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GDLAM and SPPB batteries for screening sarcopenia in community-dwelling Spanish older adults: Healthy-age network study

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ABSTRACT

Objectives: To determine the diagnostic ability of GDLAM and SPPB batteries to classify people with sarcopenia according to the European Working Group on Sarcopenia in Older People (EWGSOP19).

Study design: This cross-sectional study recruited 584 participants (240 men, 65.33 ± 8.68 years old). The diagnostic criteria of the EWGSOP19 for probable, confirmed and severe sarcopenia were used as the standard. Then, the Latin American Group for Maturity battery-GDLAM- and the short physical performance battery-SPPB- were measured. The ability as screening methods of these two batteries were determined by specific indicators including sensitivity, specificity, receiver operating characteristic (ROC) curve, and area under the ROC curves (AUC).

Main outcome measures: Anthropometric variables (Body mass, height, triceps, thigh and calf skinfolds and relaxed arm, middle-thigh and calf girths), handgrip strength (HG), chair stand, 4 m walk, and timed-up-and-go-tests (TUG) as well as the Latin American Group for Maturity battery (GDLAM) and the short physical performance battery (SPPB) were performed.

Results: The GDLAM battery shows a sensitivity from moderate to high (60.1–72.2 %), and specificity from moderate (57.6 %) to very high (90.7 %) to identify sarcopenia categories (probable, confirmed and severe). However, the SPPB battery shows a lack of classification ability for probable sarcopenia (AUC = 0.436; p = 0.123), confirmed sarcopenia (AUC = 0.499; p = 0.959) and severe sarcopenia (AUC = 0.484; p = 0.532). Those participants classified as probable sarcopenia or confirmed sarcopenia measured by GDLAM battery according to the cut-off points obtained in the ROC curve showed a higher probability to be in the probable sarcopenia (OR = 2.8; p = 0.001) or confirmed sarcopenia categories (OR = 10; p = 0.002), respectively, based on EWGSOP19 criteria.

Conclusions: The GDLAM screening battery showed improved properties in terms of distinguishing individuals at risk for sarcopenia from those who were not.

Abbreviations: BMI, Body Mass Index; CIs, confidence intervals; EWGSOP19, European Working Group on Sarcopenia in Older People; GDLAM, Latin American Group for Maturity battery; HG, handgrip strength; ISAK, International Society for Advancement on Kinanthropometry; Healthy-Age, active ageing, exercise and health network; PTS, put on and take off a t-shirt; SCMA, sit and get up from the chair and move around the house; SPP, standing up from the prone position; SPPB, short physical performance battery; SSP, stand up from sitting position; TEM, technical error of measurements; TUG, timed-up-and-go-test; UAL, University of Almería; UCA, University of Cádiz; UCAM, Catholic University San Antonio of Murcia; W10 m, walk 10 m.

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1. Introduction

Physical performance is an important indicator of health status especially in older adults. A decline in physical performance is associated with worse quality of life and negative health results, as a decline at the physical (Lee et al., 2021) and cognitive levels (Zaninotto et al., 2018), and is a good predictor of a future place of residence (home, hospital or geriatric residence) and risk of death (Pavasini et al., 2016). Through the assessment of physical performance, we can detect early functional impairment in order to take action to prevent or reverse further deterioration of physical function and possible loss of functional independence (Freiberger et al., 2012).

Sarcopenia is a disease that causes progressive loss of muscle mass, strength, and function with age (Liguori et al., 2018). The revised European consensus published in 2019 by the European Working Group on Sarcopenia in Older People (EWGSOP19), indicate that sarcopenia is a progressive disease of skeletal muscle that results in the loss of muscle mass and strength and is associated with the potential for falls, broken bones, increased loss of function and physical disability and even death (Kitamura et al., 2021; Xie et al., 2021). They therefore propose diagnostic measures and cut-off points for use in the clinical setting, such as the assessment of physical fitness and muscle mass (Cruz-Jentoft et al., 2019). Therefore, classification and measurement of function and sarcopenia in older adults is of particular importance in health care and at the policy level (Bruyère et al., 2019; Cebrià i Iranzo et al., 2020; Fried et al., 2004; Iolascon et al., 2014; Walston, 2012). Different studies have defined reference cut-off values for sarcopenia (Bahat et al., 2016; Fernandes et al., 2021; Kara et al., 2019; Phu et al., 2020; Wallengren et al., 2021; Wigodski et al., 2019).

In addition, correct diagnosis of sarcopenia requires costly tests and skilled personnel, which limits population-level screening for sarcopenia. Due to the increasing prevalence of sarcopenia with aging, there is a need for simple, rapid, valid and reliable instruments to assess sarcopenia and be able to detect it (Marcos-Pardo et al., 2021), and two well-know and widely used batteries such as the Latin American Group for Maturity battery (GDLAM) and short physical performance battery (SPPB) could be of relevance for that.

A novel instrument for the diagnosis of sarcopenia is the designed under the GDLAM battery, which is composed of five tests that assess physical performance levels and which has been previously used in numerous studies with older adults (Boechat et al., 2007; Borba-Pinheiro et al., 2016; Carrasco-Poyatos et al., 2019; Marcos-Pardo et al., 2019; Pereira et al., 2007). To our knowledge, this is the first study to test the reliability and validity of GDLAM with respect to sarcopenia, according to the EWGSOP19 reference values. Another well-known battery is the SPPB considered a valid and reliable instrument, easy and quick to use that has reliability and validity for measuring physical performance in community settings and the clinical setting (Bergland and Strand, 2019; Freiberger et al., 2012). SPPB has also been used to measure muscle mass loss and as a criterion of physical performance to define sarcopenia (Lee et al., 2021; Marcos-Pardo et al., 2020a, 2020b). Therefore, the aim of this study was to determine the diagnostic ability of GDLAM and SPPB batteries to classify people with sarcopenia according to the EWGSOP19. The hypothesis was that the GDLAM battery was a more reliable and valid instrument for the assessment of sarcopenia in community-dwelling older adults than the SPPB battery.

2. Materials and methods

2.1. Design and participants

The Healthy-Age cross-sectional study was designed to investigate the diagnostic ability of GDLAM and SPPB batteries to classify older adults with sarcopenia. The study was conducted at the Catholic University San Antonio of Murcia (UCAM), University of Cádiz (UCA) and the University of Almería (UAL) from Spain between 2020 and 2022. During the assessments, the safety measures provided by the Ministry of Public Health of the Government of Spain (Ministerio de Sanidad. Gobierno de España, 2020) and the COVID-19 committee of the university (Servicio Propio de Prevención de Riesgos Laborales y Comité UCAM Covid-19, 2020) between the evaluators and the older participants were taken into account. The study complied with the Strobe Statements and was conducted in a sports science laboratory and/or senior centers.

The sample was selected by placing advertisements in the Senior, Women's and Social Centres and by holding meetings in local communities in Murcia, Cadiz and Almeria. During the three-year duration of the study, 584 participants were recruited (65.33 ± 8.68 years old). Inclusion criteria were: (a) being over 50 years of age and (b) having functional independence. The exclusion criteria were: (a) not suffering from any musculoskeletal injury or physical limitation, (b) taking any medication that could influence their physical performance and (c) not suffering from a medically diagnosed moderate or severe cognitive impairment, or severe psychiatric problems (treatment for depression or psychosis).

2.2. Power and sample size

The power and sample size were established based on the standard deviation of the Global index variable from GDLAM battery found in an earlier study (Marcos-Pardo et al., 2020a, 2020b). A total of 584 participants were included in this study, which provided a power of 95 % and a significance level of $\alpha = 0.05$, with an estimated error of 0.38 point in Global index of GDLAM. To establish the sample size, the Rstudio 3.15.0 software was used.

2.3. Ethics approval and consent to participate

The present study obtained the approval by the Catholic University San Antonio of Murcia research ethics committee (code: CE111908), in accordance with the Declaration of Helsinki. Prior to participation in the study, all participants were informed of the study objectives and signed informed consent forms.

2.4. Procedure

All the assessments were performed in a single testing session by the same trained researchers in each center. First, a series of anthropometric variables were measured. After these, the handgrip strength (HG), chair stand, 4 m gait walk, timed-up-and-go-tests (TUG) as well as the SPPB and GDLAM battery were conducted in random order. Five minutes of rest time were allowed between tests and 2 min between trials when a test had more than one attempt.

To diagnose sarcopenia, principal component measurement was taken into consideration. HG and chair posture assessment tests were used to assess muscle strength (muscle quality). Muscle quantity (muscle mass) was assessed using kinanthropometry through formulas that estimate muscle mass (Lee et al., 2000) through corrected arm, thigh and leg girths (Vaquero-Cristóbal et al., 2016), following the methodology of previous research (Marcos-Pardo et al., 2021); and physical performance was assessed using gait speed, TUG and the SPPB battery. In relation to the EWGSOP19 cut-off points, the probability associated with each of these variables was established. If the person has a value of <27 kg (men) and 16 kg (women) in the HG test, or requires >15 s for the 5 chair stand test, the person was considered to have low muscle strength (muscle quality) (Cruz-Jentoft et al., 2019). Regarding muscle mass, it was considered low with the Lee equation, if the person has <28.3 kg (men) and 17.7 kg (women), based on the cut-off points compared to the DEXA derived EWGSOP criteria (Carnevale et al., 2018). A value <0.8 m/s for gait speed, <8 points on the SPPB battery or >20 s on the TUG were cut-off points for low physical performance (Cruz-Jentoft et al., 2019).

Based on these cut-off points, participants were classified as probable sarcopenia if they presented, in at least one test, lower values than those marked for the muscle strength tests (HG and/or chair stand test); confirmed sarcopenia if the participants had a low muscle quantity; and severe sarcopenia if they presented a low physical performance in some of the physical performance tests, following the methodology of previous studies (Cruz-Jentoft and Sayer, 2019; Fernandes et al., 2022; Marcos-Pardo et al., 2021).

2.5. Variables and instruments

Anthropometric variables: The International Society for Advancement on Kinanthropometry (ISAK) guidelines were followed for measuring the kinanthropometric parameters (Esparza-Ros et al., 2019). Body mass (kg) was evaluated in light clothing without footwear and was measured to the nearest 0.1 kg with an electronic scale (Tanita BC-418, Illinois, MA, USA). Height (cm) was measured using a stadiometer to the nearest millimeter (Tanita HR001, Illinois, MA, USA). Triceps, thigh and calf skinfolds were measured with a caliper (Harpenden, London, UK), with a precision of 0.2 mm. Relaxed arm, middle-thigh and calf girths were measured with an anthropometric measuring tape (W606PM, Lufkin, USA). The variables were measured twice, with a third measurement being necessary when the difference between the first two measurements was >5 % for the skinfolds and 1 % for the rest of the measurements. The mean of the measured values, when two measurements were performed, and the median of the values, when three measurements were performed, were used as the final value (Esparza-Ros et al., 2019). The intra- and inter-evaluator technical errors of measurements (TEM) were calculated in a sub-sample. The intra-evaluator TEM was 0.01 % for the basic measurements; 1.17 % for skinfolds, and 0.04 % for the girths; and the inter-evaluator TEM was 0.02 % for the basic measurements; 1.43 % for skinfolds and 0.05 % for the girths. After that, Body Mass Index (BMI) was calculated as weight (kg) divided by height (m) squared (Kvamme et al., 2012). BMI was classified as normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), obesity class I (30.0–34.9 kg/m^2) and obesity class II (35.0–39.9 kg/m^2) (World Health Organization, 2000). Muscle mass was estimated based on the Lee equation (Lee et al., 2000), as it is the recommended muscle mass formula for middle-aged and older adults (Alvero Cruz et al., 2009; Marcos-Pardo et al., 2021).

Muscle strength: HG was measured with the participant in an upright standing position with the arms by their sides. Each participant was asked to squeeze the grip with maximal strength for 3 s with the right hand. A mean was calculated from three repetitions (Roberts et al., 2011). A digital grip strength dynamometer was used for this (TKK 5401; Takei Scientific Instruments Co., Ltd., Tokyo, Japan) (Cruz-Jentoft et al., 2019; Marcos-Pardo et al., 2020a, 2020b).

The chair stand test was used to measure the strength of the leg muscles. This test measures the time needed by the participant to move 5 times from a seated position to a standing position as quickly as possible without using the arms. Only one test trial was allowed (Cruz-Jentoft et al., 2019).

Physical performance: Gait speed was assessed with a 4 m gait walk. For this test, the person had to walk at their usual pace and the total time needed to walk 4 m was recorded. This test has reported a high predictive validity and has been used extensively (Fernández-Huerta and Córdova-León, 2019; Guralnik et al., 1995, 2000; Ostir et al., 2002; Penninx et al., 2000). Two photocells connected to a computer were used in the test (MuscleLab, Ergotest, Langesund, Norway). These were placed at the beginning and end of the 4 m lane. The average value of two attempts was recorded.

Moreover, in the TUG test the participants had to get up from the chair, walk, go around a cone placed 3 m away, return to the chair and sit down again, without using their arms, as fast as possible without running. The best time registered of two attempts was used for the analysis (Bibiloni et al., 2017).

The SPPB is composed of the standing balance test, chair stand test and 4 m gait walk (Pavasini et al., 2016). For balance, the participant had to maintain three different positions for 10 s: (a) Feet together, (b) semi-tandem position (the ankle of one foot behind the joint of the other foot) and (c) tandem position (the toes of one foot directly behind the heel of the other foot and touching it). For the chair stand test and 4 m gait walk, the same procedure was followed as explained above. Up to 4 points could be obtained in each test, assuming a score range between 0 and 12 points. A higher score indicated a better physical performance (Guralnik et al., 2000; Pavasini et al., 2016).

Physical performance was also assessed through the GDLAM protocol of functional autonomy (Dantas et al., 2011), validated in the Spanish context (Marcos-Pardo et al., 2020a, 2020b) and composed of the following five tests:

(1) Walk 10 m (W10 m): the purpose of this test is to evaluate the gait speed of the participant for a distance of 10 m.
(2) To sit and get up from the chair and move around the house (SCMA): the objective is to assess the agility and balance of middle-aged and older adults in their life situations. With a chair fixed on the ground, two cones should be demarked diagonally to the chair, at a distance of 4 m behind and 3 m to the right and left sides of the same. The participants begin the test seated in the chair, with the feet on the floor, and with the sign "already," gets up, goes to the right, moves around the cone, returns to the chair, sits down, and takes both feet off the ground. Without hesitating, the participants do the same move to the left. Immediately, the same course is again completed, to the right and left, thus making the entire journey and circulating each cone twice, in the shortest time possible.
(3) Stand up from sitting position (SSP): the test aims to assess the functional capacity of the lower limbs. The test starts with the individual in the sitting position in a chair without arm support, and the seat at a distance from the ground of 50 cm, then, the individual stands up and takes a seat five times consecutively.
(4) Standing up from the prone position (SPP): the purpose of this test is to assess the overall ability of participants to get up the floor. The test starts with participants in a ventral decubitus position, with arms along the body; the command of "now", indicates that the participants must get up and leave the position as soon as possible.
(5) To put on and take off a T-shirt (PTS): the participants should be standing with arms along the body and a T-shirt in one of the hands. At the voice signal of "Go," they should put on the shirt and immediately take it off, returning to the starting position. This test is intended to measure the agility and coordination of the upper limbs.

The participants conducted all tests of the GDLAM battery twice in a suitable environment, in which the shortest time in seconds was recorded through a stopwatch. The equipment used consisted of a 48 cm chair (measured from the seat to the floor), a stopwatch (Casio, Malaysia), two cones, a T-shirt, a mat (Olive Fitness, Spain), and a sunny brand metal tape measure. After these tests, the GDLAM index of autonomy (GI) score was calculated (Marcos-Pardo et al., 2020a, 2020b), where the lower the value of the score, the better the result, using the following formula. All the tests were measured using time in seconds.

$$GI = [[(W10\,m + SSP + SPP + PTS) \times 2] + SCMA]/4$$

Supplementary file 1 includes an excel file with the protocol, evaluation form and more information about GDLAM battery.

2.6. Statistical analysis

The Kolmogorov–Smirnov test and Mauchly's W-test were used to evaluate the normality and the sphericity of the data. Mean and standard deviation were calculated from the quantitative variables, and frequency and percent were used for the qualitative variables.

To determine the adequacy, area under curve (AUC), cut-off point, specificity and sensitivity of GDLAM and SPPB for classification ability as probable, confirmed and severe sarcopenia, a Receiver Operating Characteristics (ROC) curve was calculated. The AUC of 1 is considered a perfect rating, lower of 0.5 represent an absence of rating accuracy, between 0.5 and 0.7 is considered poor, between 0.70 and 0.79 is considered good, between 0.80 and 0.89 is considered good, and higher than 0.90 is considered excellent.

Logistic regression analyses were used to estimate the probability or associations between the probable, confirmed and severe sarcopenia from GDLAM and probable, confirmed and severe sarcopenia from EWGSOP19 (Cruz-Jentoft et al., 2019). The results were reported as raw and adjusted odds ratios (ORs) with 95 % confidence intervals (CIs). The 95 % CI of the odds ratios was set to express the magnitude of the associations. The statistical analyses were performed using IBM SPSS Statistics (version 24.0). An error of $p \leq 0.05$ was established.

3. Results

Table 1 shows the characteristics of the participants.

ROC curve analysis is shown for GDLAM and SPPB as detector variables for probable, confirmed and severe sarcopenia; showing the AUC, error deviation, significance, 95%CI, sensitivity and specificity (Table 2). ROC curve is shown in Fig. 1.

The GDLAM battery shows a good AUC for probable sarcopenia (AUC = 0.869; p<0.001), and poor for confirmed sarcopenia (AUC = 0.617; p<0.001) and severe sarcopenia (AUC = 0.601; p<0.001). The cut-off points for probable, confirmed and severe sarcopenia were 24.46, 24.22 and 29.85; respectively; showing a sensitivity of high (72.2 %), moderate (63.0 %) and moderate (60.1 %), respectively; and specificity of very high (90.7 %), moderate (57.6 %) and moderate (58.7 %), respectively. On the other hand, the SPPB battery shows a lack of classification ability for probable sarcopenia (AUC = 0.436; p = 0.123), confirmed sarcopenia (AUC = 0.499; p = 0.959) and severe sarcopenia (AUC = 0.484; p = 0.532).

The risk associated between probable, confirmed and severe sarcopenia according to the EWGSOP19 (Cruz-Jentoft et al., 2019), with probable, confirmed and severe sarcopenia, according to the cut-off points obtained in the ROC curve is shown in Table 3. Presenting probable sarcopenia or confirmed sarcopenia measured by GDLAM battery according to the cut-off points obtained in the ROC curve are indicator for presenting probable sarcopenia (OR = 2.8; p = 0.001) or confirmed sarcopenia (OR = 10; p = 0.002), respectively, according to the EWGSOP19 (Cruz-Jentoft et al., 2019).

4. Discussion

The aim of this study was to determine the diagnostic ability of GDLAM and SPPB batteries to classify people with sarcopenia according to the EWGSOP19. Therefore, the hypothesis was that the GDLAM battery was a more reliable and valid instrument for the assessment of sarcopenia in community-dwelling older adults than the SPPB battery.

The EWGSOP criteria for the detection of probable sarcopenia, confirmed sarcopenia and severe sarcopenia were used as criteria because EWGSOP has been showed as the most specific tool to identify older adults at risk of sarcopenia (Cruz-Jentoft et al., 2019; Escriche-Escuder et al., 2021; Locquet et al., 2017).

Sarcopenia is linked with decreased in functionality, increased risk for falls, facility syndrome and risk of premature death (Cruz-Jentoft and Sayer, 2019; Kitamura et al., 2021; Xie et al., 2021), which generate an increase in health spending, but they also have an influence on the personal and social level (Mijnarends et al., 2018). In our sample 11.19 % showed probable sarcopenia, 4.26 % confirmed sarcopenia and 2.05 % severe sarcopenia based on EWGSOP19 criteria. These results are

Table 1
Characteristics of the participants (n = 584).

Variable		Total sample Mean ± SD / n (%)	Male Mean ± SD / n (%)	Female Mean ± SD / n (%)
Gender	Male (n %)	214 (36.64 %)	–	–
	Female (n %)	370 (63.36 %)	–	–
Age (years)		65.33 ± 8.68	64.23 ± 8.99	65.97 ± 8.44
Body mass (kg)		74.40 ± 14.88	83.94 ± 13.66	68.71 ± 12.34
Height (cm)		165.53 ± 10.32	174.79 ± 8.28	160.34 ± 6.91
BMI (kg/m^2)		27.02 ± 4.41	27.46 ± 3.89	26.76 ± 4.67
BMI category	Normal	194 (33.22 %)	48(24.74 %)	146 (75.26 %)
	Overweight	263 (45.03 %)	121 (46.01 %)	142 (53.99 %)
	Obesity	127 (21.75 %)	45(35.43 %)	82(64.57 %)
Handgrip strength (kg)		31.47 ± 10.98	42,66 ± 8,47	24.95 ± 5.80
Timed-up-and-go-test (s)		6.64 ± 2.08	6,27 ± 1,45	6.86 ± 2.34
Muscle mass (kg)		24.44 ± 6.64	30,31 ± 5,19	20.96 ± 4.67
Muscle mass (%)		32.81 ± 5.74	36,37 ± 4,84	30.70 ± 5.16
SPPB	SBT feet together	9.99 ± 0.09	9.99 ± 0.10	9.99 ± 0.10
	SBT semi-tandem position	9.93 ± 0.65	9.90 ± 0.79	9.90 ± 0.79
	SBT tandem position	9.75 ± 1.25	9.69 ± 1.42	9.69 ± 1.42
	4 m gait walk	0.64 ± 0.16	2.40 ± 0.55	2.68 ± 0.68
	Chair stand test	10.66 ± 4.55	9.96 ± 3.26	11.07 ± 5.12
	Final Score	10.93 ± 0.34	24.06 ± 5.65	26.27 ± 6.47
Latin American Group for Maturity Battery (GDLAM)	Walk10 m	5.83 ± 1.32	5.36 ± 1.18	6.10 ± 1.32
	SCMA	38.94 ± 11.25	35.93 ± 8.70	40.72 ± 12.18
	SSP	10.66 ± 4.55	9.96 ± 3.26	11.07 ± 5.12
	SPP	3.82 ± 2.40	3.07 ± 1.61	4.29 ± 2.68
	PTS	12.11 ± 5.49	12.27 ± 5.62	12.01 ± 5.42
	Final score	25.43 ± 6.26	24.06 ± 5.65	26.27 ± 6.47
Probable sarcopenia (EWGSOP19)	No	518 (88.69 %)	196 (37.60 %)	322 (62.40 %)
	Yes	66 (11.31 %)	23(34.85 %)	43(65.15 %)
Confirmed sarcopenia (EWGSOP19)	No	559 (95.71 %)	210 (37.57 %)	349 (62.43 %)
	Yes	25 (4.29 %)	12(50.00 %)	12(50.00 %)
Severe sarcopenia (EWGSOP19)	No	554 (94.86 %)	217 (39.16 %)	337 (60.83 %)
	Yes	30 (5.14 %)	11(36.67 %)	19(63.33 %)

BMI: Body Mass Index; SBT: Standing balance test; SCMA: Sit and get up from the chair and move around the house; SPP: Standing up from the prone position; SPPB: Short Physical Performance Battery; SSP: Stand up from sitting position; PTS: To put on and take off a T-shirt.

Table 2
Area, cut point, sensitivity and specificity of GDLAM and SPPB based on probable sarcopenia, confirmed sarcopenia and severe sarcopenia.

Test result variables	AUC	Desv. error	Pv	95%CI	Cut point	Sensitivity	Specificity
Probable sarcopenia							
GDLAM	0.87	0.03	<0.001	0.81; 0.98	24.46	72.20	90.70
SPPB	0.44	0.04	0.12	0.35; 0.52	7.00	100.00	0.00
Confirmed sarcopenia							
GDLAM	0.62	0.03	<0.001	0.57; 0.67	24.22	63.00	57.60
SPPB	0.50	0.03	0.96	0.45; 0.55	7.00	100.00	0.00
Severe sarcopenia							
GDLAM	0.60	0.03	<0.001	0.55; 0.65	29.85	60.10	58.70
SPPB	0.48	0.03	0.53	0.43; 0.54	7.00	100.00	0.00

GDLAM: Latin American Group for Maturity Battery; SPPB: Short Physical Performance Battery;

lower than those shown in previous studies involving Singaporeans adults and older adults (Lee et al., 2021), Japanese older adults (Ishii et al., 2014) or Belgians older adults (Locquet et al., 2017), but somewhat higher than those shown by European middle-aged and older adults (Marcos-Pardo et al., 2021). The disparity in sarcopenia percentages between populations could be due to social or economic variables, diet, physical activity and obesity index differences (Lee et al., 2021; Marcos-Pardo et al., 2021), although incidence rates may also vary depending on the definition used to classify sarcopenia (Locquet et al., 2017).

The SPPB has long been proposed as a suitable battery for the valuation of physical fitness in the adult and older population (Lee et al., 2021). The mean scores of our sample (10.93 ± 0.34) in SPPB are located at the optimal cut-off point limit for discriminating severe sarcopenia for functionally independent persons (score ≤ 11 points) (Lee et al., 2021), position that according to previous studies increases 1.4 times more probable to acquire motor disability within three years (Vasunilashorn et al., 2009).

The present research found that the SPPB shows a lack of ability to classify in probable, confirmed and severe sarcopenia. The sensitivity and specificity of SPPB for the assessment of sarcopenia in older adults have already been questioned in previous studies, although these parameters could be increased for the assessment of severe sarcopenia (Lee et al., 2021). This could be due to different issues. Firstly, this battery was not initially designed for this purpose and it only includes tests of balance, walking speed over a short distance and lower limb strength, leaving out other tests such as handgrip strength which has been pointed out as the physical test that could be the best screen for sarcopenia (Ishii et al., 2014). On the other hand, the SPPB has been widely criticized for being a battery in which a large proportion of the participants achieve the maximum score the so called "ceiling effect"(Bergland and Strand, 2019; Lee et al., 2021; McHorney and Tarlov, 1995). In fact, previous studies have shown that >50 % of subjects aged 21–80 years, more that 30 % of subjects over 80 years and more that 20 % of men and women across all age groups showed the maximum SPPB score (Bergland and Strand, 2019; Lee et al., 2021; McHorney and Tarlov, 1995) . Moreover, previous researches have pointed out the ceiling effect of the SPPB in Singaporeans adults of both sexes (Lee et al., 2021), Norwegian adults of both sexes (Bergland and Strand, 2019), and Canadian older women (Fleig et al., 2016), thus pointing out that the SPPB with its current scoring system is not very sensitive for assessing the real physical condition of older adults (Bergland and Strand, 2019; Lee et al., 2021). The aforementioned, could be conditioning the results of the present research in terms of its sensitivity and specificity for diagnosing sarcopenia. Therefore, based on our results, the SPPB would not be a suitable method for the assess sarcopenia in Spanish older adults.

In recent years, other types of batteries have emerged to assess the functional autonomy and independence of the older adults, among which is the GDLAM battery. This battery is based on activities of daily living (Marcos-Pardo et al., 2020a, 2020b). This likeness is significant since functional autonomy is related with activities of daily living performance. So this protocol include capacities of physical fitness including in activities of daily living as, for example, muscle resistance and power, speed, balance, agility or coordination (Dantas et al., 2014; Dantas and Vale, 2004).

A remarkable result of the present investigation is that the GDLAM battery has high sensitivity and specificity for diagnosing probable, confirmed and severe sarcopenia categories, according to the EWGSOP19. In this line, the GDLAM battery showed an AUC of 0.869, sensitivity of 72.2 % and specificity of 90.7 %. No previous research is known to have analyzed the sensitivity and specificity of the GDLAM battery for the diagnosis of sarcopenia. However, a previous study that had analyzed the ability of other batteries such as the SPPB to diagnose sarcopenia, showing in general a lower sensitivity and specificity (from 7 to 100 % and from 68 to 99 %, respectively, according to the criteria used) (Lee et al., 2021) than those found in the present investigation with the GDLAM battery. The same was true when gait speed was used to screen for sarcopenia (sensitivity of 68 to 100 % and specificity of 33 to 93 % depending on the criterion used) (Lee et al., 2021); the calf girth (sensitivity: 44 to 88 %, specificity: 51.96 to 91 %) (Kawakami et al., 2015; Lin et al., 2021; Rolland et al., 2003); handgrip strength (sensitivity: 90 to 96 %; specificity: 59 to 88 %); or the Ishii battery, which includes three variables in the estimation of sarcopenia: age, grip strength and calf girth (sensitivity: 84.9 to 89.7 %, specificity: 74.51 to 88.2 %) (Ishii et al., 2014; Lin et al., 2021). In this sense, it is necessary in the classification of sarcopenia to strike the trade-off between sensitivity and specificity of the scale, in order to avoid misclassification, as it is very common in these classifications to achieve higher specificity as a consequence of lowering the sensitivity and vice-versa (Ishii et al., 2014). Therefore, based on the results of the present investigation and previous research, the GDLAM battery may be a resource with a great balance between sensitivity and specificity for sarcopenia screening. Despite these promising results, the comparison between sensitivity and specificity of scales for the detection of sarcopenia is an important issue for future research.

Another notable finding of the present study was that those participants with probable sarcopenia according to the GDLAM battery and the calculated cut-off points on the ROC curve are 1.8 times more likely to have probable sarcopenia according to the EWGSOP19; whereas those with confirmed sarcopenia according to the GDLAM battery and the cut-off points on the ROC curve are 9 times more likely to have confirmed sarcopenia according to the EWGSOP19. These results are important given that an underestimation or overestimation of the frequency of sarcopenia could affect proposed interventions by growing the risk of providing treatment to false-positive older adults or not providing treatment to false-negative older adults (Reginster et al., 2016). Therefore, based on the results of the present research the GDLAM test could be a simple way to diagnose sarcopenia at different categories.

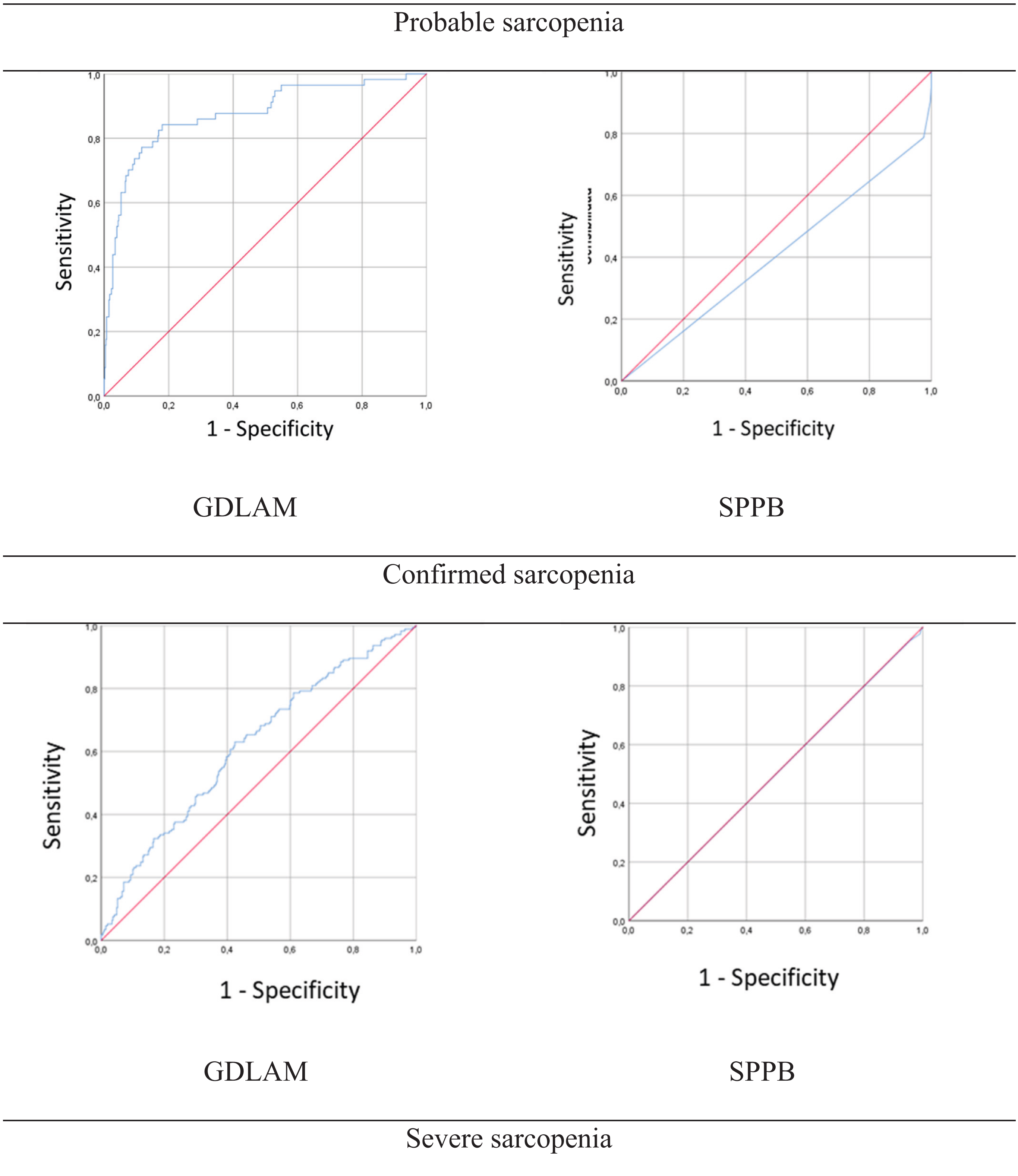

Fig. 1. ROC curve for GDLAM and SPPB based on probable, confirmed and severe sarcopenia. GDLAM: Latin American Group for Maturity Battery; SPPB: Short Physical Performance Battery.

This study has several limitations. First, the investigation focused only on community-dwelling older adults, but not those living in old adults' home. Second, only older adults from Spain were included, so the results of this research cannot be extrapolated to other populations. However, this study has also relevant strengths such as the use of physical performance test batteries for assessment of physical function

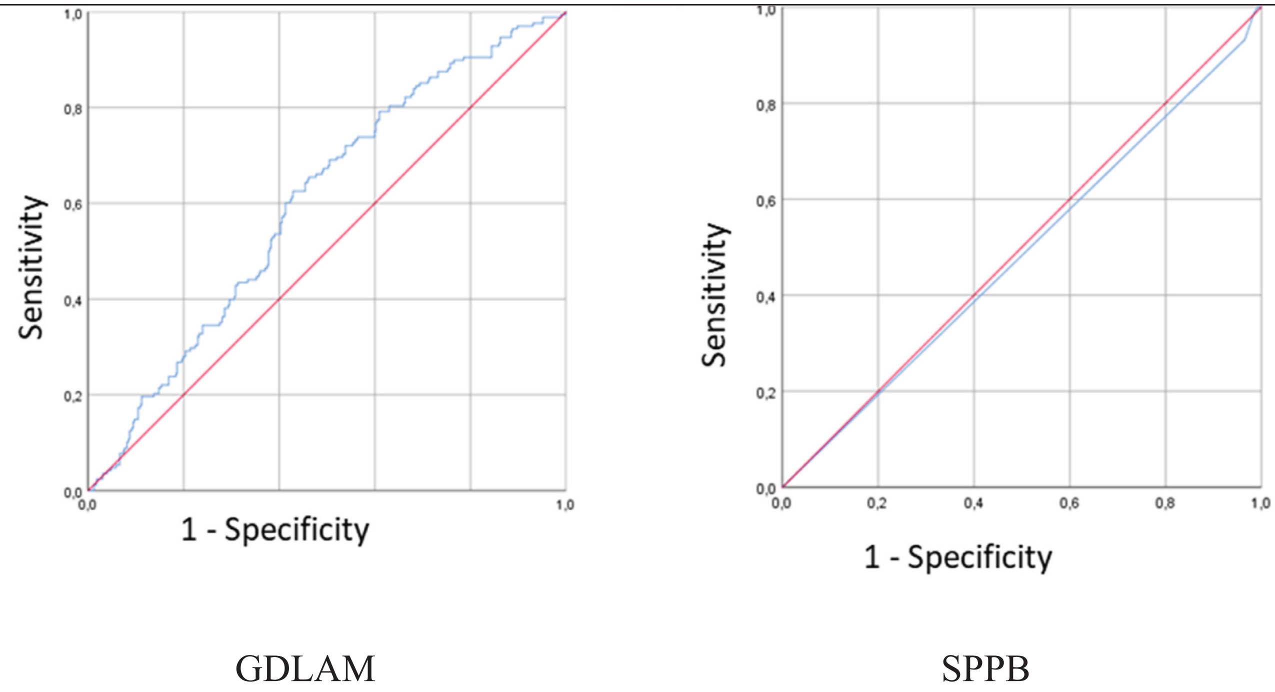

Fig. 1. (*continued*).

Table 3
Risk associated with probable, confirmed and severe sarcopenia according to the EWGSOP19 and GDLAM battery results.

Variable	Sarcopenia GDLAM	No sarcopenia GDLAM	OR	P
Probable sarcopenia (vs. no probable sarcopenia EWGSOP19)	73.68(42)	26.32(15)	2.8	0.001
Confirmed sarcopenia (vs. no probable sarcopenia EWGSOP19)	90.91(20)	9.09(2)	10	0.002
Severe sarcopenia (vs. no probable sarcopenia EWGSOP19)	100(9)	0(0)	1,615,472,457.032	0.999

OR: odds ratio.

with the validity and reliability previously proven (Freiberger et al., 2012; Marcos-Pardo et al., 2020a, 2020b). In addition, before starting the study, the evaluators completed a training program to ensure high inter-rater test-retest reliability.

5. Conclusion

The GDLAM battery can be used in the screening of distinguishing older adults at risk for sarcopenia from those who were not. Thus, we recommend the GDLAM battery for screening, geriatric assessment and for researchers. It is a more reliable and valid instrument for the assessment of sarcopenia in community-dwelling older adults than SPPB battery. Of relevance, this type of sarcopenia screening tools can be used in a clinically relevant way, at the research level or at the policy level to identify individuals with this syndrome. In addition, it can provide an individual value of functional autonomy in each of the tests evaluated and a global value of functionality in the older adults.

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CRediT authorship contribution statement

Conceptualization: PJM-P, NG-G, and RV-C; Methodology: PJM-P, NG-G and RV-C; Software: AC-B and RV-C; Investigation: PJM-P, NG-G, AC-B, DJ-P and RV-C; Data curation: PJM-P, NG-G and RV-C; Writing - original draft preparation: PJM-P, NG-G, AC-B, DJ-P and RV-C; Supervision: PJM-P; Validation: PJM-P, NG-G and DJ-P; Writing - reviewing and editing: PJM-P, NG-G, AC-B, DJ-P and RV-C.

Declaration of competing interest

The authors declare that they have no competing interests.

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