Original Article

Persevering or quitting? A systematic review of adherence and dropout in nutrition and exercise interventions for sarcopenic obesity

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Background and Objectives: The global rise in sarcopenic obesity necessitates identifying key adherence determinants in nutritional and exercise interventions to optimize outcomes. This systematic review identifies characteristics affecting adherence and dropout in these interventions. **Methods and Study Design:** We searched Web of Science, PubMed, Scopus, and Cochrane Library through January 2025, including reference lists. Using the Cochrane Risk of Bias Tool, we assessed RCTs on nutritional/exercise interventions for sarcopenic obesity. High heterogeneity and insufficient adherence reporting precluded meta-analysis for adherence; outcomes were narratively synthesized. For dropout rates, meta-analysis was conducted, including subgroup analyses (exercise, nutrition, multi-component) and meta-regression to explore moderators. **Results:** From 1,205 records, 57 studies (4,166 participants) were included. The overall dropout rate was 9%, increasing with intervention duration. Only 45.6% of studies reported adherence data. Among exercise interventions, elastic resistance had the highest adherence (91.5%), resistance training the lowest (85%). In nutritional interventions, low-calorie diets with nutraceuticals outperformed diet-only (92.1% vs. 77%). Professionally supervised interventions showed superior adherence to self-monitored programs. **Conclusions:** Current trials often inadequately report adherence data, with longer durations correlating to higher dropout rates. Evidence suggests elastic resistance exercise, low-calorie diets with nutraceuticals, and professional supervision may improve adherence. Future research should refine intervention methods and prioritize adherence reporting to enhance sarcopenic obesity care quality.

Key Words: attendance, sarcopenic obesity, physical activity, nutrition, interventions

INTRODUCTION

With the global population aging, the prevalence of sarcopenia is expected to rise significantly.[1] Sarcopenia, an age-related disease characterized by a progressive decline in skeletal muscle mass and function,[2] significantly increases the risk of falls, fractures, functional disability, and mortality among the elderly.[3, 4] This condition often necessitates long-term care, thus imposing a substantial societal and economic burden.[5, 6] Furthermore, sarcopenia is often linked to physical inactivity, which can reduce energy expenditure and contribute to obesity.[7] This interplay has led to the conceptualization of “sarcopenic obesity” (SO), a condition characterized by the co-existence of sarcopenia and obesity.[8] SO affects approximately 11% of older adults worldwide,[9] and the number of cases is projected to reach 100-200 million by 2050.[10] Critically, individuals with SO have a significantly higher risk of metabolic disorders,[11, 12] cognitive decline,[13] falls and fractures,[14] and mortality[15] compared to those with either condition alone.

Substantial evidence indicates that unhealthy eating habits and physical inactivity are the primary causes of SO, making them key areas for intervention. Since effective drugs for this condition are lacking, the most effective approach to managing SO involves a personalized combination of adequate dietary adjustments and consistent physical exercise, tailored to each individual’s health condition.[16] However, a survey involving nearly 10,000 people revealed that only 56% of middle-aged and elderly individuals engage in activities more than three times a week, and less than 30% take calcium supplements.[17] Emphasize the necessity of implementing proven

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and effective policies and programs aimed at promoting healthy diets and physical activity, in order to address the multifaceted factors that contribute to the low participation rates.

Broadly speaking, adherence refers to the extent to which patients (or participants) follow the recommendations of a prescription or intervention,[18] while cessation of an intervention for any reason is termed dropout. There is a consensus that all clinical trials should report adherence to interventions and dropout rates.[18] Low adherence levels may potentially diminish the benefits of interventions on health outcomes.[19] Although a few studies have begun to focus on adherence among patients with SO, most of these are reports on the results of individual intervention studies.[20, 21] There is a lack of comprehensive research summarizing dropout rates and adherence in nutrition and exercise interventions for SO patients.

This synthesis gap critically limits the ability to discern which intervention characteristics reliably promote long-term engagement. Therefore, understanding the factors within interventions that are associated with improved adherence and reduced dropout rates may assist clinicians and policymakers in selecting effective strategies for patients with SO, thereby enhancing long-term intervention success. Therefore, this systematic review aims to identify factors within nutrition and exercise interventions associated with improved adherence and reduced dropout rates among patients with SO.

METHODS

Institutional review board statement

This study's reporting adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)[22] and registered in the PROSPERO International prospective register of systematic reviews (protocol 2025: CRD420251166328).

Study selection

Inclusion criteria were as follows: (a) study design: RCTs; (b) population: adults (≥18 years) with SO (according to the author's criteria); (c) intervention: structured exercise and/or nutrition interventions; (d) control: participants are to continue with their existing physical activity routine and dietary habits. (e) outcome: data on dropout and/or adherence; (f) language: English. Studies that provided financial rewards for participation were excluded. No limitations were imposed based on the publication date.

Sources of information and search strategy

Two experienced and appropriately trained independent researchers, ZJ and WY, conducted searches in four electronic databases: Web of Science, PubMed, Scopus, and the Cochrane Library. The search was conducted from inception up until 5 January 2025.

To determine suitable search terms, searches were executed within PubMed's Medical Subject Headings (MeSH). Furthermore, reference articles were examined to gather frequent keywords from their titles and abstracts. An initial search strategy was trialed, leading to the identification of extra keywords, which were then integrated into the strategy.

The search strategy mainly includes the following five groups of keywords: (1) Sarcopenia: "sarcopenia" OR "sarcopenic" OR "sarcopenic obesity" OR "sarcopenic obese" OR "SO" OR "dynapenia" OR "dynapenic" OR "dynapenic obesity" OR "dynapenic obese" OR "muscle loss" OR "muscle wasting"; and (2) Obesity: "obesity" OR "obese" OR "overweight" OR "with obesity" OR "fat"; and (3) Exercise: "exercise" OR "physical exercise" OR "physical training" OR "aerobic exercise" OR "endurance training" OR "circuit-based exercise" OR "resistance Training" OR "strength Training"; and (4) Nutrition: "nutrition" OR "diet" OR "food" OR "energy intake" OR "nutrition Therapy"; and (5) Randomized controlled trial: "RCT" OR "clinical trials" OR "randomized controlled trials" OR "RCTs" OR "treatment" OR "management".

Two supplementary manual searches were undertaken to uncover further eligible studies and enhance the electronic search results. The reference lists of qualifying studies were reviewed, and references from systematic reviews targeting similar populations and interventions were also analyzed. These processes were independently conducted in duplicate by ZJ and WY in a blinded manner. Detailed search strategies for each database are available in Supplementary Table 1.

Selection of studies and data extraction

Two researchers (ZJ and WY) conducted the database searches independently. If disagreements or uncertainty arose, the results were deliberated upon with a third researcher (YK) to evaluate and reach an agreement. Eligibility was verified in three steps: titles, abstracts, and full text.

Data extraction was also conducted by ZJ and WY independently. An Excel spreadsheet was used to extract the following data from the included articles: (a) title, (b) author, (c) year of publication, (d) age, (e) percentage of females in the group, (f) details of the intervention: duration (weeks), frequency (times per week), type, and duration, (g) dropout and adherence data. Data extraction was also performed independently by two reviewers (ZJ and WY) and then compared with any discrepancies being resolved through discussion.

The eligible outcomes included adherence, calculated as the percentage of attended sessions out of the offered sessions, and dropout, which referred to the count of participants who withdrew from the study during the intervention period. For studies that omitted information on intervention adherence but provided data on the number of attended sessions and the number of offered sessions, the adherence rate was determined through calculation (attendance/offered session*100).

Risk of bias

To assess the quality of the articles, the Cochrane Risk of Bias Tool (RoB2) was employed. Studies with low overall risk of bias according to RoB2 were designated as relatively high-quality. The quality of articles was independently evaluated by two assessors (ZJ and WY). Disagreements were resolved through review by a third researcher (YK) to achieve consensus.

Statistical analysis

We conducted a meta-analysis using random effects with R version 4.4.0, utilizing the metafor package version 4.6-0 for statistical processing. Initially, we calculated the dropout rate and its 95% confidence interval (95% CI) across all studies. Subsequently, we performed subgroup analyses comparing dropout rates among different types of exercise and different nutritional approaches. Then, we conducted a meta-regression analysis to assess potential moderators that could influence dropout rates across studies. The included moderators were participant age, the percentage of females in the studies, intervention duration, exercise frequency, type of exercise, duration of each workout session, and type of nutrition. The significance level adopted was $p < 0.05$.

In this study, heterogeneity was assessed using the I^2 statistic, with values >50% indicating substantial heterogeneity. Publication bias was analyzed by visually inspecting the funnel plot and conducting Begg-Mazumdar Kendall's tau and Egger's bias tests. After analyzing the funnel plot with the results of all studies, we performed the trim and fill adjustment to remove extreme outliers and recalculated the pooled dropout rates.

According to the review protocol, when meta-analyses were not feasible due to heterogeneity, we summarized the evidence in a narrative manner

RESULTS

Search results

The initial search through the electronic databases identified 1205 records. Following the removal of duplicates and an evaluation of titles, abstracts, and full texts for inclusion criteria, 57 studies were selected for data extraction. Upon reviewing the reference lists of the included studies and systematic reviews that involved similar populations and interventions, we identified 44 articles. After removing duplicates (n=44), 57 studies were included in this review (Figure 1).

Study characteristics

Table 1 shows the main characteristics and details of the 57 included studies. The total number of patients was 4166 (Exercise interventions: n=1002; Nutrition interventions: n=1012; Combined interventions: n=2152); the mean age was 59.3 years. Five studies only included male,[23-27] twenty-eight studies only included female,[28-54] twenty-four studies comprised a mixed sample of both males and females,[20, 21, 55-76] and one study failed to disclose the gender percentage.[77] The average intervention duration across all studies was 21 weeks (range 0.2–72), with studies focusing on exercise interventions averaging 18 weeks (range 8–72), studies on nutritional interventions averaging 20 weeks (range 0.2–72), and studies on combined interventions averaging 27 weeks (range 3–72). The average frequency of exercise interventions was 3 times per week (range 2–5), with a duration of 55 min (range 30–83). Nutritional interventions were conducted on a daily basis.

The exercise studies included Aerobic Exercise (AE),[28, 54-57, 76] Resistance Exercise (RE),[29-31, 52, 56-60, 76] Aerobic Exercise and Resistance Exercise (AE+RE),[32-35, 56, 76] Elastic Resistance Exercise (ERE).[36-40] The exercise studies included Low Caloric Diet (LCD),[20, 44-47, 65, 66] Low Caloric Diet and Nutraceutical (LCD+N)[41-43, 61-64, 75, 77] and dietary behavior intervention.[21, 42, 67] The combined intervention studies included Exercise and Low Caloric Diet (E+LCD),[48, 68-71] Exercise and Nutraceutical (E+N),[23, 49-51, 53, 72] behavioral (B) intervention, and other therapies.[24-27, 70, 73, 74] Two studies did not report dropout rates,[45, 74] and two studies did not report average ages.[48, 75]

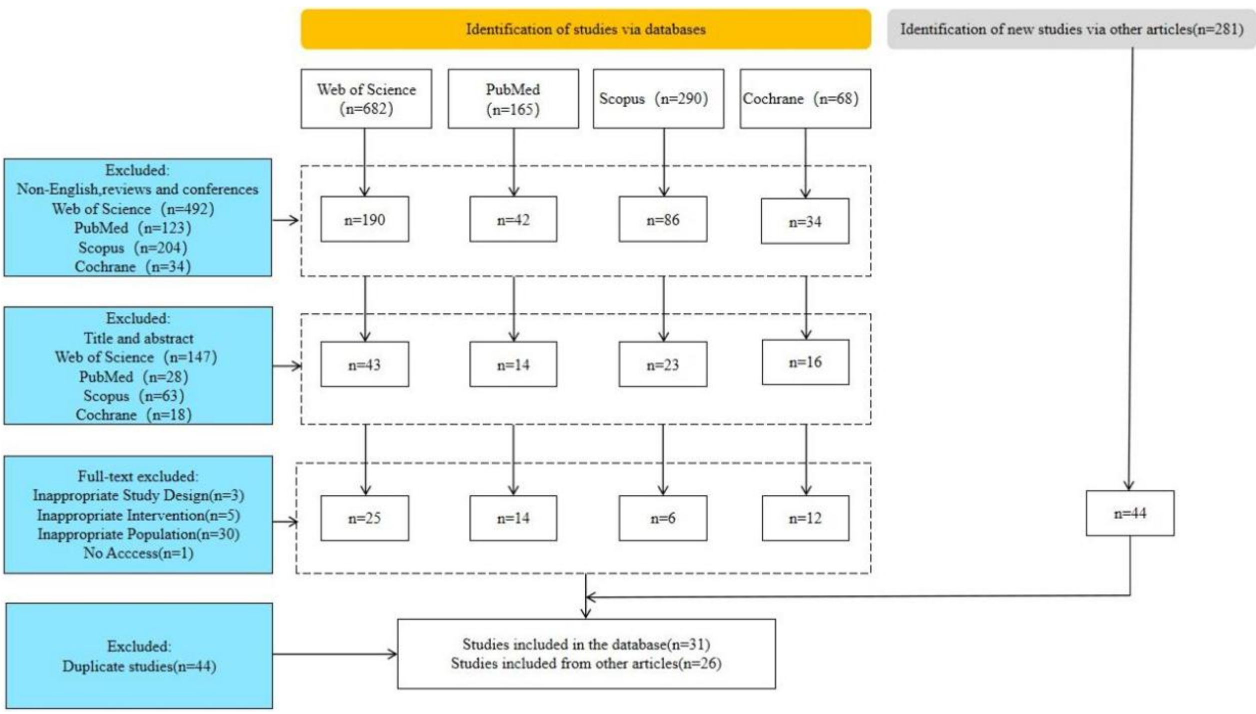

Figure 1. The flow diagram indicates the process of study selection

Table 1. Characteristics of included studies

Author, Year	Age	N (EG)	% Female	Length of Intervention	Frequency (times per week)	Type of interven-tion	Workout duration (minutes)	Dropout (EG)	Dropout rate	Adherence
Minett et al 2020	77.1	48	58.3	12	5	AE	30	4	0.08	≥50%
Jung et al 2022	75.4	15	100	12	3	AE	≈60	1	0.07	
Colleluori et al 2019	71.0	13	64.0	26	3	AE	60	2	0.15	97±1%
	72.0	15	50.0	26	3	RE	60	3	0.20	96±2%
	69.0	15	50.0	26	3	AE+RE	≈83	3	0.20	93±2%
Chen et al 2017	69.3	24	93.3	8	2	AE	60	9	0.38	
	68.9	22	80.0	8	2	RE	60	7	0.32	
	68.5	25	73.0	8	2	AE+RE	60	10	0.40	
Balachandran et al 2014	71.6	11	100	15	2	AE	≈43	3	0.27	81%
	71.0	10	88.0	15	2	RE	≈58	1	0.10	85%
El-Hak et al 2021	58.3	20	100	12	3	AE	≈30	0	0.00	
Vitale et al 2020	66.0	9	33.0	24	4	RE	55	4	0.44	≥75%
Gadelha et al 2016	66.8	69	100	24	3	RE	≈50	0	0.00	≥75%
Chiu et al 2018	79.6	37	61.0	12	2	RE	60	4	0.11	80.80%
Vasconcelos et al 2016	72.0	16	100	10	2	RE	60	2	0.13	
de Oliveira Silva et al 2018	66.9	8	100	16	2	RE	≈45	0	0.00	
Stoever et al 2018	71.5	34	41.2	16	2	RE	60	7	0.21	
Cunha et al 2018	67.5	46	100	12	3	RE	≈40	5	0.11	≥85%
Dieli-Conwright et al 2018	52.8	50	100	16	3	AE+RE	≈70	4	0.08	95%
Park et al 2017	73.5	25	100	24	5	AE+RE	≈65	0	0.00	92%
Bocalini et al 2012	63.2	23	100	12	3	AE+RE	50	0	0.00	≈87%
Gutiérrez-López et al 2021	68.1	30	100	12	3	AE+RE	60	0	0.00	
Liao et al 2017	66.4	25	100	12	3	ERE	≈48	0	0.00	97.60%
Liao et al 2018	66.7	33	100	12	3	ERE	55	4	0.12	97.60%
Huang et al 2017	68.9	18	100	12	3	ERE	55	0	0.00	
Lee et al 2021	70.1	15	100	12	3	ERE	55	0	0.00	85%
Banitalebi et al 2021	64.1	32	100	12	3	ERE	70	6	0.19	85%
Camajani et al 2022a	60.0	16	100	1.5		LCD+N		0	0.00	
Verreijen et al 2015	63.7	40	53.3	13		LCD+N		10	0.25	91%
Aparecida Silveira et al 2020		73	94.1	12		LCD+N		8	0.11	87.40%
Beavers et al 2019	71.4	47	74.5	24		LCD+N		6	0.13	
Larsen et al 2023	58.0	30	100	0.2		LCD+N		0	0.00	
	57.7	10	100	0.2		Nutrition Other		0	0.00	
Aubertin-Leheudre et al 2007	58.0	12	100	24		LCD+N		0	0.00	
Alemán-Mateo et al 2012	75.4	20	60.0	12		LCD+N		8	0.40	
Coker et al 2012	70.0	6		8		LCD+N		1	0.17	
Jabbour et al 2022	71.6	129	55.0	64		LCD+N		15	0.12	>90%

E, Exercise; AE, Aerobic Exercise; RE, Resistance Exercise; ERE, Elastic Resistance Exercise; LCD, Low Caloric Diet; N, Nutraceutical; B:Behavioral.

Table 1. Characteristics of included studies (cont.)

Author, Year	Age	N (EG)	% Female	Length of Intervention	Frequency (times per week)	Type of intervention	Workout duration (minutes)	Dropout (EG)	Dropout rate	Adherence
Limon-Miro et al 2021	49.0	34	100	24		LCD		12	0.35	
Dunn et al 2024	56.1	20	62.0	24		LCD		7	0.35	≈89%
Porter Starr et al 2016	67.9	41	80.0	24		LCD		11	0.27	85%±10%
Lee et al 2020	77.1	10	66.7	4		LCD		1	0.10	84%
Muscariello et al 2016	66.9	54	100	12		LCD				
Sammarco et al 2017	53.0	9	100	16		LCD		0	0.00	
Mojtahedi et al 2011	64.7	15	100	24		LCD		2	0.13	≈87.9%
Yin et al 2023	68.9	30	60.0	15		Nutrition Other		4	0.13	66.7%
Mey et al 2021	40.0	14	78.6	8		Nutrition Other		0	0.00	
Mason et al 2013		117	100	64	5	E+LCD	45	9	0.08	
		117	100	64	5	AE	45	12	0.10	
		118	100	64		LCD		15	0.13	
Camajani et al 2022b	56.5	12	91.7	6	2	E+LCD	30-45	0	0.00	
	56.0	12	83.3	6		LCD		0	0.00	
Verreijen et al 2017	61.5	32	59.4	10		E+LCD		10	0.31	
	63.1	25	64.0	10	3	RE	60	6	0.24	≈93%
	61.9	21	61.9	10		LCD		8	0.38	29%
Farsijani et al 2020	71.3	21	81.0	64	2.5	E+LCD	75	0	0.00	
	70.5	15	86.7	64	0.25	B	60	0	0.00	
Beavers et al 2014	66.1	135	76.0	72	3	E+LCD	30	34	0.25	
	65.8	129	75.0	72	3	AE+RE	≈30	34	0.26	
	66.0	128	70.0	72		LCD		40	0.31	
Kim et al 2016	80.9	36	100	12	2	E+N	60	0	0.00	
	81.4	35	100	12	2	AE+RE	60	1	0.03	
	81.2	34	100	12		LCD+N		1	0.03	
Karlsson et al 2021	85.9	60	65.4	12	28	E+N	≈5	8	0.13	
Demark-Wahnefried et al 2008	42.1	61	100	24	3	E+N	30	6	0.10	≈80%
	41.1	29	100	24		LCD		2	0.07	82%
Maltais et al 2016	68.0	8	0	16	3	E+N	60	0	0.00	>90%
	64.0	8	0	16	3	RE	60	0		>90%
Nabuco et al 2019	68.0	13	100	16	3	E+N	≈40	0	0.00	
Demark-Wahnefried et al 2002	42.4	10	100	24		E+N		1	0.10	
Jancey et al 2020	60.5	201	66.2	24		B		71	0.35	
Wilson et al 2021	74.0	11	0	12	3	B	50	0	0.00	
Park et al 2021	66.3	86	0	12		B		11	0.13	
Kemmler et al 2017	77.1	33	0	16	1.5	Combined Other	20	3	0.09	
	78.1	33	0	16		LCD		2	0.06	100%
Zhou et al 2018	70.4	28	0	28	2	Combined Other	20	5	0.18	
	68.8	27	0	28		LCD+N		2	0.07	
Sartorio et al 2004	45.3	1273	63.0	3	5	Combined Other	30			

E, Exercise; AE, Aerobic Exercise; RE, Resistance Exercise; ERE, Elastic Resistance Exercise; LCD, Low Caloric Diet; N, Nutraceutical; B:Behavioral.

Adherence

Due to heterogeneity in how adherence was defined and measured across studies, a meta-analysis was precluded. The primary studies used diverse metrics-such as attendance logs, exercise completion, dietary records, and supplement consumption-tailored to their specific interventions, limiting direct comparisons. We therefore conducted a narrative synthesis, focusing on patterns within comparable intervention types. Notably, only 26 of 57 trials (45.6%) reported quantifiable adherence data. The following sections summarize adherence patterns, with detailed results in Tables 2-4.

Exercise interventions

Among the 32 studies on exercise interventions, 19 (59%) reported on participants' adherence. Among these, 3 studies[34, 55, 69] did not specify their method for defining adherence. Key characteristics and adherence outcomes across different exercise modalities are summarized in Table 2.

Among the 9 studies with adherence rates above 90%, RE[23, 69, 76] and AE+RE[32, 33, 76] were the most prevalent, with 3 studies each, and adherence to AE[76] and ERE[36, 37] was the highest (≥ 97%). In studies with adherence rates below 90%, RE accounted for the highest proportion (50%). The high-adherence group had an average age of 66, an average intervention duration of 19 weeks, an average exercise session duration of 62 min, an average frequency of 3 times per week, involving a total of 209 participants. In contrast, the low-adherence group had an average age of 70, an average intervention duration of 15 weeks, an average exercise session duration of 51 min, an average frequency of 3 times per week, involving a total of 300 participants.

Nutritional interventions

Among the 27 studies on nutritional interventions, 12 (44%) reported on participant adherence. But 2 of these studies only reported adherence related to participants' attendance at dietary education sessions,[20, 47] while 1 study reported high adherence without providing specific numerical values.[67] The findings are summarized in Table 3.

The LCD interventions demonstrating the widest adherence range (29%-90%) and LCD+N interventions showing more consistent adherence (87%-100%). Different methods were used to measure adherence across studies, including session attendance, dietary records, and specific nutraceutical intake compliance.

Combined interventions

Adherence reporting was poorest in combined interventions, with only 6 of 18 studies (33%) providing data (Table 4). These studies averaged 17 weeks, involving 204 participants with 28 withdrawals (13.7%).

Adherence data for multi-component interventions revealed variable patterns across intervention types. In E+N interventions, adherence rates ranged from 42% to over 90%, with withdrawal rates between 0% and 13%. The E+LCD intervention showed a higher withdrawal rate of 31%.

Dropout

Fifty-five out of the 57 studies clearly reported dropout rates. Among the 68 intervention groups, the combined dropout rate was 9% (95% CI 6.6 to 12.3%; I^2 = 56.3%) (Figure 2). Based on the mode of intervention, the studies were categorized into three groups: exercise intervention group (E), nutrition intervention group (N), and combined interventions group (C). The results of the subgroup analysis are presented in Figure 2. The presence of publication bias was evidenced (Egger = -7.53, $p < 0.01$; Begg= -1.94, $p < 0.01$) (Figure 3). Trim and fill analysis revealed a dropout rate of 20% (95% CI 16.7 to 24.4%; I^2 = 69.2%) with 95 adjusted groups. Comparison between groups did not identify significant differences (X^2 = 1.83; p = 0.4000).

Among the 27 exercise intervention groups, the combined dropout rate was 8.9% (95% CI 5.5 to 14.2%; I^2 = 32.4%). These groups were further categorized into four types: AE, RE, AE+RE, and ERE. Figure 4 displays the results obtained from the subgroup analysis. Comparison between groups did not identify significant differences (X^2 = 2.20; p = 0.5310).

Among the 25 nutrition intervention groups, the combined dropout rate was 11.4% (95% CI 7.2 to 17.4%; I^2 = 55.9%). These groups were further categorized into three types: LCD+N, LCD and other group. The results of the subgroup analysis are presented in Figure 5. Comparison between groups did not identify significant differences (X^2 = 2.79; p = 0.2474).

Among the 17 combined intervention groups, the combined dropout rate was 8.3% (95% CI 4.1 to 15.9%; I^2 = 67.9%). These groups were further categorized into four types: E+LCD, E+R, B and other group. The results of the subgroup analysis are presented in Figure 6. Due to significant heterogeneity in the dropout rates within the E+LCD and B groups, meta-analyses were not feasible for these subgroups. Therefore, we synthesized the data through a narrative review, with the key characteristics and findings of these studies detailed in Table 5.

Meta-regression analysis indicated that the dropout rates in exercise intervention groups were not influenced by factors such as age, females in the studies, type of training, workout duration and frequency. The only training variable that exhibited a significant moderating effect on dropout rates was the length of intervention (β = 0.0041; SE = 0.0019; t = 2.2126; p = 0.0373). Meta-regression analysis revealed that dropout rates of nutrition intervention groups were moderated by the length of intervention (β = 0.0027; SE = 0.0012; t = 2.1675; p = 0.0447), no variables had a moderating effect on the dropout rates of combined intervention studies. The details of all meta-regressions are summarized in Table 6.

Risk of bias

Figure 7 presents an overview of the quality assessment of the papers using the RoB2. Detailed evaluations for each article are provided in Figure 8. Only four studies (7%) conducted concealed allocation for volunteers, while 18 studies (32%) implemented blinding for evaluators. Thirty-nine studies (68%) had losses to follow-up of less than 15%, and only ten (18%) studies reported performing intention-to-treat data analyses. The overall

Table 2. Summary of adherence in exercise interventions

Intervention type	No. of studies (reporting adherence)	Total participants (withdrawals)	Average adherence rate (range)	Average age (years)	Average session duration (min)	Average intervention duration (weeks)
AE	3[55, 57, 76]	72 (9)	89% (81%-97%)	73.2	44	18
RE	8[23, 29, 31, 57-59, 69, 76]	219 (23)	85% (75%-96%)	68.7	55	17
AE+RE	4[32-34, 76]	113 (7)	93% (92%-95%)	64.6	67	20
ERE	4[36, 37, 39, 40]	105 (10)	91.5% (85%-97.6%)	66.8	57	12

AE: Aerobic Exercise; RE: Resistance Exercise; ERE: Eccentric Resistance Exercise.

Table 3. Summary of adherence in nutritional interventions

Intervention type	No. of studies (reporting adherence)	Total participants (Withdrawals)	Adherence range	Withdrawal rate	Representative studies
LCD	6[20, 47, 50, 65, 66, 69]	136 (31)	29%-90%	6.9%-38.1%	Dunn 2024: LCD participants followed a low energy diet (1200–1600 kcal/day) each day using four portion-controlled shakes, two portion-controlled entrees, and at least five total servings of fruits and vegetables. Reported 89% session attendance with a 35% withdrawal rate. Verreijen 2017: Conducted a 10-week intervention involving a high-protein diet and five dietary consultations. Participants' dietary intake was assessed using 3-day food records at baseline, mid-intervention (5 weeks), and post-intervention (10 weeks). High-protein groups consumed 1.13 ± 0.35 g/kg/d, achieving 87% of the 1.3 g/kg/d target, with 29% of subjects meeting the goal.
LCD+N	4[26, 61, 64, 75]	275 (35)	87%-100%	6.1%-25.0%	Kemmler 2017: Conducted a 16-week intervention advising whey protein supplementation to reach a daily protein intake of 1.7–1.8 g/kg. Adherence was assessed by participant self-rating via questionnaire. All participants achieved 100% adherence, with only 2 withdrawals. Silveira 2020: Calculated total energy based on weekly weight loss targets and had participants consume 52 mL of olive oil daily. This regimen achieved 87.4% adherence, with 8 withdrawals (11%).
Nutrition Other	2[21, 67]	44 (4)	66.7%-High*	0-13.3%	Yin 2023: Conducted a 15-week dietary behavior change program based on the HAPA model, which advised a moderately low-calorie diet with adequate protein. The intervention included six face-to-face sessions, weekly calls, and a guidebook. 73.3% of participants attended at least five sessions, 26.7% maintained consistent diet diaries, 66.7% met the protein intake goal, and four participants (13%) withdrew.

*Reported as "high adherence" without specific quantitative values; LCD: Low Caloric Diet; N: Nutraceutical.

Table 4. Summary of adherence in multi-component interventions

Intervention type	No. of studies (reporting adherence)	Total participants (Withdrawals)	Adherence range
E+N	Maltais et al.[23]	16-week intervention with RE and protein shakes. Participants trained three times weekly for 1 hour, followed by a shake.	Adherence exceeded 90%, and there were no withdrawals.
E+N	Demark-Wahnefried et al.[50]	Participants were instructed to combined aerobic exercise (AE) and resistance exercise (RE) with a healthy diet (≤20% fat, rich in fruits, vegetables, and calcium). AE lasted 15-60 min, 3-5 days/week, and RE 2-3 non-consecutive days/week	Only 5 participants achieved ≥90 min/week (rated "excellent"), and 3 of 9 submitted complete food intake data. One participant withdrew (10%)
E+N	Karlsson et al.[72]	12-week intervention with four daily sit-to-stand exercises and two protein-rich supplements	42% showed high adherence, with over half completing >120 times exercises and four-fifths consuming >60 bottles supplements. Eight participants withdrew (13%)
E+N	Demark-Wahnefried et al.[50]	Participants were in the CA+EX (Calcium-rich diet with exercise) and CA+EX+FVLF (Calcium-rich, low-fat, high fruit and vegetable diet with exercise) groups. Aimed for 1200-1500 mg daily calcium and exercised ≥30 min ≥3 times weekly with strength training every other day	Adherence averaged 80% with a 10% total dropout rate. The CA+EX group showed lower adherence. Advanced cancer stage and baseline sedentary behavior were associated with lower completion rates and reduced exercise frequency, while age was negatively correlated with consultation completion and dietary adherence
E+LCD	Verreijenl.[69]	10-week intervention with a low-calorie, high-protein diet (-600kcal, 1.3 g/kg body weight) and resistance exercise 3 times weekly	Average adherence to exercise sessions was 2.8±0.3 sessions/ week. Ten participants withdrew (31%)
Combined other	Kemmler et al.[26]	Used whole-body electromyostimulation (WB-EMS) (1.5 x 20 min, moderate-to-high intensity) combined with protein supplementation (1.7-1.8 g/kg/day)	Achieved a 91% WB-EMS attendance rate, though 2 participants failed to meet protein intake requirements. Three participants withdrew (9%)

E+N: Exercise and Nutraceutical; E+LCD: Exercise and Low-Calorie Diet.

Table 5. Characteristics and dropout rates of combined intervention studies with high heterogeneity

Study (author, year)	Sample size (N)	Participant characteristics (Average age, sex)	Intervention details	Study duration	Dropout rate (%)
E+LCD					
Camajani et al.[68]	12	56.5, Mixed	AE+LCD	6 weeks	0
Farsijani et al.[70]	21	71.29, Mixed	AE+RE+LCD	64 weeks	0
Verreijen et al.[69]	32	61.5, Mixed	RE+LCD	10 weeks	31
Beavers et al.[71]	135	66.1, Mixed	AE+RE+LCD	72 weeks	25
Mason et al.[48]	117	Not Specified, Female only	AE+LCD	64 weeks	8
B					
Farsijani et al.[70]	15	70.53, Mixed	AE+RE+Health education	64 weeks	0
Wilson et al.[24]	11	74, Male only	Self-management home plan+150 min/week exercise	12 weeks	0
Jancey et al.[73]	201	60.5, Mixed	Family-based physical activity+nutrition program	24 weeks	35
Park et al.[25]	86	66.3, Male only	Smartphone app (personalized exercise+dietary consultation)	12 weeks	13

AE, Aerobic Exercise; RE, Resistance Exercise; LCD, Low Caloric Diet; B:Behavioral

Table 6. Meta-regression of dropout moderators in sarcopenic obesity patients

Moderator	*β*	95% CI		*p*
Exercise intervention group				
Age	0.0007	-0.0057	0.0071	0.8278
% Female	0.0025	-0.0013	0.0063	0.1911
Length of intervention	0.0041	0.0003	0.0079	0.0373*
Frequency (times per week)	-0.0331	-0.0890	0.0227	0.2314
Workout duration(minutes)	0.0026	-0.0017	0.0069	0.2165
Type of exercise				
Nutrition intervention group				
Age	0.0024	-0.0023	0.0071	0.3017
% Female	0.0042	-0.0011	0.0094	0.1106
Length of intervention	0.0027	0.0001	0.0053	0.0447*
Type				
Combined intervention groups				
Age	-0.0025	-0.0096	0.0046	0.4468
% Female	-0.0092	-0.2533	0.2349	0.9351
Length of intervention	-0.0001	-0.0042	0.0040	0.9563
Type				

* Significance at $p<0.05$. ** Significance at $p<0.01$

RoB2 judgments categorized 93.0% (53) of studies as "high risk", 3.5% (2) as having "some concerns", and 3.5% (2) as "low risk" of bias. The majority of studies were judged as "high risk" in the domain of "performance bias" (blinding of participants and personnel).

DISCUSSION

Key findings: intervention feasibility and evidence limitations

This systematic review investigated adherence and dropout rates in nutrition and exercise interventions for patients with SO. A critical finding is the prevalent inadequacy in measuring and reporting adherence, with only 26 studies (45.6%) providing relevant data. This reporting gap itself constitutes a major obstacle to understanding intervention feasibility and likely leads to an overestimation of adherence. Despite this limitation, the available data from RCTs indicate that under highly supervised conditions, participants can demonstrate high overall adherence (among studies reporting adherence, 86.5% showed rates greater than 80%) and a pooled dropout rate of 9%. This pattern may be attributed to potential selection bias in RCTs, which tend to recruit participants predisposed to higher adherence,[78] and suggests that interventions are feasible for a segment of the SO population who benefit from positive outcomes.

However, this encouraging picture must be critically evaluated in light of significant publication bias (Egger's test: $p < 0.01$). The trim-and-fill adjustment, which accounts for potentially missing studies, estimated a substantially higher pooled dropout rate of 20% (95% CI 16.7 to 24.4%). This indicates that the true retention challenges in SO interventions are likely more pronounced than the initial analysis suggests, and the feasibility observed in published RCTs may represent a "best-case scenario".

Adherence and dropout: Influencing factors and evidence assessment

Adherence

As over half of the studies did not report adherence data, the capacity for in-depth statistical analysis was severely limited. Based on the currently available limited data, we were unable to clarify the quantitative impact of specific factors like intervention type or duration on adherence through regression analysis. Therefore, the following findings primarily stem from comparisons of descriptive statistics.

Exercise interventions

In exercise interventions, the ERE group had the highest adherence rate (91.5%), while the RE group had the lowest (85%). This may be due to the fact that the patients in this study were mainly elderly, and ERE is simpler, easier to perform,[79] and less strenuous on joints and muscles,[80] making it more suitable for elderly SO patients with varying physical conditions. In contrast, traditional resistance training poses a higher risk of injuries and requires greater physical exertion, which may be challenging for frail SO patients. Thus, ERE is likely more effective in improving exercise adherence, particularly in the elderly population.

Interpretation from a behavioral science perspective: This finding highlights the fundamental role of physical capability in behavior change. The characteristics of ERE—low load and low injury risk—better align with the declining physiological function of elderly SO patients, addressing the physical capability barriers to implementing the intervention.

Nutritional interventions

In nutritional interventions, the low-calorie diet with nutraceutical group had a higher adherence rate (92.1%) than the low-calorie diet group (77%). This may be due to increased dietary diversity and appeal, leading to greater patient satisfaction (as evidenced by a lower dropout rate in the LCD+N group compared to the LCD group), thereby enhancing adherence.

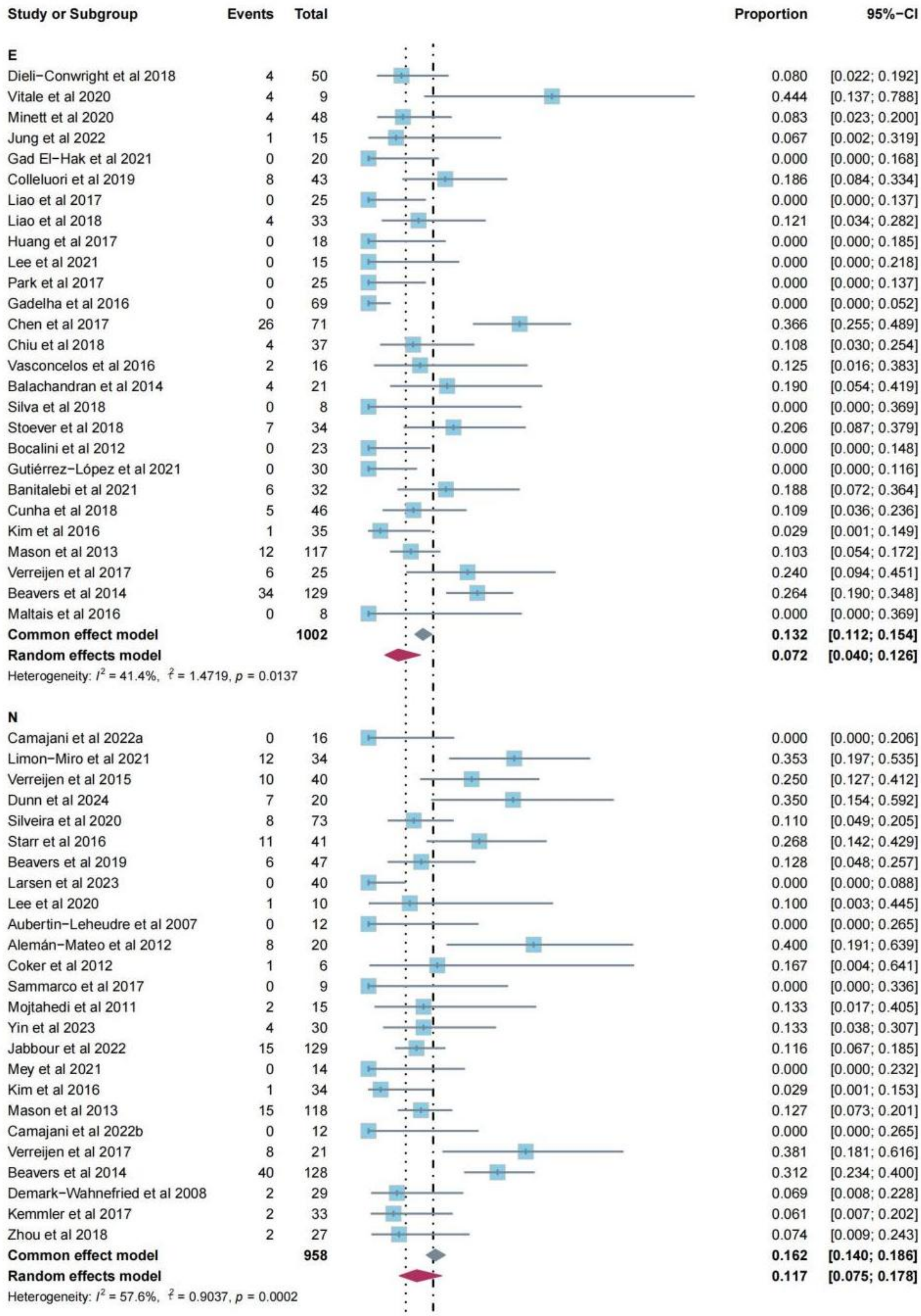

Figure 2. Meta-analysis of dropout rates for the 68 groups. E:Exercise; N:Nutrition; C:Combined

Interpretation from a behavioral science perspective: From the perspective of motivation and psychological capability, a strict LCD not only causes physiological discomfort but also continuously depletes patients' psychological resources for self-regulation and undermines their reflective motivation to persist. In contrast, LCD+N, by improving dietary variety and palatability, reduces the executive burden while enhancing the positive experience, thereby better sustaining patient engagement motivation.

Role of adherence measurement and supervision

In the combined interventions data, exercise interventions showed higher adherence and reporting rates than nutritional interventions. This is likely because exercise adherence is easier to quantify, making it more accessible

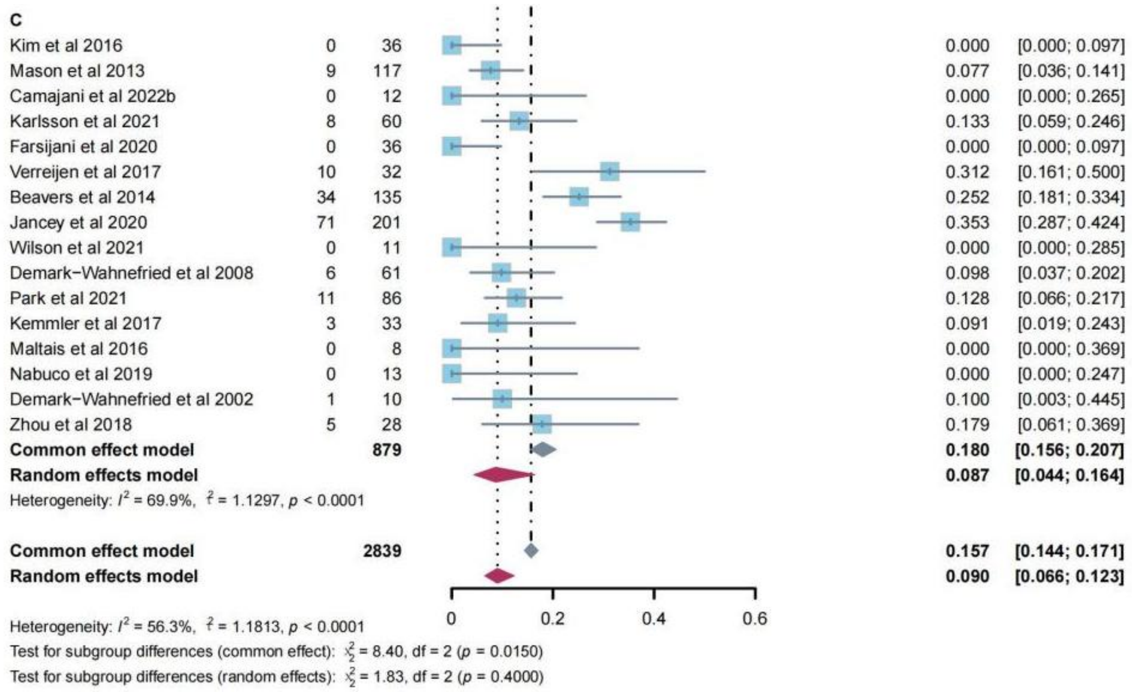

Figure 2. (cont.) Meta-analysis of dropout rates for the 68 groups. E:Exercise; N:Nutrition; C:Combined

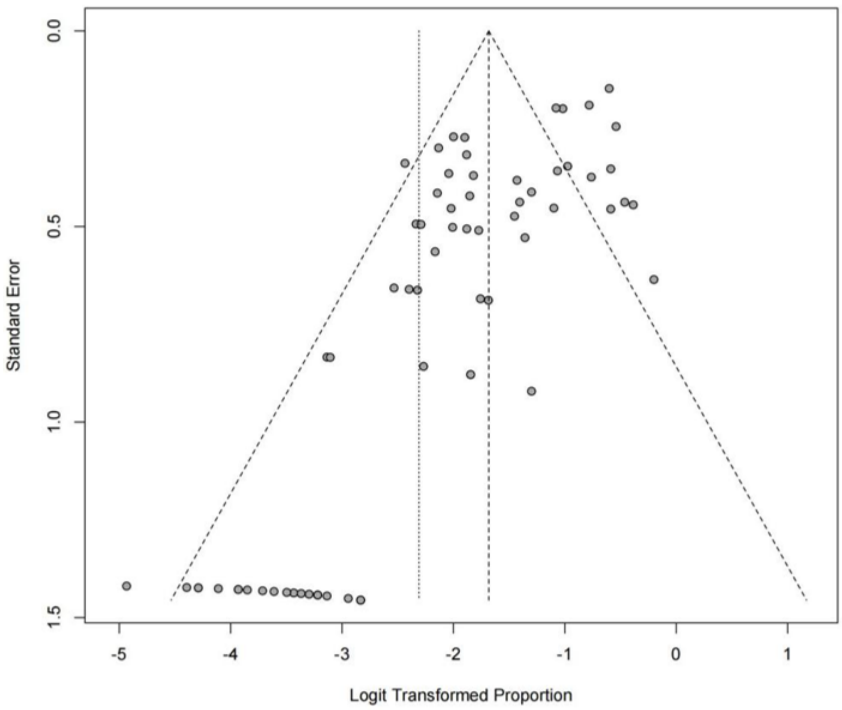

Figure 3. Funnel chart of the combined analysis

for researchers to report. This finding is consistent with the higher adherence reporting rates observed in the exercise intervention group compared to the nutritional intervention and combined interventions groups. Exercise interventions, typically conducted 3-4 times weekly, may also have higher adherence due to their lower frequency compared to daily nutritional adjustments.[19] Additionally, interventions relying on patient self-monitoring (e.g., exercise or diet logs) had lower adherence than professionally supervised interventions (e.g., classes or therapy). This suggests SO patients may lack sufficient self-management skills and rely more on professional guidance, highlighting the need to strengthen their awareness of active health behaviors in disease prevention and management.

Interpretation from a behavioral science perspective: This clearly demonstrates the influence of social opportunity on behavior maintenance. Professional supervision not only provides technical guidance but also creates a social environment of accountability and support, which compensates for the potential widespread deficit in self-management skills among SO patients.

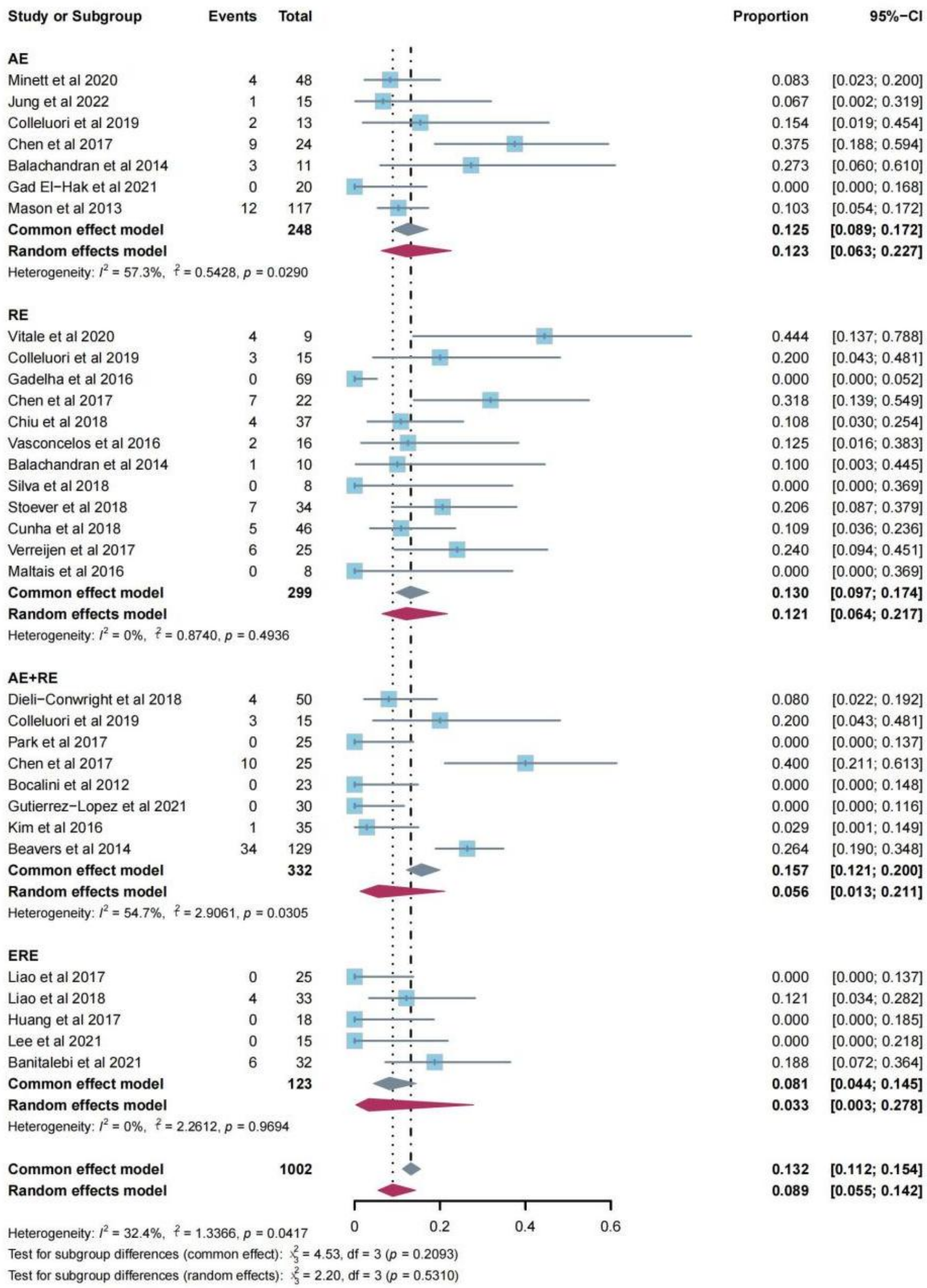

Figure 4. Meta-analysis of dropout rates for the 27 exercise intervention groups. AE: Aerobic Exercise; RE: Resistance Exercise; ERE: elastic resistance exercise

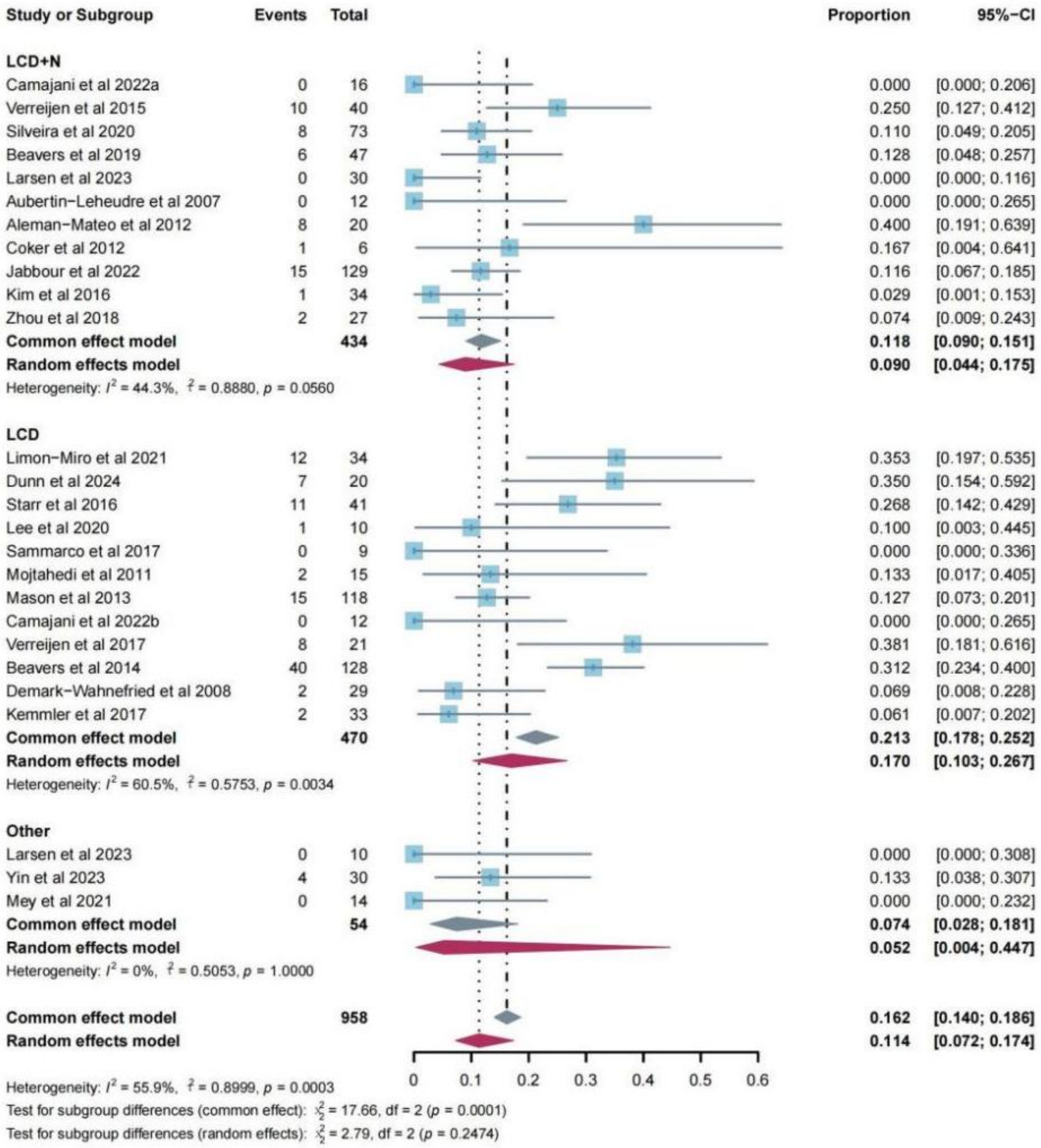

Figure 5. Meta-analysis of dropout rates for the 25 nutrition intervention groups. LCD: Low Caloric Diet; N: Nutraceutical.

Dropout rates

Nutritional interventions

The nutrition intervention group had the highest overall dropout rate (11.4%), consistent with its poor adherence. This may be due to the significant dietary adjustments required, including changes in food types, portions, and cooking methods, which are challenging to maintain long-term and are influenced by factors like family and cultural backgrounds. The LCD group had the highest dropout rate (17%), likely due to strict requirements causing physiological (e.g., hunger, reduced metabolic rate) and psychological (e.g., anxiety, depression) issues.[81] In contrast, the LCD+N group had a lower dropout rate (9%), may be because nutraceutical supplementation improved dietary diversity and reduced adverse effects, enhancing adherence.

Interpretation from a behavioral science perspective: The high dropout rate in the LCD group represents the combined impairment of multiple factors: physical capability (physiological discomfort), psychological capability (burden of dietary restraint), and motivation (diminished perceived benefits). The LCD+N strategy, by fine-tuning the regimen, helps to preserve these elements to some extent, thereby improving tolerability.

Exercise interventions

In the exercise intervention studies, the dropout rate was lowest in the ERE group (3.3%), which is consistent with the results of the compliance analysis. The dropout rate in the AE+RE group trended lower than in single-exercise groups, although this difference was not statistically significant (p = 0.5310). This pattern suggests that combined exercise may be more sustainable for SO patients, a possibility that warrants further investigation.[16, 82]

Interpretation from a behavioral science perspective: The low dropout rate in the ERE group further confirms

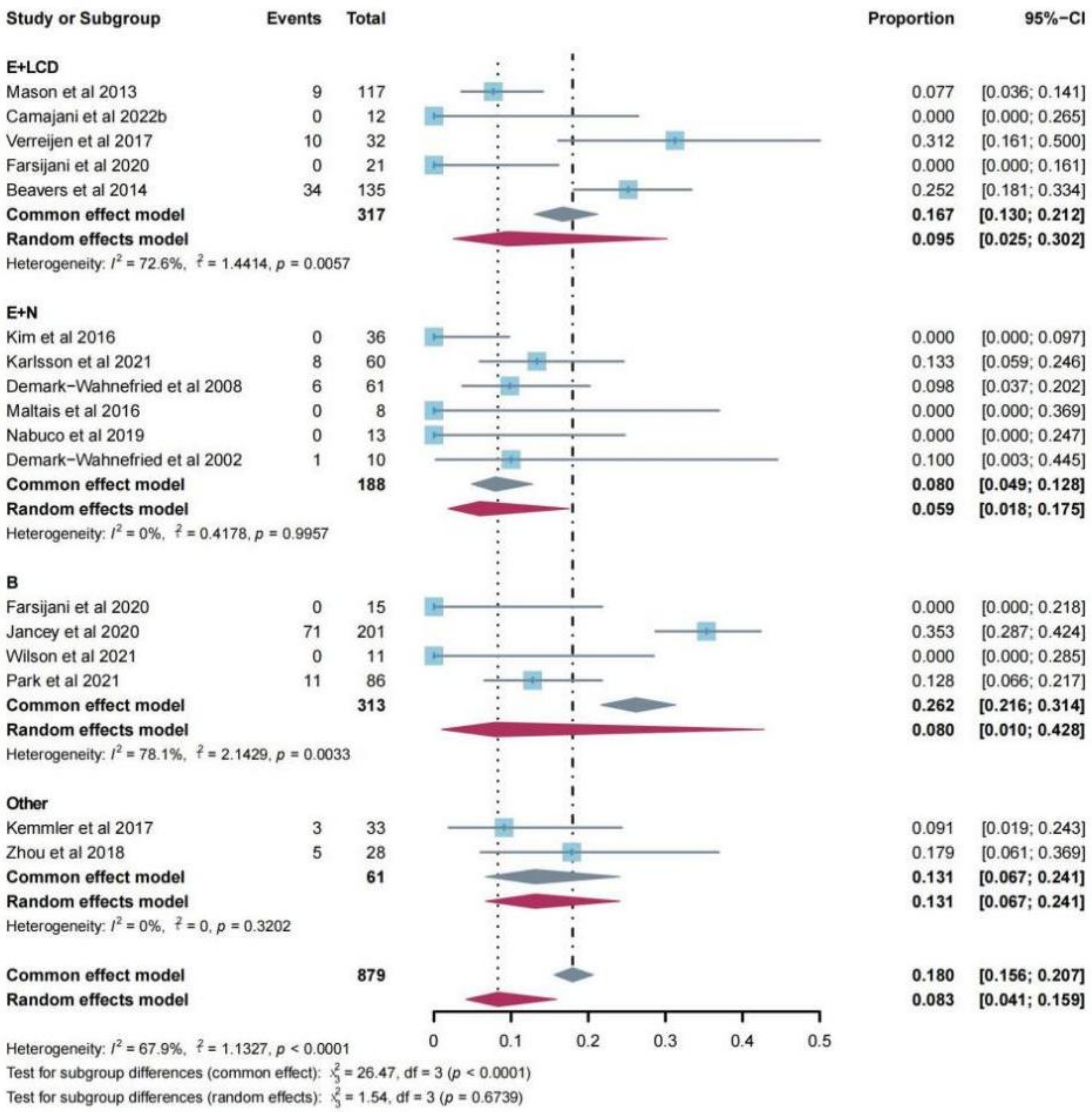

Figure 6. Meta-analysis of dropout rates for the 17 combined intervention groups. E: Exercise; LCD: Low Caloric Diet; N: Nutraceutical; B: Behavioral

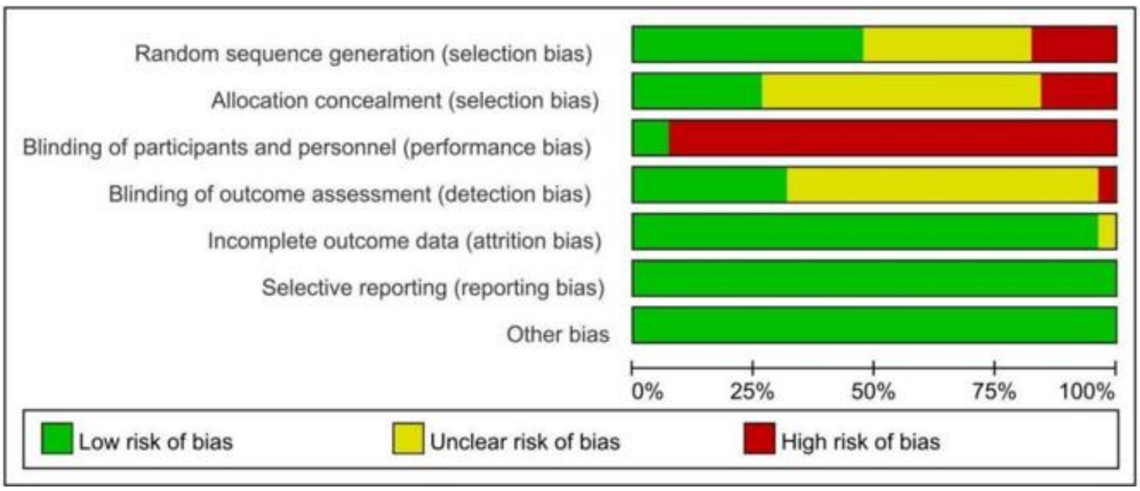

Figure 7. Risk of bias of included studies

Figure 8. Risk of bias summary of included studies

that when an intervention aligns with the patient's physical capability, the risk of dropout decreases significantly.

Combined interventions

In combined interventions, studies with larger participant numbers had higher dropout rates, likely due to reduced communication and supervision. Among smaller studies

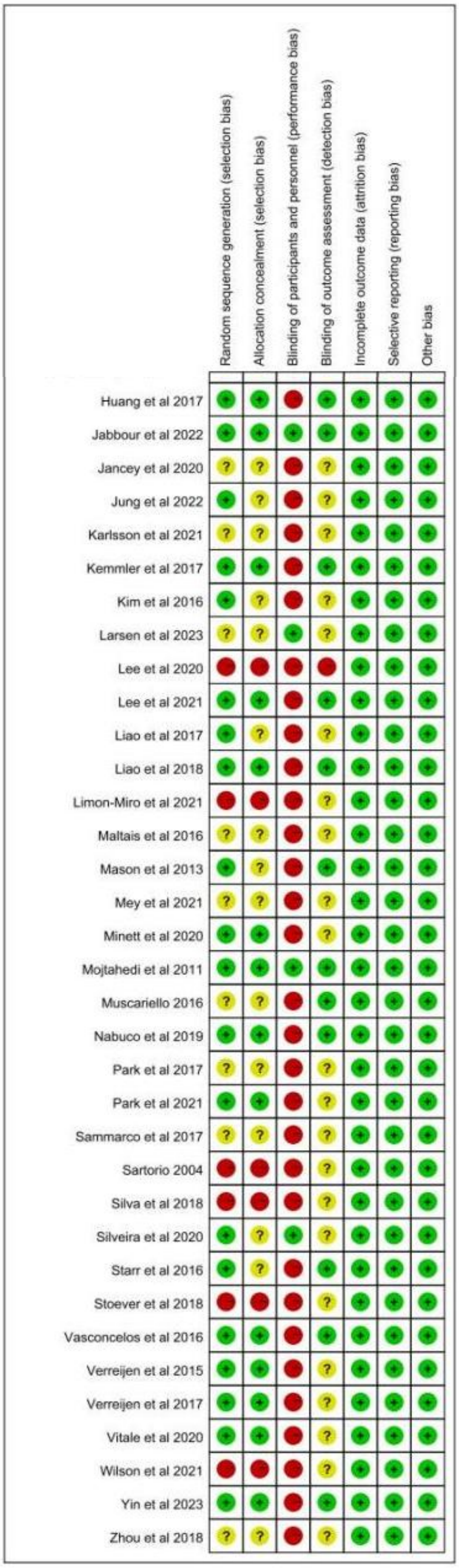

Figure 8. Risk of bias summary of included studies

(<200 participants), RE+LCD had the highest dropout rate (31%), aligning with the high dropout rates observed in standalone RE and LCD interventions.

Interpretation from a Behavioral Science Perspective: This again points to a reduction in social opportunity. As group size increases, the share of guidance, attention, and social support available per individual is diluted, weakening the crucial external environment needed to sustain participation.

Meta-analysis

This study's meta-analysis found that longer intervention durations in both dietary and exercise interventions are associated with higher dropout rates. This finding is consistent with the research by Collado-Mateo et al.[19], who investigated patients with chronic diseases and elderly individuals. Possible reasons include that prolonged dietary control and exercise plans may be constrained by multiple factors such as patients' physical conditions, schedules, interests, and family responsibilities, requiring a high degree of self-discipline, which can be highly challenging for patients. Therefore, as the intervention duration extends, patients are more likely to withdraw from the intervention. However, most studies provided non-specific reasons for withdrawal (e.g., personal/family reasons), lacking detailed information to support these findings. Consequently, we recommend researchers provide more specific withdrawal reasons to identify potential influencing factors, helping improve adherence and reduce dropout rates among SO patients.

Preliminary evidence for behavioral interventions and the integrative value of theory

Little is known about adherence to behavioral interventions in the literature. In this review, only one RCT on dietary intervention reported a behavioral intervention adherence rate below 70%.[21] However, compared to an RCT using only a low-calorie, high-protein diet (29% protein intake compliance, 38% dropout rate),[69] behavioral interventions improved adherence (66.7% protein intake compliance, 13% dropout rate). This suggests behavioral interventions may enhance adherence and reduce dropout rates in SO patients, though more studies are needed to confirm their effectiveness.

Although dedicated research on behavioral interventions is limited, the COM-B model provides a unified theoretical lens through which to understand all the aforementioned findings on adherence and dropout rates. It systematically consolidates fragmented observations into an examination of Capability, Opportunity, and Motivation. Therefore, utilizing this framework to guide the design and evaluation of future research will contribute to the development of more persistently effective intervention strategies.

Limitations and future directions: enhancing the equity and practical value of adherence research

This review adhered to PRISMA guidelines and offers preliminary insights for optimizing SO interventions; however, the available evidence exhibits important limitations. The included studies employed heterogeneous diagnostic criteria for sarcopenic obesity. This lack of a unified definition has resulted in enrolled populations with varying severity, which limits the direct comparability of studies and compromises the generalizability of our findings. Although quantitative testing was not feasible with the available data, it is plausible that adherence and dropout rates differ systematically between populations defined by stricter versus broader diagnostic criteria.

Furthermore, the methodological quality of the evidence is constrained by the inherent risk of bias in behavioral trials. As per the RoB2 assessment, a high proportion of studies were at overall "high risk", primarily because blinding of participants and personnel is not feasible in exercise and nutrition interventions. While this specific limitation may have a lesser impact on the objective outcomes of adherence and dropout reported here, it still warrants consideration. Additionally, from a meta-analytic perspective, some studies contributed multiple intervention arms that were treated as independent. This approach was taken to preserve the unique clinical characteristics of each distinct intervention, but it introduces a potential for non-independence that should be acknowledged.

A more critical issue is the suboptimal reporting of adherence and dropout data. The variability in how adherence was defined and measured across studies, coupled with the fact that most studies provided only vague reasons for withdrawal (e.g., "personal reasons"), failing to document specific barriers. This obscures the practical challenges patients face and may introduce reporting bias, as studies with high adherence are more likely to be published. These reporting gaps also preclude meaningful equity analysis. Crucial questions about which subgroups (e.g., by socioeconomic status) are more likely to drop out remain unanswered, undermining the equity of the findings.

To address these issues, future research should prioritize the adoption of standardized SO definitions to ensure population homogeneity. Building on this foundation, studies must mandate the detailed reporting of adherence metrics and specific, categorized dropout reasons. Developing more consistent approaches to measuring adherence would further enhance the comparability of future evidence. Furthermore, integrating behavioral science frameworks (e.g., COM-B) into intervention design and evaluation is essential for understanding the determinants of adherence. Finally, a concerted effort must be made to prospectively collect equity-related data across socioeconomic, educational, and cultural dimensions to identify high-risk subgroups and inform the development of more inclusive and accessible intervention strategies.

Conclusion

In existing dietary and exercise RCTs for sarcopenic obesity patients, only 45.6% reported adherence and dropout data during the intervention period, with just 3 studies (5.3%) presenting granular adherence data in tables, such as a breakdown of participant counts by adherence level or quantitative completion rates for specific intervention components. Intervention duration significantly influences dropout rates. Elastic resistance exercise, low-calorie diets with nutraceuticals, and professionally supervised interventions may yield better outcomes for sarcopenic obesity patients. To reduce publication bias and identify factors affecting intervention effectiveness, adherence data should be consistently reported. Future efforts should establish standardized reporting guidelines for adherence data and encourage researchers to include such data in their studies. Therefore, future research should establish standardized adherence reporting guidelines and validate these adherence-promoting strategies across diverse clinical settings, thereby equipping clinicians with actionable evidence to improve long-term health outcomes in this patient population.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURES
The authors declare no conflict of interest.

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