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A review of osteosarcopenic obesity related to nutritional intake and exercise

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Abstract : Recently, osteosarcopenic obesity (OSO) has been identified and notified world wide. Therefore, this study reviewed OSO related to lifestyle factors such as nutritional intake and exercise. Due to aging, OSO may be initiated by dietary factors and obesity related factors. Reduced muscle mass and increased fat mass may negatively impact bone health causing OSO. The complication of OSO development should be related to dietary imbalance combined with declined exercise and this may contribute to induce OSO by decreasing bone mass, muscle mass, and increasing obesity with aging. To prevent OSO, reaching peak bone mass and building optimal muscle and fat mass through exercise would be recommended. For treating OSO, balanced dietary intake and regular exercise through a whole life would be needed. In addition, sufficient carbohydrate and fat intake for minimizing protein catabolism would be recommended to prevent OSO. The combination of aerobic exercise and resistance training also would be an effective intervention for OSO population.

Keywords : Osteosarcopenic obesity, Sarcopenia, Nutrition, Exercise, Body composition

1. Introduction

Previous studies proved that low muscle mass is correlated to low bone mineral density[1, 2]. Recently, osteosarcopenic obesity (OSO) has been identified and notified world wide and it has been known as the triad of bone muscle and adipose tissue impairment in the human body[3, 4]. Evaluating OSO seems to be very important and thus OSO risk estimation would be needed for prevention and treatment of OSO. Due to aging, OSO may be initiated by dietary factors and obesity related factors (Fig.1). Reduced muscle mass and increased fat mass may negatively impact bone health [5]. Kim et al. [6] examined BMD and skeletal muscle mass of 1,308 male and 1,171 female Korean aged over 65 years and they found that sarcopenia is positively associated with BMD and there is a strong correlation between sarcopenia and osteoporosis (OP). Due to aging, metabolically active tissue mass, especially muscle mass would be decreased (sarcopenia) and induce increased adipose tissue and lowered resting metabolic energy expenditure.

Several studies determined that OP prevalence is higher in sedentary women [7,8]. Lim et al. [9] investigated 3,149 Korean adults and they found that calcium deficiency,

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smoking, and lack of exercise were the most significant factors related to induce osteoporosis in Korean adults. Similar as this previous study, Ishimi [7] also mentioned that nutrition, physical activity (PA), smoking, and alcohol consumption were the most influenced factors related to osteoporosis in Japanese adults. In addition, numerous studies found that women who participate in various type sports or in sports have positive relationship to higher health conditions. Physical activity performed during the growing years is thought to be the most osteogenic, with the greatest potential for increasing peak bone mass and reducing risk for OP later in life [10]. Therefore, it seems that nutritional and lifestyle factors would be the important corrective factors for preventing and/or treating OSO.

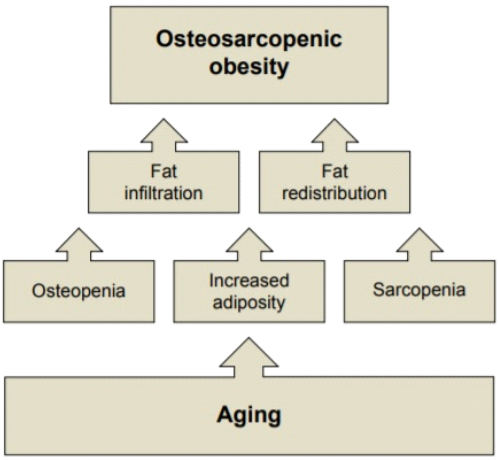

Fig. 1. Changes in body fat and muscle tissues with aging leading to osteosarcopenic obesity [5].

This study focuses on OSO and its related factors although OSO have various metabolic and physiologic factors in the body. Especially, nutritional intake and exercise related to OSO has been discussed.

2. Osteosarcopenic obesity and nutritional intake

It has been known that macronutrient inake is related to the etiology of OSO. The OSO involves the decrease of osteoblastogenesis and myogenesis, with the simultaneous increase in adipogenesis and inflammation induced by aging, obesity, poor diet, and etc [11]. Chronic poor macronutrient intake may also contribute OSO development. Adipogenesis also increases in fat tissue, as well as muscle hypertrophy and fat redistribution. Osteopenia and OP combines with sarcopenia and obesity may result in the loss of functionality and strength in the human body [12]. Acceptable macronutirient intake ranges for adults are 45–65% of carbohydrate (CHO), 20–35% of fat, and 10–35% of protein [12].

Carbohydrate have many physiological function and it has been known that CHO may stabilize protein [12]. With aging, elderly adults tend to have impaired regulation of food intake and thus total energy intake is declined [13]. In addition, CHO intake study have shown in controversial results related to bone health [14,15]; however, these researches commonly suggested that bone metabolism is influenced by macronutrient intake and commented that low CHO intake may not positively affect bone health. This suggests that low CHO intake induces low blood glucose and low insulin levels combined with elevated glucagon and higher gluconeogenesis from protein catabolism and reduces bone formation and increases bone resorption, which may cause OSO. In addition, CHO intake after intensive exercise may help muscle protein synthesis [16]. Therefore, optimal amount of CHO intake should be considered in maintaining bone health and muscle mass in relation to OSO.

Optimal protein intake is considered as one of important factors for maintaining of body protein and muscle mass in humans. It has been known that protein may be easily

catabolized with aging combined to OSO because of low-grade of inflammation [12] and this suggests that people with aging need to intake more protein to prevent and/or treat OSO. However, Volpi et al. [17] commented that elderly people tends to have lowe intake of protein because of dental issues, taste changes, sedentary behavior, and a dependance of food preparation by others, which may increase OSO risk in elderly population. Heaney and Layman [18] stated that high protein intake should be balanced with micronutrient intake such as fresh fruits and vegetables. If the balance is broken, high protein intake induces urinary calcium loss and thus it affects bone mineral status. In addition, low protein intake may also negatively affect muscle anabolism and bone formation [19], although there is not enough previous researches focused on the association of low protein intake and muscle and bone metabolism. Therefore, optimal amount of protein intake should be considered in the prevention and/or treatment of the chronic diseases such as osteoporosis, sarcopenia, and OSO.

Fat is known to be essential for forming and maintaining cell membrane [12]. Especially, higher intake of eicosappentaenoic acid (EPA) and docosahexaenoic acid (DHA) promotes bone formation, reduces the negative effects of excessive adipose tissue, and benefits muscle mass as well [20]. With this respect, several previous studies reported that EPA and DHA intake promotes muscle protein synthesis in young and middle-aged people, increases fat oxidation, and induces better physical performance in old population [21-23].

Micronutrient intake is a critical factor for maintaining health with aging and several deficiencies in micronutrient intake may induce OSO [24]. It has been reviewed that a sufficient intake of micronutrient such as calcium (Ca), iron (Fe), vitamin C, and vitamin D may prevent OSO [12]. Moreover, it has been known that vitamin D deficiency may induce muscle weakness and decreased BMD, and protect body from adipogenesis and inflammatory response in the human body [25]. Also, previous studies [26-28] stated that vitamin D has a significant association with abnormal body composition such as osteoporosis, sarcopenia, and obesity.

Kim et al. [29] investigated diet quality in 6129 Korean women aged 50 years and older and they found that balanced macro-and micro nutrient intake in women aged 50 years and older was less likely to have OSO. They suggested that maintaining balanced diet might protect body from multiple body composition abnormalities such as OSO in elderly adults. In addition, another Korean study [30] surveyed an association of vitamin D intake and OSO in 2485 Korean men and 3423 Korean women and they found that adequate intake of vitamin D reduced the risk of OSO. Therefore, it seems that adequate vitamin D intake would be important to prevent OSO.

Summarizing previous studies, inappropriate macronutrient intake may induce unhealthy aging and lead the development of OSO. Macronutrient imbalances may affect bone and muscle mass and function. Chronic poor macronutrient intake may induce OSO by developing high blood glucose, low insulin levels, and low protein synthesis and therefore, higher intake of dietary fibers, lower intake of simple CHO, and sufficient intake of protein may help to prevent OSO. With aging, muscle mass improvement, bone mass maintenance, and body fat reduction would be important for preventing OSO. Therefore, sufficient CHO and fat intake for minimizing protein catabolism would be recommended to prevent and treat OSO. Balanced macro-and micro nutrient intake would be a critical factor for preventing and treating OSO.

3. Osteosarcopenic obesity and exercise

Previous studies stated that the prevalence of

OSO is associated with declined exercise especially in middle-aged and older population and regular exercise would be an effective intervention for preventing and treating OSO [31-33]. Moreover, a recent study [34] emphasized that nutritional intervention with macro-and micronutrient and physical activity intervention would improve the body composition in elderly population with OSO.

A study [33] investigated an association of OSO and physical performance in 606 Mexican older people and they found that OSO was related to poor physical performance with 2 times increased OSO risk. They also mentioned that poor physical performance was induced by less physical activity, which increased the loss of bone and muscle mass in elderly population. Another study [35] examined the effects of resistance training (RT) volume on OSO in 62 Brazilian elderly women and they concluded that a 12-week RT with 3 sets and 3 times per week was effective to highly improve OSO risk factors.

Resistance training (RT) is a type of exercise improving muscular strength and hypertrophy and reducing body fat by inducing lipid metabolism. Therefore, RT promotes a positive impact on the body composition in OSO populations [35]. A recent study [35] analyzed the effects of RT in OSO women and they found that RT increased strength and skeletal muscle mass, and decreased body fat in elderly women with OSO. In this study, there was no BMD changes during 12-week RT period. Otherwise, few studies found that long term RT was effective in improving BMD in OSO population [31,32]. Those studies emphasized that interventions such as RT, adequate protein and calcium dietary intake, associated with maintenance of appropriate levels of vitamin D, have a positive effect on bone not along with RT only.

From the standpoint of the exercise program effect on OSO, recent studies[36-38] found that the combination of aerobic exercise and RT also would be an effective intervention for OSO population. These studies recommended that combined exercise of aerobic exercise and RT in sedentary and/or older people can improve body composition and thus positively contribute to OSO condition. They also emphasized that a good nutritional intake including appropriate amount of vitamin D and protein and weight-loss diet would effectively modified OSO and concluded that at least 12 weeks of regular exercise (the combination of aerobic exercise and RT) in elderly population with OSO may induce positive outcomes in body composition and functional mobility.

4. Conclusion

The complication of OSO development should be related to nutritional intake and regular exercise. Nutritional imbalance may contribute to induce OSO by decreasing bone mass, muscle mass, and increasing obesity with aging. Sufficient CHO and fat intake for minimizing protein catabolism would be recommended. To prevent OSO, reaching peak bone mass and building optimal muscle and fat mass throughout regular exercise would be recommended. For treating OSO, healthy dietary intake with balanced macro-and micro nutrient through a whole life along with regular physical exercise would be needed. The combination of aerobic exercise and RT also would be an effective intervention for OSO population. In addition, longitudinal studies would be necessary to better understand dietary intake combined with exercise effects on OSO prevalence.

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