPD. Low skeletal muscle mass is a risk factor for mortality in patients with idiopathic pulmonary fibrosis \(^{(66)}\) \(^{(67)}\).

Sarcopenia in respiratory diseases is caused by aging, decreased activity, chronic inflammation, and malnutrition; malnutrition and sarcopenia overlap in COPD patients \(^{(68)}\). Patients with COPD have chronically elevated inflammatory cytokines \(^{(69)}\). Muscle strength and skeletal muscle mass were significantly correlated with high-sensitivity tumor necrosis factor (TNF), IL-6, and aging, and lower BMI, cardiovascular complications, and elevated high-sensitivity TNF were associated with sarcopenia in COPD patients \(^{(70)}\).

The combination of exercise and nutrition therapy effectively increases body weight and muscle mass and improves exercise tolerance, especially in patients with malnutrition. Nutritional supplementation for stable COPD patients increases weight gain, muscle mass, 6-min walk distance, and health-related QOL \(^{(71)}\). The combination of nutritional supplementation and exercise resulted in greater weight gain, with greater improvement in the malnutrition group than in the nutritional supplementation alone group. In the statement of nutritional assessment and therapy in COPD from the European Respiratory Society, nutritional intervention is probably effective in malnourished patients, most likely when combined with exercise \(^{(72)}\). Recently, the definitions and diagnostic criteria for respiratory sarcopenia and sarcopenic respiratory disability have been developed \(^{(73)}\). Future studies should examine the prevalence and impact of interventions, including nutritional therapy, in older patients with respiratory diseases.

**Cardiovascular diseases**

The obesity paradox occurs in patients with cardiovascular disease. Weight loss, cachexia, and loss of muscle mass are risk factors for poor prognosis. Increasing BMI improves cardiovascular and all-cause mortality in patients with coronary artery disease \(^{(74)}\) and heart failure \(^{(75)}\). Unintentional progressive weight loss is an independent predictor of all-cause mortality in patients with chronic heart failure \(^{(76)}\). The prevalence of cachexia and sarcopenia in ambulatory patients with heart failure was 18.8% and 21.3%, respectively \(^{(77)}\); in addition, 6.7% of patients had comorbid cachexia and sarcopenia \(^{(78)}\). Skeletal muscle loss in patients with heart failure exacerbates other clinical symptoms, leading to decreased QOL, prolonged hospitalization, increased frequency of readmission, and reduced survival \(^{(78)}\). Sarcopenia is an independent predictor of 1-year mortality in patients with heart failure with reduced ejection fraction and preserved ejection fraction \(^{(79)}\).

To improve cachexia in heart failure, a combination of appropriate medications, nutritional therapy, and exercise is useful. Nutritional therapy increases body weight; it reduces all-cause mortality and hospital readmission in patients with heart failure coexisting with malnutrition or cardiac cachexia, but the strength of the evidence is poor \(^{(80)}\). Systemic inflammation is associated with increased skeletal muscle breakdown, leading to decreased skeletal muscle mass and strength \(^{(81)}\). Exercise reduces inflammatory cytokines and improves exercise tolerance in patients with heart failure \(^{(82)}\).

Aerobic exercise training counteracts skeletal muscle wasting in the therapeutic strategies of cardiac cachexia \(^{(83)}\). Compre-
hensive cardiac rehabilitation, including nutrition, exercise, and medication, has been shown to increase nutritional intake and improve muscle strength and walking speed, even in patients with sarcopenia hospitalized with cardiovascular disease (84).

**Diabetes, kidney disease, and liver disease**

Many patients with diabetes, kidney disease, and liver disease have nutritional disorders that lead to increased complications and mortality (85), (86), (87). The mechanisms of the onset of sarcopenia due to hyperglycemia have not been elucidated, but an accumulation of advanced glycation end-product (88), changes in the skeletal muscle extracellular matrix, and reduced insulin action have been suggested as possible factors (89). Decreased physical function and loss of muscle mass are attributed to inflammation and atherosclerosis syndrome (89), cardio-renal anemia syndrome, and abnormal bone mineral metabolism associated with chronic kidney disease (90). Liver disease is often associated with sarcopenia due to elevated ammonia and low branched-chain amino acid levels caused by protein-energy malnutrition (90), (91).

The combination of nutritional and physical therapy is effective for the treatment of diabetes and liver disease. A Cochrane review of patients at high risk of developing type 2 diabetes reported that a combination of nutritional therapy and physical activity intervention reduced or delayed the onset of type 2 diabetes compared with each intervention alone (91). A systematic review of patients with cirrhosis showed that exercise and nutritional therapy effectively improve sarcopenia (91).

**Cancer**

Most patients with cancer who require rehabilitation are malnourished or sarcopenic (92). Weight loss is associated with shorter survival, lower QOL (93), poor adherence to anticancer therapy, and increased side effects in patients with cancer (94), (95). Furthermore, patients with gastrointestinal cancers, such as esophageal cancer, frequently develop malnutrition and skeletal muscle weakness, which leads to increased postoperative complications and mortality (96), (97), (98).

The effects of comprehensive interventions, including exercise and nutrition therapy, have been reported in cancer patients. The updated clinical practice guidelines for rehabilitation nutrition recommend enhanced nutritional care for patients undergoing (or after) anticancer treatment and rehabilitation (certainty of evidence: moderate; recommendation level: weak) (94). In patients with upper gastrointestinal cancer, preoperative physical rehabilitation, and nutritional interventions, mainly whey protein, improved preoperative and postoperative exercise tolerance than usual care (99). Physical rehabilitation and nutritional intervention in the perioperative period reportedly improved postoperative muscle strength in patients with sarcopenic older gastric cancer (100). Combined exercise and nutritional interventions have shown safety and high compliance in older pancreatic cancer and nonsmall cell lung cancer patients undergoing chemotherapy (100). Thus, nutritional physical therapy is recommended in the perioperative period, including preoperatively and during chemotherapy, in patients with cancer.

**Sports**

It is important for physical therapists to assess athletes’ nutritional status and cooperate with dietitians as needed. The combined application of nutritional care management is beneficial in physical therapy for injured athletes (101), (102). Immobilization of the affected area, decreased activity, and increased muscle protein catabolism due to trauma or postsurgical inflammation cause loss of skeletal muscle mass and weakness, affecting the possibility of returning to play (103), (104). In addition, limited or decreased physical activity may increase body fat deposition. The combination of rehabilitation and nutritional management reduces postoperative complications, minimizes disability and loss of skeletal muscle mass, and maximizes the possibility of returning to play (105). In nutritional management, the following are considered: metabolic fluctuations during trauma or postoperatively and energy consumption in rehabilitation (106). Physical therapy for returning to play often involves high-intensity exercise, which increases energy expenditure. A negative energy balance decreases skeletal muscle mass. Therefore, physical therapists need to cooperate with dietitians and consider optimizing energy requirements, nutrient timing, and use of selected nutritional supplements.

In other cases, athletes may experience low energy availability (LEA) because of increased energy expenditure due to exercise or extreme dietary restrictions. The prevalence of LEA in athletes is 22%–58%; it is present in both sexes but is particularly common in women (107). Para-athletes with spinal cord injury also have a high risk of LEA (108). Long-term LEA can cause health problems such as emaciation, osteoporosis, amenorrhea, and anemia and affect sports performance (108), (109). Previous studies have shown that physical therapists involved in athletic rehabilitation lack knowledge and awareness of LEA and nutritional status (108). Adjusting the physical therapy program and the load considering the nutritional status leads to the prevention of LEA and its complications (e.g., stress injury and stress fracture) (110). Physical therapists need to use nutritional screening to assess the nutritional status of athletes and cooperate with dietitians and clinicians to prevent and improve LEA (110).

**Anorexia nervosa**

Anorexia nervosa (AN) is a complex, severe disease characterized by abnormal eating behavior. Severe malnutrition with excessive weight loss causes cardiovascular, gastrointestinal disorders, and metabolic abnormalities (111). Fat intake is often reduced in patients with AN compared with healthy controls, while the carbohydrate and protein intake results are not consistent (112). The American Psychiatric Association guidelines for AN recommend starting at 30–40 kcal/kg/day (approxi-
mately 1,000-1,600 kcal/day) and increasing gradually to 70-100 kcal/kg/day during the weight gain phase. National Institute for Clinical Excellence guidelines for AN recommend 0.5-1 kg as a weekly weight gain goal for inpatients and 0.5 kg for outpatients. Thus, approximately 3,500-7,000 kcal per week are recommended to achieve these goals. It is necessary to select a variety of foods without avoiding essential nutrients. During the initiation of nutritional therapy, attention should be paid to refeeding syndrome caused by rapid refeeding. Refeeding syndrome is caused by hypophosphatemia, hypokalemia, and hypomagnesemia, which lead to arrhythmia, congestive heart failure, and hypotension.

It is controversial how to manage physical activity and exercise in patients with AN. Many patients with AN have hyperactivity. Hyperactivity leads to increased energy requirements to achieve weight gain, worse clinical outcomes, longer hospital stays, and relapse of AN. Thus, rest has been a priority for patients with AN. However, controlled physical activity and low-intensity resistance training can be performed safely and may be beneficial in restoring lean mass, maintaining bone mineral density, and decreasing anxiety. It is unclear what level of physical activity and exercise is safe and beneficial in patients with AN.

Depression
Depression is a psychiatric disorder closely related to nutritional factors in the prevention and treatment phases. Meta-analysis shows that obesity and metabolic syndrome lead to the onset of depression, and conversely, depression is accompanied by overeating and decreased physical activity, which causes obesity and metabolic syndrome. Mediterranean diet is associated with a lower risk of depression. The American Psychiatric Association recommends supplementation of eicosapentaenoic acid and docosahexaenoic acid among n-3 (omega-3) unsaturated fatty acids for mood disorders, impulse control disorders, and psychotic disorders.

Increasing physical activity and exercise are effective for depression. A Cochrane systematic review reported that the effect of exercise on depression was mild to moderate. Both aerobic and anaerobic exercise is effective in reducing depression symptoms. For major or minor depression in subjects aged 60 years or older, high-intensity (80% maximum load) progressive RT improved depression symptoms compared with low-intensity (20% maximum load). In addition, for mild to moderate major depression, the 17.5 kcal/kg/week exercise group reduced depression symptoms, while the 7 kcal/kg/week group was as effective as the control group. Both aerobic and resistance exercise are beneficial for depression, and the higher the intensity and volume, the more effective.

3. Future Perspectives
This review discusses the results of studies that provide evidence for the beneficial effects of disease-specific nutritional physiotherapy; however, the evidence for nutritional physical therapy is not abundant. Further clinical research is needed to provide evidence for disease-specific nutritional physiotherapy.

This is the secondary English version of the original Japanese manuscript for “Disease-specific nutritional physical therapy: A position paper by the Japanese Association of Rehabilitation Nutrition”.

Article Information

Conflicts of Interest
None

Acknowledgement
We would like to thank the Japanese Society of Nutrition and Swallowing Physical Therapy for their advice in developing this position paper. We are also grateful for public comments on this paper.

Author Contributions
Substantial contributions to the conception or design of the work: Tatsuro Inoue, Izumi Takeuchi, Yuki Iida, Kohei Takahashi, Fumihiko Nagano, Shinjiro Miyazaki, Kengo Shirado, Yoshihiro Yoshimura, Ryo Mamosaki, Keisuke Maeda, and Hidetaka Wakabayashi
Drafting the work: Tatsuro Inoue, Izumi Takeuchi, Yuki Iida, Kohei Takahashi, Fumihiko Nagano, Shinjiro Miyazaki, Kengo Shirado, Yoshihiro Yoshimura, Ryo Mamosaki, Keisuke Maeda, and Hidetaka Wakabayashi
Final approval of the version to be published: Tatsuro Inoue, Izumi Takeuchi, Yuki Iida, Kohei Takahashi, Fumihiko Nagano, Shinjiro Miyazaki, Kengo Shirado, Yoshihiro Yoshimura, Ryo Mamosaki, Keisuke Maeda, and Hidetaka Wakabayashi
Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: Tatsuro Inoue, Izumi Takeuchi, Yuki Iida, Kohei Takahashi, Fumihiko Nagano, Shinjiro Miyazaki, Kengo Shirado, Yoshihiro Yoshimura, Ryo Mamosaki, Keisuke Maeda, and Hidetaka Wakabayashi

Approval by Institutional Review Board (IRB)
Not applicable.

* The editors-in-chief of the Journal of the Japanese Association of Rehabilitation Nutrition and JMA journal have given permission for secondary publication of this position paper.

* This article is based on a study first reported in the Journal of the Japanese Association of Rehabilitation Nutrition. 2021; 5(2):p 217-225(Japanese).

Journal articles published ahead of issue (print): Inoue T et al. Disease-specific nutritional physical therapy: A position paper.
paper by the physical therapist section of the Japanese Association of Rehabilitation Nutrition. The Journal of the Japanese Association of Rehabilitation Nutrition. 2021.

The original version is available at https://sites.google.com/site/jsrhnt/ポジションペーパー?authuser=0.

References

1. Cruz-Jentoft AJ, Sayer AA. Sarcopenia. Lancet. 2019;393(10191):2636-46.
2. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16-31.
3. Yamada M, Nishiguchi S, Fukutani N, et al. Prevalence of sarcopenia in community-dwelling Japanese older adults. J Am Med Dir Assoc. 2013;14(12):911-5.
4. Kitamura A, Seino S, Abe T, et al. Sarcopenia: prevalence, associated factors, and the risk of mortality and disability in Japanese older adults. J Cachexia Sarcopenia Muscle. 2021;12(1):30-8.
5. Chen LK, Liu LK, Woo J, et al. Sarcopenia in Asia: consensus report of the Asian working group for sarcopenia. J Am Med Dir Assoc. 2014;15(2):95-101.
6. Chen LK, Woo J, Assantachai P, et al. Asian working group for sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment. J Am Med Dir Assoc. 2020;21(3):200-307.e2.
7. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol Med Sci. 2001;56(3):46-56.
8. Makizako H, Tsutsumimoto K, Shimada H, et al. Social frailty among community-dwelling older adults: recommended assessments and implications. Ann Geriatr Med Res. 2018;22(1):3-8.
9. Watanabe Y, Hirano H, Arai H, et al. Relationship between frailty and oral function in community-dwelling elderly adults. J Am Geriatr Soc. 2017;65(1):66-76.
10. Shimada H, Makizako H, Lee S, et al. Impact of cognitive frailty on daily activities in older persons. J Nutr Health Aging. 2016;20(7):729-35.
11. Shimada H, Makizako H, Doi T, et al. Combined prevalence of frailty and mild cognitive impairment in a population of elderly Japanese people. J Am Med Dir Assoc. 2013;14(7):518-24.
12. Yamada M, Arai H. Social frailty predicts incident disability and mortality among community-dwelling Japanese older adults. J Am Med Dir Assoc. 2018;19(12):1099-103.
13. Tsutsumimoto K, Doi T, Makizako H, et al. Social frailty has a stronger impact on the onset of depressive symptoms than physical frailty or cognitive impairment: a 4-year follow-up longitudinal cohort study. J Am Med Dir Assoc. 2018;19(6):504-10.
14. Kim H, Kim M, Koijima N, et al. Exercise and nutritional supplementation on community-dwelling elderly Japanese women with sarcopenic obesity: a randomized controlled trial. J Am Med Dir Assoc. 2016;17(11):1011-9.
15. Kim H, Suzuki T, Saito K, et al. Long-term effects of exercise and amino acid supplementation on muscle mass, physical function and falls in community-dwelling elderly Japanese sarcopenic women: a 4-year follow-up study. Geriatr Gerontol Int. 2016;16(2):175-81.
16. Kim HK, Suzuki T, Saito K, et al. Effects of exercise and amino acid supplementation on body composition and physical function in community-dwelling elderly Japanese sarcopenic women: a randomized controlled trial. J Am Geriatr Soc. 2012;60(1):16-23.
17. Yoshimura Y, Wakabayashi H, Yamada M, et al. Interventions for treating sarcopenia: a systematic review and meta-analysis of randomized controlled studies. J Am Med Dir Assoc. 2017;18(6):553.e1-553.e16.
18. de Labra C, Guimaraes-Pinheiro C, Maseda A, et al. Effects of physical exercise interventions in frail older adults: a systematic review of randomized controlled trials physical functioning, physical health and activity. BMC Geriatr. 2015;15(1):1-6.
19. World Health Organization. Body mass index-BMI. World Health Organization regional office for EUROPE home page [Internet]. [cited 21 Jul 2021]. Available from: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi?fbclid=IwAR2doyjCek
20. National Health and Nutrition Examination Survey (2019). Ministry of Health, Labour and Welfare [Internet]. [cited 21 Jul 2021]. Available from: https://www.mhlw.go.jp/content/000710991.pdf
21. Artaud F, Singh-Manoux A, Dugravot A, et al. Body mass index trajectories and functional decline in older adults: three-city Dijon cohort study. Eur J Epidemiol. 2016;31(1):73-83.
22. Scott D, Chandrasekara SD, Laslett LL, et al. Associations of sarcopenic obesity and dynapenic obesity with bone mineral density and incident fractures over 5-10 years in community-dwelling older adults. Calcif Tissue Int. 2016;99(1):30-42.
23. Hirani V, Naganathan V, Blyth F, et al. Longitudinal associations between body composition, sarcopenic obesity and outcomes of frailty, disability, institutionalisation and mortality in community-dwelling older men: the Concord Health and Aeging in Men Project. Age Ageing. 2017;46(3):413-20.
24. Boucher J, Kleinridders A, Kahn CR. Insulin receptor signaling in normal and insulin-resistant states. Cold Spring Harb Perspect Biol. 2014;6(1):a009191.
25. Czech MP. Insulin action and resistance in obesity and type 2 diabetes. Nat Med. 2017;23(7):804-14.
26. Liao CD, Tsauo JY, Wu YT, et al. Effects of protein supplementation combined with resistance exercise on body composition and physical function in older adults: a systematic review and meta-analysis. Am J Clin Nutr. 2017;106(4):1078-91.
27. Jones AM, Carter H. The effect of endurance training on parameters of aerobic fitness. Sports Med. 2000;29(6):373-86.
28. Fujita S, Rasmussen BB, Cadenas JG, et al. Aerobic exercise
overcomes the age-related insulin resistance of muscle protein metabolism by improving endothelial function and Akt/mammalian target of rapamycin signaling. Diabetes. 2007;56(6):1615-22.

29. Herridge MS, Tansey CM, Marté A, et al. Functional disability 5 years after acute respiratory distress syndrome. N Engl J Med. 2011;364(14):1293-304.

30. Schefold JC, Bierbrauer J, Weber-Carstens S. Intensive care unit-acquired weakness (ICUAW) and muscle wasting in critically ill patients with severe sepsis and septic shock. J Cachexia Sarcopenia Muscle. 2010;1(2):147-57.

31. Gandham A, Mesinovic J, Jansons P, et al. Falls, fractures, and areal bone mineral density in older adults with sarcopenic obesity: a systematic review and meta-analysis. Obes Rev. 2021;22(5):e13187.

32. Stevens RD, Dowdy DW, Michaels RK, et al. Neuromuscular dysfunction acquired in critical illness: a systematic review. Intensive Care Med. 2007;33(11):1876-91.

33. de Jonghe B, Lacherade JC, Sharshar T, et al. Intensive care unit-acquired weakness: risk factors and prevention. Crit Care Med. 2009;37(10):309-15.

34. Friedrich O, Reid MB, Van den Berge G, et al. The sick and the weak: neuromopathies/myopathies in the critically ill. Physiol Rev. 2015;95(3):1025-109.

35. Suettca C, Frandsen U, Jensen L, et al. Aging affects the transcriptional regulation of human skeletal muscle disuse atrophy. PLoS One. 2012;7(12):e51238.

36. Bartlett RH, Dechert RE, Mault JR, et al. Measurement of metabolism in multiple organ failure. Surgery. 1982;92(4):771-9.

37. Phillips SM, Dickerson RN, Moore FA, et al. Protein turnover and metabolism in the elderly intensive care unit patient. Nutr Clin Pract. 2017;32(1):112S-20S.

38. Dirks ML, Wall BT, Snijders T, et al. Neuromuscular electrical stimulation prevents muscle disuse atrophy during leg immobilization in humans. Acta Physiol. 2014;210(3):628-41.

39. Inoue T, Maeda K, Nagano A, et al. Undernutrition, sarcopenia, and frailty in fragility hip fracture: advanced strategies for improving clinical outcomes. Nutrients. 2020;12(12):1-26.

40. Malafarina V, Reginster JY, Cabrerizo S, et al. Nutritional status and nutritional treatment are related to outcomes and mortality in older adults with hip fracture. Nutrients. 2018;10(5):1-26.

41. Godziuk K, Prado CM, Woodhouse LJ, et al. The impact of sarcopenic obesity on knee and hip osteoarthritis: a scoping review. BMC Musculoskelet Disord. 2018;19(1):1-10.

42. Oosting E, Hoogeboom TJ, Dronkers JJ, et al. The influence of muscle weakness on the association between obesity and inpatient recovery from total hip arthroplasty. J Arthroplasty. 2017;32(6):1918-22.

43. Takahashi K, Momosaki R, Yasufuku Y, et al. Nutritional therapy in older patients with hip fractures undergoing rehabilitation: a systematic review and meta-analysis. J Am Med Dir Assoc. 2020;21(9):1364-1364.e6.
strength, and physical function in post-stroke patients with sarcopenia: a randomized controlled trial. Nutrition. 2019;58:1-6.

58. Takeuchi I, Yoshimura Y, Shimazu S, et al. Effects of branched-chain amino acids and vitamin D supplementation on physical function, muscle mass and strength, and nutritional status in sarcopenic older adults undergoing hospital-based rehabilitation: a multicenter randomized controlled trial. Geriatr Gerontol Int. 2019;19(1):12-7.

59. Marco E, Sánchez-Rodríguez D, Dávalos-Yerovi VN, et al. Malnutrition according to ESPEN consensus predicts hospitalizations and long-term mortality in rehabilitation patients with stable chronic obstructive pulmonary disease. Clin Nutr. 2019;38(5):2180-6.

60. Dávalos-Yerovi V, Marco E, Sánchez-Rodríguez D, et al. Malnutrition according to GLIM criteria is associated with mortality and hospitalizations in rehabilitation patients with stable chronic obstructive pulmonary disease. Nutrients. 2021;13(2):1-11.

61. Kwan HY, Maddocks M, Nolan CM, et al. The prognostic significance of weight loss in chronic obstructive pulmonary disease-related cachexia: a prospective cohort study. J Cachexia Sarcopenia Muscle. 2019;10(6):1330-8.

62. Sepúlveda-Loyola W, Osadnik C, Phu S, et al. Diagnosis, prevalence, and clinical impact of sarcopenia in COPD: a systematic review and meta-analysis. J Cachexia Sarcopenia Muscle. 2020;11(5):1164-76.

63. Benz E, Trajanoska K, Lahousse L, et al. Sarcopenia in COPD: a systematic review and meta-analysis. Eur Respir Rev. 2019;28(154):1-13.

64. Swallow EB, Reyes D, Hopkinson NS, et al. Quadriceps strength predicts mortality in patients with moderate to severe chronic obstructive pulmonary disease. Thorax. 2007;62(2):115-20.

65. Schols AM, Broekhuizen R, Weling-Scheepers CA, et al. Body composition and mortality in chronic obstructive pulmonary disease. Am J Clin Nutr. 2005;82(1):53-9.

66. Moon SW, Choi JS, Lee SH, et al. Thoracic skeletal muscle quantification: low muscle mass is related with worse prognosis in idiopathic pulmonary fibrosis patients. Respir Res. 2019;20(1):1-9.

67. Awano N, Inomata M, Kuse N, et al. Quantitative computed tomography measures of skeletal muscle mass in patients with idiopathic pulmonary fibrosis according to a multidisciplinary discussion diagnosis: a retrospective nationwide study in Japan. Respir Investig. 2020;58(2):91-101.

68. De Blasio F, Di Gregorio A, de Blasio F, et al. Malnutrition and sarcopenia assessment in patients with chronic obstructive pulmonary disease according to international diagnostic criteria, and evaluation of raw BIA variables. Respir Med. 2018;134:1-5.

69. Gan WQ, Man SF, Senthilcevan A, et al. Association between chronic obstructive pulmonary disease and systemic inflammation: a systematic review and a meta-analysis. Thorax. 2004;59(7):574-80.

70. Byun MK, Cho EN, Chang J, et al. Sarcopenia correlates with systemic inflammation in COPD. Int J Chron Obstruct Pulmon Dis. 2017;12:669-75.

71. Ferreira IM, Brooks D, White J, et al. Nutritional supplementation for stable chronic obstructive pulmonary disease. Cochrane Database Syst Rev. 2012;12:CD000998.

72. Schols AM, Ferreira IM, Franssen FM, et al. Nutritional assessment and therapy in COPD: a European Respiratory Society statement. Eur Respir J. 2014;44(6):1504-20.

73. Nagano A, Wakabayashi H, Maeda K, et al. Respiratory sarcopenia and sarcopenic respiratory disability: concepts, diagnosis, and treatment. J Nutr Health Aging. 2021;25(4):507-15.

74. Romero-Corrál A, Montori VM, Somers VK, et al. Association of bodyweight with total mortality and with cardiovascular events in coronary artery disease: a systematic review of cohort studies. Lancet. 2006;368(9536):666-78.

75. Oreopoulos A, Padwal R, Kalantar-Zadeh K, et al. Body mass index and mortality in heart failure: a meta-analysis. Am Heart J. 2008;156(1):13-22.

76. Rossignol P, Masson S, Barlera S, et al. Loss in body weight is an independent prognostic factor for mortality in chronic heart failure: insights from the GISSI-HF and Val-HeFT trials. Eur J Heart Fail. 2015;17(4):424-33.

77. Emami A, Saitoh M, Valentova M, et al. Comparison of sarcopenia and cachexia in men with chronic heart failure: results from the studies investigating co-morbidities aggravating heart failure (SICA-HF). Eur J Heart Fail. 2018;20(11):1580-7.

78. Lena A, Anker MS, Springer J. Muscle wasting and sarcopenia in heart failure—the current state of science. Int J Mol Sci. 2020;21(18):1-27.

79. Konishi M, Kagiyma N, Kamiya K, et al. Impact of sarcopenia on prognosis in patients with heart failure with reduced and preserved ejection fraction. Eur J Prev Cardiol. 2021;28(9):1022-9.

80. Habayeh D, de Moraes MB, Slea A, et al. Nutritional interventions for heart failure patients who are malnourished or at risk of malnutrition or cachexia: a systematic review and meta-analysis. Heart Fail Rev. 2021;26(5):1103-18.

81. Koshikawa M, Harada M, Noyama S, et al. Association between inflammation and skeletal muscle proteolysis, skeletal mass and strength in elderly heart failure patients and their prognostic implications. BMC Cardiovasc Disord. 2020;20(1):228.

82. Gielen S, Adams V, Möbius-Winkler S, et al. Anti-inflammatory effects of exercise training in the skeletal muscle of patients with chronic heart failure. J Am Coll Cardiol. 2003;42(5):861-8.

83. Loncar G, Springer J, Anker M, et al. Cardiac cachexia: hic et nunc. J Cachexia Sarcopenia Muscle. 2016;7(3):246-60.

84. Harada H, ai H, Niifyama H, et al. Effectiveness of cardiac rehabilitation for prevention and treatment of sarcopenia in patients with cardiovascular disease - a retrospective cross-sectional analysis. J Nutr Health Aging. 2017;21(4):449-56.

85. Kim TN, Park MS, Yang SJ, et al. Prevalence and determinant factors of sarcopenia in patients with type 2 diabetes: the...
Ross PJ, Ashley S, Norton A, et al. Do patients with weight loss have a worse outcome when undergoing chemotherapy for lung cancer? Br J Cancer. 2004;90(10):1905-11.

90. Stubbins R, Bernicker EH, Quigley EMM. Cancer cachexia: a multifactorial disease that needs a multimodal approach. Curr Opin Gastroenterol. 2020;36(2):141-6.

91. Motoori M, Fujitani K, Sugimura K, et al. Skeletal muscle loss during neoadjuvant chemotherapy is an independent risk factor for postoperative infectious complications in patients with advanced esophageal cancer. Oncology. 2018;95(5):281-7.

92. Hijazi Y, Gondal U, Aziz O. A systematic review of prehabilitation programs in abdominal cancer surgery. Int J Surg. 2017;39:156-62.

93. Minnella EM, Awashiri R, Loiselle SE, et al. Effect of exercise and nutrition prehabilitation on functional capacity in esophageagastrectomy cancer surgery: a randomized clinical trial. JAMA Surg. 2018;153(12):1081-9.

94. Yamamoto K, Nagatsuna Y, Fukuda Y, et al. Effectiveness of a preoperative exercise and nutritional support program for elderly sarcopenic patients with gastric cancer. Gastro Cancer. 2017;20(5):913-8.

95. Naito T, Mitsunaga S, Miura S, et al. Feasibility of early multimodal interventions for elderly patients with advanced pancreatic and non-small-cell lung cancer. J Cachexia Sarcopenia Muscle. 2019;10(1):73-83.

96. Smith-Ryan AE, Hirsch KR, Saylor HE, et al. Nutritional considerations and strategies to facilitate injury recovery and rehabilitation. J Athl Train. 2020;55(9):918-30.

97. Papadopoulou SK. Rehabilitation nutrition for injury recovery: does it exist? Nephrol Dial Transplant. 2000;15(7):953-60.

98. Silverberg D, Wexler D, Blum M, et al. The cardio-renal anaemia syndrome: does it exist? Nephrol Dial Transplant. 2003;18(9):7-12.

99. Mori K, Nishide K, Okuno S, et al. Impact of diabetes on sarcopenia and mortality in patients undergoing hemodialysis. BMC Nephrol. 2019;20(1):1-7.

100. Chang KY, Chen JD, Wu WT, et al. Is sarcopenia associated with hepatic encephalopathy in liver cirrhosis? A systematic review and meta-analysis. J Formos Med Assoc. 2019;118(4):833-42.

101. Takayama K, Atagi S, Imamura F, et al. Quality of life and nutrition management strategies. Clin Gastroenterol Hepatol. 2012;10(2):117-25.

102. Shimizu P. Prevalence of sarcopaenia and its association with diabetes mellitus and its associated complications in people at risk. J Gerontol A Biol Sci Med Sci. 2014;70(9):1446-53.
117 Szabo CP, Green K. Hospitalized anorexics and resistance training: impact on body composition and psychological well-being. A preliminary study. Eat Weight Disord. 2002;7(4):293-7.

118 Luppino FS, de Wit LM, Bouvy PF, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry. 2010;67(3):220-9.

119 Pan A, Keum N, Okereke OI, et al. Bidirectional association between depression and metabolic syndrome: a systematic review and meta-analysis of epidemiological studies. Diabetes Care. 2012;35(5):1171-80.

120 Sánchez-Villegas A, Delgado-Rodríguez M, Alonso A, et al. Association of the Mediterranean dietary pattern with the incidence of depression: the Seguimiento Universidad de Navarra/University of Navarra follow-up (SUN) cohort. Arch Gen Psychiatry. 2009;66(10):1090-8.

121 Freeman MP, Hibbeln JR, Wisner KL, et al. Omega-3 fatty acids: evidence basis for treatment and future research in psychiatry. J Clin Psychiatry. 2006;67(12):1954-67.

122 Cooney GM, Dwan K, Greig CA, et al. Exercise for depression. Cochrane Database Syst Rev. 2013;12(9):CD004366.

123 Craft LL, Perna FM. The benefits of exercise for the clinically depressed. Prim Care Companion J Clin Psychiatry. 2004;6(3):104-11.

124 Gordon BR, McDowell CP, Hallgren M, et al. Association of efficacy of resistance exercise training with depressive symptoms: meta-analysis and meta-regression analysis of randomized clinical trials. JAMA Psychiatry. 2018;75(6):566-76.

125 Singh NA, Stavrinos TM, Scarbek Y, et al. A randomized controlled trial of high versus low intensity weight training versus general practitioner care for clinical depression in older adults. J Gerontol A Biol Sci Med Sci. 2005;60(6):768-76.

126 Dunn AL, Trivedi MH, Kampert JB, et al. Exercise treatment for depression: efficacy and dose response. Am J Prev Med. 2005;28(1):1-8.

127 Izquierdo M, Merchant RA, Morley JE, et al. International exercise recommendations in older adults (ICFSR): expert Consensus Guidelines. J Nutr Health Aging. 2021;25(7):824-53.

128 Inoue T, Iida Y, Takahashi K, et al. Disease-specific nutritional physical therapy: a position paper by the Japanese Association of Rehabilitation Nutrition. J Jpn Assoc Rehabil Nutr. 2021;5:217-25. Japanese.

129 Zhou W, Shi B, Fan Y, et al. Effect of early activity combined with early nutrition on acquired weakness in ICU patients. Medicine. 2020;99(29):e21282.

130 Hirsch KR, Wolfe RR, Ferrando AA. Pre- and post-surgical nutrition for preservation of muscle mass, strength, and functionality following orthopedic surgery. Nutrients. 2021;13(5):1675.

131 Chu SF, Liou TH, Chen HC, et al. Relative efficacy of weight management, exercise, and combined treatment for muscle mass and physical sarcopenia indices in adults with overweight or obesity and osteoarthritis: a network meta-analysis of randomized controlled trials. Nutrients. 2021;13(6):1992.

132 Hirsch KR, Wolfe RR, Ferrando AA. Pre- and post-surgical nutrition for preservation of muscle mass, strength, and functionality following orthopedic surgery. Nutrients. 2021;13(5):1675.

133 Yamamoto K, Tsuchihashi-Makaya M, Kinugasa Y, et al. Japanese heart failure society 2018 scientific statement on nutritional assessment and management in heart failure patients. Circ J. 2020;84(8):1408-44.

134 Araki E, Goto A, Kondo T, et al. Japanese clinical practice guideline for diabetes 2019. Diabetol Int. 2020;11(3):165-223.

135 Yamagata K, Hoshino J, Sugiyama H, et al. Clinical practice guideline for renal rehabilitation: systematic reviews and recommendations of exercise therapies in patients with kidney diseases. Ren Replace Ther. 2019;5(1):304-13.

136 Perumpail BJ, Li AA, Cholankeril G, et al. Optimizing the nutritional support of adult patients in the setting of cirrhosis. Nutrients. 2017;9(10):1114.

137 Sim A, Burns SF. Review: questionnaires as measures for low energy availability (LEA) and relative energy deficiency in sport (RED-S) in athletes. J Eat Disord. 2021;9(1):41.