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UNVEILING RESEARCH GAPS IN SARCOPENIC OBESITY AMONG YOUNG ADULTS: INSIGHT FROM OPEN KNOWLEDGE MAP AND VOS VIEWER

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ABSTRACT

Sarcopenic obesity (SO) refers to the coexistence of elevated body fat mass and sarcopenia. Sarcopenia is characterized by a reduction in muscle mass, leading to diminished skeletal muscle mass and impaired functional status. While research on SO is predominantly focused on the elderly, it is conceivable that younger adults also experience SO, especially considering the high incidence of sedentary lifestyles within this demographic. This study wants to identify the distribution of research topics and the existing gaps in the literature. The research utilized a bibliometric analysis, integrating the Open Knowledge Map (OKM) and VOSviewer (VV) applications. The analysis revealed that the key clusters are associated with "insulin resistance," "body composition," and "muscle strength." Data from developing nations is scarce. There is insufficient research into the effects of genetic, epigenetic, and psychosocial factors on SO. Combined interventions involving nutrition and resistance training show significant promise in enhancing muscle mass and functionality, yet long-term assessments and synergistic mechanisms require additional investigation. While exercise and nutrition-based interventions yield encouraging outcomes, multidisciplinary research incorporating social, economic, and cultural factors is essential for a comprehensive understanding of SO. The development of universal diagnostic criteria is crucial to address methodological discrepancies that impede the comparability of studies.

Kata Kunci:

Sarcopenia obesitas;
usia muda;
malnutrisi;
analisis bibliometrik

ABSTRAK

Obesitas sarcopenic (SO) adalah peningkatan massa lemak tubuh dan penurunan massa otot rangka sehingga terjadi gangguan status fungsional. Penelitian tentang SO sebagian besar terfokus pada lansia, namun bukan tidak mungkin terjadi pada dewasa muda, mengingat tingginya gaya hidup sedentary pada kelompok ini. Tujuan studi adalah untuk mengidentifikasi sebaran topik penelitian dan kesenjangan yang ada dalam literatur. Penelitian ini menggunakan analisis bibliometrik dengan mengintegrasikan aplikasi Open Knowledge Maps (OKM) dan VosViewer (VV). Analisis mengungkapkan bahwa cluster utama penelitian terkait dengan "resistensi insulin", "komposisi tubuh", dan "kekuatan otot." Data dari negara-negara berkembang masih langka. Tidak ada cukup penelitian mengenai pengaruh faktor genetik, epigenetik, dan psikososial pada SO. Peran intervensi gabungan (nutrisi dan latihan fisik) jangka panjang untuk meningkatkan massa dan fungsi otot perlu dilakukan. Meskipun intervensi berbasis olahraga dan nutrisi memberikan hasil yang menggembirakan, penelitian multidisiplin yang menggabungkan faktor sosial, ekonomi, dan budaya sangat penting untuk pemahaman komprehensif tentang SO. Pengembangan kriteria diagnostik universal juga sangat penting untuk mengatasi perbedaan metodologi yang menghambat komparabilitas penelitian.

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INTRODUCTION

Sarcopenic obesity (SO) is a condition characterized by obesity and sarcopenia (Bahat, 2022). This concept was first introduced by Rosenberg in 1989 (Rosenberg, 1997). In 2000, Baumgartner defined it as a phenotype of sarcopenia and obesity (Baumgartner et al., 2004). It was later classified as a pathological condition in 2016 and included in the ICD-10 (To & First, 2023). Sarcopenia refers to the loss of muscle mass and function, marked by a decrease in skeletal muscle mass (SMM) and a drop in functional ability. This issue becomes more severe with aging (Sayer & Cruz-Jentoft, 2022). SMM

declines at a rate of over 3% every decade, beginning around age 30 and a steady decline at 60 years (Volpi et al., 2004). In contrast, fat mass keeps increasing until about age 75. Thus, although age is a major factor in the loss of SMM, body mass index (BMI) also significantly influences this change (Enderle et al., 2023). Sarcopenia is associated with a greater buildup of body fat because resting energy expenditure (REE) and total energy expenditure both fall. Low SMM raises the risk of falls and disability, mortality, and other health problems that can diminish a person's quality of life. When SMM is low and fat mass is high, these two conditions work together. This means there is a combined risk to a person's health due to these two metabolic issues. Therefore, it is crucial to avoid these harmful clinical outcomes (Jang et al., 2023).

Sarcopenic obesity has become a major health concern recently because of the increasing rates of obesity and low muscle mass (LMM). Several studies have shown a wide range of SO prevalence, from 0.1% to 85.3% in men and 0% to 80.4% in women; specifically, 0.9% in men and 1.4% in women, while sarcopenic overweight prevalence was found to be 6.5% in men and 6.0% in women (Purcell et al., 2021; Wagenaar et al., 2021). Research done in Brazil reported a prevalence rate of 29.3%, and a systematic review and meta-analysis covering 50 studies found a global prevalence of SO at 11% (de Campos et al., 2020; Gao et al., 2021). The significant differences in prevalence were linked to changes in the definition of SO. As a result, in 2022, experts from the European Society for Clinical Nutrition and Metabolism (ESPEN) and the European Association for the Study of Obesity (EASO) published a standardized definition of SO (Donini et al., 2022). In Indonesia, the prevalence of SO among older adults is reported to be 28% (Silalahi et al., 2021). However, there is insufficient specific data for the young adult group. Research carried out in different areas shows that obesity rates among teenagers and young adults are continuously increasing, with obesity impacting 20% of the general population (Bhaskara et al., 2020). This indicates that SO could also be found in young adults despite the lack of direct measurement data.

The United Nations and several global organizations generally define youth as individuals aged 15-24 years (Clendenning, 2019). Weight gain in this age group occurs more rapidly than in other age groups throughout an individual's life course (Guddal et al., 2020). Young adults with obesity have a nearly 30% higher risk of developing cardiovascular diseases (CVD) and dying from CVD before the age of 55 (Schmidt et al., 2013). Although obesity-related comorbidities often start to emerge during this stage, they are commonly asymptomatic, so young adults usually are not aware of them. Besides, sedentary lifestyles among young adults are increasing. Nearly 44% of young adults in Malaysia have a sedentary lifestyle (Juliana et al., 2021). Similarly, 53% of women and 47% of men also adopt a sedentary lifestyle in Indonesia. In fact, a sedentary lifestyle is a risk factor for obesity (OR 1.2; 95% CI 0.6-2) in men and (OR 1.5; 95% CI 0.7-3) in women. It is also a risk factor for low appendicular muscle mass (OR 1.5; 95% CI 0.9-3) and low hand grip strength (OR 1.6; 95% CI 0.6-4.2), all of which is a trigger factor for sarcopenic obesity (Rachmawati et al., 2023). Extended sitting time exceeding 7 hours daily was linked to a heightened risk of sarcopenia (OR=1.98). An increase in screen time by approximately 1.5 hours each day correlated with a 3.5 cm^3 rise in visceral fat volume. People who fell short of physical activity guidelines (150 minutes weekly) faced a 5.14 times greater risk of developing sarcopenia in comparison to those who engaged in regular physical activity (Tzeng et al., 2020).

Engaging in physical activity activates metabolic pathways crucial for fat burning, such as the insulin-like growth factor-1 (IGF-1) and mechanistic target of rapamycin (mTOR) pathways (Park et al., 2021). The activity of these signaling pathways diminishes when physical activity levels drop, leading to reduced muscle protein synthesis and heightened muscle breakdown. Consequently, there is a decline in the basal metabolic rate, which results in excess energy being stored as fat (Whitaker et al., 2017). Then, we want to identify existing research gaps and how tools such as OKM and VV can be used to navigate relevant literature.

METHOD

Type of Research

The research methodology includes a literature review using OKM and Publish or Perish (PoP) applications. The OKM application has utilized PubMed as its data source, where the “most relevant” option is selected. Six types of articles have been identified for review, including case reports, clinical studies, clinical trials, journal articles, observational studies, and randomized control trials. Publish or

Perish operated on version 8 with data sourced from PubMed. The data gathered from PoP is examined using VV version 1.6.20.

Data Collection

This study was conducted by VV through several steps. Analysis using OKM started by selecting data sources from PubMed using keywords such as "sarcopenic obesity," "young adults," and "late adolescent," specifying the time range as 2018-2023. Afterward, a visualization of clusters was generated based on metadata mapping.

Data Analysis and Processing

Analysis using PoP by using similar keywords to those in OKM, namely "sarcopenic obesity," "young adults," and "late adolescent." The data were collected from PubMed as journal publications within 2018-2023 with a maximum of 1000 articles; the selected data were then processed and saved in RIS format. Analysis using VV by inputting the RIS file extracted from PoP. Keywords for VV were extracted from the titles and abstracts of the articles.

Each word was selected using a binary method to ensure that if multiple identical keywords were found, they would be counted as a single word. Then, from the 10 thresholds recommended by VV, we increased to 20 thresholds to increase the grouping of terms. From the initially recommended 58% of terms, the threshold was increased to 100% to improve the efficiency of the cluster results. Finally, 34 out of the 99 recommended terms were selected. The visualization for network, overlay, and density was created. The heightened thresholds and grouping of terms in VV were implemented to enhance the quality, relevance, and interpretability of the analytical outcomes. This methodology can lead to more distinct and insightful network visualizations, facilitating a deeper comprehension of concept connections. The incorporation of all suggested terms adds to the credibility of the analytical results. It amplifies the chances that the analysis has encompassed the full range of topics pertinent to the research.

RESULT

Open Knowledge Map Analysis

Almost all of the studies are from developed countries; of the 12 clusters, there are four major clusters. The largest cluster is "insulin resistance, skeletal muscle, adult etiology" with 23 literature sources, overlapping with several clusters, namely (1) Anthropometric diagnosis, biomarkers, bone fragility; (2) Mortality, heart failure, the obesity paradox; (3) Criteria for sarcopenia diagnosis; (4) Malnutrition, bowel disease, sarcopenia; (5) Inflammatory bowel disease, non-alcoholic liver disease, and bariatric surgery. The second-largest cluster, with 13 literature sources, is "mortality, heart failure, obesity paradox." The next cluster is "cardiovascular disease, muscle to the fat ratio," followed by "aerobic exercise, physical performance, nutrition," which has 11 literature sources. These four major clusters intersect in elucidating the connections among metabolism, obesity, and chronic health issues. For instance, insulin resistance in skeletal muscle (cluster 1) can influence the risk of cardiovascular diseases (cluster 3), whereas aerobic exercise (cluster 4) serves as a method to enhance both conditions. The “obesity paradox” (cluster 2) illustrates the intricate role that body fat plays in diverse health scenarios. Cluster 1 outlines the processes behind insulin resistance in skeletal muscle resulting from chronic inflammation, oxidative stress, and mitochondrial dysfunctions.

Theoretically, inflammatory agents like TNF-α, IL-6, and MCP-1 are crucial in triggering inflammatory pathways such as IKKβ/NF-κB, which lead to reduced insulin sensitivity and mitochondrial impairment in the skeletal muscle of adults suffering from obesity or aging. The “obesity paradox” phenomenon reveals that obesity can sometimes correlate with a more favorable outcome in certain situations, such as heart failure. Nevertheless, this connection is complex, as obesity continues to be a major risk factor for mortality and cardiovascular diseases. Related mechanisms encompass chronic inflammation, alterations in body composition, and the interplay between visceral fat and cardiovascular tissues. The muscle-to-fat ratio serves as a crucial measure of cardiovascular well-being.

A reduction in muscle tissue or an increase in visceral fat can elevate the likelihood of developing cardiovascular illnesses. Research indicates that nutritional and exercise strategies can enhance this ratio, promoting cardiovascular and metabolic wellness. Engaging in aerobic exercise

positively influences metabolic and cardiovascular health by boosting mitochondrial function and insulin sensitivity while also reducing systemic inflammation. A blend of proper nutrition and regular physical activity can maximize physical performance and lower the chances of obesity-related diseases.

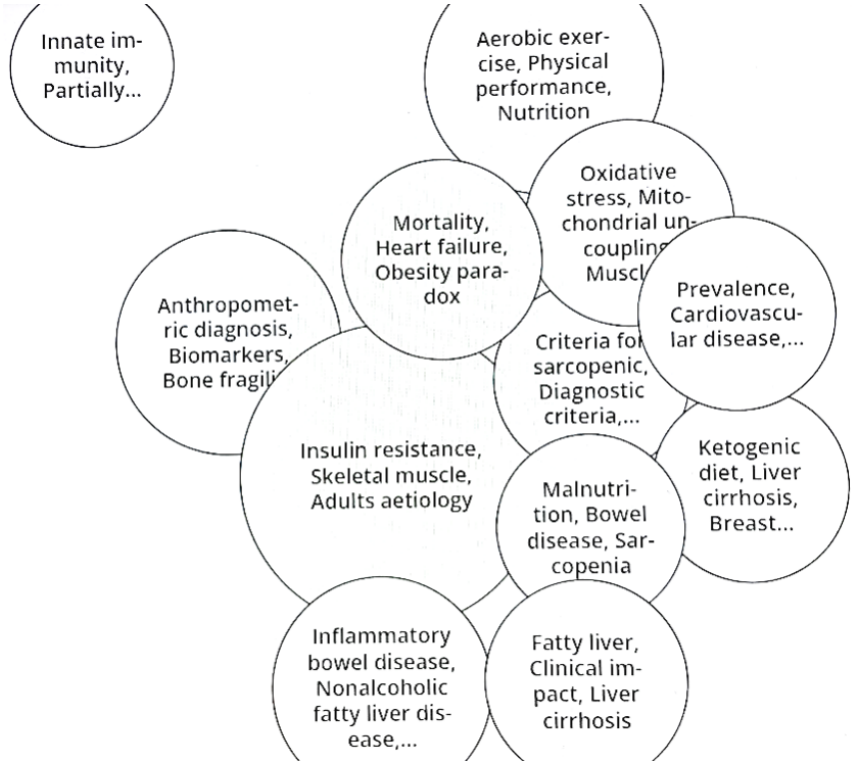

Figure 1. Open Knowledge Map (OKM) analysis results

Table 1. OKM analysis results and conclusion

No	**Clusters**	**Number of literature sources**
1	Insulin resistance and SO etiology in adulthood	23
2	Oxidative stress, mitochondrial uncoupling, and muscle atrophy	9
3	Anthropometric diagnosis, biomarker, bone fragility	9
4	Criteria for sarcopenic diagnosis	4
5	Aerobic exercise, physical performance, nutrition	11

Vos Viewer Analysis

Unlike OKM, which allows direct access to relevant literature, the Vos Viewer application only allows users to view the topic conclusions derived from various acquired literature. The trend/development of research on sarcopenic obesity can be observed through the overlay visualization (Figure 2) in the VV application. By the end of 2021, there is an increasing trend in several research topics, including muscular strength and physical performance and their links to insulin resistance and metabolic syndrome. Then, at the beginning of 2022, SO begins to be associated with waist circumference and cardiovascular diseases, as indicated by the small light green nodes for waist circumference and CVD. Finally, after mid-2022, SO begins to be linked with diabetes, physical activity, and BMI.

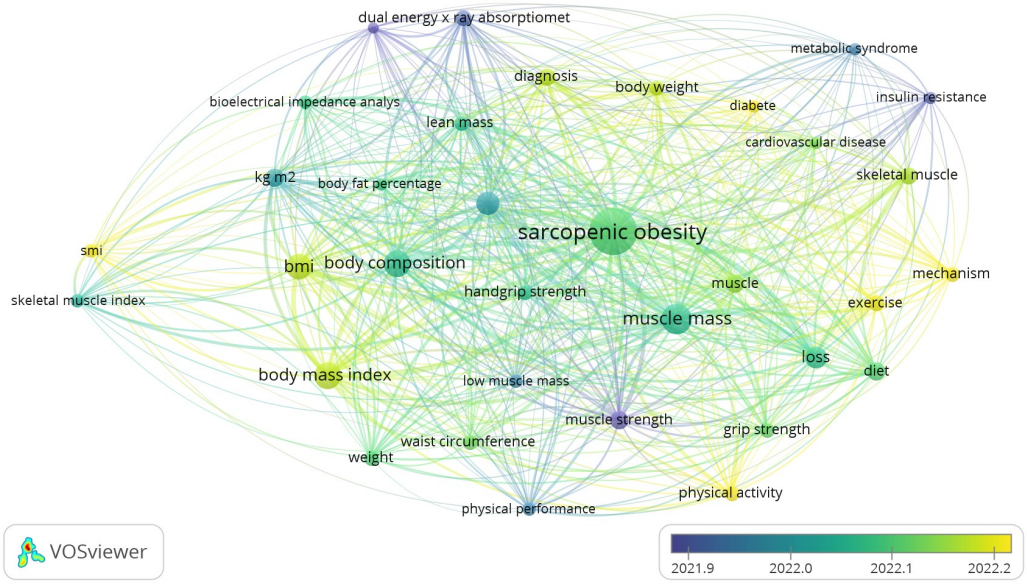

Figure 2. Overlay visualization of research on sarcopenic obesity

Recent studies on SO have shown that VV analysis results indicate a significant risk for metabolic diseases (including insulin resistance and metabolic syndrome) alongside an elevated cardiovascular risk. The primary strategies for managing this condition include nutritional interventions, exercise, and medical therapies. The assessment of body composition and BMI is crucial for diagnosing SO. Abdominal fat is more associated with metabolic complications compared to subcutaneous fat. A variety of measurement methods, such as dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA), are employed to evaluate muscle mass and body fat.

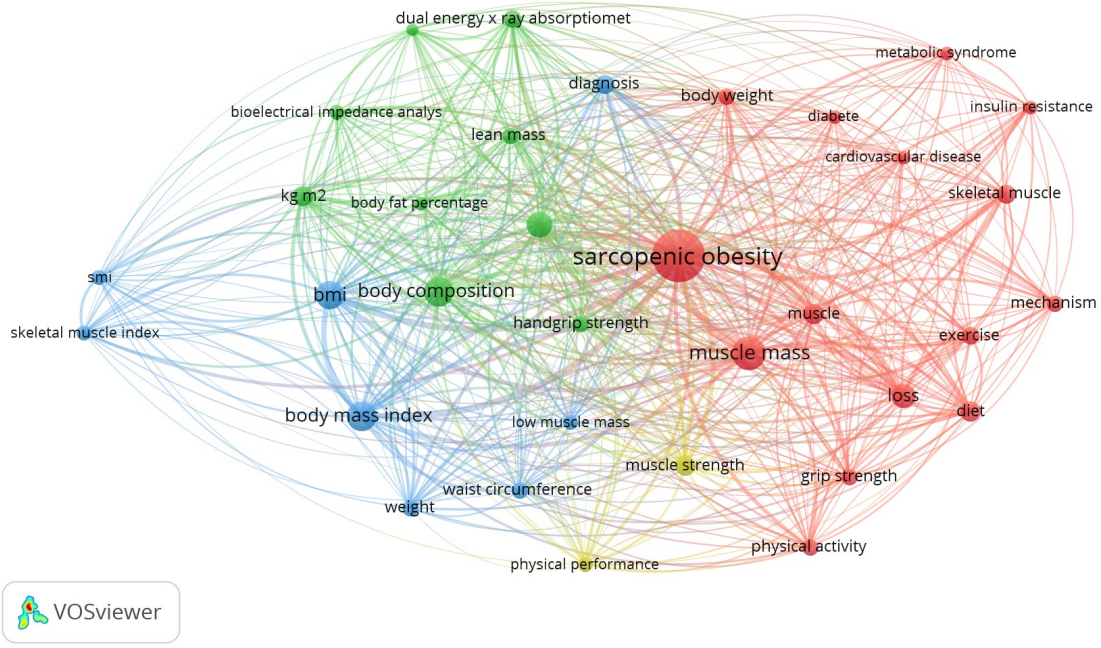

Figure 3. Network visualization of research on sarcopenic obesity

The depiction of SO clusters utilizing VV (Figure 3) illustrates the connections among important terms like “muscle mass,” “insulin resistance,” “body composition,” and “physical activity.” The largest node in cluster red represents muscle mass, while the other topics appear unclear and small, indicating that these topics have only received limited attention. Cluster green is mainly associated with body composition, while the other topics within this cluster have only received limited attention. Cluster three blue primarily shows that BMI is the only one receiving detailed attention as a diagnostic tool for OS, while the other variables, such as waist circumference and SMI, have not received as much attention. Cluster yellow, related to physical performance, is the smallest. These four VV clusters are in line with the clusters generated by the OKM analysis.

This portrayal aids in grasping the primary themes and interconnections of SO-related studies across various clusters. The cluster entitled “sarcopenic obesity and muscle mass” (red) emphasizes the link between SO, loss of muscle mass, and associated conditions such as insulin resistance and metabolic syndrome. Numerous studies have identified physiological mechanisms, including chronic inflammation, myosteatosis, and oxidative stress, that contribute to accelerated muscle loss in individuals with SO. Furthermore, muscle metabolic adaptations, such as reduced mitochondrial capacity, may worsen this condition. Strategies like consistent physical activity and a high-protein diet have been demonstrated to assist in enhancing muscle mass and metabolic function. The "body composition (green) and BMI (blue)" cluster encompasses metrics related to body composition, BMI, and bioelectrical impedance analysis. These metrics play a crucial role in diagnosing SO, which necessitates recognizing abnormal fat mass and fat-free mass.

Recent studies indicate that relying solely on BMI is insufficient to identify SO, as it fails to distinguish between muscle mass and fat mass. The implementation of advanced technologies facilitates more precise detection of variations in muscle and body fat. Research suggests that utilizing a combined evaluation of DXA and physical function metrics, like handgrip strength, is beneficial for diagnosing SO in older adults. The "physical performance" cluster (yellow) examines the interplay between physical activity, physical performance, and the prevention of cardiovascular diseases in individuals with SO. Engaging in physical activity, particularly aerobic and resistance exercises, has been demonstrated to enhance muscle strength, insulin sensitivity, and mitochondrial metabolic function. Studies affirm the significance of integrating exercise programs with dietary strategies to reduce cardiovascular risks in those affected by SO.

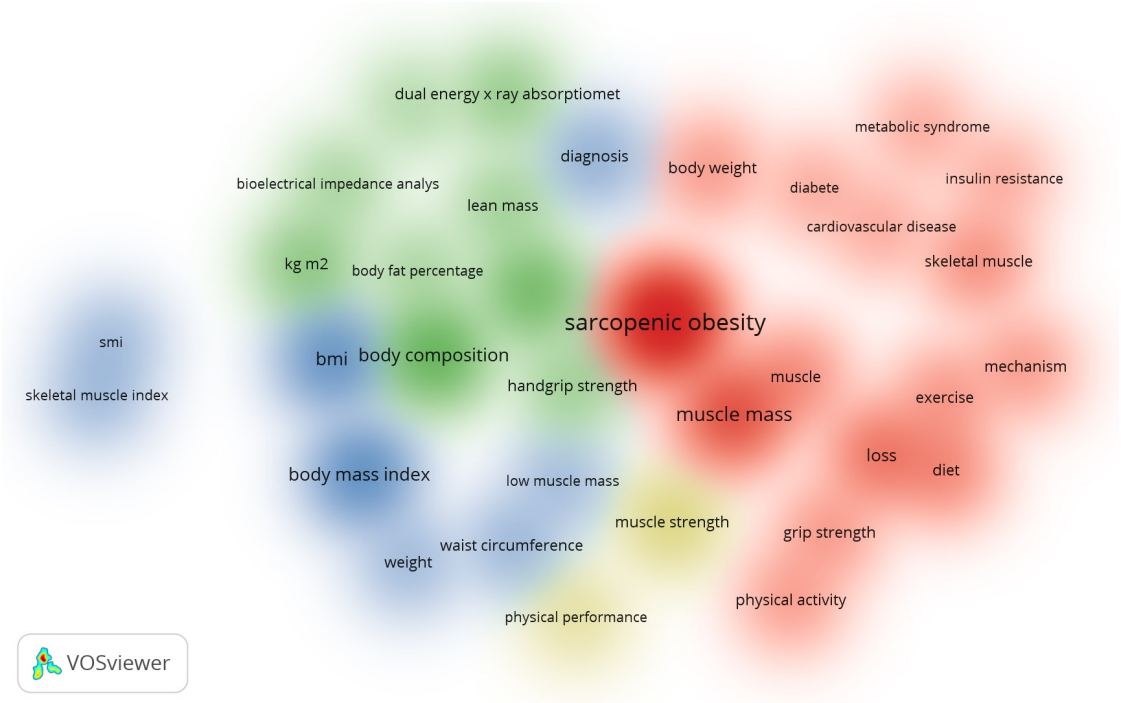

Figure 4. Cluster density visualization of research on sarcopenic obesity

Based on Figure 4, the results of the VV analysis can be seen in the tabulation presented in Table 2 below. Although there have already been numerous research topics within cluster 1, in-depth studies are still limited. The most significant opportunity for in-depth research is related to physical performance because research on this topic is still relatively limited. Although this topic has started to gain attention since the end of 2021 (Figure 2), there is still ample room for further in-depth research. The crimson cluster encompasses the link between SO and insulin resistance, metabolic syndrome, and cardiovascular risks. Evidence indicates that SO intensifies systemic inflammation, which plays a role in metabolic dysfunction and cardiovascular illnesses. The azure cluster regarding physical assessments emphasizes the evaluation of skeletal muscle strength and mass. The SMI serves as a crucial metric for assessing the extent of sarcopenia, particularly in relation to obesity, along with handgrip strength and waist circumference evaluations. Subsequent assessments (emerald cluster) utilizing BIA or DXA should be performed to gain deeper insights into the distribution of muscle mass and fat in individuals with SO.

Table 2. Tabulation of cluster data based on VV analysis

No.	Topics	Number of topics
Cluster 1	Sarcopenic obesity	15
	Muscle mass	
	Muscle	
	Body weight	
	Diabetes	
	Cardiovascular diseases	
	Metabolic syndrome	
	Insulin resistance	
	Skeletal muscle	
	Mechanism	
	Exercise	
	Loss	
	Diet	
	Grip strength	
	Physical activities	
Cluster 2	Body composition	7
	Hand grip strength	
	Body fat percentage	
	Lean mass	
	Kg/m^2	
	Bioelectrical impedance analysis	
	Dual energy x-ray absorptiometry	
Cluster 3	Diagnosis	8
	Body mass index	
	BMI	
	Body weight	
	Waist circumference	
	Low muscle mass	
	Skeletal muscle index	
	SMI	
Cluster 4	Physical performance	2
	Muscular strength	

DISCUSSION

Some of the research gaps that emerge from the examination of OKM and VV are (1) deficiencies in comprehending biological mechanisms; (2) absence of multidisciplinary strategies; (3) uneven geographical distribution of research; (4) assessment of the efficacy of combined interventions; (5) variable diagnostic criteria; and (6) the influence of genetics and epigenetics. Although the clusters "mechanism," "exercise," and "diet" indicate a strong connection with SO, a significant portion of the literature only explores aspects of the biological mechanism, such as chronic inflammation, insulin resistance, and mitochondrial dysfunction. Previous studies indicate that mitochondrial dysfunction serves as a primary pathophysiological mechanism in SO, influencing both physical performance and metabolic health. A reduction in mitochondrial efficiency can heighten oxidative stress and worsen chronic inflammation along with insulin resistance (Chen et al., 2023). Research has also pointed out that interventions like aerobic exercises and strength training can markedly enhance mitochondrial biogenesis, VO2max levels, and muscular performance, presenting a viable management strategy for individuals with SO (Hadjispyrou et al., 2023). While these mechanisms have been recognized, the intricate causal links among them necessitate a more thorough investigation. The "mechanism" category is solely concentrated on muscle biology and metabolism, while the influence of genetics and epigenetics remains infrequently examined. Furthermore, while chronic inflammation contributes to mitochondrial dysfunction, the specific roles of mediators such as proinflammatory cytokines still need to be explored. A comprehensive approach incorporating a blend of molecular biomarkers, metabolomic assessments, and advanced imaging techniques is essential for a deeper understanding of these connections. This could pave the way for the creation of precision-based treatments for SO, especially those categorized as young adults.

Previous studies indicate that the identification of SO frequently employs various techniques, such as DXA and BIA. Variations in worldwide diagnostic guidelines lead to notable discrepancies in the estimation of prevalence and assessment of severity for SO (Zhuang et al., 2024). Current agreements, including those from the European Society for Clinical Nutrition and Metabolism (ESPEN) and the European Association for the Study of Obesity (EASO), advocate for a multi-faceted diagnostic strategy, which encompasses evaluating muscle function and body mass using standards that are specific to gender and age. For instance, ESPEN/EASO established that integrating measurements of fat mass and muscle mass through DXA or BIA, along with weight-adjusted indices, can enhance the reliability of diagnostic outcomes (Donini et al., 2022). Nevertheless, there is a scarcity of epidemiological research on the prevalence of SO in developing nations despite the fact that lifestyle and dietary shifts in these areas elevate the risk of SO (Clemente-Suárez et al., 2023). By broadening diagnostic research to include these nations and implementing global consensus, a more profound comprehension of the prevalence of SO may be realized. This understanding could lead to targeted interventions that address the unique challenges faced by populations in developing countries, ultimately contributing to improved health outcomes and a reduction in the burden of SO. Such targeted interventions could include community-based nutrition programs, increased access to physical activity resources, and public health campaigns aimed at raising awareness about the risks associated with SO. These initiatives would not only empower individuals to make healthier choices but also foster a supportive environment that encourages sustainable lifestyle changes, thereby enhancing overall community health and resilience against SO.

Implementing these strategies requires collaboration among healthcare providers, policymakers, and community organizations to ensure that resources are effectively allocated and tailored to meet the specific needs of at-risk populations. Such collaboration can lead to innovative solutions and comprehensive approaches that address the multifaceted nature of SO, ultimately promoting healthier living and improving the quality of life for affected individuals. By prioritizing education and access to resources, communities can create a culture of health that not only mitigates the impact of SO but also encourages physical activity and balanced nutrition as foundational elements of well-being. This holistic approach fosters an environment where individuals are empowered to make informed health choices, leading to sustainable lifestyle changes that can significantly reduce the prevalence of SO and enhance overall community well-being.

The categories "exercise," "diet," and "muscle strength" indicate a primary emphasis on physical or nutritional approaches. Nevertheless, integrated interventions, like the combination of

physical activity with nutritional treatment or medication, have not been extensively assessed. Previous studies have underscored the possible advantages of merging physical activity with nutritional supplements. While exercise and nutritional strategies on their own have shown effectiveness, the combined effect of these two approaches is gaining acknowledgment (Emakpor et al., 2024).

Exercise, particularly resistance training, is recognized for its ability to promote muscle protein synthesis and enhance muscle strength. When paired with protein supplements, especially essential amino acids or whey protein, the maintenance and increase of muscle mass can be improved, particularly in older adults experiencing sarcopenia (McKendry et al., 2020). Vitamin D is acknowledged for its crucial role in bolstering muscle function and strength. Studies indicate that vitamin D supplementation when combined with physical activity, can enhance muscle performance and avert muscle mass decline (Zhang & Li, 2024). This integrated approach yields the best results when implemented consistently rather than sporadically. A systematic review highlighted that consistent resistance training combined with these dietary supplements enhances muscle mass and functionality, particularly in the elderly population (Ren et al., 2024). However, additional research is necessary to investigate the long-term implications and fine-tune this combined approach. There is also a pressing need for more extensive studies that examine specific doses and timing of supplementation in relation to exercise programs.

The strength of this research lies in its integration of two applications, OKM and VV, for literature search and analysis. The use of both applications has the potential to enhance existing research on the theme of SO in young adults. However, a limitation of this study is that not all of the analysed data included young adult respondents due to the constraints of the study in relation to this population.

CONCLUSION AND SUGGESTION

Based on the analysis using OKM and VV, it is evident that publications on SO in young adults have increased notably since the end of 2021. It also generated 4-5 major clusters up to the present time. The largest cluster is related to the correlation between sarcopenic obesity and insulin resistance, yet the precise mechanisms correlating the two topics are still unclear. Future studies may concentrate on finding molecular biomarkers for prompt detection and prognosis, creating more accessible and precise diagnostic techniques, and optimizing specific interventions on a population basis. Successful management of SO necessitates a comprehensive strategy: dietary modifications, increased physical activity, and pharmacological methods. This multifaceted approach not only aims to address the immediate symptoms of SO but also seeks to understand its underlying mechanisms, paving the way for targeted therapies that can enhance overall health outcomes in young adults.

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