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The SARC-F is a useful screening tool for detecting primary sarcopenia but not disease-related sarcopenia in ageing polio survivors

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Abstract

Aim: To determine if the SARC-F questionnaire is a suitable tool to detect sarcopenia in two cohorts: 1) age-matched otherwise healthy older adults; and 2) polio survivors.

Design: A cross-sectional study of polio survivors and matched controls was undertaken utilising validated screening tools.

Subjects/Patients: 42 older adults living in community South Australia: 12 otherwise healthy older adults and 30 polio survivors.

Methods: Sarcopenia assessment was carried out using the SARC-F (strength, assistance walking, rise from a chair, climb stairs, and falls) questionnaire, grip strength to assess muscle strength, bioelectrical impedance (BIA) to measure central muscle mass, and gait speed to assess physical performance, distinguishing between those with primary and polio-related sarcopenia.

Results: There were significant differences ($p<0.001$) between the polio affected limb and the non-affected limb for leg circumference. SARC-F positive subjects had significant reductions in muscle strength and gait speed but not muscle mass. The presence of polio-related sarcopenia was negatively associated ($r2=0.422$, $p<0.001$) with nutritional state.

Conclusion: Our study demonstrated that while there were differences between polio survivors and otherwise healthy controls in terms of screening via the SARC-F, it is helpful to discern between primary and secondary (i.e. disease-related) sarcopenia in older adults. For polio-related sarcopenia (i.e. significant muscular asymmetry), we assert that the SARC-F as a screening tool is not suitable. An alternative tool that combines objective data sensitive to differences across limbs, may be more appropriate in confirming sarcopenia in the polio-survivor population.

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Introduction

Aging causes the human muscular system to undergo changes related to reductions in muscle mass, strength, and function. This is due to alterations in the quality of remaining muscle tissue commonly referred to as sarcopenia[1]. Despite being included as a disease in the International Classification of Disease in 2016[2], there is no universally agreed upon clinical definition or diagnostic criteria. The European Working Group on Sarcopenia in Older People (EWGSOP2)[3] as well as the Asian Working group for Sarcopenia (AWGS)[4] have defined sarcopenia as a multidimensional condition characterized by low muscle mass, low muscle strength, and low physical performance. Secondary sarcopenia can occur as a result of comorbidities such as diabetes, heart failure, immobility, and other conditions[3] and can be divided into categories based on the clinical manifestation – activity-related, disease-related, or nutrition-related[5]. Disease-related sarcopenia can accelerate the progression of muscle atrophy, in addition to primary sarcopenia. As an example, after cerebral infarction (stroke), there is a decrease in the number of recruited motor neurons, which affects muscle tissue structure[6]. As polio survivors often have asymmetric involvement between upper and lower limbs, and in muscles within a limb[7], there may be additional considerations when screening for sarcopenia in this population.

Sarcopenia is a major problem in terms of public health as it can lead to physical frailty, functional decline, limitations in mobility, and premature mortality. There is a progressive loss and atrophy of type II ('fast-twitch') muscle fibres and an up to 50% decrease in motor units by the 8th decade of life[1]. Muscle function progressively deteriorates as motor unit loss is not supplemented by the reinnervation of existing motor neurones[1]. The prevalence of sarcopenia in Australians is estimated to be ~7.8% (≥65 years) and up to 40% in those aged 80 years and over[8]. There are several algorithms currently focused on sarcopenia in an otherwise healthy population[3][9]. We aimed to extend the EWGSOP2[3] algorithm specific to polio-related sarcopenia.

Polio is caused by a viral infection that invades the nervous system and leads to various degrees of asymmetrical muscle paralysis in some individuals. Following the introduction of vaccination during the mid-1950s, poliomyelitis rates in Australia rapidly declined and Australia was declared polio-free in 2002[10]. Currently, there are tens of thousands of polio survivors in Australia [11]. Although outbreaks of polio have significantly reduced through vaccinating against the disease, 15-80% of all poliomyelitis survivors develop post-polio conditions[7][10]. Post-polio syndrome (PPS) is a clinical diagnosis where symptoms may become apparent anywhere between 15-30 years after exposure to poliomyelitis[12] and is characterized by progressive or new muscle weakness, generalized fatigue, muscle atrophy, and pain[13].

Health issues seen in normal aging populations with sarcopenia such as weakness, falls, and difficulty to perform activities of daily living (ADLs), are also observed in aging polio survivors[14]. To date, the EWGSOP2[3] algorithm has not been used for characterising sarcopenia in ageing community-dwelling polio survivors. This research project aims to detect the prevalence of sarcopenia in ageing community-dwelling South Australian polio survivors, in accordance with international criteria. Our main hypothesis is that, although the SARC-F is accurate and useful in detecting primary sarcopenia, it is unknown whether this is the same in polio survivors.

Methods

Study Population

Participants were recruited from several information sessions informing polio survivors about this study, with the aim of establishing two equally matched groups. The inclusion criteria were:

1. 60 years of age or older,
2. able to converse in English,
3. have no more than five medical comorbidities,
4. ambulant in the community, and
5. did not have an active neoplastic disease, poorly-controlled cardiac, respiratory, or endocrine diseases, stroke, and/or other neurological diseases.

All participants who fulfilled the exclusion criteria were invited to participate and gave their informed consent. The study including this consent procedure was approved by the Queen Elizabeth Hospital and Central Adelaide Local Health Network Research and Ethics Committees (approval reference: Q20170810).

Sarcopenia screening.

The SARC-F questionnaire includes five items selected to reflect the health status changes associated with the consequences of primary sarcopenia[3][9]. . This questionnaire (shown in Table S1 in the supplementary material) has previously been shown to have good internal consistency, reliability and factorial, criterion and construct validity, with cut-off scores (>4/10) associated with deficits across a range of functional scales. The SARC-F has low-to-moderate sensitivity and very high specificity to predict low muscle strength[15].

Muscle strength.

Measuring grip strength is simple and inexpensive, with low grip strength a powerful predictor of poor patient outcomes such as longer hospital stays, increased functional limitations, poor health-related quality of life, and mortality[16]. Patients with polio have been identified as between 74 and 77% as strong as the normal population, highlighting applicability within this cohort[17]. Muscle strength was measured using a grip dynamometer (Jamar Hydraulic Hand Dynamometer-Model number: 5030J1; JLW instruments, Chicago IL). The EWGSOP2 sarcopenia cut-off point for low grip strength is < 27kg for men and < 16 kg for women[3].

Muscle quantity.

Bioelectrical impedance analysis (BIA)[18] has been explored for the estimation of total or appendicular skeletal muscle mass (ASM). This method derives the estimate of muscle mass based on whole-body electrical conductivity that uses a conversion equation calibrated with a reference of dual-energy X-ray absorptiometry (DXA) measured lean mass and is validated in both healthy and clinical populations [19]. ASM was measured by BIA using the In Body 570 system (California, USA) where 15 impedance measurements are made by using 3 different frequencies (5kHz, 50kHz, 500kHz) at each of 5 segments (right arm, left arm, trunk, right leg, left leg). This enables measurements of percentage body fat, muscle distribution, and body water balance[20]. Appendicular skeletal muscle mass (ASM) measured by BIA is calculated using the Janssen BIA equation[21]:

Skeletal muscle mass (kg) = [Height^2/BIA resistance x0.41] + [gender x 3.825] = [age x (-0.71)] = 5.102.

The appendicular skeletal mass index (ASMI) was determined by ASM / height (cm)^2 and expressed as kg/m^2 . The EWGSOP2 sarcopenia cut-off point for low ASMI is < 7.0 kg/m^2 for male and <5.5 kgm^2 for females[3].

Anthropometry, specifically quadriceps and calf circumference, were measured according to standard guidelines for muscle hypertrophy assessment[22][23]. Circumference measures have been shown to predict performance and survival in older people (cut-off point <31cm)[24] and are strongly correlated with appendicular lean mass (r=0.84 and 0.86, males and females respectively), particularly in populations outside the normal-weight BMI range (18-24.9). Circumference measurement alongside a BMI-adjustment approach which adjusts for the confounding effects of adiposity has been a useful clinical estimate of skeletal muscle mass[23].

Physical performance

Physical performance is defined as 'an objectively measured whole-body function related to locomotion[3]. This involves not only muscle performance, but central and peripheral nervous function. Gait speed has been well supported in the literature for both sarcopenia[25] and polio survivors[26]. One method utilised with this population is the 4-metre gait speed test[27]. A 4-metre gait speed was recorded according to the EWGSOP2 algorithm to assess physical performance and hence the severity of sarcopenia[3]. To perform the test, a flat unobstructed course was identified, where 4 metres was marked out with tape. The mean value was used to calculate the 4-metre gait speed expressed in ms^{-1}. The EWGSOP2 sarcopenia cut-off point for low physical performance of gait speed is $\leq 0.8ms^{-1}$ (~2.8km/hr) for both males and females[3].

Nutritional status

Nutritional status was assessed by the mini-nutritional assessment (MNA)[28], which is an 18-item questionnaire that classifies a participant as normally nourished (score 24-30), at risk for malnutrition (score 17-23.5), or malnourished (score < 17). The MNA is well validated in the hospital, community, and long-term care settings[29].

Statistical analysis

All statistical analyses were performed with Graph Pad Prism version 8.1.2[30]. Descriptive statistics are presented as percentages and means with standard deviations. Simple group testing based on continuous and categorical data was performed with independent *t*-tests. The distributional properties were examined visually. In the case of skewed data, the Wilcoxon-Mann-Whitney test was used to analyse the data. A P value < 0.05 was considered statistically significant.

Results

A total of 30 participants (30% of those invited to participate) were included in this research, with a mean age of 73.6 ± 6.3 years, body mass index (BMI) of 29.5 ± 5.9 $kg.m^2$, and minimal residual paralysis, as well as being ambulatory in the community (Table 1). There were 12 matched control participants with a mean age of 71.4 ± 9.9 years, and a BMI of 27.1 ± 6.35 $kg.m^2$. There were no significant differences between the groups in age or common comorbidities. While the polio group had a slightly higher BMI, this was not statically significant (p=0.24).

Table 1. The distributions of participants in terms of demographic characteristics

	Polio Survivors	Control Group	P value
Total participants (N)	30	12	
Male/Female n (%)	14/16 (47%)	6/6 (50%)	N/A
Age, mean (SD) (years)	73.1 ± 5.0 (Male) 74.1 ±7.5 (Female)	73.8 ± 8.9 (Male) 69.0 ± 10.8 (Female)	0.39
BMI, mean (SD) kg/m^2	30.0 ± 5.9 (Male) 29.0 ± 5.8 (Female)	26.7 ±3.5 (Male) 27.5 ± 9.2 (Female)	0.24
Range of age at which contracted polio	1-6 years	0	
Limbs affected	Lower limb (28) Upper limb (2)	0 0	
Current Mobility Aids Ankle foot orthosis Knee ankle foot orthosis Single point stick 4-wheel walker	 12 2 4 4	 0 0 0 0	
Educational status	High school or above	High school or above	
Financial status	Pensioner	Pensioner	

As outlined in Figures S1 and S2 in the supplementary material, eight SARC-F positive and six SARC-F negative polio survivors were found to be at risk of malnutrition (p=0.003), as identified by the MNA. There was a significant negative correlation between SARC-F and MNA (Figure S2), mean difference of 2.540 ± 1.170 (95% CI 0.1687 to 4.911, p=0.018), demonstrating an association between sarcopenia and risk of malnutrition. Following the algorithm described by EWGSOP2[3] and extended to polio-related sarcopenia, the SARC-F questionnaire raised clinical suspicion of sarcopenia in 11 of 30 participants (six female and five male). By contrast, none of the age-matched control group had SARC-F scores suggestive of sarcopenia and/or a mobility disability (Figure 1). The SARC-F score was significantly higher in polio survivors than in the controls (2.6 vs 0.2, respectively, *p*=0.015).

Activity-related sarcopenia:

All polio patients, even those using orthotics or mobility aids, were independent and ambulatory. None of the community-dwelling matched-control participants used mobility aids. At least 12 in the polio survivor group relied upon mobility aids, demonstrating apparent neuromuscular dysfunction and functional impairment. There was a significant difference between SARC-F positive and SARC-F negative polio survivors for gait speed, according to age (Figure 2a), but not gender (Figure 2b). Among the 11 males identified as possible sarcopenic, there was a non-significant reduction in grip strength (p=0.08; Figure 3a). Female polio survivors had significantly lower grip strength within their group (14 vs 20kg, *p* = 0.02, Figure 3b). Notably, six of the 11 SARC-F positive subjects (four female and two men) also had grip strength below the EWGSOP2 cut-off value suggestive of sarcopenia[3].

When evaluating thigh circumference there was a statistically significant difference between that for polio affected and non-affected limbs (Figure 4). The mean difference between the two was 4.361 ± 3.837 (95% CI 2.702 to 6.020).

Discussion

The primary aim of this study was to investigate the usefulness of the SARC-F screening tool in discerning the prevalence of sarcopenia in aging polio survivors. Whilst there appeared to be an increased prevalence of primary sarcopenia, a number of traits specific to post-polio sequelae make it difficult to determine whether the SARC-F directly applies to polio survivors. As outlined earlier, secondary sarcopenia can be identified as activity-related, disability-related, or nutrition-related. Our findings suggest that the SARC-F may attribute primary sarcopenia to polio survivors based on their pre-existing post-polio functional ability, as it does not have elements to accommodate additional secondary sarcopenia traits. The secondary finding relates to the EWGSOP2 algorithm[3], where the combination of SARC-F for screening with strength-based measures such as grip strength and measures of asymmetry such as thigh circumference, appear clinically practical, timely and cost-saving compared to other – more expensive – options.

Although previous studies have indicated that SARC-F has a low sensitivity of as low as 25% in those with sarcopenia[15], there is a potential for this to be much higher. In polio survivors, a predominance of muscle mass loss (either acute or chronic) on one side more than the other should be considered. Measures that take into account limb size and outline a substantial difference between limbs would be a useful addition to the SARC-F and EWGSOP2 algorithm. The data presented in Figure 4 highlights differences between the polio affected and the less-affected limb, which in many cases exceeded >1.5cm. Given the atrophy associated with neurological conditions such as post-polio syndrome, adding limb circumference could further clarify the disease-specific aspects of sarcopenia, where evaluating limb circumference in addition to functional impairments will better position the SARC-F to screen for secondary sarcopenia[7].

In our study, only female polio survivors had significant GS and SARC-F differences. Low GS is a strong predictor of poor patient outcomes such as a lower health-related quality of life, higher risk of disability, longer hospital stays, and mortality[16]. Further, grip strength has been investigated in polio survivors to help reduce such negative outcomes[16]. Hence, grip strength is easy to obtain in clinical practice, and in combination with screening via the SARC-F is useful in obtaining further evidence for a diagnosis of sarcopenia. In the polio survivor population, where asymmetry is a usual feature, grip strength may be used to determine differences between limbs. Applying an asymmetry measure of grip strength may also allow greater accuracy using the SARC-F and in extending the EWGSOP2 to polio survivors.

BIA aimed at measuring ASMI did not find any differences between those screened as positive or negative for sarcopenia, based on the SARC-F. One possible explanation is that total rather than segmental ASM was measured by BIA. As mentioned above, asymmetrical muscle atrophy occurs in polio-affected upper and lower limbs leading to variation of lean muscle mass only detectable by segmental ASM. Furthermore, the muscles of the functional limb in polio survivors may undergo compensatory hypertrophy. Hypertrophy amplifies the difference in circumference and/or grip strength and is a response to the extra reliance placed on a limb to compensate for the loss of muscle mass in the more affected limb. Hence, BIA may lack validity and sensitivity in the polio survivor population, as it may in other conditions associated with asymmetrical muscle mass changes[5]. Thus, when total ASM is measured, segmental ASM assessment would also be beneficial in clinical settings.

In order to investigate the potential severity of sarcopenia, 4-m gait speed was aimed to stratify those screened as positive according to their physical performance. There was a difference in positive and negative scores with those identified as positive sitting near the EWGSOP2 cut-off scores (0.8 ms^{-1}). Gait speed was reduced in a small proportion of SARC-F positive females indicating they were also experiencing a decline in physical performance. Walking speed is important in the polio survivor population as it can be a key contributor to mobility, and help to reduce the risk and management of falls[7][13]. Hence, our results highlight that further validation of gait speed, or an alternative element, is required for the assessment of both primary and polio-related sarcopenia.

Strengths and limitations

A major strength of our study is that it is the first one to use the EWGSOP2 criteria[3] to screen for sarcopenia in the community-dwelling aging population, consisting of both polio survivors and age-matched participants. Secondly, all measurements in each participant were performed with the same equipment (dynamometer and BIA) on the same day by the designated research officer. Condition-specific assessments of this mobility restricted, and hence more sedentary group may demonstrate a more accurate prevalence of sarcopenia in the polio survivor cohort. Further, the clinical presentation of polio survivors can be varied, with unreliable self-report of bulbar symptoms or dysfunction during acute polio. Further still, the utilization of magnetic resonance imaging or computerized tomography scan may have been superior to BIA in estimating ASM; however, the cost and participant inconvenience were outside the scope of this study.

Conclusion

This study is the first to extend the EWGSOP2 algorithm[3] for sarcopenia case-finding, using the SARC-F, muscle strength, muscle quantity, and physical performance measures in ambulatory community-dwelling polio survivors. Although there is a benefit in using the SARC-F tool in screening for primary sarcopenia, the disease-related aspects associated with polio survivors impact the ability to discern sarcopenia from disability in this population. We recommend further research to include muscle strength measures and anatomic asymmetry with the SARC-F to determine sarcopenia severity against functional performance measures. Technology that assesses whole-body muscle mass (e.g. DEXA) and other options such as calf circumference, thigh circumference, and thenar atrophy may add clarity when evaluating the asymmetrical considerations specific to this population. Although this study has added further evidence for the SARC-F to be used by clinicians in community settings to assess the risk of developing sarcopenia, further research is necessary to strengthen the evidence supporting the implementation of the SARC-F in aging polio survivors.

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Disclosure Statements

- “We confirm that we have read the Journal’s position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.”
- The authors declare no conflict of interest.

Figures

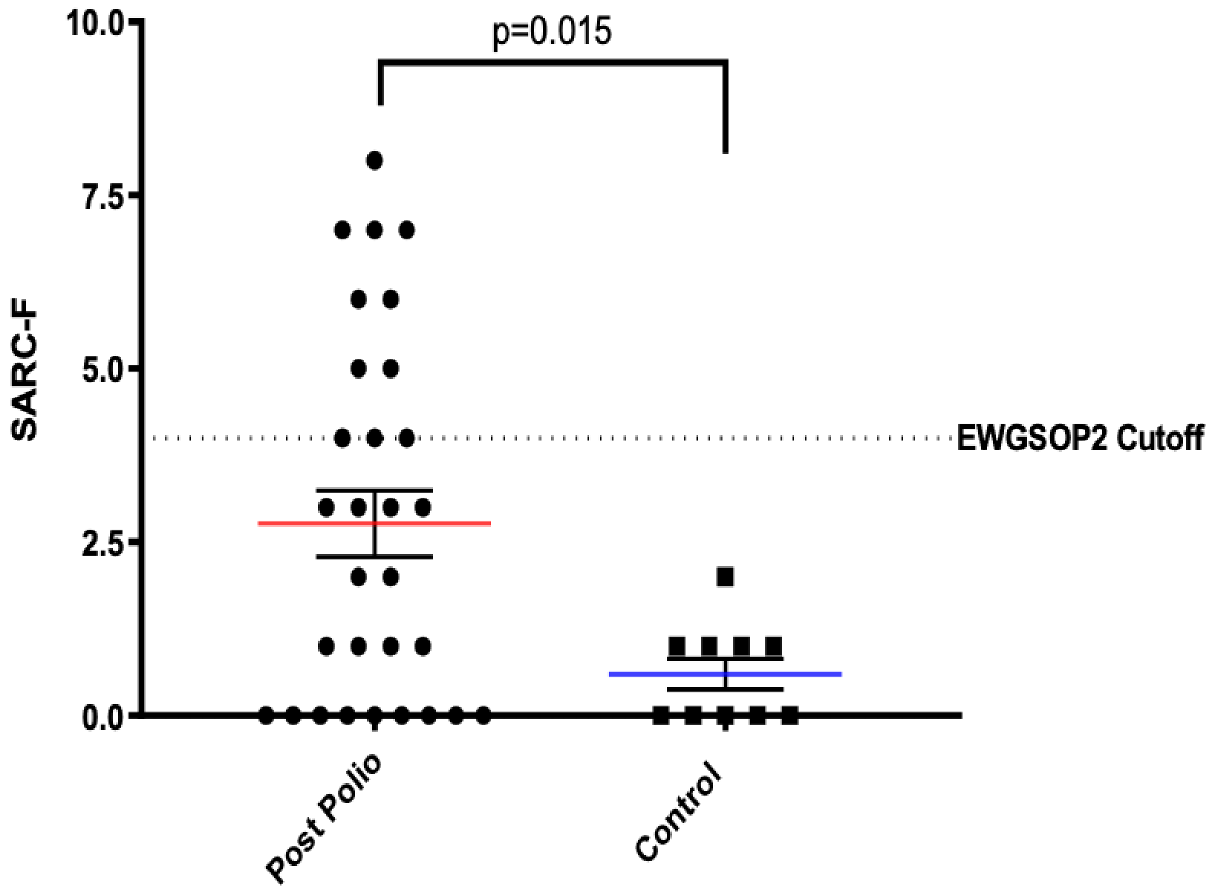
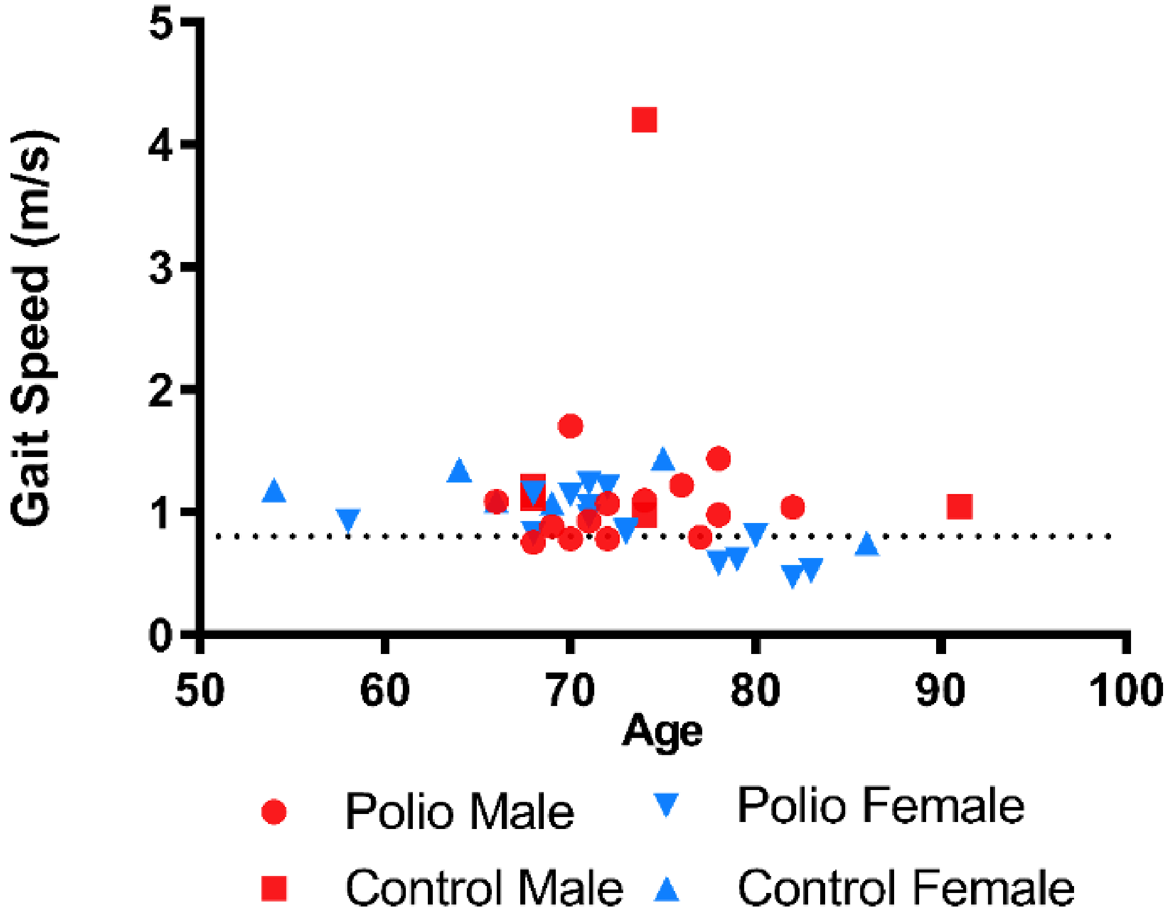
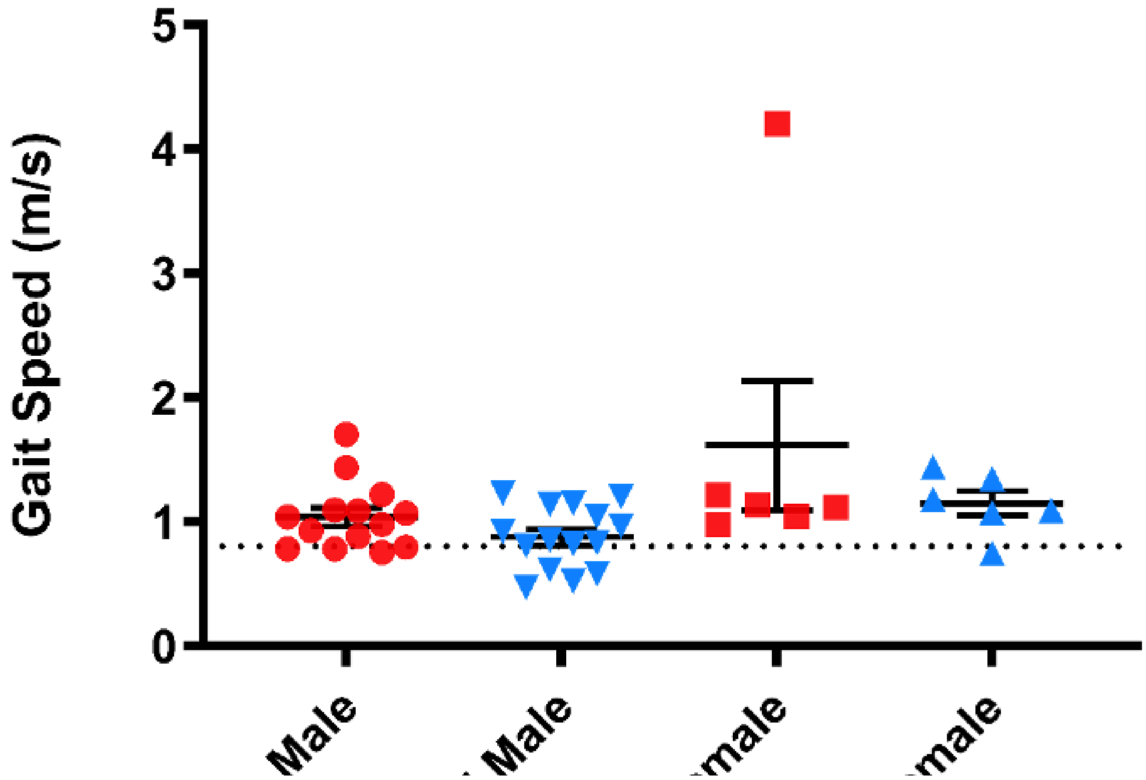


Figure 1. *SARC-F scores in polio survivors compared to age-matched controls*


Gait Speed (m/s)
0
1
2
3
4
5
50
60
70
80
90
100
Age
Polio Male
Polio Female
Control Male
Control Female


Gait Speed (m/s)
0
1
2
3
4
5
Male
Male
male
male

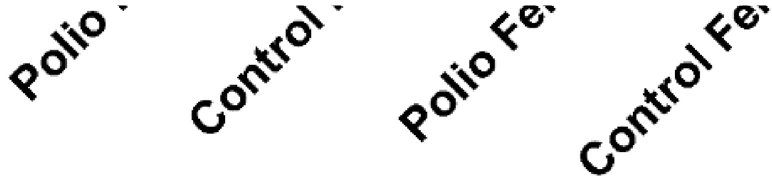


Figure 2. *Gait speed according to gender and polio status, A. According to age and B. According to gender and whether individuals were polio survivors or matched controls.*

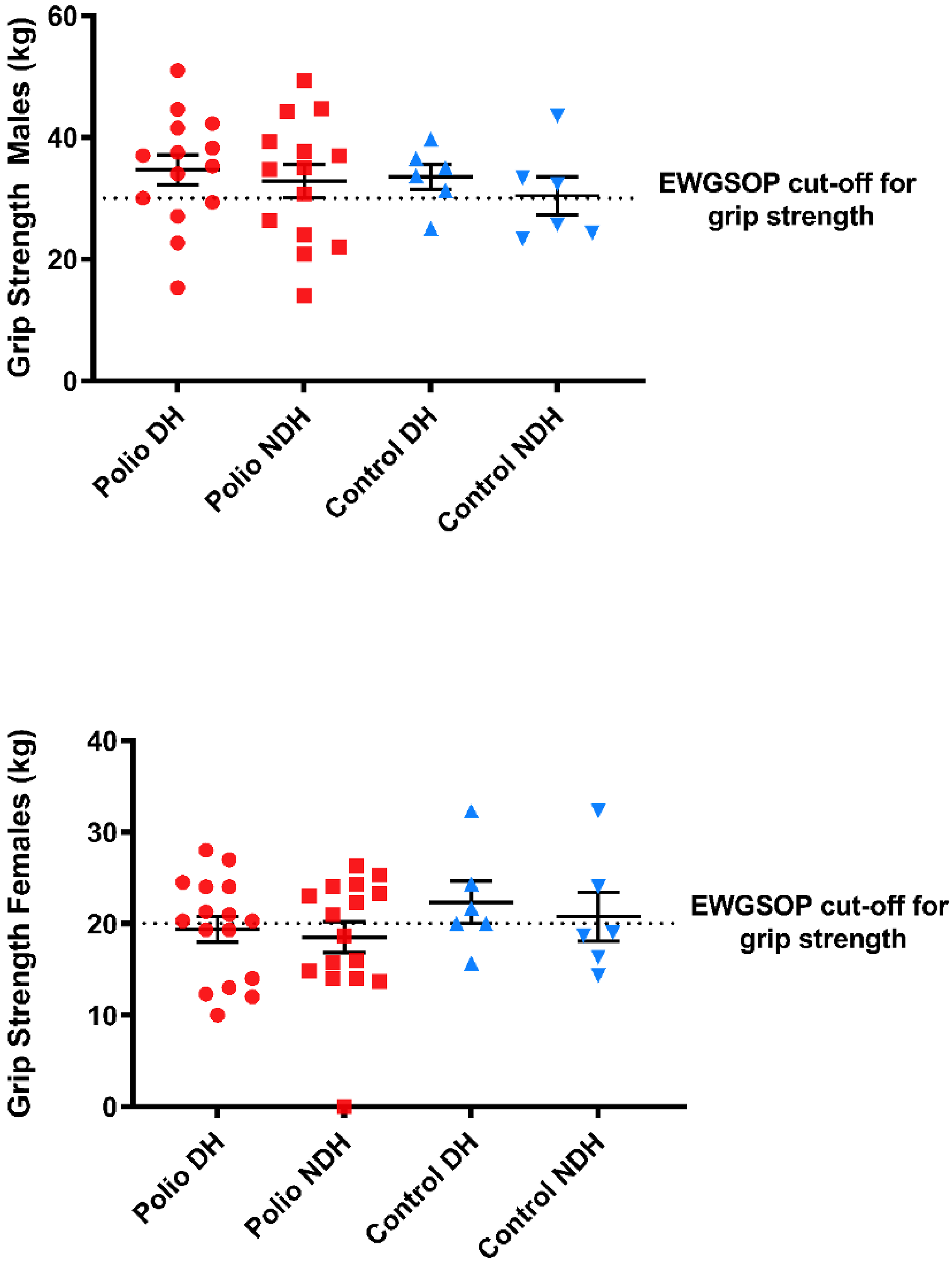


Figure 3. *Dominant hand (DH) and non-dominant hand (NDH) grip strength values according to A. Males and B. Females*

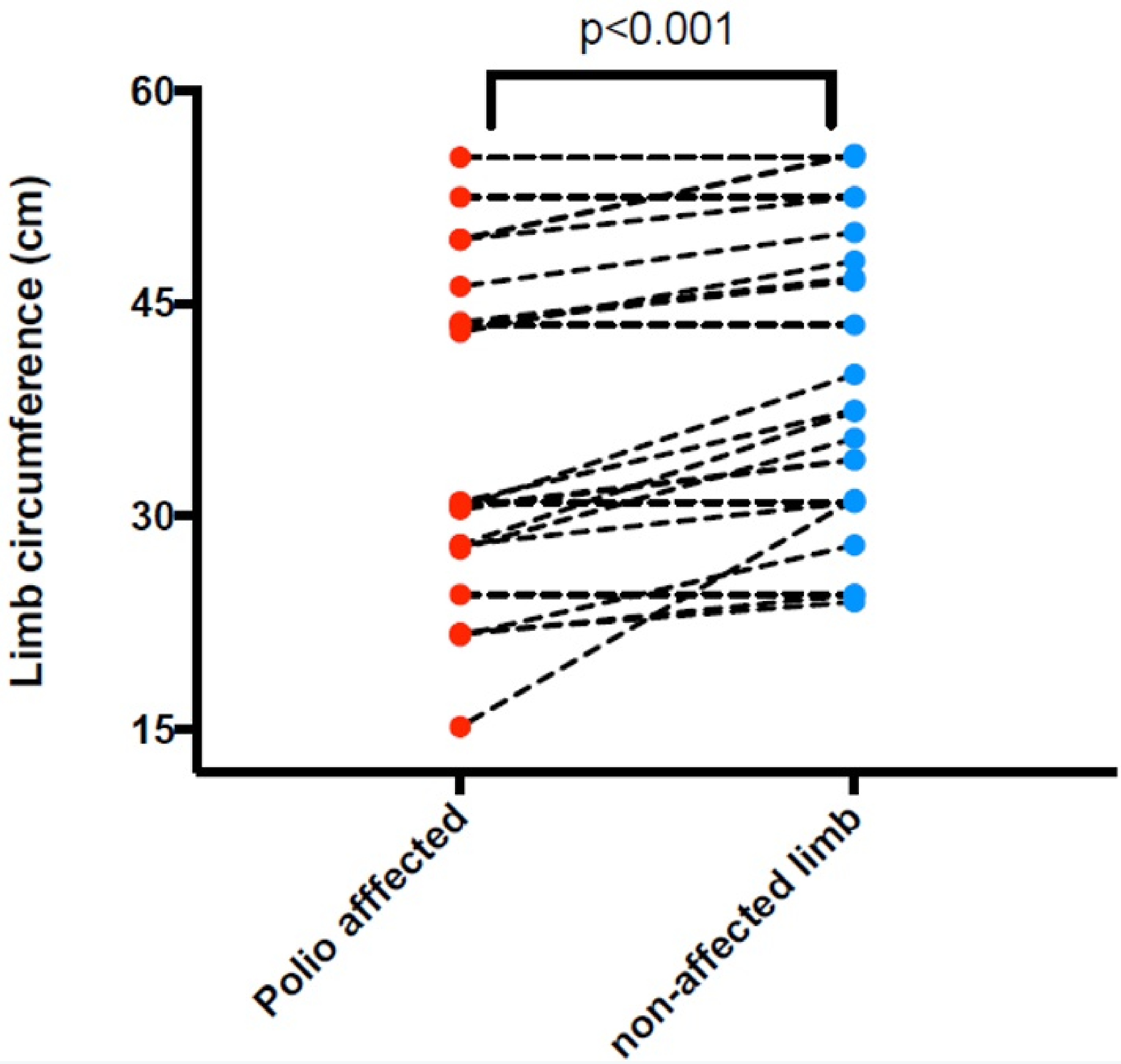


Figure 4. *Thigh circumference (cm) comparison of polio affected and non-affected limbs*

Supplementary Material

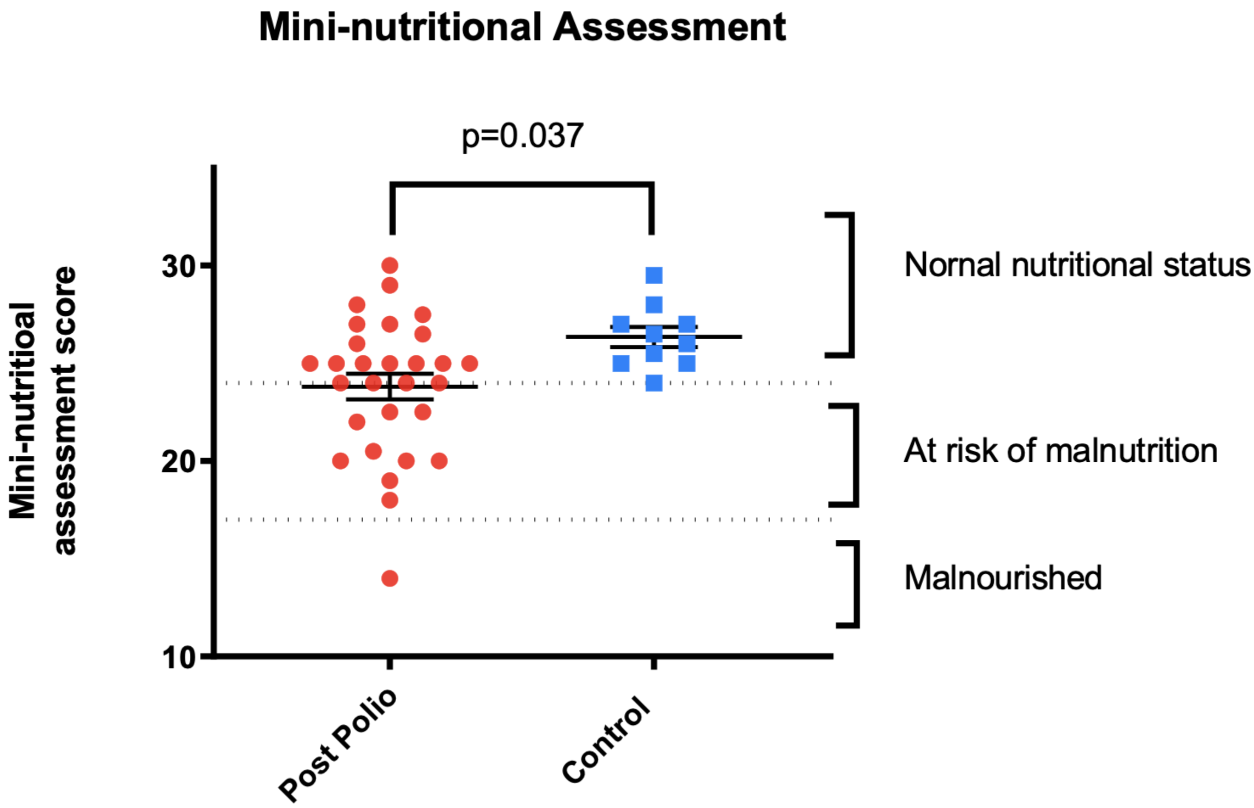


Figure S1. *Nutritional status of polio survivors and controls*

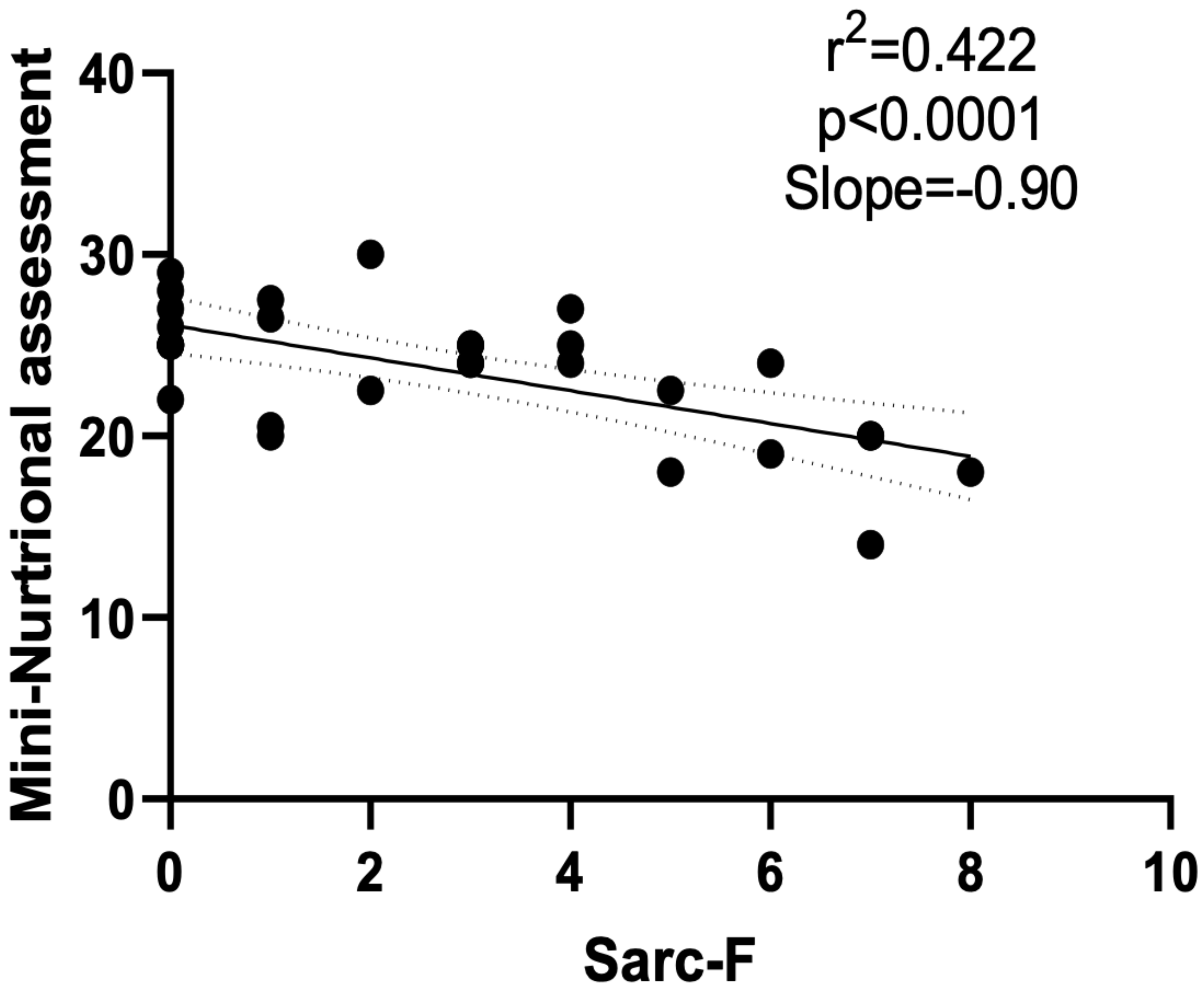


Figure S2. *Relationship between nutritional status and SARC-F scores*

Table S1. SARC-F Components

Component	Question	Scoring
Strength	How much difficulty do you have in lifting 10 lb (~4.5kg)?	None = 0 Some = 1 A lot or unable = 2
Assistance in Walking	How much difficulty do you have walking across the room?	None = 0 Some = 1 A lot, use aids, or unable = 2
Rise from Chair	How much difficulty do you have transferring from a chair or bed?	None = 0 Some = 1 A lot or unable = 2
Climb Stairs	How much difficulty do you have climbing a flight of 10 stairs?	None = 0 Some = 1 A lot or unable = 2
Falls	How many times have you fallen in the past year?	None = 0 1-3 falls = 1 ≥ 4 falls = 2

Table S2 illustrates the sensitivity and specificity characteristics of the SARC-F questionnaire used in this study to screen for sarcopenia in aging polio survivors were 0.75 and 0.77, respectively.

Table S2. Predictive capacity of SARC-F according to ESWGOP-2 algorithm for the polio survivor group

	SARC-F positive (11)	**SARC-F negative (19)**
ESWGOP 2 probable (Grip strength)	6	2
ESWGOP 2 negative (Grip strength)	5	1
ESWGOP 2 positive – Confirm (ASM-BIA)	0	0
ESWGOP 2 positive – Severity (Gait speed)	5	1
Sensitivity	0.75	
Specificity	0.77%	

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