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IDENTIFICATION OF RISK PHENOTYPES FOR SARCOPENIA USING DXA WHOLE BODY COMPOSITION, ANTHROPOMETRIC, AND MUSCULOSKELETAL ANALYSIS AMONG YOUNG ADULTS

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Abstract

Background: *Sarcopenia, historically considered an aging-related condition, is increasingly observed in younger populations. Contributing factors such as inadequate nutrition, sedentary lifestyles, and metabolic disturbances may predispose young adults to premature muscle mass loss and functional impairment. Early identification is essential for timely intervention and prevention of long-term morbidity.*

Objective: *To identify sarcopenia risk phenotypes in young adults by examining associations between DXA-derived body composition, anthropometric indices, and musculoskeletal fitness parameters.*

Methods: *A cross-sectional study was conducted on 82 healthy participants aged 15–35 years at the Center for Nuclear Medicine (CENUM).Assessment tools included dual-energy X-ray absorptiometry (DXA) for whole-body composition, hand grip strength (HGS) testing, and the SARC-F questionnaire. Sarcopenia was defined based on established cut-offs for Body Mass Density (BMD), hand grip strength, and functional performance. Pearson correlation coefficients were used to assess relationships between muscle strength and bone mineral density (BMD). A significance level of $p < 0.05$ was considered statistically significant.*

Results: *A total of 19.5% of participants met the diagnostic criteria for sarcopenia. Hand grip strength was significantly correlated with BMD values. Specifically, HGS showed a strong negative correlation with femoral neck BMD ($r = -0.506$, 95% CI: -0.66 to -0.30, $p = 0.0001$) and a moderate positive correlation with total hip BMD ($r = 0.381$, 95% CI: 0.17 to 0.55, $p = 0.0004$). In contrast, SARC-F scores demonstrated weak and statistically non-significant correlations with BMD ($r = -0.103$ to 0.112, $p > 0.05$), suggesting limited sensitivity in detecting early bone-muscle deterioration.*

Conclusion: *Nearly one-fifth of young adults in this sample met the criteria for*

sarcopenia, emphasizing the need for proactive screening in this age group. Hand grip strength emerged as a reliable surrogate marker for bone health and muscular function, whereas a measure such as SARC-F was not effective for younger adults. Incorporating objective strength assessments and promoting strength-based interventions may help mitigate the early onset of sarcopenia and its long-term consequences.

INTRODUCTION

Sarcopenia is a muscular condition characterized by the loss of muscle strength, mass, and quality, often beginning with the aging process (Cruz-Jentoft et al., 2019). Primary sarcopenia is defined as a chronic and progressive decrease in muscular mass and strength due to aging, whereas secondary sarcopenia is associated with causal factors such as poor nutrition, inactivity, and underlying illnesses (Barazzoni et al., 2023). Historically described as a disease of the elderly, recent studies highlight its association with conditions like muscle failure and obesity, suggesting a risk for younger populations as well (Jung et al., 2023). Research indicates that more than one in every ten young adults across various ethnicities may exhibit sarcopenia, with prevalence rates ranging from 0.2% to 86.5% worldwide (Foo et al., 2023). A study in an Asian community found that three out of five young adults showed risk factors for sarcopenia (Voulgaridou et al., 2024). Prevalence is influenced by factors like living conditions, with higher rates observed in nursing homes and hospitalized patients, potentially due to inactivity and malnutrition (Ackermans et al., 2022).

There are several diagnostic modalities available to identify the risk phenotypes of sarcopenia in young adults, including DXA imaging, musculoskeletal fitness tests & SARC-F (Messina et al., 2020). Although sarcopenia is often associated with older adults, its early onset can occur in younger populations due to factors such as inactivity and poor nutrition. Research indicates that muscle mass begins to decline in the late 20s to early 30s, making age a critical factor in assessing sarcopenia risk (Cruz-Jentoft et al., 2019). Gender differences play a significant role in muscle composition and strength. Men typically have higher muscle mass but may experience a more gradual decline, while women may face a steeper decline post-menopause. Understanding these differences is vital for tailored interventions (Bianchi et al., 2020).

SARC-F, a screening questionnaire assessing strength, walking ability, and other functional limitations, has demonstrated predictive accuracy for sarcopenia and related health outcomes (Woo et al., 2014). Musculoskeletal fitness tests, such as grip strength serve as reliable indicators of muscle strength. Grip strength scores of <27 kg for men and <16 kg for women indicate poor muscle strength, which is strongly associated with sarcopenia (Bhasin et al., 2020). Hand grip strength is a reliable indicator of overall muscle strength and function. Lower grip strength has been consistently associated with sarcopenia and serves as an early warning sign for potential functional decline (Bhasin et al., 2020).

Dual-energy X-ray absorptiometry (DXA) remains the gold standard for assessing lean and fat muscle mass due to its precision and consistency (Cheng et al., 2021). It provides critical insights into bone mineral density (BMD), which is closely linked to muscle function. Lower BMD values, often observed in sarcopenic individuals, correlate with increased risks of fractures and functional decline (Khan et al., 2021). Studies suggest that declining BMD in sarcopenic individuals may result from reduced mechanical loading due to muscle weakness, highlighting the interdependence of bone and muscle health (Mäntynen et al., 2020).

Literature Review

Cheng et al. (2021) established DXA as the most accurate method for evaluating BMD and muscle mass, making it essential for sarcopenia diagnosis (Cheng et al. (2021). C reported that individuals with sarcopenia often present with reduced BMD, particularly in weight-bearing bones, increasing their risk of fractures (Cheng et al. 2021). Research by Mäntynen et al. (2020) further supports this connection, indicating that lower BMD in sarcopenic individuals is likely due to decreased mechanical stimulation from weakened muscles,

leading to progressive bone loss (Mäntynen et al. 2020).

Yasud Takai and colleagues (2022) focused on physical fitness analysis, particularly measuring grip strength using a factory-calibrated hand dynamometer (TKK 5401; Takei, Tokyo, Japan). Participants were instructed to hold the dynamometer with their arms at their sides, elbows extended, and without pressing it against their bodies. The dynamometer was adjusted to the participant's comfort, and each participant completed two trials. The highest value from both trials was used for analysis (Yasud & Takai, 2022).

Chweighofer et al. (2024) studied sarcopenia detection through BIA and DEXA, noting that BIA values were higher than DEXA measurements, but both methods met sarcopenia criteria for males and females. The Bland-Altman analysis showed that both methods fell within the limits of agreement, indicating that BIA can accurately detect sarcopenia. The study also assessed musculoskeletal fitness using handgrip strength and vertical leap power tests, and participants at risk for sarcopenia were identified based on body composition measures (Chweighofer et al., 2024).

Woo et al. (2014) validated SARC-F as a simple screening tool for sarcopenia, assessing strength, walking ability, and functional limitations. However, studies indicate that its predictive accuracy may be lower in young adults (Woo et al. 2014). Foo et al. (2023) reported that sarcopenia prevalence in young adults varies widely (0.2%–86.5%), with factors like physical inactivity and obesity contributing to early muscle loss (Foo et al. 2023). Voulgaridou et al. (2024) emphasized that in Asian populations, up to 60% of young adults exhibit risk factors for sarcopenia, highlighting the need for early detection and intervention strategies (Voulgaridou et al. 2024).

Methodology

Participant Characteristics

The participants included 82 apparently healthy young adults aged between 15-35 years old. Participants were recruited via notice board at CENUM, Centre for Nuclear Medicine in Lahore and through social media, with no specific criteria listed; thus, the sample size included a wide range of the general population. All voluntary participants who expressed their interest in the study signed a consent form prior to participation.

Study Design

The current cross-sectional study was performed CENUM, Centre for Nuclear Medicine.

Data Management

The study measured hand grip strength and body composition using dual-energy X-ray absorptiometry (DXA). The SARC-F structured questionnaire, gathering demographic data and pertinent diagnostic measurements will all be used in the data collection process. This methodology aims to provide reliable insights into health outcomes within the selected population in order to make a substantial contribution to future research and public health activities.

Objective

Comparison of DXA Whole Body composition Musculoskeletal Fitness test & SARC-F among young adults for identification of risk of Sarcopenia.

Hypothesis

Null Hypothesis (H0): There are no significant associations between DXA whole body composition, SARC-F and musculoskeletal analysis in identifying risk phenotypes for sarcopenia among young adults.

Alternative Hypothesis (H1): Significant associations exist between DXA whole body composition, SARC-F and musculoskeletal analysis in identifying risk phenotypes for sarcopenia among young adults.

Instruments

HOLOGIC Bone Densitometer (DXA Machine)
Model: Discovery W
Serial Number: 82330
Additional Equipment: Jammer Dynamometer

Inclusion Criteria:

- Young Adults (between 15-35)

Exclusion Criteria:

- Elderly Patients
- Children below the age of 18 Years
- Diagnosed Malignancy

- Diagnosed Patients
- Diseased Individuals such as Chronic Illness and Malignancies

Data Collection Procedure

The study adhered to the ethical guidelines of Superior University Lahore, ensuring participants' rights and confidentiality. Written informed consent was obtained from parents/guardians, and all procedures were explained. Participants were assured of anonymity, informed of the voluntary nature of the study, and their right to withdraw at any time without penalties or impact on regular treatment. Data collection involved DXA Whole Body Imaging including Lumber Spine & Left Hip, Hand Grip Test through Dynamometer & SARC-F Questionnaire.

Data Analysis

Data will be analyzed using SPSS version 26. The statistical analyses include frequency distribution and Pearson correlation to see the strength and relation among all parameters. All participants were requested for their informed consent, ensuring that they are aware of their rights and the study's goal, after ethical approval from Superior University review board.

Results

Age Category

	Frequency	Percent	Valid Percent	Cumulative Percent
15-22	46	56.1	56.1	56.1
23-28	28	34.1	34.1	90.2
29-36	8	9.8	9.8	100.0
Total	82	100.0	100.0	

Table 1 show the study population consisted of 82 participants, with the majority (56.1%) in the 15–22 age groups, followed by 34.1% in the 23–28 range and 9.8% in the 29–36 range.

Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Female	71	86.6	86.6	86.6
Male	11	13.4	13.4	100.0
Total	82	100.0	100.0	

Table 2 shows showed a predominance of females (86.6%), which could impact the results, given the differences in muscle mass, bone mineral density (BMD), and sarcopenia risk between genders.

Dynamometer Hand Grip Test

	Frequency	Percent	Valid Percent	Cumulative Percent
Excellent >56 in Male	4	4.9	4.9	4.9
Fair 39-44 in Male	2	2.4	2.4	7.3
Poor <39 in Male	5	6.1	6.1	13.4

Excellent>36 in Female	5	6.1	6.1	19.5
Average 25-30 in Female	1	1.2	1.2	20.7
Fair 19-24 in Female	8	9.8	9.8	30.5
Poor <19 in Female	57	69.5	69.5	100.0
Total	82	100.0	100.0	

Table 3 showed Hand grip strength was categorized according to reference values for males and females. Notably, 69.5% of females had poor grip strength (<19 kg), while only 6.1% of males into the poor strength category. This highlights a significant discrepancy in muscle function between genders, which aligns with previous studies indicating that females have lower skeletal muscle mass and strength due to hormonal and physiological differences (Cruz-Jentoft et al., 2019).

Strength, How much difficulty do you have in lifting and carrying 10 pounds?

	Frequency	Percent	Valid Percent	Cumulative Percent
None	70	85.4	85.4	85.4
Some	7	8.5	8.5	93.9
A lot	5	6.1	6.1	100.0
Total	82	100.0	100.0	

Table 4 showed that 6.1% had significant difficulty lifting 10 pounds, which could indicate early muscle weakness.

Assistance in Walking, How much difficulty do you have walking across a room?

	Frequency	Percent	Valid Percent	Cumulative Percent
None	74	90.2	90.2	90.2
Some	7	8.5	8.5	98.8
A lot	1	1.2	1.2	100.0
Total	82	100.0	100.0	

Table 5 showed that 8.5% reported difficulty walking across a room, a concern considering the young age of the cohort

Rise From Chair, How much difficulty do you have transferring from a chair or bed?

	Frequency	Percent	Valid Percent	Cumulative Percent
None	64	78.0	78.0	78.0
Some	14	17.1	17.1	95.1
A lot	4	4.9	4.9	100.0
Total	82	100.0	100.0	

Table 6 showed that 17.1% faced challenges rising from a chair, a predictor of lower limb weakness.

Climb Stairs, How much difficulty do you have climbing a flight of 10 stairs?

	Frequency	Percent	Valid Percent	Cumulative Percent
None	66	80.5	80.5	80.5
Some	13	15.9	15.9	96.3
A lot	3	3.7	3.7	100.0
Total	82	100.0	100.0	

Table 7 showed that 15.9% reported difficulty climbing stairs, further supporting muscle weakness as a risk factor.

Fall, How many times have you fallen in the past year?

	Frequency	Percent	Valid Percent	Cumulative Percent
None	57	69.5	69.5	69.5
Some	23	28.0	28.0	97.6
A lot	2	2.4	2.4	100.0
Total	82	100.0	100.0	

Table 8 showed that While 69.5% of participants reported no falls in the past year, 28% experienced occasional falls, and 2.4% had frequent falls. This is concerning because falls are a known consequence of sarcopenia and musculoskeletal frailty (Beaudart et al., 2017).

Total Scoring for Prediction of Sarcopenia and Poor Outcome

	Frequency	Percent	Valid Percent	Cumulative Percent
Non-Sarcopenic	66	80.5	80.5	80.5
Sarcopenic	16	19.5	19.5	100.0
Total	82	100.0	100.0	

Table 9 showed that 19.5% of the participants were classified as sarcopenic, despite being in a young age group. This suggests that sarcopenia may be an under recognized issue in adults, warranting early intervention strategies.

Correlations SARC-F & Whole Body BMD

		SARC-F	Whole Body BMD
SARC-F	Pearson Correlation	1	-.074
	Sig. (2-tailed)		.520
	N	82	82
Whole Body BMD	Pearson Correlation	-.074	1
	Sig. (2-tailed)	.520	
	N	82	82

Table 10 showed the Pearson correlation coefficient (r=−0.074) indicates a weak negative correlation between SARC-F scores and whole body BMD. The p-value (0.520) is not statistically significant, suggesting no strong association between self-reported sarcopenia risk and overall bone mineral density in this population.

Correlations SARC-F & Lumber Spine BMD

		SARC-F	Lumber Spine BMD
SARC-F	Pearson Correlation	1	-.082
	Sig. (2-tailed)		.469
	N	82	82
Lumber Spine BMD	Pearson Correlation	-.082	1
	Sig. (2-tailed)	.469	
		82	82

Table 11 showed the Pearson correlation coefficient (r=−0.082) suggests a slightly stronger but still weak negative relationship between SARC-F scores and lumbar spine BMD. The p-value (0.469) remains non-significant; indicating that lumbar spine BMD is not strongly affected by muscle strength or functional limitations in this cohort.

Correlations SARC-F & Neck of Femur BMD

		SARC-F	Neck of Femur BMD
SARC-F	Pearson Correlation	1	-.104
	Sig. (2-tailed)		.363
	N	82	82
Neck of Femur BMD	Pearson Correlation	-.104	1
	Sig. (2-tailed)	.363	
	N	82	82

Table 12 showed the Pearson correlation coefficient (r=−0.104) is slightly more negative than the previous correlations, implying a weak inverse relationship between sarcopenia risk and femoral neck BMD. The p-value (0.363) is still non-significant, suggesting that self-reported muscle weakness does not significantly predict femoral neck BMD in this sample.

Correlations SARC-F & Total Hip BMD

		SARC-F	Total Hip BMD
SARC-F	Pearson Correlation	1	-.075
	Sig. (2-tailed)		.508
	N	82	82
Total Hip BMD	Pearson Correlation	-.075	1
	Sig. (2-tailed)	.508	
	N	82	82

Table 13 showed The Pearson correlation coefficient (r=−0.075r = -0.075r=−0.075) again shows a weak negative association between SARC-F scores and total hip BMD. The p-value (0.508) remains above the significance threshold, indicating no strong evidence of a meaningful correlation between sarcopenia risk and hip bone density.

Correlations Dynamometer Hand Grip Test & Whole Body BMD

			Dynamometer Hand Grip Test	Whole Body BMD
Correlations	Dynamometer Hand Grip Test	Pearson Correlation	1.000	-.354**
		Sig. (2-tailed)	.	.001
		N	82	82
	Whole Body BMD	Correlation Coefficient	-.354**	1.000
		Sig. (2-tailed)	.001	.
		N	82	82

Table 14 showed the Pearson correlation coefficient (r=−0.354r = -0.354r=−0.354) indicating a moderate negative correlation between the dynamometer hand grip test and whole body BMD. The p-value (0.001) is statistically significant, suggesting that lower hand grip strength is significantly associated with lower whole body BMD in this population.

Correlations Dynamometer Hand Grip Test & Lumber Spine BMD

			Dynamometer Hand Grip Test	Lumber Spine BMD
Correlations	Dynamometer Hand Grip Test	Pearson Correlation	1.000	-.330**
		Sig. (2-tailed)	.	.0025
		N	82	82
	Lumber Spine BMD	Correlation Coefficient	-.330**	1.000
		Sig. (2-tailed)	.0025	.
		N	82	82

Table 15 showed the Pearson correlation coefficient (r=−0.330r = -0.330r=−0.330) indicating a moderate negative correlation between the dynamometer hand grip test and lumbar spine BMD. The p-value (0.0025) is statistically significant, suggesting that individuals with lower grip strength tend to have lower lumbar spine BMD.

Correlations Dynamometer Hand Grip Test & Neck of Femur BMD

			Dynamometer Hand Grip Test	Neck of Femur BMD
Correlations	Dynamometer Hand Grip Test	Pearson Correlation	1.000	-.506*
		Sig. (2-tailed)	.	.0001
		N	82	82
	Neck of Femur BMD	Correlation Coefficient	-.506*	1.000
		Sig. (2-tailed)	.0001	.
		N	82	82

Table 16 showed the Pearson correlation coefficient (r=−0.506r = -0.506r=−0.506) indicating a strong negative correlation between the dynamometer hand grip test and neck of femur BMD. The p-value (0.0001) is statistically significant, demonstrating that

decreased grip strength is closely associated with lower BMD at the neck of the femur, which is a critical site for osteoporosis-related fractures.

Correlations Dynamometer Hand Grip Test & Total Hip BMD

			Dynamometer Hand Grip Test	Total Hip BMD
Correlations	Dynamometer Hand Grip Test	Pearson Correlation	1.000	.381**
		Sig. (2-tailed)	.	.0004
		N	82	82
	Ne Total Hip BMD	Correlation Coefficient	.381**	1.000
		Sig. (2-tailed)	.0004	.
		N	82	82

Table 17 showed the Pearson correlation coefficient (r=0.381r = 0.381r=0.381) indicating a moderate positive correlation between the dynamometer hand grip test and total hip BMD. The p-value (0.0004) is statistically significant, suggesting that higher grip strength is associated with greater total hip BMD. This positive correlation may indicate that better muscle strength contributes to improved bone density at weight-bearing sites.

Discussion

My findings indicate that SARC-F scores were weakly negatively correlated with whole body, lumbar spine, femoral neck, and total hip BMD, but none of these associations were statistically significant. This suggests that self-reported functional decline may not be a strong predictor of bone mineral density (BMD), at least in a younger population. A study in an aging cohort similarly found that SARC-F alone was not an adequate screening tool for predicting osteoporosis, as it failed to strongly correlate with BMD at key skeletal sites (Shen et al., 2024). Another study emphasized that while SARC-F is useful for detecting functional impairments, it does not necessarily reflect changes in bone mass, particularly in younger individuals (Pang & Eng, 2023).

Research also indicates that the lumbar spine and femoral neck are sites more sensitive to age-related BMD loss due to their weight-bearing function and higher trabecular bone content (Ma et al., 2023). My findings align with these results, as the correlation between SARC-F and BMD was slightly stronger at the femoral neck than at other sites, though still not statistically significant. Additionally, previous studies have found that while frailty and BMD loss are linked, their causal relationship remains unclear, suggesting that direct muscle strength measures may be more predictive of bone health (Zhou et al., 2023).

Given that my study population is composed of younger adults, the weak correlation may be explained by the fact that significant bone loss has not yet occurred. Prior research has shown that the predictive value of SARC-F for osteoporosis increases with age and is particularly relevant in populations with existing mobility limitations (Osei-Hyiaman et al., 2023). Thus, SARC-F may be a more effective predictor of BMD in older adults or individuals with established sarcopenia.

My findings show that hand grip strength was significantly correlated with BMD at multiple skeletal sites. Whole body and lumbar spine BMD were moderately negatively correlated with grip strength, while femoral neck BMD showed a strong negative correlation (r=−0.506r = -0.506r=−0.506, p = 0.0001). Conversely, total hip BMD exhibited a positive correlation with grip strength (r=0.381r = 0.381r=0.381, p = 0.0004). These results indicate that muscle strength plays a crucial role in bone health, particularly in weight-bearing regions.

A Mendelian randomization study confirmed that grip strength is causally linked to higher BMD at

weight-bearing sites, particularly in the hip and lumbar spine, which aligns with my findings (Liang et al., 2023). Another large-scale study demonstrated that individuals with lower grip strength had significantly reduced BMD at the femoral neck, reinforcing the importance of muscle function in maintaining bone integrity (Foley et al., 2023).

Interestingly, my findings revealed a positive correlation between grip strength and total hip BMD, suggesting that better muscle strength may contribute to enhanced bone density in weight-bearing areas. This is consistent with research showing that resistance training and high-impact exercise can improve hip BMD by stimulating bone remodeling (Wu et al., 2023). Furthermore, a study in adolescents found that grip strength was a strong predictor of hip and femoral BMD, emphasizing the long-term impact of muscle strength on skeletal health (Chan et al., 2023).

Studies have also found that grip strength is a better predictor of osteoporosis risk than self-reported functional assessments like SARC-F (Bailey et al., 2023). This further supports my findings that grip strength, rather than questionnaire-based screening, is a stronger indicator of bone health. Additionally, grip strength has been linked to fracture risk, particularly in individuals with low body mass, highlighting its role in musculoskeletal health (Valdimarsson et al., 2023).

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