

Journal Pre-proof



Critical appraisal of Definitions and diagnostic criteria for sarcopenic obesity based on A SYSTEMATIC REVIEW

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1 **CRITICAL APPRAISAL OF DEFINITIONS AND DIAGNOSTIC CRITERIA FOR SARCOPENIC OBESITY BASED ON A**
2 **SYSTEMATIC REVIEW**

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4

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37 **KEYWORDS:** obesity, sarcopenia, sarcopenic obesity

38

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46 **ABSTRACT**

47 BACKGROUND. Sarcopenic obesity is a clinical and functional condition characterized by the coexistence of
48 excess fat mass and sarcopenia. Currently, different definitions of sarcopenic obesity exist and its diagnostic
49 criteria and cut-offs are not universally established. Therefore, the prevalence and sensitivity of this
50 condition for any disease risk prediction is affected significantly.

51 AIM. This work was conducted under the auspices of the European Society for Clinical Nutrition and
52 Metabolism (ESPEN) and the European Association for the Study of Obesity (EASO). An international expert
53 panel performed a systematic review as an initial step to analyze and summarize the available scientific
54 literature on the definitions and the diagnostic criteria for sarcopenic obesity proposed and /or applied in
55 human studies to date.

56 METHODS. The present systematic review was performed according to the Preferred Reporting Items for
57 Systematic Reviews and Meta-Analyses (PRISMA) statement. The search was conducted in April 2018 in
58 three databases (PubMed, Scopus, Web of Science). Human studies conducted in both sexes, irrespective
59 of ethnicity, and published from 2007 to 2018 were included; cohorts of individuals with obesity and acute
60 or chronic conditions and treatments reported to negatively influence skeletal muscle mass and function
61 independently of obesity were excluded from final analyses. The quality of the studies was evaluated using
62 the Newcastle-Ottawa Scale (NOS) adapted for cross sectional studies.

63 RESULTS. The electronic search retrieved 2335 papers of which 75 met the eligibility criteria. A marked
64 heterogeneity in definitions and approaches to diagnose sarcopenic obesity was observed. This was mainly
65 due to differences in the definitions of obesity and sarcopenia, in the methodologies used to assess body
66 composition and physical function, and in the reference values for the variables that have been used
67 (different cut-offs, interquartile analysis, diverse statistical stratification methods). This variability may be
68 attributable, at least in part, to the availability of the methodologies in the different settings, to the
69 variability in specialties and backgrounds of the researcher, and to the different settings (general
70 population, clinical settings, etc.) where studies were performed.

71 CONCLUSION. The results of the current work support the need for consensus proposals on: 1) definition of
72 sarcopenic obesity; 2) diagnostic criteria both at the level of potential gold-standards and acceptable
73 surrogates with wide clinical applicability, and with related cut-off values; 3) methodologies to be used in
74 actions 1 and 2. First steps should be aimed at reaching consensus on plausible proposals that would need
75 subsequent validation based on homogeneous studies and databases, possibly based on analyses of
76 existing cohorts, to help define the prevalence of the condition, its clinical and functional relevance as well
77 as most effective prevention and treatment strategies.

78

79 **LIST OF ABBREVIATIONS**

- 80 AFFM: appendicular fat-free mass
- 81 ASM: appendicular skeletal muscle
- 82 BIA: bioelectrical impedance analysis
- 83 BMI: body mass index
- 84 CT: computed tomography scan
- 85 DXA: dual-energy X-ray absorptiometry
- 86 EASO: European Association for the Study of Obesity
- 87 ESPEN: European Society for Clinical Nutrition and Metabolism
- 88 EWGSOP: European Working Group on Sarcopenia in Older People
- 89 FFM: fat-free mass
- 90 FM: fat mass
- 91 HGS: handgrip strength
- 92 MAMC: mid-arm muscle circumference
- 93 NOS: Newcastle-Ottawa Scale
- 94 PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
- 95 WC: waist circumference
- 96 WT: WEIGHT
- 97

98 **BACKGROUND**

99 Sarcopenic obesity is a clinical and functional condition characterized by the coexistence of excess fat mass
100 (FM) and sarcopenia. The latter literally refers to reduced skeletal muscle mass or myopenia, while muscle
101 dysfunction with low muscle strength (dynapenia) and performance were also part of the concept when
102 the term sarcopenia was introduced [1] and have been notably included in accepted consensus initiatives
103 to define the condition in the geriatric community [2, 3]. Sarcopenic obesity tends to be more common in
104 older subjects but it can also be found in younger obese patients with disability, during acute (ICU) or
105 chronic disease [chronic kidney disease, chronic obstructive pulmonary disease, congestive
106 heart failure, cancer, after bariatric surgery (particularly in the absence of nutritional supervision)],
107 or submitted to long-lasting incongruous dietary regimens and weight cycling. It is also likely that
108 this condition may be present across the age spectrum in non-clinical scenarios [5, 6]. Indeed, the
109 aetiology of sarcopenia is multi-factorial, and obesity *per se* may represent an additional
110 independent determinant for development of muscle loss and dysfunction due to the negative
111 impact of obesity-related metabolic derangements, such as systemic and skeletal muscle oxidative
112 stress, inflammation and insulin resistance [7]; higher prevalence in the obese population of
113 chronic non-communicable diseases with nutritional and metabolic muscle-catabolic impact;
114 sedentary lifestyle which is exacerbated by comorbidities. On the other hand, sarcopenia may
115 facilitate fat accumulation, meaning that it may be difficult to establish whether a subject with
116 obesity has sarcopenia as primary or secondary condition.

117 From the clinical standpoint, sarcopenic obesity potentially leads to the cumulative risk derived from
118 the two individual body composition phenotypes [8-11]. Strong evidence demonstrated worse
119 outcomes for individuals with obesity, under many different heterogeneous clinical conditions,
120 ranging from cancer to chronic organ failures [12]. In the field of obesity, an emerging awareness
121 of the importance of physical function to patient risk stratification has translated into composite
122 tools including comorbidities and disabilities, that may ultimately reflect the presence of muscle
123 dysfunction (e.g. Edmonton Obesity Staging System) [13]. In the clinical nutrition community,
124 simple clinical malnutrition diagnostic criteria have been launched recently in a global consensus
125 document, which allows for a malnutrition diagnosis when low skeletal muscle mass is present,
126 irrespective of body mass index (BMI), when additional non-anthropometric pathophysiological
127 criteria are fulfilled [14]. Although it is outside the context of this work, some evidence suggests
128 that overweight-obesity may be protective in chronically ill and older individuals. A clear definition
129 of sarcopenic obesity and, in particular, an understanding of the role that the different

130 components of body composition have on functional parameters, comorbidity and mortality can
131 clarify the extent and importance of the so-called obesity paradox.

132 Different definitions of sarcopenic obesity have been used in research and its diagnostic criteria and
133 cut-offs are not established. Hence, the published prevalence of this condition ranges from 2.75%
134 to over 20%, depending on the applied diagnostic criteria and the methods of body composition
135 assessment [15, 16]. Moreover, the lack of a universally accepted definition, diagnostic criteria
136 and cut-offs significantly affect the sensitivity of any disease risk prediction work for sarcopenic
137 obesity. Conflicting data also exist regarding the link between low skeletal muscle mass and
138 functional impairment since skeletal muscle mass and strength or performance are not
139 consistently related [17, 18], and its relationship may differ between primary and secondary
140 sarcopenia. However, as an association between obesity *per se* and poor physical performance has
141 been demonstrated, long-term consequences of reduced skeletal muscle mass on physical
142 performance are potentially more severe in individuals with obesity than in subjects without
143 obesity with the same amount of skeletal muscle [19-21]. In obesity, an imbalance between
144 fat-free mass (FFM), excess FM, and total body size may indeed appear earlier than the onset of old
145 age [15, 22], leading to relatively low FFM even when skeletal muscle mass is preserved [6]. In addition, as
146 mentioned above, low skeletal muscle function related to sarcopenic obesity may not only result from an
147 imbalance between FM and skeletal muscle, but it may also be the consequence of impaired skeletal
148 muscle metabolic capacities together with biological effects of excess fat on contractile skills [21, 23-25].

150 **Aim**

151 In recent years, the European Society for Clinical Nutrition and Metabolism (ESPEN) and the European
152 Association for the Study of Obesity (EASO) have issued joint statements calling for further collaborative
153 efforts aimed at overcoming existing hurdles towards clinical applicability of the sarcopenic obesity
154 concept [26, 27]. Under the extended auspices of ESPEN and EASO, the current initiative involved an
155 international expert panel who performed a systematic review as an initial step to analyze and summarize
156 the available scientific literature about the definitions and the diagnostic criteria for sarcopenic obesity
157 proposed and /or applied so far in human studies. For the mainly methodological purpose of the current
158 work, we focused our search on studies primarily involving obese individuals in the absence of acute or
159 chronic conditions or treatments with potential independent negative impact on skeletal muscle
160 metabolism and mass (such as surgery, cancer, kidney disease).

162 **MATERIALS AND METHODS**

163 The present systematic review was registered in the PROSPERO database
164 (<https://www.crd.york.ac.uk/PROSPERO/>) (registration number: CRD42019133328) and performed
165 applying the following steps according to the PRISMA procedure (28).

166 Literature Search

167 A pool of international experts was initially created, consisting of delegates from the European Association
168 for the Study of Obesity (EASO) and the European Society for Clinical Nutrition and Metabolism (ESPEN)
169 with expertise in body composition, sarcopenia and obesity. Three members of the Expert Group (LMD, LB
170 and RB) coordinated the activities undertaken within the group to conduct the systematic review. The
171 search was conducted in April 2018 in three databases: PubMed, Scopus and Web of Science. Additional
172 articles of potential relevance were also manually searched. The search was conducted based on
173 pre-defined key words including "sarcopenia", "obesity", "sarcopenic obesity", "sarcopenic adiposity",
174 "lipotoxic sarcopenia". Boolean operators (AND, OR), to establish logical associations between the different
175 terms and the search used in the systematic review was: [keywords and MeSH (medical subject heading)
176 terms] were combined as: ("sarcopenia"[MeSH Terms] OR "sarcopenia"[All Fields]) AND ("obesity"[MeSH
177 Terms] OR "obesity"[All Fields]) OR (sarcopenic[All Fields] AND ("obesity"[MeSH Terms] OR "obesity"[All
178 Fields])) OR (Sarcopenic[All Fields] AND ("adiposity"[MeSH Terms] OR "adiposity"[All Fields])) OR
179 (Lipotoxic[All Fields] AND ("sarcopenia"[MeSH Terms] OR "sarcopenia"[All Fields])) OR (Osteosarcopenic[All
180 Fields] AND ("obesity"[MeSH Terms] OR "obesity"[All Fields])) AND ("2008/04/08"[PDat] :
181 "2018/04/05"[PDat] AND "humans"[MeSH Terms] AND ("adult"[MeSH Terms] OR "adult"[MeSH
182 Terms:noexp] OR "aged"[MeSH Terms])). The searches from the three independent databases were
183 combined and duplicates were removed to create a master file used for titles and abstracts screening. In
184 addition, no language restrictions were applied in searching the databases.

185 Study Selection

186 Human studies conducted in male and female adult populations, irrespective of ethnicity, and published in
187 from 2007 to 2018 were included in the systematic review. Publications in all languages were included. The
188 selection of the studies was performed in a three-step selection process involving the evaluation of 1) titles,
189 2) abstracts and 3) full texts. Two investigators independently screened for eligibility at each step. If
190 consensus was reached, articles were either excluded or moved to the next stage. In case of a discrepancy
191 between investigators, a third investigator from the coordinating team resolved each case by discussion
192 with the reviewers until a consensus was reached.

193 Main reasons for exclusion of articles from the systematic review were: 1) undefined classification of
194 sarcopenic obesity; 2) papers not reporting original research data, such as narrative reviews or
195 commentaries, 3) duplicate analyses conducted on the same samples (first published paper was included),
196 4) inadequate description of methods used to assess body composition or define sarcopenic obesity cases
197 and 5) clinical studies including patient groups with diagnosis of chronic and acute diseases or undergoing

198 treatments that could per se cause catabolic changes in protein turnover with independent negative impact
199 on skeletal muscle mass and/or function [such as cancer, hemodialysis, surgery].

200

201 Data extraction and quality assessment

202 The following information was extracted from the eligible articles: author, year of publication, study type,
203 sample size, participants' characteristics (nationality, age, sex), sarcopenic obesity definition, diagnostic
204 criteria (methods, parameters and cut-off points) used to define sarcopenic obesity, and the aim(s) of the
205 study. In addition, the quality of the studies was evaluated using the Newcastle-Ottawa Scale (NOS)
206 adapted for cross sectional studies [29]. The NOS assesses the quality of the studies in three key areas: 1)
207 selection of the study group in terms of clinical examination (score 0-5 stars); 2) comparability of the groups
208 such as the use of matching or multivariate techniques (score 0-2 stars); 3) ascertainment of outcome such
209 as the use of standardised or validated measures (score 0-3 stars).

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212 **RESULTS**213 Search results

214 The study selection process is presented in Figure 1. The electronic search retrieved 2335 references. After
215 removing duplicate references, a total of 2134 titles and abstracts were screened for eligibility. 160
216 references were selected for full text evaluation and 75 articles [5, 12, 24, 30-101] were included in the
217 systematic review. A quantitative synthesis (meta-analysis) was not performed since the data did not allow
218 conduct of a formal meta-analysis due to the heterogeneity in the definitions of sarcopenic obesity,
219 application of diagnostic cut offs and use of different body composition methods.

220 Study characteristics

221 The main characteristics of the 75 articles selected in the systematic review are summarized in Tables 1 and
222 2. All were published between 2007 and 2018 and the total number of participants included in this
223 systematic review was 217,973, with a sample size ranging from 17 to 15,132 participants. We observed a
224 greater inclusion of women (54.3%) and the mean age of the participants was 64.8±4.5 years (range:
225 20-92). Studies were conducted in different continents including Asia [Japan, China, Korea, Thailand and
226 Taiwan (1 study) [71], Japan (3 studies) [55, 58, 63], Korea (22 studies) [24, 32, 34, 35, 46, 47, 54, 59-62,
227 64-67, 70, 72, 79, 80, 83, 88, 96], Taiwan (4 studies) [44, 69, 73, 75]], Oceania [Australia (4 studies) [53,
228 92-94]]; North and South America [Brazil (7 studies) [49, 50, 76, 81, 89, 90, 99]; United States (11 studies)
229 [5, 36-40, 68, 86, 95, 97, 100]; Canada (1 study)[42]] and Europe [France (1 study) [12], Germany (1 study)
230 [57], United Kingdom (3 studies) [30, 33, 52], Italy (9 studies) [43, 48, 74, 78, 82, 85, 87, 91, 98], Spain (3
231 studies) [31, 77, 84], Italy and Slovenia (1 study) [41], Turkey (1 study) [51]]. Three studies were conducted
232 simultaneously in different continents: [Finland, Poland, Spain, China, Ghana, India, Mexico, Russia and
233 South Africa (1 study) [101]; United Kingdom and Korea (1 study) [45]; United Kingdom, United States and
234 Canada (1 study) [56]].

235 Study design were predominantly cross-sectional (64 studies, one of which was nested in a retrospective
236 cohort [57]) followed by prospective cohort studies (6 studies) [33, 40, 43, 52, 92, 93] and randomized
237 clinical trials (5 studies) [36, 44, 58, 69, 78]. The aims of the studies were different and a summary of key
238 areas of investigation of these studies is summarized in Figure 2. Briefly, 9 studies explored the role of
239 biological and lifestyle factors in the pathogenesis of sarcopenic obesity [vitamin D levels (3 studies) [62, 79,
240 96], inflammation (1 study) [91], cardiorespiratory fitness (1 study) [60], leptin (1 study) [63] or physical
241 activity (3 studies) [54, 84, 88]]. A large proportion of studies evaluated the association of sarcopenic
242 obesity with risk of comorbidities [inflammation (5 studies) [39, 71, 82, 85, 91], metabolic syndrome (6
243 studies) [47, 65, 70, 72, 73, 85], altered lipid (2 studies) [34, 90] or glucose metabolism (5 studies) [47, 54,
244 64, 86, 100], non-alcoholic fatty liver disease (1 study) [67], cardiovascular diseases and function (7
245 studies) [33, 35, 47, 50, 59, 60, 83], chronic kidney diseases (1 study) [97], multimorbidity (1 study) [32]],
246 impaired physical function [physical activity level/function (9 studies) [12, 30, 42, 54, 68, 75, 76, 79, 89],

247 disability or impaired exercise capacity (3 studies) [56, 87, 101], balance (1 study) [94], risk (1 study) [93] or
248 fear (1 study) [31] of falling], musculoskeletal disorders [bone health (1 study) [94], fractures (1 study) [92],
249 osteoarthritis (1 study) [66], osteoporosis (2 studies) [46, 92]], mental health [depression (1 study) [55] and
250 psychological health (1 study) [45]], low quality of life (3 studies) [40, 45, 99], hospitalization (1 study) [87]
251 and risk of mortality (4 studies) [33, 38, 52, 75]. Finally, 6 studies tested clinical interventions in sarcopenic
252 obesity populations including exercise training to improve physical function (3 studies) [36, 44, 69], effects
253 of exercise and nutrition on recovery from sarcopenic obesity (2 studies) [58, 80] and protein intake for the
254 prevention of lean-mass loss in older individuals (1 study) [78].

255 Definitions of sarcopenic obesity

256 The definition of sarcopenic obesity in the majority of the studies (66 studies) was based on the
257 co-existence of obesity and sarcopenia (used as a synonymous of low or reduced skeletal muscle mass),
258 which were regarded as two distinct categories (Table 2). Less frequently (only 3 studies [50, 81, 99])
259 sarcopenic obesity was defined by calculating the population distribution of the residuals of linear
260 regression models applied to predict appendicular fat-free mass (AFFM) using independent variables such
261 as height (in meters) and fat-mass (FM) (in kg). Two studies used the FM to FFM or the visceral adipose
262 tissue area to thigh muscle area ratios to identify cases of sarcopenic obesity [41, 70].

263

264 Different studies defined sarcopenia among individuals with obesity as a low muscle strength (also defined
265 as dynapenia by some of the authors) [52] characterised by a reduction of handgrip strength (HGS).
266 However, the term dynapenic obesity was used in three studies only [40, 87, 95].

267

268 No study defined sarcopenia according to a co-existence of reduced muscle strength and mass [1].

269 Diagnostic criteria and measurement methods

270 Studies were characterized by a large variability in the application of physiological measurements used to
271 define sarcopenia and obesity. Specifically, 19 different measurements of sarcopenia and 10 measurement
272 of adiposity were applied across the studies (Table 3) with appendicular skeletal muscle (ASM) divided by
273 weight (ASM/wt) or adjusted by height in meters squared (ASM/h²) and BMI being the most frequently
274 applied measurements of sarcopenia and obesity, respectively. In addition, the heterogeneity of the
275 diagnostic assessment of sarcopenic obesity was further increased by the application of different cut-off
276 points for the same measurements (Table 4). These cut off points were often borrowed from established
277 guidelines (i.e., BMI ≥ 30 kg/m² for obesity), whereas in other studies population-specific cut-offs were
278 derived by calculating specific parameters from the distributions of the individual measurements (i.e.,
279 n-tiles, SDs or z scores).

280 Diagnostic procedures for the assessment of body composition and functional status were:

- 281 - dual-energy X-ray absorptiometry (DXA) for the definition of sarcopenia (44 studies) [5, 12, 24, 32, 34,
282 37, 39, 42, 45-47, 49, 50, 53, 54, 58-62, 64, 66-68, 69, 71, 72, 74, 75, 79, 80-83, 85, 88-90, 92, 93, 94, 96,
283 97, 99] and for the assessment of excess adiposity (17 studies) [5, 12, 24, 37, 39, 42, 46, 50, 58, 69, 74,
284 82, 89, 90, 92, 93, 94];
- 285 - anthropometry [BMI, mid-arm muscle circumference (MAMC), waist circumference (WC)] for the
286 definition of sarcopenia (1 study) [30] and for the assessment of excess adiposity (44 studies) [12, 30,
287 32, 34-37, 40, 43-45, 47-49, 51, 53, 54, 57, 59, 61, 62, 64, 66, 67, 68, 71, 73, 75, 76, 78-80, 83, 85-88,
288 91, 94, 95, 97, 98, 100, 101] ;
- 289 - muscle strength measures [hand dynamometry (18 studies) [30, 31, 36, 51-53, 55, 57, 58, 69, 75, 87,
290 91-95, 101], maximal knee extensor strength (1 study) [40]];
- 291 - measures of physical performance: gait speed [6-minute walk test (6MWT) (3 studies) [69, 75, 101];
292 4-meter walking test (3 studies) [36, 51, 93]; 3 meter walking test (2 studies) [30, 89], 3 meter Timed
293 Get Up and Go (1 study) [31], 5 meter walking test (2 studies) [55, 58], gait-rite (1 study) [53], 10-meter
294 walking test [57]];
- 295 - bioelectrical impedance analysis (BIA) for the definition of sarcopenia (21 studies) [12, 31, 35-38, 44,
296 48, 51, 55-57, 65, 73, 74, 76-78, 84, 98, 100] and for the assessment of excess adiposity (12 studies) [31,
297 37, 38, 51, 55-57, 65, 74, 77, 84, 98];
- 298 - computed tomography scan (CT) for the definition of sarcopenia (5 studies) [43, 63, 70, 86, 94] and for
299 the assessment of excess adiposity (6 studies) [44, 60, 63, 70, 94, 96].

300 Quality assessment

301 The average score obtained from the application of the Newcastle-Ottawa scale (Table 5) was 8.3 (range:
302 6-10). All studies employed validated measurement procedures, provided a clear description of assessment
303 of the outcome and appropriately described the statistical approaches used to analyze the data. The
304 majority of studies adopted effective sampling strategies to enhance the representativeness of the study
305 population, the analysis controlled for both the most important factor and for confounding factors.

306

307 **DISCUSSION**

308 Although the term sarcopenic obesity has been widely used and the electronic search retrieved 2335
309 papers, the main result of this systematic review was the demonstration of the marked heterogeneity in
310 definitions and approaches to diagnose sarcopenic obesity. Therefore, despite mounting awareness of its
311 pathophysiological and clinical relevance, clinical research on sarcopenic obesity has been performed using
312 markedly heterogeneous approaches for both definition and diagnostic criteria. This may be due to
313 differences in the definitions of obesity and sarcopenia, in the methodologies used to assess body
314 composition and physical function, and in the reference values for the variables that have been used
315 (different cut-offs, interquartile analysis, diverse statistical stratification methods). In regards to the choice
316 of the methodologies that have been adopted in sarcopenic obesity diagnosis, the variability may be
317 attributable, at least partially, to the availability of procedures in different settings, to the variability in
318 specialties and backgrounds of the researchers who worked in this field, and the different settings where
319 studies were performed. Such a relevant heterogeneity prevents the authors from drawing firm conclusions
320 for the phenotypical diagnosis of sarcopenic obesity at the clinical and functional levels. The present
321 systematic review, in fact, poses more questions than those which it can answer.

322

323 1) How to define and diagnose sarcopenic obesity - role of skeletal muscle function and of different
324 measures of obesity

325 For diagnosis of both obesity and sarcopenia, variable phenotypical components and criteria have been
326 employed in analyzed papers. Ensuing variability represents a primary hurdle for clinical approaches to
327 sarcopenic obesity.

328

329 **SARCOPENIA: SKELETAL MUSCLE MASS AND FUNCTION:** Although the term sarcopenia literally refers to
330 lack of flesh (low muscle mass), from its inception it named a condition of low muscle mass and impaired
331 function. Nevertheless, it has been used widely to define low skeletal muscle mass with no functional
332 evaluation. Widely accepted definitions and diagnostic algorithms for sarcopenia proposed by the
333 geriatrics, nutrition and cachexia scientific communities [102], however, notably require coexistence of
334 both low skeletal muscle mass and function for diagnosis. In a recent consensus statement, the
335 European Working Group on Sarcopenia in Older People (EWGSOP) further suggested that
336 functional parameters should become increasingly relevant to diagnose sarcopenia in older adults [3]. This
337 suggestion appears to stem from the well-established lack of consistent associations between skeletal
338 muscle mass and function, whereas impaired functional status retains an obvious independent clinical
339 value and prognostic impact in these population. In fact, all methods used for the measurement/
340 estimation of skeletal muscle mass (anthropometry, DXA, BIA) have shown major limitations. Additionally,
341 lean mass assessed with these methods may not be strongly related with functional or other clinical

342 relevant outcomes [6], although more recent and promising procedures (e.g. D₃-creatine dilution) may
343 show a better association with functional impairment or clinical consequences [103, 104]. Finally, low
344 muscle mass is also part of the definition of malnutrition and cachexia, so this finding is not specific of
345 sarcopenia [14, 102].

346

347 The current systematic review, however, demonstrated lack of systematic approaches to these
348 fundamental issues in the available literature: the vast majority of papers indeed utilized muscle mass
349 surrogates, with very limited use of functional parameters. With regards to the analysis of body
350 composition, different compartments were measured (FFM, appendicular lean mass, ASM) and diverse
351 terms were used to define sarcopenia (reduced FFM, lean mass, ASM). In addition, even the most utilized
352 parameter, ASM, has been used with different normalization factors. Based on commonly accepted
353 requirement of both skeletal muscle mass and function impairment to define sarcopenia in aging (primary
354 sarcopenia), the terms sarcopenic obesity would become highly questionable when functional parameters
355 are missing; myopenic obesity would become more appropriate, thereby leading to a potential terminology
356 issue. The above inconsistencies clearly represent a limitations for clinical applicability of the sarcopenic
357 obesity concept.

358

359 OBESITY: Most articles defined and stratified obesity based on BMI values, most likely for its simple
360 evaluation and wide utilization. FM was, however, employed in a number of studies implementing body
361 composition analysis techniques, and WC was selected in studies supporting the assumption that excess
362 visceral abdominal adiposity may directly contribute to low muscle mass and function through related
363 metabolic derangements. In fact, obesity is linked with adverse outcomes both from a clinical and a
364 functional point of view. Also importantly, awareness of the inadequacy of body mass parameters is also
365 emerging in the obesity community, leading to an increasingly endorsement of composite clinical tools to
366 define and stratify patient risk and prognosis. This includes functional status (e.g. disability level) [105] that
367 might be per se considered a surrogate for risk or presence of low muscle mass and-or function [106, 107].
368 Clearly, such discrepancies should be addressed in future studies and consensus statements.

369

370 2) How to define and diagnose sarcopenic obesity: diagnostic criteria based on a single (or
371 composite) parameter vs separate obesity and sarcopenia criteria

372 One important question is whether sarcopenic obesity is the co-existence of two distinct diseases that can
373 be individually assessed in a given individual, or whether low skeletal muscle mass and higher FM interact
374 synergistically to determine a clinical phenotype with its own specific identity. In the latter scenario,
375 diagnostic procedures that concomitantly evaluate both body composition parameters would be needed
376 (e.g. the ratio between FM and FFM). Since the amount of skeletal muscle mass that defines sarcopenia

377 may be different in obese compared to non-obese persons, relative measures including both muscle and fat
378 compartments could better define sarcopenic obesity. It should however be pointed out that only a
379 minority of studies selected in the present systematic review have employed unified parameters with both
380 fat and muscle measurements related in a single criterion. Among available examples, studies conducted by
381 Siervo et al [6, 108] have shown that the ratio of visceral FM/ASMI is a better predictor of mortality and
382 diabetes risk compared to the more simple FM/FFM ratio. Similar results were found in the K-NHANES and
383 the sarcopenic obesity cohorts in East Asia, where visceral adipose tissue and thigh muscle ratios from CT
384 scans were used [63, 70].

385 Conversely, it is more complex to envision single composite parameters also including skeletal muscle
386 function, and the use of separate diagnostic criteria for sarcopenia and obesity could allow to better
387 differentiate different degrees of individual body composition disturbances and, potentially, their
388 association with functional impairment.

389 It should be finally pointed out that the definition of true predictive capacity for any given outcome
390 needs a proper risk prediction approach in large and prospective cohorts. Moreover, it is important to
391 consider that parameters must be derived in the same population and possibly externally validated at least
392 once in an independent cohort.

393

394 3) What are reference cut-offs for body composition and functional parameters

395 Body composition is affected by ethnicity and sex. On the one hand, setting specific reference values for
396 different age groups and populations belonging to different ethnic groups is, therefore, a necessity and
397 would increase the accuracy and reliability of sarcopenic obesity diagnosis. On the other hand, this would
398 inevitably lead to higher difficulties in consensus procedures and when comparing data collected in
399 different populations and settings. Additionally, age plays a pivotal role in body composition alterations. In
400 geriatric settings, it must be considered whether the reference value to define excess FM or reduced
401 muscle mass is a young (normative population) or a contemporary (coeval) group.

402

403 4) Do we need sarcopenic obesity criteria for research or daily clinical practice (or both)?

404 Methodological variability with different techniques employed also clearly emerged from the current
405 results and strongly contributed to inconsistencies. In sarcopenic obesity research, technologically advanced
406 instruments (e.g. Nuclear Magnetic Resonance - NMR), not usually available in clinical practice, can be used
407 in order to achieve gold-standard, highly accurate assessment of different components of body
408 composition. The situation in clinical practice is obviously different, as easily applicable tools are needed. In
409 the obesity and clinical nutrition field, unlike other areas of medicine, surrogate measurements have been
410 commonly used (e.g. BMI) that have important limitations and are unable to capture abnormalities in body
411 composition, especially those that cause sarcopenic obesity.

412 From a methodological point of view, a reasonable and rational approach would imply the
413 definition of optimal methods and diagnostic approaches to define sarcopenic obesity in an effort to
414 establish a reference against which, at a later time, simple clinical measurements can be tested for
415 diagnostic sensitivity and specificity. It is conceivable that different approaches could be then
416 recommended with gold standard techniques established for more accurate studies in limited subsets of
417 patients, while acceptable less demanding, clinically reproducible and validated surrogates could be
418 employed for large population studies or routine clinical practice. The issue of consensus on tools of choice
419 for both approaches remains however an unmet priority, and these fundamental questions should be
420 addressed in the near future by experts and clinicians in the field. Since existent epidemiological data,
421 although partially discordant, indicate a high prevalence and clinical and functional consequences of
422 sarcopenic obesity, it is probably appropriate to suggest that relatively sophisticated instruments (e.g. BIA
423 and DXA) should be eventually made more widely available and used to achieve a reliable diagnosis.
424

425 5) Role of different clinical factors in the pathogenesis of sarcopenic obesity

426 Last but certainly not least question, the pathogenesis of sarcopenic obesity is still partially unknown. As
427 also summarized above, aging, inflammation, sedentary lifestyle, complex hormonal and metabolic
428 derangements, genetics all seem to play a role [109, 110]. Other clinical factors have been implied (e.g.
429 disability, bariatric surgery without nutritional supervision, long-lasting incongruous dietary regimens) and
430 their role in the pathogenesis of sarcopenic obesity needs to be further investigated. It appears therefore
431 necessary to conduct exploratory association studies, although a consensus on the definition of sarcopenic
432 obesity may be primarily needed since the role of predictors may vary depending on how sarcopenic
433 obesity is operationalized. It seems generally reasonable to hypothesize that sarcopenia in obesity may
434 have different trajectories in terms of natural history when compared to sarcopenia in individuals without
435 obesity: indeed, changes in body compartments are interconnected, as shown by recent review articles by
436 Dulloo et al [111, 112]. As a rule of thumb, evidence suggests that FFM and FM may be subject the so-called
437 “one quarter rule”: for any increment in body fat, a parallel change in FFM occurs, corresponding
438 approximately to 25%. The initial paradigm for sarcopenia proposing an initial decline in skeletal muscle
439 quantity (formerly referred to as presarcopenia) followed by loss of strength and function is currently being
440 questioned [101] and could all the more be less applicable and generalizable for sarcopenic obesity.
441 Moreover, subjects with obesity may present with alterations in glucose metabolism often linked to muscle
442 dysfunction regardless of the loss of FFM. Natural history of sarcopenia coupled to obesity clearly needs to
443 be further elucidated by future research. An important aspect concerning sarcopenic obesity is weight
444 cycling and body composition trajectory [113] as it may induce repeated FFM loss which is not completely
445 recovered during weight regain in relation to post-restriction metabolic and hormonal alterations during
446 refeeding [114].

447

448 Limitations and strengths:

449 It should be pointed out that the current systematic review has some relevant limitations. Firstly, it
450 included literature from the last ten years. In addition, for the methodological purpose of the current work,
451 that does not address general or disease-specific clinical outcomes, the authors decided to focus on studies
452 in obese individuals in the absence of acute or chronic conditions and treatments reported to negatively
453 influence skeletal muscle mass and function independently of obesity (such as surgery, cancer, kidney
454 disease). We, however, consider this decision not to affect the ability to address the aim of our paper, i.e.
455 to analyze definitions and diagnostic criteria adopted in the literature to investigate sarcopenic obesity. In
456 addition, it should be pointed out that under the current exclusion criteria, the search still resulted in
457 selection of a large number of papers with a large sample of subjects. The latter indeed appears to be a
458 remarkable strength of the current review, as well as the overall high study quality.

459

460 Conclusions and open questions:

461 In conclusion, the current systematic review demonstrated the profound inadequacy of available research
462 on sarcopenic obesity in terms of consistency of definition, diagnostic criteria and methodological issues.
463 Results indeed do not allow definitive conclusions on the prevalence and relevance of sarcopenic obesity
464 from a clinical and functional standpoint. The above limitations negatively impact general awareness and
465 implementation of the sarcopenic obesity concept. The authors of this systematic review as well as ESPEN,
466 and EASO call for action to reach consensus proposals on 1) definition of sarcopenic obesity 2) diagnostic
467 criteria both at the level of potential gold-standards and acceptable surrogates with wide clinical
468 applicability, with related cut-off values that may importantly need regional differentiation; 3)
469 methodologies to be used in actions 1 and 2. Since pathogenetic mechanisms underlying the onset of
470 sarcopenic obesity are still incompletely understood, efforts towards their elucidation including both
471 clinical and pre-clinical research will also be needed and likely to improve results of actions 1, 2 and 3. The
472 authors are aware that first steps should be aimed at reaching consensus on plausible proposals that would
473 need subsequent validation based on homogeneous studies and databases, possibly based on analyses of
474 existing cohorts, to help define the prevalence of the condition, its clinical and functional relevance, as well
475 as most effective prevention and treatment strategies.

476

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478 and wrote the manuscript; E Parrinello collected the data and built the tables; JM Bauer, S Bischoff, Y
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480 Heymsfield, T Higashiguchi, A Laviano, A Lenzi, E Poggiogalle, CM Prado, J Salvador Rodriguez, Y Rolland, F

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485

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Table 1. General characteristics of the studies included in the systematic review

	Country	Sample size (n)	Gender (n)		Age (M±SD)	Study design
			M	F		
Aggio DA, et al. (2016) [30]	UK	1286	1286	0	83.1 ±5.2	cross-sectional
Aibar-Almazán A, et al. (2018) [31]	Spain	235	0	235	70.65 ±19.86	cross-sectional
An KO, et al, (2016) [32]	Korea	10118	4887	5231	58.7 ±0.3	cross-sectional
Atkins JL, et al.. (2014) [33]	UK	4051	4051	0	70.3 ±5.5	prospective cohort study
Baek J, et al. (2013) [34]	Korea	1150	618	532	43.55±11.45	cross-sectional
Baek SJ, et al. (2014) [35]	Korea	3483	1466	2017	> 64	cross-sectional
Bahat G, et al. (2018) [51]	Turkey	992	308	684	M=76.3±6.9; F=74.3±7.2	cross-sectional
Balachandran A, et al. (2014) [36]	USA	17	1	16	Circuit training=71.6±7.8; hypertrophy= 71±8.2	RCT
Batsis JA, et al. (2013) [37]	USA	4984	2452	2532	M=70.3F=71.3	cross-sectional
Batsis JA, et al. (2014) [38]	USA	4652	2283	2369	M=70.0±0.2; F=71.1±0.34	cross-sectional
Batsis JA, et al. (2015) [39]	USA	2025	756	1269	68.2 ±5.4	prospective cohort study
Batsis JA, et al. (2016) [40]	USA	4984	2452	2532	71.1 ±0.19	cross-sectional
Biolo G, et al. (2015) [41]	Italy & Slovenia	200	89	111	M=48 ±12; F=51 ±12	cross-sectional
Bouchard DR, et al. (2009) [42]	Canada	904	439	465	68-82	cross-sectional
Cesari M, et al. (2009) [43]	Italy	934	421	513	74.5 ±7.0	prospective cohort study
Chen HT, et al. (2017) [44]	Taiwan	60	10	50	65-75	RCT
Cho Y, et al. (2015) [45]	Korea, UK	11521	4934	6587	Normal=43.3 ±0.1; SO =48.4±0.5	cross-sectional
Chung JH, et al.(2016) [46]	Korea	6889	3385	3504	M=60.5±0.2; F=63.1±0.2	cross-sectional
Chung JY, et al. (2013) [47]	Korea	2943	1250	1693	M=69.0±6.3; F=69.3±6.4	cross-sectional
De Rosa E, et al. (2015) [48]	Italy	131	51	80	M: 50±5 F: 50±4	cross-sectional
Domiciano DS, et al. (2013) [49]	Brazil	611	0	611	73.22 ±5.21	cross-sectional
dos Santos EP, et al. (2014) [50]	Brazil	149	0	149	67.2 ±6.1	cross-sectional
Hamer M, et al. (2017) [52]	UK	6864	3129	3735	66.2 ±9.5	prospective cohort study
Huo YR, et al. (2016) [53]	Australia	680	238	442	79 ±9	cross-sectional
Hwang B, et al. (2012) [54]	Korea	2221	964	1257	M=69.4±6.6; F=69.8±6.8	cross-sectional
Ishii S, et al. (2016) [55]	Japan	1731	875	856	> 65	cross-sectional

Joppa P, et al. (2016) [56]	UK, USA, Canada	2548	1586	962	63.5 ±7.1	cross-sectional
Kemmler W, et al. (2016) [57]	Germany	1325	0	1325	76.4 ±4.9	cross-sectional (retrospective cohort)
Kim H, et al. (2016) [58]	Japan	307	168	139	> 70	RCT
Kim JH, et al. (2015) [59]	Korea	3320	1458	1862	54.3 ±0.3	cross-sectional
Kim TN, et al. (2014) [60]	Korea	298	119	179	40.1 ±11.2	cross-sectional
Kim TN, et al. (2009) [24]	Korea	526	198	328	M=52.2±14.4; F=51.2±14.8	cross-sectional
Kim YS, et al. (2012) [61]	Korea	10485	4486	5999	M=31.0±5.5; F=30.8±5.6	cross-sectional
Kim MK, et al. (2011) [62]	Korea	3169	1380	1789	63.6	cross-sectional
Kohara K, et al. (2011) [63]	Japan	782	303	479	M=67.9±8.5; F=66.3 ±8.2	cross-sectional
Kwon SS, et al, (2017) [64]	Korea	8707	4192	4515	M= 45.63 ±0.23; F= 44.31 ±0.21	cross-sectional
Lee J, et al. (2016) [65]	Korea	309	85	224	M= 70.7 ±6.3 F=66.4 ±7.2	cross-sectional
Lee S, et al. (2012) [66]	Korea	2893	1249	1644	66	cross-sectional
Lee YH, et al. (2015) [67]	Korea	15132	5617	9515	≥ 20	cross-sectional
Levine ME, et al. (2012) [68]	USA	2287	1002	1285	70.60 ±7.9	cross-sectional
Liao CD, et al. (2017) [69]	Taiwan	46	0	46	67.3 ±5.2	RCT
Lim KI, et al. (2010) [70]	Korea	264	126	138	47-54	cross-sectional
Lim JP, et al. (2015) [71]	Asia (Japan, China, Korea, Thailand, Taiwan)	143	44	99	68±8.2	cross-sectional
Lim S, et al. (2010) [72]	Korea	565	287	278	≥ 65	cross-sectional
Lu CW, et al. (2013) [73]	Taiwan	600	144	456	63.6 ±10.1	cross-sectional
Marini E, et al. (2012) [74]	Italy	207	75	132	M=75.8±6.9; F=70.8±4	cross-sectional
Meng P, et al. (2014) [75]	Taiwan	101	101	0	88.8 ±3.7	cross-sectional
Moreira MA, et al. (2016) [76]	Brazil	491	0	491	49.95±5.56	cross-sectional
Muñoz-Arribas A, et al. (2013) [77]	Spain	306	76	230	82.5 ±2.3	cross-sectional
Muscariello E, et al. (2016) [78]	Italy	1030	0	1030	obese=30.9 ±7.9; normal-weight=28.5±7.6	RCT
Oh C, et al. (2017) [79]	Korea	4452	1929	2523	> 60	cross-sectional
Oh C., et al. (2015) [80]	Korea	1433	658	775	> 60	cross-sectional
Oliveira RJ, et al. (2011) [81]	Brazil	607	0	607	44.8 ±19.9	cross-sectional
Park SH, et al. (2013) [83]	Korea	6832	3409	3423	49.3	cross-sectional
Pedrero-Chamizo R, et al. (2015) [84]	Spain	2747	645	2102	M=72.4±5.4; F=72±5.2	cross-sectional
Perna S, et al. (2017) [82]	Italy	639	196	443	80.9 ±7.77	cross-sectional
Poggiogalle E, et al. (2016) [85]	Italy	727	141	586	45.72±13.56	cross-sectional
Prado CM, et al. (2014) [5]	USA	13.236	6580	6.656	M= 44.57 ±0.33;	cross-sectional

					F= 46.8 ±0.36	
Ramachandran R, et al. (2012) [86]	USA	539	280	259	71.1 ±0.1	cross-sectional
Rolland Y, et al. (2009) [12]	France	1308	0	1308		cross-sectional
Rossi AP, et al. (2017) [87]	Italy	846	370	476	74.5 ±6.9	cross-sectional
Ryu M, et al. (2013) [88]	Korea	2264	940	1324	73.2	cross-sectional
Santos VRD, et al. (2017) [89]	Brazil	116	47	69	83.3 ±2.7	cross-sectional
Santos VRD, et al. (2017) [90]	Brazil	113	41	72	83.4 ±2.9	cross-sectional
Schrager, et al. (2007) [91]	Italy	871	378	493	74.0 ±7.1	cross-sectional
Scott D, et al. (2016) [92]	Australia	1089	534	555	62	prospective cohort study
Scott D, et al. (2017) [93]	Australia	1486	1486	0	> 70	prospective cohort study
Scott, D, et al. (2018) [94]	Australia	168	75	93	67.7 ±8.4	cross-sectional
Sénéchal M, et al. (2012) [95]	USA	3007	1515	1492	65.4 ±10	cross-sectional
Seo JA, et al. (2012) [96]	Korea	484	216	268	72.1 ±4.7	cross-sectional
Sharma D, et al. (2014) [97]	USA	11643	5785	5858	> 20	cross-sectional
Siervo M, et al. (2012) [98]	Italy	763	0	763	45.4 ±16.8	cross-sectional
Silva Neto LS, et al. (2012) [99]	Brazil	56	0	56	64 ±5.74	cross-sectional
Srikanthan P, et al. (2010) [100]	USA	14528	7017	7511	45.0	cross-sectional
Tyrovolas S, et al. (2015) [101]	Finland, Poland, Spain, China, Ghana, India, Mexico, Russia, South Africa	18363	8303	10060	> 65	cross-sectional

Legend: M = Male; F = Female; SO = Sarcopenic Obesity; RCT: randomized clinical trial.

Table 2: Definition and diagnostic criteria adopted in the studies included in the systematic review

	SO Definition	Diagnostic Criteria (parameters)	Diagnostic Criteria (cut-off)	Methods for diagnosis (procedures)	Outcome
Aggio DA, et al. (2016) [30]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: MAMC, GS, HGS; Obesity: WC	Sarcopenia: lowest two-fifths of the MAMC distribution plus GS <30 kg or GS ≤0.8 m/s; Obesity: WC > 102 cm	Anthropometry, dynamometer, 3m walking test	association with low physical functions
Aibar-Almazán A, et al. (2018) [31]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: EWGSOP criteria (SMI, GS, HGS); Obesity: FM%	Sarcopenia: ASM/h ² < 6.42 Kg/m ² plus HGS < 20 kg or GS < 0.8 m/s; Obesity: FM > 35%	BIA, dynamometer, 3m walking test with Up and Go (TUG) test	association with fear of falling
An KO, et al, (2016) [32]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: WC	Sarcopenia: SMI 1 SD below the mean of a young population reference group (< 30.1% M and 21.2% F). Obesity: WC sex-specific cutoff point for Asians (≥ 90 cm M and 80 cm F)	Anthropometry, DXA	association with multimorbidity
Atkins JL, et al.. (2014) [33]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: FFMI; Obesity: WC	Sarcopenia: lowest two-fifths of the FFMI (≤16.7 kg/m ²); Obesity: those above the percentile point of FMI corresponding to the WC obesity cutoff (28.7th percentile) (>11.1 kg/m ²).	Anthropometry, BIA	association with cardiovascular disease and mortality

Baek J, et al. (2013) [34]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² or ASM/Wt; Obesity: BMI	Sarcopenia: ASM/h ² or ASM/Wt 1 SD below the mean of the young reference group; Obesity: BMI ≥ 25 kg/m ²	Anthropometry, DXA	association with dyslipidemia
Baek SJ, et al. (2014) [35]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: BMI	Sarcopenia: ASM/h ² ≤ 2 SD below reference values from young (10.7 kg/m ² M and 8.6 kg/m ² F); Obesity: BMI > 25 kg/m ²	Anthropometry, BIA	association with cardiac autonomic nervous dysfunction
Bahat G, et al. (2018) [51]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: EWGSOP criteria (SMI, GS, HGS); Obesity: FM or BMI	Sarcopenia: SMI < 9.2 kg/m ² M, 7.4 kg/m ² F and HGS < 22 kg F, < 32 kg M or GS < 0.8 m/s; Obesity: FM above 60th percentile or BMI ≥ 30 kg/m ²	Anthropometry, BIA, dynamometer, 4m walking test	prevalence
Balachandran A, et al. (2014) [36]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: EWGSOP criteria (SMI, GS, HGS); Obesity: BMI	Sarcopenia: ASM/h ² < 10.76 kg/m ² M, 6.76 kg/m ² F plus GS < 1 m/s or HGS < 30 kg M and < 20 kg F; Obesity: BMI > 30 kg/m ²	Anthropometry, BIA, dynamometer, 4m walking test	improving of physical function through different type of training
Batsis JA, et al. (2013) [37]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM% or WC;	8 different definitions for sarcopenia: 1) ASM/h ² : < 7.26 kg/m ² M, < 5.45 kg/m ² F; 2) Total body skeletal mass/m ² < 9.12 kg/m ² M - 6.53 kg/m ² F; 3) Total body skeletal mass/h ² : < 5.7kg/m ² F; 4) ASM/h ² : < 8.51 - 6.29 kg/m ² M; 5) ASM/body	DXA, BIA, Anthropometry	prevalence

			<p>mass: < 25.7% M, < 19.4% F; 6) ASM/h²: < 7.4 - 5.14 kg/m² M; 7) Total skeletal muscle mass/Wt: < 30.7%; 8) ASM/h²: < 8.81kg/m² M, <7.36 kg/m² F; Obesity, 6 different definitions: 1) FM > 27% M, 38% F; 2) FM > 37.16% M, 40.01% F; 3) FM: > 42.9% F; 4) FM > 28% M, 35% F; 5) WC: > 102 cm M, 88 cm F; 6) FM: > 20.7% M, 31.7% F</p>		
Batsis JA, et al. (2014) [38]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity FM%	Sarcopenia: SMI (ASM/h ²). M: class I: 8.51–10.75 kg/m ² ; class II: ≤8.50 kg/m ² ; F: class I: 5.76–6.75 kg/m ² ; class II: ≤5.75 kg/m ² ; Obesity: FM ≥ 27% M and ≥ 38% F	BIA	association with mortality
Batsis JA, et al. (2015) [39]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ALM; ALM/BMI ratio; Obesity: FM%	Sarcopenia: ALM <19.75 kg M and <15.02 kg F OR ALM/BMI ratio <0.789 M and <0.512 F; Obesity: FM > 25% M and 35% F	DXA	association with inflammation
Batsis JA, et al. (2016) [40]	dynapenic obesity	Dynapenia: HGS; Obesity: BMI	Dynapenia: knee extensor strenght in the lowest tertile (M: 365.8 - 458.2 N; F 235.3 - 304.1 N); Obesity: BMI >30 Kg/m ²	Anthropometry, Maximal knee extensor strenght	impact of SO on physical function and QoL in patients with osteoarthritis

Biolo G, et al. (2015) [41]	Sarcopenic obesity	SO: FM/FFM RATIO	SO: FM/FFM RATIO > 0,8	BIA	assessment of predictive power of ABSI on the FFMI
Bouchard DR, et al. (2009) [42]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM%	Sarcopenia: ASMI 2 SD below the mean of a cohort of young adults (<6.29 kg/m ² F and <8.51 kg/m ² M); Obesity: FM ≥35% F and ≥28% M	DXA	association with low physical functions
Cesari M, et al. (2009) [43]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: calf CSA; Obesity: BMI	Sarcopenia: calf CSA in the lowest tertile; Obesity: BMI>30kg/m ²	Anthropometry, CT	skeletal muscle and fat mass are not significant risk factors for mortality
Chen HT, et al. (2017) [44]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI and VFA	Sarcopenia= ASM/Wt ≤ 32,5 M; ≤25,7 F; Obesity =BMI ≥ 25 Kg/cm ² and VFA ≥ 100 cm ²	Anthropometry, BIA, CT	effects of different types of exercise
Cho Y, et al. (2015) [45]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: WC	Sarcopenia: ASM/Wt < 23,8% F, < 30,3% M (< 1 SD below the mean value of the reference group); Obesity: WC ≥ 90 cm M, ≥ 85 cm F	Anthropometry, DXA	association with adverse psychological health and lower QoL
Chung JH, et al.(2016) [46]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM%	Sarcopenia: ASM/h ² < 7,26 Kg/m ² M, < 5,45 Kg/m ² F (<2 SDs below the sex-specific mean of a young reference group); Obesity: FM >30% M, >40% F	DXA	association with osteoporosis

Chung JY, et al. (2013) [47]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: ASM/Wt < 32,5% M, < 25,7% F (1 SD below the mean of a reference group); Obesity: BMI \geq 25 Kg/m ²	Anthropometry, DXA	association with insulin resistance, metabolic syndrome and cardiovascular disease risk factors
De Rosa E, et al. (2015) [48]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: BMI	Sarcopenia: MODERATE (between 1 - 2 SD) SMI 8.44 - 9.53 kg/m ² and SEVERE (below 2 SD) SMI \leq 8.43 kg/m ² M, MODERATE SMI 6.49 - 7.32 kg/m ² and SEVERE SMI \leq 6.48 kg/m ² F; Obesity: BMI \geq 30 Kg/m ²	Anthropometry, BIA	prevalence and definition
Domiciano DS, et al. (2013) [49]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: BMI	Sarcopenia: SMI < 5,45 Kg/m ² F; Obesity: BMI \geq 30 Kg/m ² ; The 20th percentile was defined as the cutoff point for sarcopenia, corresponded to a residual of -1.45 in the population studied	Anthropometry, DXA	definition
dos Santos EP, et al. (2014) [50]	Sarcopenic obesity	Sarcopenia: SMI (ASM/h ²); SO: prediction equation for AFFM	Sarcopenia: SMI < 5,45 Kg/m ² F; SO: the residual values of a regression equation that predicts AFFM based on height (m) and FM (kg). The equation: predicted AFFM = 14.529 + (17.989 x h) + (0.1307 x FM). the cutoff value corresponds to a residual \leq 3.4	Anthropometry, DXA	absent of an association with cardiometabolic risk

Hamer M, et al. (2017) [52]	Sarcopenic obesity	SO: obese individuals in the lowest tertile of sex-specific HGS	SO: BMI >30 Kg/m ² in the lowest tertile of sex-specific HGS (35.3 kg M and 19.6 kg F)	Dynamometer, anthropometry	SO did not confer any greater risk than sarcopenia alone; weight loss combined with sarcopenia presented the greatest risk of mortality
Huo YR, et al. (2016) [53]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcoepnia: EWGSOP criteria; Obesity: BMI	Sarcopenia: ALM/h ² <5.5 kg/m ² F and <7.26 kg/m ² M plus GS <80 cm/s or HGS <20 kg F and <30 kg M; Obesity: BMI ≥ 30 Kg/m ²	Anthropometry, DEXA, Dynamometer, Gait rite	definition
Hwang B, et al. (2012) [54]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: WC	Sarcopenia: ASM/Wt 2 SD below mean value of sex-specific young normal people; Obesity: WC ≥ 90 cm M and ≥ 85 cm F	Anthropometry, DEXA	prevalence of SO and association with medical conditions as insulin resistance, inappropriate nutrition, low physical activity
Ishii S, et al. (2016) [55]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² , HGS, GS; Obesity: FM%	Sarcopenia: ASM/h ² 2 SD below the mean values of young reference groups (< 7.0 kg/m ² M, < 5.8 kg/m ² F) plus HGS < 30 Kg M, < 20 Kg F or GS < 1,26 m/s M and F; Obesity: FM% in the highest quintile (cutoff values: 29.7% M, 37.2% F)	BIA, dynamometer, 5 m walking test	association with depressive symptoms

Joppa P, et al. (2016) [56]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: FFMI; Obesity: FMI	Sarcopenia: FFMI < 10th percentile of the reference values; Obesity: FMI ≥ 90th percentile of the reference values	BIA	valuation of effects of SO on exercise capacity, health status, systemic inflammation in patients with COPD
Kemmler W, et al. (2016) [57]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: EWGSOP and IWGS; Obesity: BMI, FM%	Sarcopenia: EWGSOP: $ASM/h^2 \leq 5.45 \text{ kg/m}^2$ plus $GS \leq 0,8 \text{ m/s}$ or HGS at <20 kg; IWGS = $GS \leq 1.0 \text{ m/s}$ and ASM/h^2 in the lowest quintile; Obesity: $BMI \geq 30 \text{ kg/m}^2$ and $FM \geq 35 \%$	Anthropometry, BIA, dynamometer, 10m GS test	prevalence
Kim H, et al. (2016) [58]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: SMI or HGS or GS; Obesity: FM%	Sarcopenia: $SMI < 5,67 \text{ Kg/m}^2$ or $HGS < 17.0 \text{ kg}$ or $GS < 1.0 \text{ m/s}$; Obesity: $FM \geq 32\%$	DXA, dynamometer, 5m walking test	effects of exercise and nutrition
Kim JH, et al. (2015) [59]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: $ASM/weight < 1 \text{ sd}$ below the mean of the sex-specific healthy reference group. Cutoff point 31.30% M and 24.76% F. Obesity: $BMI \geq 25.0 \text{ kg/m}^2$	Anthropometry, DXA	association with cardiovascular disease
Kim TN, et al. (2014) [60]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: VFA	Sarcopenia: $SMI < 36,3\% \text{ M}$, $< 28,5\% \text{ F}$ (1 SD below the sex-specific mean value for a young reference group); Obesity: $VFA \geq 100 \text{ cm}^2 \text{ F}$,	DXA, CT	low cardiorespiratory fitness increase risk of SO

			$\geq 130 \text{ cm}^2 \text{ M}$		
Kim TN, et al. (2009) [24]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h^2 ; Obesity: FM%	Sarcopenia: $\text{ASM} < 7,40 \text{ Kg}/\text{m}^2 \text{ M}$, $< 5,14 \text{ Kg}/\text{m}^2 \text{ F}$ (2 DS below the sex-specific normal mean of a reference group); Obesity: FM $> 20,21\% \text{ M}$, $31,71\% \text{ F}$ (upper two quintiles). 4 different groups: 1) normal body fat and muscle mass, 2) sarcopenia, 3) obesity, 4) SO	DXA	prevalence
Kim YS, et al. (2012) [61]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h^2 or ASM/Wt ; Obesity: WC	Sarcopenia: $\text{ASM}/\text{h}^2 < 7,50 \text{ Kg}/\text{m}^2 \text{ M}$, $< 5,38 \text{ Kg}/\text{m}^2 \text{ F}$ or $\text{ASM}/\text{Wt} < 32,2\% \text{ M}$, $< 25,6\% \text{ F}$ ($< 1\text{SD}$ below mean of young reference group); Obesity: WC $> 90 \text{ cm M}$, $> 85 \text{ cm F}$	Anthropometry, DXA	prevalence
Kim MK, et al. (2011) [62]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: AMS/Wt ; Obesity: BMI	Sarcopenia: $\text{ASM}/\text{Wt} < 29,5\% \text{ M}$, $< 23,2\% \text{ F}$ ($< 2 \text{ SD}$ of young reference population); Obesity: BMI $\geq 27.5 \text{ Kg}/\text{m}^2$;	Anthropometry, DXA	vitamin D levels lower in subjects with sarcopenia, regardless of obesity

Kohara K, et al. (2011) [63]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: thigh CSA/Wt; Obesity: VFA	Sarcopenia: thigh CSA/Wt < 1SD below young reference group (< 1,9 cm ² /Kg M, < 1,6 cm ² /Kg F); Obesity: VFA >100 cm ² for M and F	CT	leptin may link visceral obesity and sarcopenia
Kwon SS, et al, (2017) [64]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: ASM/Wt < 30,98 M, < 24,81 F (- 1 SD below the mean of a reference group); Obesity: BMI ≥ 25 Kg/m ²	Anthropometry, DXA	association with insulin resistance
Lee J, et al. (2016) [65]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: FM%	Sarcopenia: ASM/Wt. Class I between 42,9 - 38,2% M, between 35,6 - 32,2% F (between 1 -2 SD of young reference group); Class II < 38,2% M, < 32,2% F (below 2 SD); Obesity: FM > 25.8% M and 36.5% F (2 highest quintiles); SO was defined as class II sarcopenia plus obesity	BIA	association with metabolic syndrome
Lee S, et al. (2012) [66]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: ASM/Wt < 26,8% M, < 21% F (<2SD of mean in a young reference group); Obesity: BMI ≥ 27.5 Kg/m ²	Anthropometry, DXA	association with osteoarthritis
Lee YH, et al. (2015) [67]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: SMI ≤ 32.2% M and ≤ 25.5% F (< 1 SD below mean sex-specific reference group). Obesity: BMI ≥ 25 kg/m ²	Anthropometry, DXA	sarcopaenia have an increased risk of NAFLD regardless of obesity

Levine ME, et al. (2012) [68]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ALM/Wt; Obesity: WC	Sarcopenia: ASM < 25.72% M and 19.43% F (<2 SD below the mean of a young reference group); Obesity: WC > 102 cm M, >88 cm F.	Anthropometry, DXA	association with low physical functions
Liao CD, et al. (2017) [69]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: SMI, HGS, GS; Obesity: FM%	Sarcopenia: SMI < 7.15 kg/m ² plus HGS < 14.3 kg or GS < 1.0 m/s; Obesity: FM >38%	DXA, dynamometer, 6m GS test	elastic resistance exercise exerted benefits on the body composition, muscle quality and physical function in patients with SO
Lim KI, et al. (2010) [70]	Sarcopenic obesity	SO: VFA (visceral fat area)/TMA (thigh muscle area) Median	VFA/TMA Median higher 50th percentile (0,90 F and 0,93 M)	CT	association with metabolic syndrome
Lim JP, et al. (2015) [71]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² from AWSG; Obesity: WC	Sarcopenia: ASM/h ² < 7.0 kg/m ² M, < 5.4 kg/m ² F, HGS <26 Kg M, <18 kg F, GS <0.8 m/s; Obesity: WC > 90 cm M, > 85 cm F	Anthropometry, DXA	association with inflammation
Lim S, et al. (2010) [72]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² and ASM/Wt; Obesity: VFA	Sarcopenia: ASM/h ² < 7.09 kg/m ² in M, < 5.27 kg/m ² in F and ASM/Wt < 29.9% in M and 25.1% in F (1 SD below the sex-specific mean for a young reference group); Obesity: VFA >100 cm ²	Abdominal CT, DXA	prevalence and association with metabolic syndrome (ASM/Wt is more associated)

Lu CW, et al. (2013) [73]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: SMI <37% M, < 27.6% F; Obesity: BMI \geq 25 kg/m ²	Anthropometry, BIA	association with metabolic syndrome
Marini E, et al. (2012) [74]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM%	Sarcopenia: SMI < 7.26 kg/m ² M, < 5.45 kg/m ² F; Obesity: FM > 27% M, > 38% F	BIVA, DXA	BIVA (bioelectrical impedance vector analysis) discriminates SO individuals
Meng P, et al. (2014) [75]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: EWGSOP criteria (SMI, HGS, GS); Obesity: BMI	Sarcopenia: SMI% < 28.0% M plus GS \leq 0.8 m/s or HGS < 22.4 kg M; Obesity: BMI > 27.5 kg/m ²	Anthropometry, Dynamometer, 6m walking test, DXA	prevalence of SO and association with low physical functions
Moreira MA, et al. (2016) [76]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: WC	Sarcopenia: SMI < 6.08 kg/m ² (< 20th percentile of the sample) ; Obesity: WC \geq 88 cm	Anthropometry, BIA	association with low physical functions
Muñoz-Arribas A, et al. (2013) [77]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: total muscle mass; Obesity: FM%	Sarcopenia: total muscle mass \leq 8.11 Kg M, \leq 5.80 Kg F (2 lowest quintile). Obesity: FM \geq 33.08% M, \geq 43.91% F (2 highest quintile)	BIA	adequate physical conditions are associated with a low risk of SO

Muscariello E, et al. (2016) [78]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: Muscle mass index (MMI); Obesity: BMI	Sarcopenia: Class I, Muscle mass index (MMI) $< 8.3 \text{ kg/m}^2$; Class II $< 7,3 \text{ Kg/m}^2$ (if BMI $\geq 30 \text{ kg/m}^2$), Class I MMI $< 7,4 \text{ kg/m}^2$; Class II $< 6,8$ (if BMI $< 25 \text{ kg/m}^2$) (2 standard deviations below the mean of the reference group); Obesity: BMI $\geq 30 \text{ kg/m}^2$	Anthropometry, BIA	adequate protein intake could contribute to the prevention of lean-mass loss in obese older people
Oh C, et al. (2017) [79]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: ASM/Wt < 1 SD below the mean value of a reference group; Obesity: BMI $\geq 25 \text{ kg/m}^2$	Anthropometry, DXA	sarcopenia association with metabolic related factors, physical activity, vitamin D levels
Oh C., et al. (2015) [80]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: BMI	Sarcopenia: ASM/Wt < 44 % M, 52 % F (less than 1 SD below the mean of a reference sample); Obesity: BMI $\geq 25 \text{ Kg/m}^2$	Anthropometry, DXA	body composition changes are related to nutrient intakes in elderly men but not elderly women; women have a higher prevalence of SO than men
Oliveira RJ, et al. (2011) [81]	Sarcopenic obesity	SO: prediction equation for AFFM	Sarcopenia: FFM ≤ 2 SD of the mean of the reference sample consisting of young woman; SO: the residual values of a regression equation that predicts AFFM based on h (m) and FM (kg). The equation: predicted AFFM = -	DXA	cut-off proposal based on reduced functional capacity

			14.529 + (17.989 x h) + (0.1307 x FM). the cutoff value corresponds to a residual ≤ 3.4		
Park SH, et al. (2013) [83]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: WC	Sarcopenia: ASM/Wt < 29,5% M, < 23,2% F; Obesity: WC ≥ 90 cm M, ≥ 85 cm F	Anthropometry, DXA	association with hypertension
Pedrero-Chamizo R, et al. (2015) [84]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: RMM% (relative muscle mass = Sketetal muscle mass/Wt%); Obesity: FM%	Sarcopenia: RMM < 6,20% F, < 8,62% M (lower 2 quintiles); Obesity: FM > 40,90% F, > 30,33% M (upper 2 quintiles of the reference group). 4 Groups: 1)Normal, 2)Obesity, 3)Sarcopenia, 4)SO.	BIA	physical activity and reduced risk of SO
Perna S, et al. (2017) [82]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM%	Sarcopenia: SMI (ASM/h ²) below the 5th centile for age- and gender-matched healthy subjects; Obesity: FM > 38% F, > 27% M	DXA	sarcopenic subjects appears more vulnerable than SO for fractures, edema, inflammation, malnutrition
Poggiogalle E, et al. (2016) [85]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² or ASM/Wt; Obesity: BMI	Sarcopenia: ASMM/h ² < 6.54 Kg/m ² M, < 4.82 Kg/m ² F or ASMM/Wt < 0.2827 M, < 0.2347 F (< 2 SD than the sex-specific mean of a young population). Obesity: BMI	Anthropometry, DXA	association with metabolic syndrome and low-grade inflammation

			$\geq 30 \text{ Kg/m}^2$		
Prado CM, et al. (2014) [5]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FMI (FM/h ²)	4 specific body-composition phenotypes: 1)LA-HM (low adiposity high muscle: ASMI 50 - 100 Kg/m ² ; FMI 0 - 49,99 Kg/m ²); 2)HA-HI (high adiposity high muscle: ASMI 50-100 Kg/m ² ; FMI 50-100 Kg/m ²); 3) LA-LM (low adiposity low muscle: ASMI 0-49.99 Kg/m ² ; FMI: 0-49,99 Kg/m ²); 4) HA-LM (high adiposity low muscle ASMI 0-49,99 Kg/m ² ; FMI: 50-100 Kg/m ²). The HA-LM cutoffs were as follows: class I (ASMI: 40-49.99 Kg/m ² ; FMI: 60-100 Kg/m ²), class II (ASMI: 20-39.99 Kg/m ² ; FMI: 80-100 Kg/m ²), and class III (ASMI: 0-19.99 Kg/m ² ; FMI: 80-100 Kg/m ²).	DXA	definition

Ramachandran R, et al. (2012) [86]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: thigh CSA; Obesity: BMI, WC	Sarcopenia: adjusted thigh muscle area < 93,8 cm ² F, < 110,7 cm ² M (lowest sex-specific tertile); Global adiposity = BMI > 27 kg/m ² ; Central adiposity = WC > 88 cm F, > 102 cm M; 8 different groups	Anthropometry, CT	obesity association with glucose intolerance, unrelated to low muscle mass
Rolland Y, et al. (2009) [12]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM%	Sarcopenia: ASM/h ² < 5,45 Kg/m ² F (<2 SD below young ref group from Rosetta study); Obesity: FM% > 60th percentile	DXA	association with low physical functions
Rossi AP, et al. (2017) [87]	dynapenic obesity	Dynapenia: HGS; Obesity: WC	Dynapenia: HGS < 33 kg M, < 19 kg F (lowest tertile); Obesity: WC > 99 cm M, 95 cm F	Anthropometry, Dynamometer	association with disability and hospitalization
Ryu M, et al. (2013) [88]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt; Obesity: WC	Sarcopenia: ASM/Wt < 2 SD. Obesity: WC ≥ 90 cm for M and ≥ 85 cm for F	Anthropometry, DXA	physical activity and reduced risk of SO
Santos VRD, et al. (2017) [89]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ALM/h ² , GS; Obesity: FM%	Sarcopenia: ALM/h ² < 7.59kg/m ² M and 5.57kg/m ² F (2 SD below the mean of a reference group) + GS < 0.8m/s; Obesity: FM% > 60th percentile (34.1 M and 44.2% F)	DXA, 3m walking test	association with low physical functions

Santos VRD, et al. (2017) [90]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: FM%;	Sarcopenia: SMI < 7.59 kg/m ² M and 5.57 kg/m ² F (2 SD below the mean of a reference group); Obesity: FM%>27% M and 38% F	DXA	high FM is associated with high blood concentration of TG and low MM show low mean levels of LDL-c
Schrager, et al. (2007) [91]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: HGS; Obesity: BMI, WC	Sarcopenia: HGS in lowest tertiles: < 33 Kg M and 19 Kg F; Obesity: GLOBAL=BMI>30 Kg/m ² , CENTRAL=WC in upper sex specific tertile (>98 M and 95 F)	Anthropometry, Dynamometer	contribution of inflammation in development and progression of SO
Scott D, et al. (2016) [92]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM; Dynapenia: limb muscle strength; Obesity: FM	Sarcopenia: ASM in the lowest sex-specific tertile (M ≤ 1.09; F ≤ 0.92); Dynapenia: the lowest sex-specific tertile for lower-limb muscle strength (M ≤ 112 kg; F ≤ 47.5 kg); Obesity: highest sex-specific tertile for FM (M > 27.02 kg; F > 32.83 kg)	DXA, dynamometer	association with osteoporosis
Scott D, et al. (2017) [93]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: EWGSOP and FNIH; Obesity: FM%	Sarcopenia: EWGSOP: ALM/h ² < 7.25 kg/m ² plus HGS < 30 kg or GS < 0.8 m/s; FNIH: ALM/BMI < 0.789 plus HGS < 26 kg; Obesity: FM > 30%	DXA, Dynamometer, 4m walking test	EWGSOP-defined sarcopenic obesity is associated with increased fall rates over 2 years, and FNIH-defined sarcopenic obese men have increased fracture risk over 6 years compared with non-sarcopenic obese men.

Scott, D, et al. (2018) [94]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: FNIH definition (ALM/BMI plus HGS); Obesity: BMI, FM%	Sarcopenia: ALM/BMI < 0.789 M, < 0.512 F plus HGS <26 kg M, < 16 kg F; Obesity: BMI \geq 30, FM% \geq 30 M, \geq 40 F	DXA, CT, Dynamometer, Anthropometry	higher level of ALM association with better bone health and balance
S�n�chal M, et al. (2012) [95]	dynapenic obesity	Dynapenia: HGS; Obesity: WC	Dynapenia: Lowest Leg Muscle strength tertile (M: 31.0 \pm 8.4 Nm; F: 21.0 \pm 5.3 Nm); Obesity: Sex- and Ethnicity-Specific WC cutoffs;	Anthropometry, Dynamometer	association with metabolic risk factors
Seo JA, et al. (2012) [96]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: VFA on CT	Sarcopenia: ASM/h ² <1 SD below the sex-specific mean of a young reference group (< 6.75 kg/m ² M and < 4.96 kg/m ² F). Obesity: VFA \geq 100 cm ² .	DXA, CT	greater VFA and lower MM are associated with lower 25(OH)D; SO do not have an additive association
Sharma D, et al. (2014) [97]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/h ² ; Obesity: BMI	Sarcopenia: ASMI < 5.45 kg/m ² F and < 7.26 kg/m ² M (2 SD below the sex-specific means for a reference group); Obesity: BMI > 30 kg/m ²	Anthropometry, DEXA	association with CKD
Siervo M, et al. (2012) [98]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ALM/h ² ; Obesity: BMI, FM%, WC, FMI.	Sarcopenia: SMI < 6,76 Kg/m ² (2 SD below the means of a reference group); Obesity: BMI \geq 30.0 kg/m ² , WC > 88.0 cm, FM% \geq 35.0%, FMI \geq 9.5 kg/m ² .	Anthropometry, BIA	prevalence

Silva Neto LS, et al. (2012) [99]	Sarcopenic obesity	SO: prediction equation for AFFM	The prediction equation for AFFM was: $AFFM = -14.529 + (17.989 \times h) + (0.1307 \times FM)$. The cutoff point corresponded to a residual value (the measured AFFM minus the AFFM predicted by the equation) ≤ -3.4 (≤ 2 SD from the mean of the reference group). Who showed a residual value ≤ -3.4 was classified as having inadequate FFM for their body area, which indicates sarcopenic obesity	DEXA	association with low QoL
Srikanthan P, et al. (2010) [100]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/Wt according to Janssen; Obesity: BMI	Sarcopenia: SMI < 2 SD below the sex specific (31.0% M, 22.0% F); Obesity: BMI > 30 kg/m ²	Anthropometry, BIA	sarcopenia, independent of obesity, is associated with adverse glucose metabolism
Tyrovolas S, et al. (2015) [101]	coexistence of obesity and sarcopenia (distinct diagnosis)	Sarcopenia: ASM/BMI, HGS, GS; Obesity: BMI	Sarcopenia: ASM/BMI in the lowest quintile (differs cut off for country) plus GS in lowest quintile or HGS < 30 Kg M, < 20 Kg F; Obesity: BMI ≥ 30 Kg/m ²	Anthropometry, dynamometer, 6m GS test	association of low muscle mass with disability

Legend: M = Male; F = Female; SO = Sarcopenic Obesity BMI = Body Mass Index; FM = Fat Mass; FFM = Fat Free Mass; FFMI = Fat Free Mass Index; FMI = Fat Mass Index = FM/h²; HGS = Hand Grip Strength; GS = Gait Speed; WC = Waist Circumference; ALM = Appendicular Lean Mass; ASM = Appendicular Skeletal

Muscle Mass; AFFM= Appendicular Fat Free Mass; SMI = Skeletal Muscle Mass Index; ASMI = Appendicular Muscle Mass Index; VFA = Visceral Fat Area; CSA = Cross Sectional Area; ABSI = A Body Shape Index ($WC/(BMI^{2/3} \times height^{1/2})$); NAFLD = Nonalcoholic Fatty Liver Disease; CKD = Chronic Kidney Disease; QoL = Quality of Life; AWSG = Asian Working Group for Sarcopenia

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Table 3: Parameters considered in the different studies to define sarcopenia and obesity

Sarcopenia		Obesity	
Parameter	N° of studies	Parameters	N° of studies
ASM/Wt	20	BMI	23
ASM/h ²	18	FM	19
ASM/h ² plus GS or HGS (EWGSOP criteria)	7	WC	10
ASM/h ² or ASM/Wt	3	VFA	4
FFMI	2	BMI or FM	3
MM (calculated with MAMC) plus GS or HGS	1	BMI or WC	2
ASM	1	FMI	2
ASM/h ² and GS (IWGS criteria)	1	BMI and VFA	1
HGS	1	BMI, FM, WC, FMI	1
ASM/h ² and ASM/Wt	1	FM or WC	1
ASM/h ² or GS or HGS	1		
Thigh muscle CSA/Wt	1		
Thigh muscle CSA	1		
ALM or ALM/BMI ratio	1		
ALM/BMI plus HGS	1		
ALM/BMI plus HGS or GS	1		
ALM/BMI plus HGS (FNIH definition) and ALM/h ² plus HGS or GS (EWGSOP definition)	1		
calf CSA	1		
MMI	1		
SMI plus HGS or GS (EWGSOP criteria) and SMI plus GS (IWGS criteria)	1		
TMM	1		

Legend: ALM= appendicular lean mass (kg); ASM= appendicular skeletal mass (kg); BMI= body mass index; CSA= cross sectional area (cm²); FFMI= fat free mass index; FM= fat mass (%); FMI= fat mass index; GS= gait speed (m/s); h= height; HGS= hand grip strength (kg); MM: muscle mass (kg); MAMC= mid-upper arm

muscle circumference (cm); SMI= skeletal mass index; VFA= visceral fat area (cm²); WC= waist circumference (cm); Wt=weight (Kg); TMM= Total Muscle Mass (kg).

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Table 4. Cut-points considered in the papers included in the systematic review for the definition of sarcopenia and obesity

	Diagnostic Criteria (cut-points)	
	Sarcopenia	Obesity
Aggio DA, et al. (2016) [30]	lowest two-fifths of the MAMC distribution plus HGS <30 kg or GS \leq 0.8 m/s	WC > 102 cm
Aibar-Almazán A, et al. (2018) [31]	ASM/h ² < 6.42 Kg/m ² plus HGS < 20 kg or GS < 0.8 m/s	FM > 35%
An KO, et al, (2016) [32]	SMI 1 SD below the mean of a young population reference group (< 30.1% M and 21.2% F)	WC sex-specific cutoff point for Asians (\geq 90 cm M and 80 cm F)
Atkins JL, et al.. (2014) [33]	lowest two-fifths of the FFMI (\leq 16.7 kg/m ²)	those above the percentile point of FMI corresponding to the WC obesity cutoff (28.7th percentile) (>11.1 kg/m ²)
Baek J, et al. (2013) [34]	ASM/h ² or ASM/Wt 1 SD below the mean of the young reference group	BMI \geq 25 kg/m ²
Baek SJ, et al. (2014) [35]	ASM/h ² \leq 2 SD below reference values from young (10.7 kg/m ² M and 8.6 kg/m ² F)	BMI > 25 kg/m ²
Bahat G, et al. (2018) [51]	SMI < 9.2 kg/m ² M, 7.4 kg/m ² F and HGS < 22 kg F, < 32 kg M or GS < 0.8 m/s	FM above 60th percentile or BMI \geq 30 kg/m ²
Balachandran A, et al. (2014) [36]	ASM/h ² < 10.76 kg/m ² M, 6.76 kg/m ² F plus GS < 1 m/s or HGS < 30 kg M and < 20 kg F	BMI > 30 kg/m ²
Batsis JA, et al. (2013) [37]	8 different definitions: 1)ASM/h ² : < 7.26 kg/m ² M, < 5.45 kg/m ² F; 2) Total body skeletal mass/m ² < 9.12 kg/m ² M - 6.53 kg/m ² F; 3) Total body skeletal mass/h ² : < 5.7kg/m ² F; 4) ASM/h ² : < 8.51 - 6.29 kg/m ² M; 5) ASM/body mass%: < 25.7% M, < 19.4% F; 6) ASM/h ² : < 7.4 - 5.14 kg/m ² M; 7) Total skeletal muscle mass/Wt: < 30.7%; 8) ASM/h ² : < 8.81kg/m ² M, <7.36 kg/m ² F	6 different definitions:1) FM > 27% M, 38% F; 2) FM > 37.16% M, 40.01% F; 3) FM: > 42.9% F; 4) FM > 28% M, 35% F; 5) WC: > 102 cm M, 88 cm F; 6) FM: > 20.7% M, 31.7% F
Batsis JA, et al. (2014) [38]	SMI (ASM/h ²). M: class I: 8.51–10.75 kg/m ² ; class II: \leq 8.50 kg/m ² ; F: class I: 5.76–6.75 kg/m ² ; class II: \leq 5.75 kg/m ²	FM \geq 27% M and \geq 38% F
Batsis JA, et al. (2015) [39]	ALM <19.75 kg M and <15.02 kg F OR ALM/BMI ratio	FM > 25% M and 35% F

	<0.789 M and <0.512 F	
Batsis JA, et al. (2016) [40]	Dynapenia: knee extensor strenght in the lowest tertile (M: 365.8 - 458.2 N; F 235.3 - 304.1 N)	BMI \geq 30 Kg/m ²
Biolo G, et al. (2015) [41]	SO: FM/FFM RATIO > 0,8	
Bouchard DR, et al. (2009) [42]	ASMI 2 SD below the mean of a cohort of young adults (<6.29 kg/m ² F and <8.51 kg/m ² M)	FM \geq 35% F and \geq 28% M
Cesari M, et al. (2009) [43]	calf CSA in the lowest tertile	BMI>30kg/m ²
Chen HT, et al. (2017) [44]	ASM/Wt \leq 32,5 M, \leq 25,7 F	BMI \geq 25 Kg/cm ² and VFA \geq 100 cm ²
Cho Y, et al. (2015) [45]	ASM/Wt < 23,8% F, < 30,3% M (< 1 SD below the mean value of the reference group)	WC \geq 90 cm M, \geq 85 cm F
Chung JH, et al.(2016) [46]	ASM/h ² < 7,26 Kg/m ² M, < 5,45 Kg/m ² F (<2 SDs below the sex-specific mean of a young reference group)	FM >30% M, >40% F
Chung JY, et al. (2013) [47]	ASM/Wt < 32,5% M, < 25,7% F (1 SD below the mean of a reference group)	BMI \geq 25 Kg/m ²
De Rosa E, et al. (2015) [48]	MODERATE (between 1 - 2 SD) SMI 8.44 - 9.53 kg/m ² and SEVERE (below 2 SD) SMI \leq 8.43 kg/m ² M, MODERATE SMI 6.49 - 7.32 kg/m ² and SEVERE SMI \leq 6.48 kg/m ² F	BMI \geq 30 Kg/m ²
Domiciano DS, et al. (2013) [49]	SMI < 5,45 Kg/m ² F	BMI \geq 30 Kg/m ²
dos Santos EP, et al. (2014) [50]	Sarcopenia: SMI < 5,45 Kg/m ² F; SO: the residual values of a regression equation that predicts AFFM based on height (m) and FM (kg). The equation: predicted AFFM = 14.529 + (17.989 x h) + (0.1307 x FM). the cutoff value corresponds to a residual \leq 3.4	
Hamer M, et al. (2017) [52]	SO: BMI >30 Kg/m ² in the lowest tertile of sex-specific HGS (35.3 kg M and 19.6 kg F)	
Huo YR, et al. (2016) [53]	ALM/h ² <5.5 kg/m ² F and <7.26 kg/m ² M plus GS <80 cm/s or HGS <20 kg F and <30 kg M	BMI \geq 30 Kg/m ²
Hwang B, et al. (2012) [54]	ASM/Wt 2 SD below mean value of sex-specific young normal people (29.53% M and 23.20% F)	WC \geq 90 cm M and \geq 85 cm F
Ishii S, et al. (2016) [55]	ASM/h ² 2 SD below the mean values of young reference groups (< 7.0 kg/m ² M, < 5.8 kg/m ² F) plus HGS < 30 Kg M, < 20 Kg F or GS < 1,26 m/s M and F	FM% in the highest quintile (cutoff values: 29.7% M, 37.2% F)
Joppa P, et al. (2016) [56]	FFMI < 10th percentile of the reference values	FMI \geq 90th percentile of the reference values
Kemmler W, et al. (2016) [57]	EWSGOP: ASM/h ² \leq 5.45 kg/m ² plus GS \leq 0,8 m/s or	BMI \geq 30 kg/m ² and FM \geq 35 %

	HGS at <20 kg; IWGS: GS \leq 1.0 m/s, and ASM/h ² in the lowest quintile	
Kim H, et al. (2016) [58]	SMI < 5,67 Kg/m ² or HGS < 17.0 kg or GS < 1.0 m/s	FM \geq 32%
Kim JH, et al. (2015) [59]	ASM/Wt < 1 sd below the mean of the sex-specific healthy reference group. Cutoff point 31.30% M and 24.76% F	BMI \geq 25 kg/m ²
Kim TN, et al. (2014) [60]	ASM/h ² < 7,50 Kg/m ² M, < 5,38 Kg/m ² F or ASM/Wt < 32,2% M, < 25,6% F (< 1SD below mean of young reference group)	WC >90 cm M, >85 cm F
Kim TN, et al. (2009) [24]	ASM < 7,40 Kg/m ² M, < 5,14 Kg/m ² F (2 DS below the sex-specific normal mean of a reference group). 4 differents groups: 1) normal body fat and muscle mass, 2) sarcopenia, 3) obesity, 4) SO	FM > 20,21% M, 31,71% F (upper two quintiles)
Kim YS, et al. (2012) [61]	ASM/Wt < 29,5% M, < 23,2% F (< 2 SD of young reference population)	BMI \geq 27.5 Kg/m ²
Kim MK, et al. (2011) [62]	SMI < 36,3% M, < 28,5% F (1 SD below the sex-specific mean value for a young reference group)	VFA \geq 100 cm ² F, \geq 130 cm ² M
Kohara K, et al. (2011) [63]	tight CSA/Wt < 1SD below young reference group (< 1,9 cm ² /Kg M, < 1,6 cm ² /Kg F)	VFA >100 cm ²
Kwon SS, et al, (2017) [64]	ASM/Wt < 30,98 M, < 24,81 F (- 1 SD below the mean of a reference group)	BMI \geq 25 Kg/m ²
Lee J, et al. (2016) [65]	ASM/Wt. Class I between 42,9 - 38,2% M, between 35,6 - 32,2% F (between 1 -2 SD of young reference group); Class II < 38,2% M, < 32,2% F (below 2 SD); SO was defined as class II sarcopenia plus obesity	FM > 25.8% M and 36.5% F (2 highest quintiles)
Lee S, et al. (2012) [66]	ASM/Wt < 26,8% M, < 21% F (<2SD of mean in a young reference group)	BMI \geq 27.5 Kg/m ²
Lee YH, et al. (2015) [67]	SMI \leq 32.2% M and \leq 25.5% F (< 1 SD below mean sex-especific reference group)	BMI \geq 25 kg/m ²
Levine ME, et al. (2012) [68]	ASM < 25.72% M and 19.43% F (<2 SD below the mean of a young reference group)	WC > 102 cm M, >88 cm F
Liao CD, et al. (2017) [69]	SMI < 7.15 kg/m ² plus HGS < 14.3 kg or GS < 1.0 m/s	FM >38%
Lim KI, et al. (2010) [70]	ASM/h ² < 7.0 kg/m ² M, < 5.4 kg/m ² F, HGS <26 Kg M, <18 kg F, GS <0.8 m/s	WC > 90 cm M, > 85 cm F
Lim JP, et al. (2015) [71]	VFA/TMA Median higher 50th percentile (0,90 F and	

	0,93 M)	
Lim S, et al. (2010) [72]	ASM/h ² < 7.09 kg/m ² in M, < 5.27 kg/m ² in F and ASM/Wt < 29.9% in M and 25.1% in F (1 SD below the sex-specific mean for a young reference group)	VFA >100 cm ²
Lu CW, et al. (2013) [73]	SMI <37% M, < 27.6% F	BMI ≥ 25 kg/m ²
Marini E, et al. (2012) [74]	SMI < 7.26 kg/m ² M, < 5.45 kg/m ² F	FM > 27% M, > 38% F
Meng P, et al. (2014) [75]	SMI% < 28.0% M plus GS ≤ 0.8 m/s or HGS < 22.4 kg M	BMI > 27.5 kg/m ²
Moreira MA, et al. (2016) [76]	SMI < 6.08 kg/m ² (< 20th percentile of the sample)	WC ≥88 cm
Muñoz-Arribas A, et al. (2013) [77]	total muscle mass ≤ 8.11 Kg M, ≤ 5.80 Kg F (2 lowest quintile)	FM ≥33.08% M, ≥43.91% F (2 highest quintile)
Muscariello E, et al. (2016) [78]	Class I: Muscle mass index (MMI) < 8.3 kg/m ² ; Class II: < 7,3 Kg/m ² (if BMI ≥30kg/m ²); Class I: MMI < 7,4 kg/m ² ; Class II < 6,8 (if BMI < 25 kg/m ²) (2 standard deviations below the mean of the reference group)	BMI ≥30 kg/m ²
Oh C, et al. (2017) [79]	ASM/Wt 1 SD below the mean value of a reference group	BMI ≥ 25 kg/m ²
Oh C., et al. (2015) [80]	ASM/Wt < 44 % M, 52 % F (less than 1 SD below the mean of a reference sample)	BMI ≥ 25 Kg/m ²
Oliveira RJ, et al. (2011) [81]	Sarcopenia: FFM ≤ 2 SD of the mean of the reference sample consisting of young woman; SO: the residual values of a regression equation that predicts AFFM based on h (m) and FM (kg). The equation: predicted AFFM = -14.529 + (17.989 x h) + (0.1307 x FM). the cutoff value corresponds to a residual ≤ 3.4	
Park SH, et al. (2013) [83]	ASM/Wt < 29,5% M, < 23,2% F	WC ≥ 90 cm M, ≥ 85 cm F
Pedrero-Chamizo R, et al. (2015) [84]	RMM < 6,20% F, < 8,62% M (lower 2 quintiles) 4 Groups: 1)Normal, 2)Obesity, 3)Sarcopenia, 4)SO.	FM > 40,90% F, > 30,33% M (upper 2 quintiles of the reference group).
Perna S, et al. (2017) [82]	SMI (ASM/h ²) below the 5th centile for age- and gender-matched healthy subjects	FM > 38% F, > 27% M
Poggiogalle E, et al. (2016) [85]	ASMM/h ² <6.54 Kg/m ² M, < 4.82 Kg/m ² F or ASMM/Wt <0.2827 M, <0.2347 F(< 2 SD than the sex-specific mean of a young population)	BMI ≥ 30 Kg/m ²
Prado CM, et al. (2014) [5]	4 specific body-composition phenotypes: 1)LA-HM (low adiposity high muscle: ASMI 50 - 100 Kg/m ² ;	4 specific body-composition phenotypes: 1)LA-HM (low adiposity high muscle: ASMI 50 - 100 Kg/m ² ;

	FMI 0 - 49,99 Kg/m ²); 2)HA-HI (high adiposity high muscle: ASMI 50-100 Kg/m ² ; FMI 50-100 Kg/m ²); 3) LA-LM (low adiposity low muscle: ASMI 0–49.99 Kg/m ² ; FMI: 0–49,99 Kg/m ²); 4) HA-LM (high adiposity low muscle ASMI 0-49,99 Kg/m ² ; FMI: 50-100 Kg/m ²). The HA-LM cutoffs were as follows: class I (ASMI: 40–49.99 Kg/m ² ; FMI: 60–100 Kg/m ²), class II (ASMI: 20–39.99 Kg/m ² ; FMI: 80–100 Kg/m ²), and class III (ASMI: 0–19.99 Kg/m ² ; FMI: 80–100 Kg/m ²).	FMI 0 - 49,99 Kg/m ²); 2)HA-HI (high adiposity high muscle: ASMI 50-100 Kg/m ² ; FMI 50-100 Kg/m ²); 3) LA-LM (low adiposity low muscle: ASMI 0–49.99 Kg/m ² ; FMI: 0–49,99 Kg/m ²); 4) HA-LM (high adiposity low muscle ASMI 0-49,99 Kg/m ² ; FMI: 50-100 Kg/m ²). The HA-LM cutoffs were as follows: class I (ASMI: 40–49.99 Kg/m ² ; FMI: 60–100 Kg/m ²), class II (ASMI: 20–39.99 Kg/m ² ; FMI: 80–100 Kg/m ²), and class III (ASMI: 0–19.99 Kg/m ² ; FMI: 80–100 Kg/m ²).
Ramachandran R, et al. (2012) [86]	adjusted thigh muscle area < 93,8 cm ² F, < 110,7 cm ² M (lowest sex-specific tertile); 8 different groups	BMI > 27 kg/m ² ; WC > 88 cm F, > 102 cm M
Rolland Y, et al. (2009) [12]	ASM/h ² < 5,45 Kg/m ² F (<2 SD below young ref group from Rosetta study)	FM% > 60th percentile
Rossi AP, et al. (2017) [87]	Dynapenia: HGS < 33 kg M, < 19 kg F (lowest tertile)	WC > 99 cm M, 95 cm F
Ryu M, et al. (2013) [88]	ASM/Wt < 2 SD	WC ≥ 90 cm for M and ≥ 85 cm for F
Santos VRD, et al. (2017) [89]	ALM/h ² < 7.59kg/m ² M and 5.57kg/m ² F (2 SD below the mean of a reference group) + GS < 0.8m/s	FM% > 60th percentile (34.1 M and 44.2% F)
Santos VRD, et al. (2017) [90]	SMI < 7.59 kg/m ² M and 5.57 kg/m ² F (2 SD below the mean of a reference group)	FM%>27% M and 38% F
Schrager, et al. (2007) [91]	HGS in lowest tertiles: < 33 Kg M and 19 Kg F	GLOBAL=BMI>30 Kg/m ² , CENTRAL=WC in upper sex specific tertile (>98 M and 95 F)
Scott D, et al. (2016) [92]	Sarcopenia: ASM in the lowest sex-specific tertile (M ≤ 1.09; F ≤ 0.92); Dynapenia: the lowest sex-specific tertile for lower-limb muscle strength (M ≤ 112 kg; F ≤ 47.5 kg)	highest sex-specific tertile for FM (M > 27.02 kg, F > 32.83 kg)
Scott D, et al. (2017) [93]	EWGSOP: ALM/h ² <7.25 kg/m ² plus HGS <30 kg or GS <0.8 m/s; FNIH= ALM/BMI <0.789 plus HGS <26 kg	FM > 30%
Scott, D, et al. (2018) [94]	ALM/BMI < 0.789 M, < 0.512 F plus HGS <26 kg M, < 16 kg F	BMI≥30 kg/m ² , FM%≥ 30 M, ≥ 40 F
Sénéchal M, et al. (2012) [95]	Dynapenia: Lowest Leg Muscle strength tertile (M: 31.0 ± 8.4 Nm; F: 21.0 ± 5.3 Nm)	Sex- and Ethnicity-Specific WC cutoffs
Seo JA, et al. (2012) [96]	ASM/h ² <1 SD below the sex-specific mean of a young reference group (< 6.75 kg/m ² M and < 4.96 kg/m ² F)	VFA ≥ 100 cm ²
Sharma D, et al. (2014) [97]	ASMI < 5.45 kg/m ² F and < 7.26 kg/m ² M (2 SD below the sex-specific means for a reference group)	BMI > 30 kg/m ²

Siervo M, et al. (2012) [98]	SMI < 6,76 Kg/m ² (2 SD below the means of a reference group)	BMI ≥ 30.0 kg/m ² , WC > 88.0 cm, FM% ≥ 35.0%, FMI ≥ 9.5 kg/m ²
Silva Neto LS, et al. (2012) [99]	The prediction equation for AFFM was: $AFFM = -14.529 + (17.989 \times h) + (0.1307 \times FM)$. The cutoff point corresponded to a residual value (the measured AFFM minus the AFFM predicted by the equation) ≤ -3.4 (≤ 2 SD from the mean of the reference group). Who showed a residual value ≤ -3.4 was classified as having inadequate FFM for their body area, which indicates sarcopenic obesity	
Srikanthan P, et al. (2010) [100]	SMI < 2 SD below the sex specific (31.0% M, 22.0% F)	BMI > 30 kg/m ²
Tyrovolas S, et al. (2015) [101]	ASM/BMI in the lowest quintile (different cut off for contry) plus GS in lowest quintile or HGS < 30 Kg M, < 20 Kg F	BMI ≥ 30 Kg/m ²

Legend: M = Male; F = Female; SO = Sarcopenic Obesity BMI = Body Mass Index; FM = Fat Mass; FFM = Fat Free Mass; FFMI = Fat Free Mass Index; FMI = Fat Mass Index = FM/h²; HGS = Hand Grip Strenght; GS = Gait Speed; WC = Waist Circumference; ALM = Appendicular Lean Mass; ASM = Appendicular Skeletal Muscle Mass; AFFM= Appendicular Fat Free Mass; SMI = Skeletal Muscle Mass Index; ASMI = Appendicular Muscle Mass Index; VFA = Visceral Fat Area; CSA = Cross Sectional Area; ABSI = A Body Shape Index ($WC/(BMI^2/3 \times height^{1/2})$); NAFLD = Nonalcoholic Fatty Liver Disease; CKD = Cronic Kidney Disease; QoL = Quality of Life; AWSG = Asian Working Group for Sarcopenia

Table 5. Quality assessment of the papers included in the systematic review [Modesti Pa et al. Plos One 2016 (29)]

	Selection (0-5 stars)	Comparability (0-2 stars)	Outcome (0-3 stars)	Total score
Aggio DA, et al. (2016) [30]	4	2	3	9
Aibar-Almazán A, et al. (2018) [31]	3	2	3	8
An KO, et al, (2016) [32]	4	2	3	9
Atkins JL, et al.. (2014) [33]	4	2	3	9
Baek J, et al. (2013) [34]	2	2	3	7
Baek SJ, et al. (2014) [35]	4	2	3	9
Bahat G, et al. (2018) [51]	2	2	3	7
Balachandran A, et al. (2014) [36]	4	2	3	9
Batsis JA, et al. (2013) [37]	4	2	3	9
Batsis JA, et al. (2014) [38]	4	2	3	9
Batsis JA, et al. (2015) [39]	2	2	3	7
Batsis JA, et al. (2016) [40]	4	2	3	9
Biolo G, et al. (2015) [41]	4	2	3	9
Bouchard DR, et al. (2009) [42]	4	2	3	9
Cesari M, et al. (2009) [43]	2	2	3	7
Chen HT, et al. (2017) [44]	4	2	3	9
Cho Y, et al. (2015) [45]	4	2	3	9
Chung JH, et al.(2016) [46]	4	2	3	9
Chung JY, et al. (2013) [47]	2	1	3	6
De Rosa E, et al. (2015) [48]	2	2	3	7
Domiciano DS, et al. (2013) [49]	2	2	3	7
dos Santos EP, et al. (2014) [50]	2	1	3	6
Hamer M, et al. (2017) [52]	5	2	3	10
Huo YR, et al. (2016) [53]	5	1	3	9
Hwang B, et al. (2012) [54]	5	2	3	10
Ishii S, et al. (2016) [55]	5	2	3	10
Joppa P, et al. (2016) [56]	5	2	3	10
Kemmler W, et al. (2016) [57]	5	2	3	10
Kim H, et al. (2016) [58]	4	2	3	9

Kim JH, et al. (2015) [59]	5	2	3	10
Kim TN, et al. (2014) [60]	3	2	3	8
Kim TN, et al. (2009) [24]	5	2	3	10
Kim YS, et al. (2012) [61]	5	2	3	10
Kim MK, et al. (2011) [62]	2	2	3	7
Kohara K, et al. (2011) [63]	5	2	3	10
Kwon SS, et al, (2017) [64]	2	1	3	6
Lee J, et al. (2016) [65]	5	2	3	10
Lee S, et al. (2012) [66]	5	2	3	10
Lee YH, et al. (2015) [67]	5	2	3	10
Levine ME, et al. (2012) [68]	3	1	3	7
Liao CD, et al. (2017) [69]	2	1	3	6
Lim KI, et al. (2010) [70]	2	1	3	6
Lim JP, et al. (2015) [71]	2	1	3	6
Lim S, et al. (2010) [72]	2	1	3	6
Lu CW, et al. (2013) [73]	3	1	3	7
Marini E, et al. (2012) [74]	3	2	3	8
Meng P, et al. (2014) [75]	3	1	3	7
Moreira MA, et al. (2016) [76]	2	2	3	7
Muñoz-Arribas A, et al. (2013) [77]	3	2	3	8
Muscariello E, et al. (2016) [78]	3	2	3	8
Oh C, et al. (2017) [79]	5	2	3	10
Oh C., et al. (2015) [80]	3	2	3	8
Oliveira RJ, et al. (2011) [81]	3	2	3	8
Park SH, et al. (2013) [83]	5	2	3	10
Pedrero-Chamizo R, et al. (2015) [84]	5	2	3	10
Perna S, et al. (2017) [82]	3	2	3	8
Poggiogalle E, et al. (2016) [85]	5	2	3	10
Prado CM, et al. (2014) [5]	3	2	3	8
Ramachandran R, et al. (2012) [86]	4	2	3	9
Rolland Y, et al. (2009) [12]	5	2	3	10
Rossi AP, et al. (2017) [87]	5	2	3	10
Ryu M, et al. (2013) [88]	2	1	3	6
Santos VRD, et al. (2017) [89]	2	1	3	6

Santos VRD, et al. (2017) [90]	4	2	3	9
Schrager, et al. (2007) [91]	4	2	3	9
Scott D, et al. (2016) [92]	5	2	3	10
Scott D, et al. (2017) [93]	2	1	3	6
Scott, D, et al. (2018) [94]	5	1	3	9
Sénéchal M, et al. (2012) [95]	2	2	3	7
Seo JA, et al. (2012) [96]	5	1	3	9
Sharma D, et al. (2014) [97]	3	1	3	7
Siervo M, et al. (2012) [98]	2	1	3	6
Silva Neto LS, et al. (2012) [99]	4	2	3	9
Srikanthan P, et al. (2010) [100]	3	1	3	7
Tyrovolas S, et al. (2015) [101]	5	2	3	10

PRISMA FLOW DIAGRAM

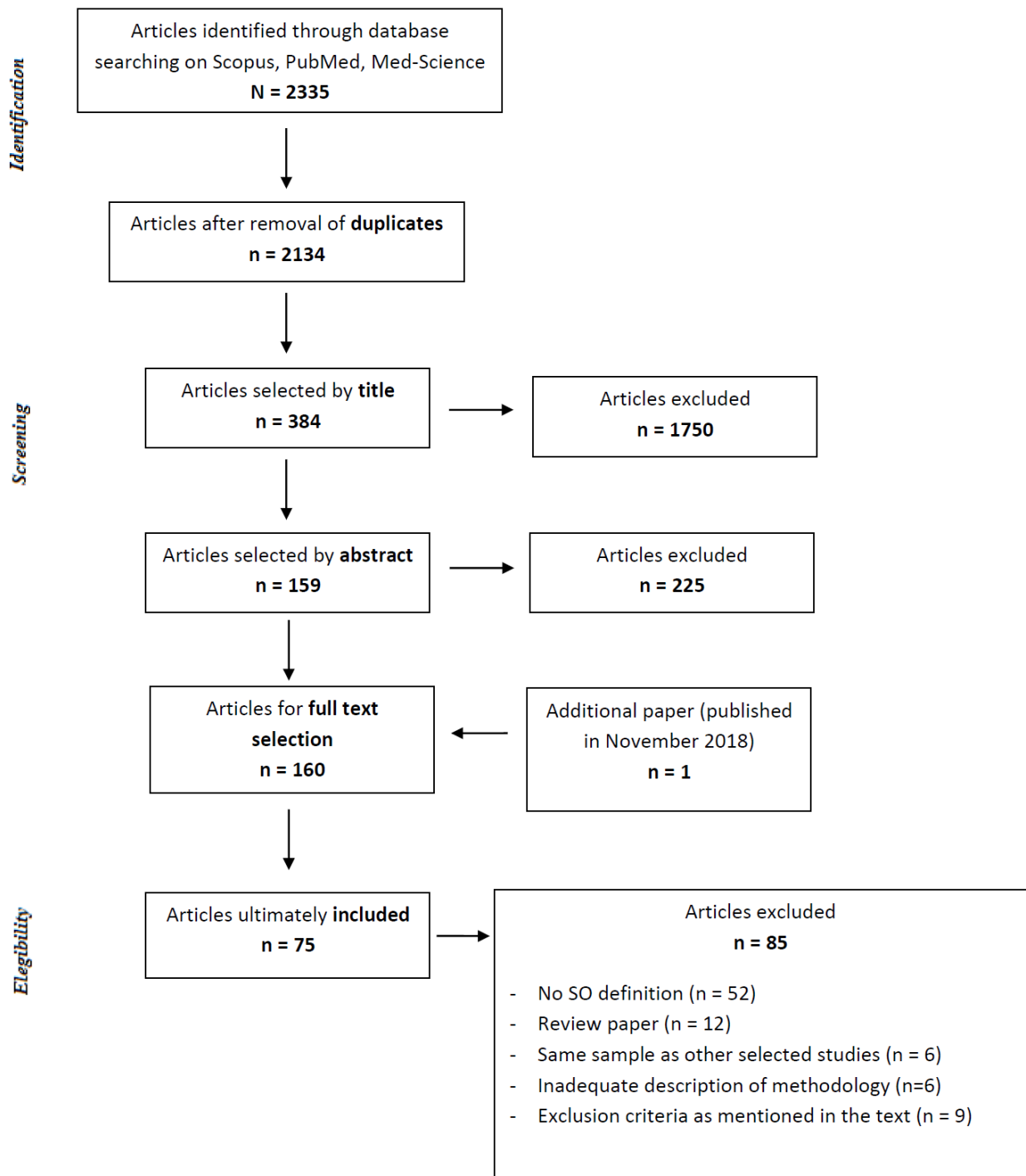


Figure 1. PRISMA flow diagram

Legend. SO: sarcopenic obesity

Number of studies

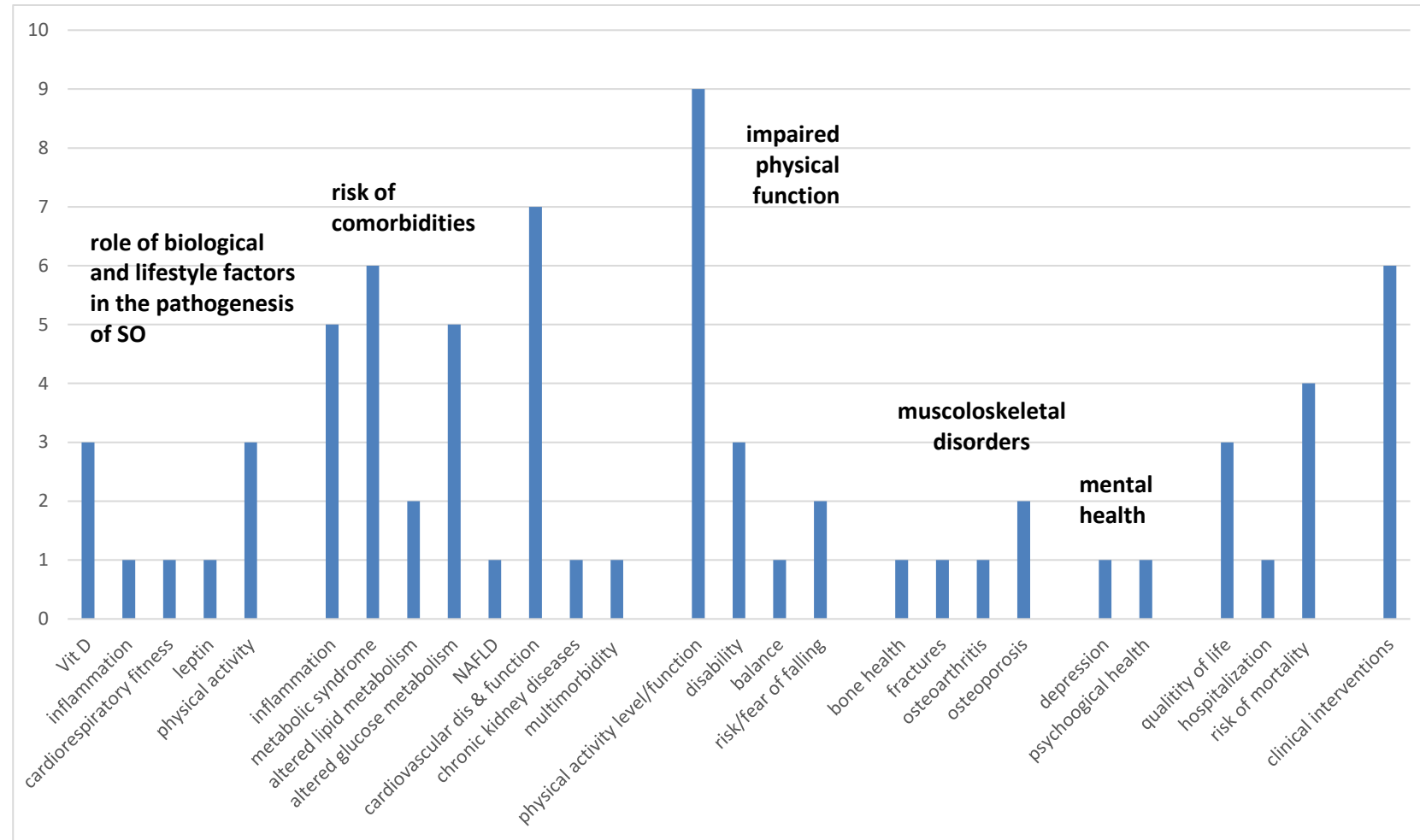


Figure 2. Abbreviated description of Aims of N=75 studies included in the analysis

Legend. SO: sarcopenic obesity ; NAFLD: non-alcoholic fatty liver disease