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Exercise Biomedicine – Health and performance, 60 credits

Association of Height, Weight, and Hand Grip Strength with Body Composition in Individuals with Spondylarthritis

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by

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Abstract

Background: Body composition is an important health parameter in several disease conditions, e.g., the inflammatory back disease spondylarthritis (SpA). Body mass index (BMI) is the most common anthropometric body composition assessment but has several limitations. As a result, several studies have been carried out to improve its validity by combining different body parameters. Nickerson equation (NE) is one of the equations developed to address the limitation of BMI. However, the knowledge is lacking on the preference of the NE which includes BMI (body weight and height), hand grip strength, and sex to estimate body fat percent over BMI alone among individuals with spondylarthritis.

Aim: This study aims to assess the association between BMI and the Nickerson equation (NE) -estimate body fat percentage- with body composition measured with bioelectrical impedance assessment (BIA) and in individuals with spondylarthritis.

Methods: Thirty-two individuals with SpA 17 women and 15 men with a median (range) age of 47 (30-66) years were included. The weight (kg), length (cm), hand grip strength (kg), and sex were registered to estimate values of body composition by the NE. BIA was equally used to assess total body fat %, visceral fat (cm^2), and skeletal muscle mass (kg). Associations between the NE, or body mass index (BMI), and BIA were analyzed by Spearman's correlations (r_s).

Results: The result shows that the NE has a r_s of 0.6 to BIA total body fat higher than the BMI correlation coefficient of 0.3 but NE has a lower coefficient of 0.3 to visceral fat than the BMI which is 0.6, NE also has a negative correlation coefficient of 0.6 to skeletal muscles.

Conclusion: This study suggested that the Nickerson Equation which combines BMI, hand grip strength, and sex is a better assessment of body composition in individuals with spondylarthritis and encourages clinicians to consider using the Nickerson equation in clinical setting instead of BMI where access to precise assessment tools is unavailable.

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1. Introduction

Obesity is defined as the excessive accumulation of body fat and is considered a chronic disease by the World Health Organization (WHO) which poses a major public health challenge throughout the developed world (WHO, 2013). Consequently, obesity poses a great challenge for national health systems because of the resulting physical and psychological health issues (Svenja *et al.* 2021). The 21st century has witnessed an increasing interest in classifying human health status in accordance with the percentage of fat in the individual (Gallagher *et al*. 2000). Body composition assessment has advanced in nutrition-, physical activity-, and health studies because of the important role of excess body fat and its distribution on the onset and progression of non-communicable chronic diseases (Rezende *et al.* 2007). Body fat percentage has also been reported as a good measure of the incidence and prognosis of cardiovascular diseases and metabolic syndromes (Ramírez-Vélez *et al.* 2017). This has made it an important factor in the health promotion program for the general population (Lee, Lee & Yeun, 2017) and the management of chronic diseases (Baker, 2020), which include Spondylarthritis.

Spondylarthritis (SpA) is a common name for related chronic inflammatory disorders which includes psoriatic arthritis, arthritis related to inflammatory bowel disease, reactive arthritis, a subgroup of juvenile idiopathic arthritis, and ankylosing spondylitis (Dougados & Beaten, 2011). Ankylosing spondylitis is an axial spondylarthritis that is characterized by inflammation of the axial skeleton, peripheral joints, and entheses and one of the most common chronic diseases that has genetic causative (Sieper & Poddubnyy, 2017; Hwang, Ridley & Reveille 2021). There is a report that shows no correlation between body composition (Body fat percentage) and the incidence of SpA disease (Chennouf *et al.* 2022; Kaffel *et al.* 2022). However, a higher fat mass index is said to be correlated with worse treatment effects (biological disease-modifying anti-rheumatic drugs) in SpA (Rios, 2020). This also correlates with cardiovascular fitness (Vanautgaerden *et al*. 2020). Therefore, it is important to use an accurate method when measuring body composition in people with SpA. This study examined the association between bioelectric impedance analysis (BIA) with the Nickerson equation which integrates body mass index (BMI), handgrip strength, and sex (Nickerson *et al*., 2020) in individuals with spondylarthritis.

2. Background

Obesity is considered a major health problem worldwide which results in decreased life expectancy because of its strong association with the occurrence of chronic medical diseases, and impairment of health-related quality of life, and it is considered one of the most important public health priorities (Djalalinia, *et al.* 2015). An effective body composition assessment is an important step in health promotion and prevention of diseases. The gold standards for evaluating obesity are Computed Tomography (CT), dual-energy X-ray absorptiometry (DXA) (Rollins, *et al.* 2017), and BIA. There are some anthropometric calculations often adopted in nonclinical environments in the classification of obesity. These anthropometric calculations combine some body parameters such as height, weight, handgrip strength, and waist circumference (Swainson *et al.* 2017). Body mass index (BMI) is also one of the common anthropometric assessments used in nonclinical environments. The BMI formula is the weight (in kilogram) divided by the square of the height (in meters) and usually classifies body composition into underweight (<18.5kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese (>30.0 kg/m^2). BMI's height and weight anthropometric-based estimation has been reported to have specific limitations in accurately assessing body composition at the individual level, but it provides a good general description of the fat mass characteristics in a healthy population (Ellis, 1999). BMI is equally limited in discriminating between body fat percentage and skeletal muscle mass (Hung, *et al.* 2017) and this implies that a person can have a high BMI but still have a low fat mass and vice versa (Nuttall, 2015). Several attempts have been made to improve these limitations, some of these attempts to improve the validity of BMI anthropometrics were regression equations developed to estimate BF% by Womersley and Durnin, Jackson, Deurenberg, and Gallagher (Nickerson *et al.* 2020). These equations use BMI and combine other descriptive variables like sex and race as the main prediction variables (Nickerson *et al.,* 2020). One of the most recent anthropometric tools that aim at improving the validity of BMI across all populations was reported by Nickerson *et al.* (2020) which developed an equation that took into consideration the handgrip strength (HGs) and the sex coefficient with BMI in the assessment of body fat (BF) in an apparently healthy individual. HGs have also been reported to be negatively influenced by demographics (sex and age), anthropometric (height, arm's length, and girth), and disease activity variables (Heredia, 2005). The forearm girth, hand skeletal muscle, and bone mineral content are factors also influencing handgrip strength (Jürimäe, 2009). Therefore, handgrip strength, sex, and obesity influence the disease activity, progress, and response to treatment differently in both men and women with spondylarthritis and are related to worse disease activity scores (Neuenschwander *et al.* 2020).

2.1. Spondylarthritis

Spondylarthritis (SpA) dates back thousands of years before Christ (BC) as reported by medieval skeleton HLA-B27 typing (Zeidler, Calin & Amor, 2011). Until the early 1960s, ankylosing spondylitis and other SpA were considered variants of rheumatoid arthritis (RA), then the formal medical community separated SpA from RA and thereafter, recognized to be inter-connected in terms of clinical, laboratory, and imaging features (Ashrafi *et al*. 2020). SpA is a severe and disabling chronic illness characterized by a variety of manifestations that decrease life expectancy. The clinical presentation varies across individuals with SpA with the most common manifestations including inflammatory back pain, peripheral arthritis, pain, and temporary or permanent functional impairments that adversely affect everyday life. SpA can broadly be classified into two classes which are: axial and peripheral. The axial SpA may also have peripheral clinical features and vice versa (Deodhar, 2019). The most common type of SpA is axial SpA which can be non-radiographic or radiographic axial SpA, which is also termed ankylosing spondylitis (Sieper, Joachim, & Denis, 2017). Ankylosing spondylitis is an inflammatory autoimmune disease that mainly affects spine joints, causing severe chronic pain, and in more advanced cases, it can cause spinal fusion (Zhum, 2019; Taurog *et al.* 2016). This fusion is caused by the degree of disease activity over time on the impairment of function because of structural damage and inflammation of the spinal bones (Baraliakos & Braun, 2012). It usually includes the spinal joints, sacroiliac joints (SIJs), and their adjacent soft tissues, such as tendons and ligaments. SpA can also lead to fibrosis and calcification, resulting in the loss of flexibility. Its main clinical manifestations include back pain and progressive spinal rigidity as well as inflammation of the hips, shoulders, and peripheral joints (Kerschbaumer *et al*. 2017). Generalized bone loss (osteoporosis), local (pathological) bone formation, and fragility fractures also occur in axSpA (Soos *et al*. 2022).

2.2. Diagnosis of Spondylarthritis

Patients with inflammatory back pain, secondary to SpA will usually complain about morning spontaneous onset of back pain, awakening because of back pain during the second half of the night, and alternating buttock pain, and these pain symptoms are often reported to improve by movement rather than by rest (Sieper, *et al.* 2009). Diagnosis of SpA often involves several clinical features both radiological and non-radiological. The most common characteristic symptom of SpA is chronic back pain in the form of inflammatory back pain (IBP) (Kiltz *et. al.* 2017). This is an early sign that suggests further examination to be carried out with the use of magnetic resonance imaging (MRI) for differential diagnosis (Rudwaleit *et al.* 2004). MRI in patients suspected to have SpA is important for early clinical diagnosis, differential diagnosis, monitoring, and prognosticating patients with confirmed SpA (Aouad, Maksymowych, Baraliakos & Ziade, 2020).

2.3. Etiology of Spondylarthritis

The exact etiology and pathogenesis of spondylarthritis are still not well documented but several lines of evidence indicate that genetics plays an important role in individuals' susceptibility, while environmental factors such as infections and gut dysbiosis, also contribute to SpA pathogenesis (Sharip, Aigul, and Kunz. 2020). The disease usually starts in the third decade of life with a male-to-female ratio of two to one for radiographic axSpA and one to one for non-radiographic axSpA (Sieper & Denis 2017).

2.4. Epidemiology

SpA is an increasingly common disease with large variations of prevalence, features and symptoms reported in different countries. These variations can partly be explained by differences in demographic and methodologic characteristics of epidemiology studies (Stolwijk, 2016). The following are the reported prevalence of SpA in the general population from country to country: 0.01% in Japan, 2.5% in Alaska, 0.47% in France, 0.84% in Lithuania, 1.73% in Germany, 1.73%, 1.05% in Turkey, 1.6% in Portugal, 0.49% in Greece, and 1.4% in the United States (Stolwijk *et al.* 2012). In Sweden as a whole, the prevalence was reported to be 1.9 % (Bakland & Nossent, 2013) and 0.45% in southern Sweden (Haglund *et al.* 2011).

2.5. Treatment of Spondylarthritis

The management of patients with spondylarthritis is a multidisciplinary approach (Pham, et al. 2011) with requires pharmacological and non-pharmacological treatment modalities (Agrawal & Machado. 2020).

2.5.1. Pharmaceutical

Nonsteroidal anti-inflammatory agents (NSAIDs) are usually the first choice of pharmaceutical therapy (Van der Heijde, 2016). However, increased cardiovascular (CV) risk associated with NSAIDs is well-documented in the general population, thus, limiting the use of these drugs in patients with SpA, a population already at potentially high CV risk (So, Ho, Tam, Lai-Shan, 2022). There are four other biologics approved in many countries, all directed against TNFα, these are infliximab, etanercept, adalimumab, and golimumab (Baraliakos & Braun, 2012).

2.5.2. Non-Pharmacological

In the past two decades, new insights have emerged regarding the role of therapeutic exercise in inflammatory rheumatic diseases and it significant anti-inflammatory effect (Grazio, Grubišić, & Brnić 2019). Evidence from qualitative have shown that supervised exercise is beneficial to the disease outcomes independent of pharmacological treatment (Baraliakos, 2022). The most effective exercise protocol remains unclear even though there is evidence that supervised therapeutic exercises are beneficial (Verhoeven, 2019). One of the main causes of death in individuals with spondylarthritis is cardiovascular disease (Prati, 2017), exercise will improve their cardiopulmonary function as well as other physical functions, disease activity, chest expansion, pain condition, stiffness, and spinal mobility therefore improving their overall wellbeing (O'Dwyer, O'Shea, & Wilson 2014). Also, High-intensity exercises reduced disease symptoms (pain, fatigue, stiffness) and inflammation in patients with SpA (Sveaas *et al.* 2020). The exercise protocols involve flexibility, cardiopulmonary, stretching, and muscular strength exercises. The protocol is usually targeted to reverse the symptoms presentations and is required to be carried out under supervision (Dagfinrud *et al.* 2011). Exercises like hydrotherapy, or exercise based on global postural re-education performed in groups offer a promising alternative therapy for patients with SpA (Ribeiro *et al.* 2007).

2.6. Body Composition in Spondylarthritis

Spondylarthritis has been reported to be associated with changes in body composition and intramuscular fat which may alter muscle function and contribute to cardiometabolic disorders (Villedon *et al.* 2021). The human body is mainly composed of four molecular-level components: water, fat, proteins, and minerals. Fat has attracted the most attention because an excessive amount of body fat is related to increased morbidity, mortality, and chronic medical diseases like spondylarthritis. (Borga *et al.* 2018). Body composition and fat distribution vary between males and females, these differences are more evident in patients with an inflammatory disease, such as spondylarthritis (Rusman, van Vollenhoven, & van der, 2018). Women with spondylarthritis have significantly higher fat mass, body fat %, and lower fat-free mass (Sebastián *et al.* 2017) which may result in lower quality of life in females compared to males (Casper *et al.* 2016). Also, Leptin (an adipocyte hormone that sends nutritional status to the central nervous system (CNS) and peripheral organs) secreted from fat tissue is usually found at higher levels in obese women and seems to be associated with greater spinal radiographic progression when it rises during the disease (Ibáñez and Horst-Bruinsma, 2020). This research is suggestive that accurate estimation of body composition can give an insight into SpA activities and progression.

2.6.1. Assessment of Body Composition

There are various well-established methods and techniques for estimating body composition which include underwater weighing, dual-energy X-ray absorptiometry (DEXA), total body water, total-body electrical conductivity, total body potassium, and computed tomography. These methods are often not available in many secondary and primary health centers (Zuguo *et al.* 2002). The different methods are often adopted with consideration of their availability, ease of use, cost, accuracy, consistency, and reproducibility. The most sophisticated, valid, and reliable methods that allow the quantifying of body components are hydrostatic weighing and DEXA (Heyward, 2001). BIA is another accuracy, simplicity, low cost, and excellent correlation with DXA, CT, or magnetic resonance imaging (MRI) method frequently used to assess body composition and calculate BF% in clinical practice (Xu *et al*. 2011). However, these methods have limited use in the evaluation of population groups, due to the high cost and complexity therefore, their use is restricted to laboratories and very specific clinical situations (Heyward, 2001). These facilities are not available in every setting that requires body fat evaluation and as a result, anthropometric assessments are often adopted. Several research studies have been carried out to develop and improve the validity of anthropometric calculations which are universally available. One of the most used anthropometric tools is the BMI, which is a non-invasive technique for body composition assessment using two matrices, weight, and height.

2.6.2. Body Mass Index (BMI)

The BMI is a non-invasive anthropometric calculation that has been reported to be correlated to disease activities in spondylarthritis, to both axial and peripheral new bone formation and inflammation by imaging (Bakirci, *et. al.* 2020). Liew *et al*. (2020) reported higher BMI is associated with worse outcomes including response to biologic medications, demonstrating an association between an overweight/obese BMI and higher disease activity in studies of spondylarthritis (SpA). Another study reported that Ankylosing Spondylitis Disease Activity Score (ASDAS) is not affected by BMI in axSpA patients and therefore, it is not necessary to consider BMI when assessing axSpA patients (Vargas *et al.* 2016). The varying result may be due to the limitation of sensitivities and specificity in the use of BMI across different age populations, and ethnic populations (Duncan, Duncan, & Schofield. 2009). BMI has been combined with some other parameters to improve the ability to estimate the BF, one example is the combination of BMI and waist circumference (WC) which is widely used to predict percentage BF (Aeberli *et al.* 2013). Another example is to measure handgrip strength (HGs) in combination with BMI, HGs have been used as an indicator of overall physical strength and health (Massey-Westrop et al., 2004). This study considered the Nickerson equation, an equation developed by Nickerson *et al.* 2020 integrates HGs and sex variables with BMI to assess body fat percentage. The equation was developed to enhance the validity and sensitivity of BMI in an apparently healthy individual.

2.6.3. Handgrip Strength

The HGs test is one of the common methods to assess muscle strength (Shinyoung *et al.* 2021). Muscle wasting is often a prominent feature in some chronic diseases and has been specifically reported to be high in spondylarthritis (Shao, Dai, & Wei. 2023) which significantly affects patient morbidity and mortality (Valido et al 2019). The fat area is inversely correlated with HGs, and it is associated with disease activity and disability in individuals with SpA (Villedon *et al.* 2021). The HGs and pinch strength were reported to be lower among patients with Rheumatoid Arthritis (Sferra 2018). There has also been a report of a correlation between muscle strength and disease activity in individual with SpA (Amador et. al. 2019). BMI and HGs can be used to assess a patient's ability to return to routine activities and jobs, as well as to track progress and compare the efficacy of different treatment strategies in chronic musculoskeletal disease (Salaffi *et. al.* 2021).

2.6.1. The Nickerson Equation

An equation developed by Nickerson et. al., 2020 integrates handgrip strength and sex variables with BMI to assess body fat percentage. The equation was developed to enhance the validity and sensitivity of BMI in healthy individuals. The equation has been compared with other BMI-based calculations which are $\mathrm{BMI}_{\mathrm{WOMERSLEY}}$, $\mathrm{BMI}_{\mathrm{JACKSON}}$, $\mathrm{BMI}_{\mathrm{DEURENBERG}}$, and $\mathrm{BMI}_{\mathrm{GALLAGHER}}$, and was reported to have the lowest central error and individual error margin and 95% limit of agreement with these equations.

This equally has been tested among healthy Hispanic and non-Hispanic White populations was reported that this equation is not ethnic-specific (Nickerson *et al.* 2020). This study examined the correlation between the Nickerson equation with Bioelectrical Impedance Analysis (BIA) and compared it with the correlation of BMI with BIA in people with spondylarthritis to adopt the most valid anthropometric method in people with SpA.

2.7. Significant of study

Lean mass and fat mass are important factors in spondylarthritis disease condition and studies have shown these factors affect outcome measures in the treatment of spondylarthritis (Kaffel, *et al*. 2022). However, the best anthropometric index for assessing quality remains to be established (Villedon *et al*. 2021).

2.8. Aims

This study aims to assess the association between BMI and the Nickerson equation (NE) -estimate body fat percentage- with body composition measured with bioelectrical impedance assessment (BIA) and in individuals with spondylarthritis.

Research questions

1. What is the association level between BMI and body composition (total body fat, visceral body fat, and skeletal muscle mass) assessment in individuals with spondylarthritis?
2. What is the level of association of the NE with BIA body composition (total body fat, visceral body fat, and skeletal muscle mass) assessment in individuals with spondylarthritis?

3. Methods

A cross-sectional study design was adopted, and data was extracted from the baseline measurement of an ongoing randomized control trial investigating the effects of high-intensity interval training (HIIT) on physiological, inflammatory, and self-reported health parameters in individuals with SpA. The study extracted data from both the control and experimental groups. The data collected included biodata, weight, height, hand grip strength, total body fat, visceral fat, and skeletal muscle percent. Individual fat mass percentage and skeletal mass percentage were collected with BIA. The BMI and The Nickerson equation (Nickerson *et al.* 202) were calculated from each parameter and were duly recorded. Information sheets and oral explanations of all the details of the research including risks and benefits were made available to individual participants. Participants who showed interest in continuing were given a consent form to fill out and sign before data collection.

3.1. Participants

Participants were individuals between the ages of 18 and 65 who have been confirmed to have axSpA and have been managing arthritis in a rheumatoid clinic in southern Sweden. Patients experiencing spondylarthritis were identified through their clinic case history notes by their physiotherapist working at the clinic and were subsequently contacted through the physiotherapist. The identified patients were further screened for cardiovascular diseases and other contraindicated in high-intensity exercises before their recruitment into the intervention study.

3.2. Data collection

The Bioelectrical Impedance Analysis (BIA) is a non-invasive device used widely both in healthy subjects and patients for the determination of the Fat Mass (FM), Free Fat Mass (FFM), and Total Body Water (TBW) in subjects without significant fluid and electrolyte abnormalities (Kyle et. al., 2004). The usage involves the passage of a painless low amplitude electrical current applied through cables connected to electrodes placed in contact with the skin. The machine measures the resistance (R) and reactance (Xc) to estimate the body compartments: FM, FFM, and TBW (Mirele, 2014). The participants were prepared in accordance with the manufacturer’s manual to use the BIA machine (no narcotics, no food, no heavy exercises, and a total empty bladder exercise before usage). The handgrip dynamometer that was used in this research was a hand dynamometer (KERN Sohn GmbH, Balingen, Germany), this measures the handgrip strength which provides objective and quantifiable information about the function of the hand and integrity of the upper body and other muscle groups. This is sometimes used as an indicator of overall body strength, it is an integral part of basic test batteries used in sports and is a marker of general health status (Markovic, 2020). A stadiometer and weighing scale were used to assess the height and weight in meters and kilograms respectively.

3.3. The Nickerson Equation (NE)

The Nickerson equation is as follows: BF% = 21.504 - (12.484 x RHGs) - (7.998 x sex) +(0.722 x BMI) Sex = (0 for females and 1 for males). Where the BF% = body fat percentage, BMI= body mass index, and RHG = relative-hand grip strength which is the sum of the right and left grip strength divided by the body mass in kilograms (Nickerson *et. al*. 2020). The results of this equation were compared with BIA visceral fat, body fat, and skeletal muscles.

3.4. Statistics

Statistical analyses were performed using IBM SpSS (version. SPSS 29) and Microsoft Excel. Descriptive statistics such as median and ranges (min-max) were used to present the age, height weight, BMI, and fat distributions in this research. The data were initially tested for normal distribution using the Shapiro-Wilk test which shows that the data were not normally distributed. As a result, non-parametric analysis was used (Grech and Calleja, 2018). Spearman's rho correlation (r_s) was used in the analysis and compared the body fat percentage, visceral fat, skeletal muscle mass, and Nickerson equation and used to compare the correlation between BMI with visceral fat, total body fat, and skeletal muscles. The correlation coefficient reference point was as follows: 0: No correlation, 0.1 to 0.2: Poor, 0.5 to 0.3: Weak, 0.6 to 0.7: Moderate, 0.9 to 0.8: Strong correlation, 1: Perfect Correlation and the correlation can either positive correlation or negative correlation (Haldun Akoglu 2018). The significant level was set at a P-value of 0.05.

3.5. Ethic

The procedure of this research was in line with the Helsinki Declaration which is the universally recognized ethical norms for the medical and scientific sectors for conducting medical research that involves human subjects ("World Medical Association Declaration of Helsinki," 2013). The data usage was strictly with the agreement with the participant's signature in the consent form before the collection of their data. Participation in the research was completely voluntary, the participant's right to withdraw from the study with or without any reason without notice was respected and this was explained to the participant before the commencement of their participation.

All the assessment tools, information sheets, and consent forms were made available in the Swedish language. The data extracted was used for the purpose of this thesis only. The anonymity of the participants was maintained so as not to allow personal information traced back to any participant. Confidentiality of the data collected was adhered to, all data was protected, and the data were all analyzed on a password system without an internet connection on the site at Halmstad University. The ethics application was approved by the ethics advisory board, dnr-number 2019-04155 and 2022-03114-02.

3.6. Equality and Sustainability Goals

Sustainable Development Goals (SDGs) 1, 2, & 8 were set to reduce poverty, end hunger, and economic growth. The research aimed at improving the assessment of body compositions of individuals with SpA using the anthropometric equation, which is more accessible in all communities. Relevant health assessment is an important step in providing good healthcare and the availability of healthcare in a community is closely related to their ability to work and improve the economy (reduction of poverty). Also, SDG 3 which emphasizes the need for good health, well-being, and reduction of a sedentary lifestyle was targeted in this study. Which is to simplify the assessment of the body composition in SpA, precise and objective assessment before treatment and rehabilitation is very important to the optimal prognosis of disease management and overall well-being of individuals with SpA. Nickerson's equation equally factors in the role of sex of the individual (gender) in establishing an accurate assessment. This shows details of sex variability were paid adequate attention which is in line with the goal of SDG 5 gender equality. Anthropometric body assessment is not dependent on mechanical or electrical machines with emissions making a more sustainable and accessible form of body assignment also in line the SDG Goal 7 the advocate for affordable and renewable clean energy. SDG 10 which aims to reduce inequality, and access to simple evidence-based precise methods of assessing body composition by low-income countries tends to reduce the healthcare need gap between these countries and advanced countries that have access to more standard assessment equipment.

4.0. Result

The total number of participants was 32, 17 females and 15 males. Age ranges from 31 to 66 years, with a median age of 46.5. The participants have a BMI range of 17.5 (min-max; 19.0-36.5) and a median of 24.0. The body fat percentage with the BIA range was 26.4 (9.5-35.9) and a median of 22.7.

Table 1: Descriptive table: the table below shows the variable, range, and median.

Variables	Range (Min-Max)	Median
Age (years)	36 (30-66)	46.50
Height (cm)	31.4 (156-187.4)	173.4
Weight (kg)	65.5 (52.5-118	73.4
Means HGs (kg)	129 (20.65-149.9)	36.77
Relative HGs (kg/kg)	1.08 (0.31-1.39)	0.5
Visceral Fat	159.2 (28.6-187.8)	71.2
Total Fat %	26.4 (9.5-35.9)	22.7
BMI	17.5 (19-36.5)	24.05
Skeletal Muscle (kg)	23.6 (20.6-44.2)	32.2
Nickerson equation	23.9 (13.05-36.95)	30.11

The Muscle Mass, visceral, and total body fat were measured with BIA. The BMI was calculated using the formula weight divided by the square of the height.

4.1. Association between BMI and total body fat, visceral fat, and skeletal muscles mass

The strength of the correlation between BMI and Fat mass was weak at rs 0.38, with a p-value of 0.03. The strength of the correlation between BMI and Visceral fat was moderate with r of rs 0.63 at a p-value of 0.001 while the strength of BMI and skeletal muscle correlation was weak at 0.5 at the p-value of 0.003.

Table 2. Association between BMI and Total Body fat, Visceral fat, and Skeletal muscle mass.

	Correlation coefficient r	p-value
Total Body fat	0.38	0.03
Visceral fat	0.63	0.001
Skeletal muscle mass	0.5	0.003

The coefficient was predicted at a 95% confidence interval.

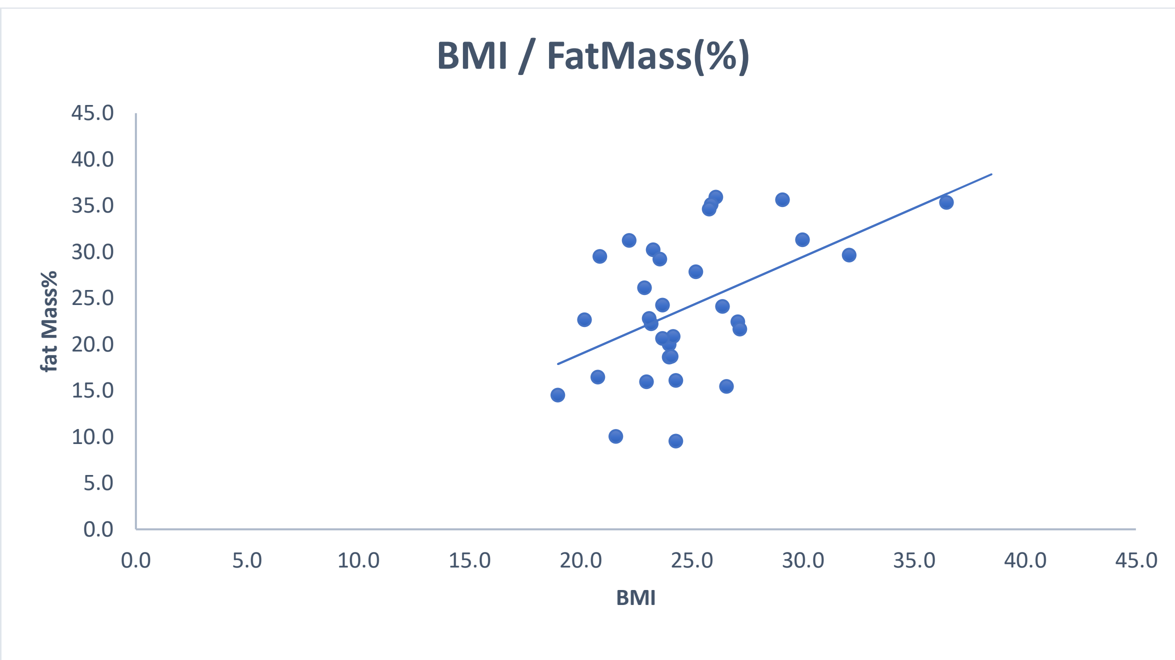

Figure 1: This is a graph showing the relationship between BMI and fat mass**.**

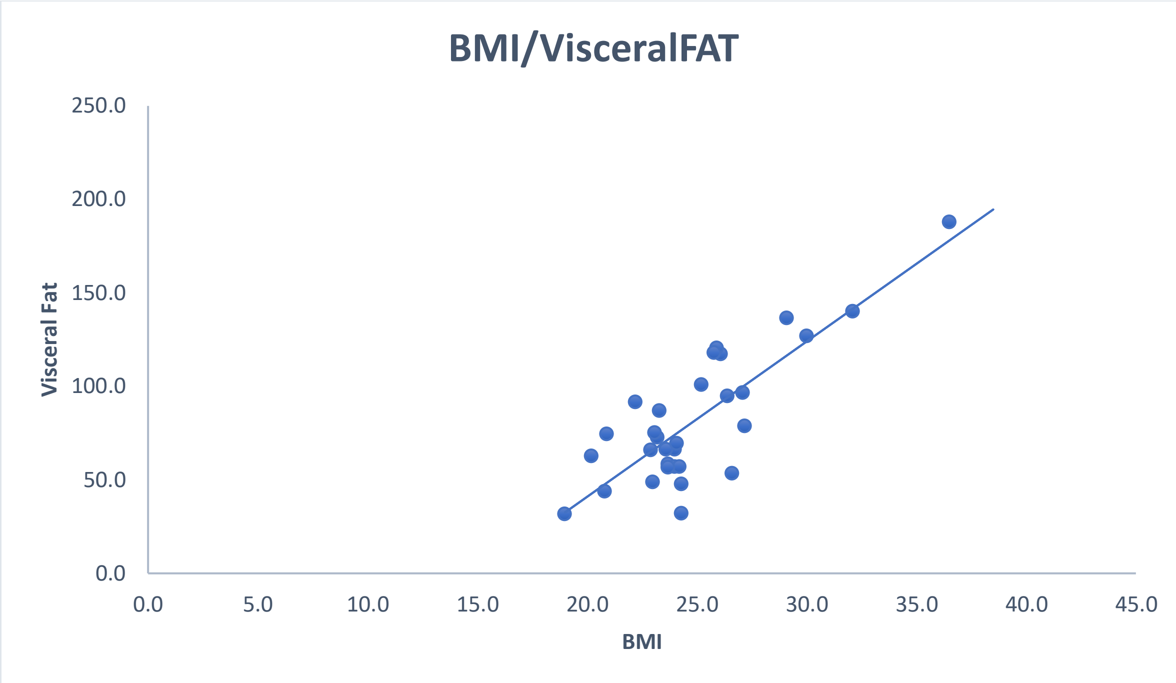

Figure 2: This is a graph showing relationship between the BMI and Visceral fat

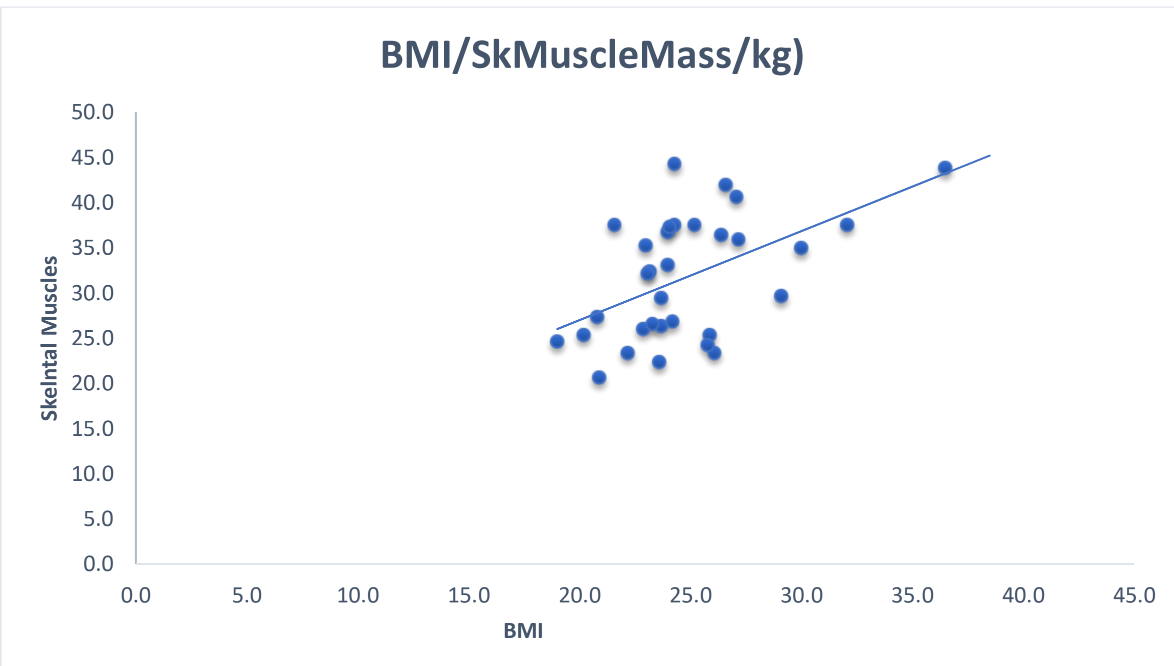

Figure 3: Graph showing the relationship between the BMI and Skeletal Muscles

4.2. Association between Nickerson equation and total body fat, visceral fat, and skeletal muscles mass

The strength of the correlation between Nickerson equation and Fat mass was strong at rs0.65, with a p-value of 0.01. The strength of the correlation between Nickerson equation and Visceral fat was weak with r of rs0.38 at a p-value of 0.03 while the strength of Nickerson equation and skeletal muscle had a moderate negative correlation at rs -0.63 at a p-value of 0.001.

Table 3. Association between Total Body fat, Visceral fat, Skeletal muscle mass, and Nickerson Equation.

	Correlation coefficient r	**p-value**
Total Body fat	0.65	<0.01
Visceral fat	0.38	0.03
Skeletal muscle mass	-0.63	<0.001

The coefficient was predicted at 95% confidence interval.

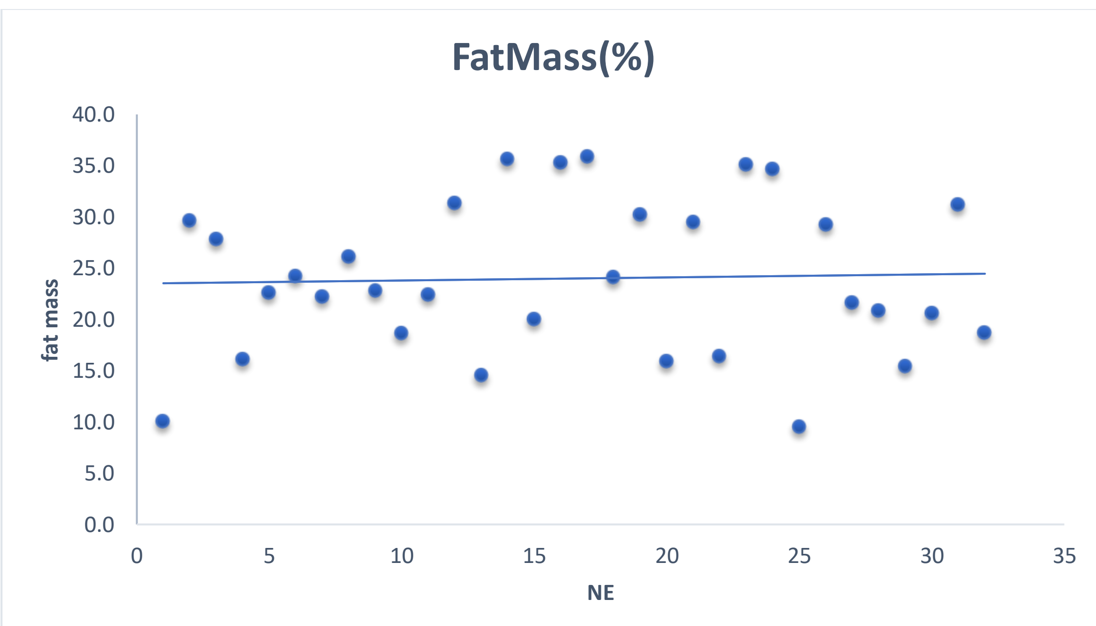

Figure 4: Graph showing the relationship between the NE and fat mass

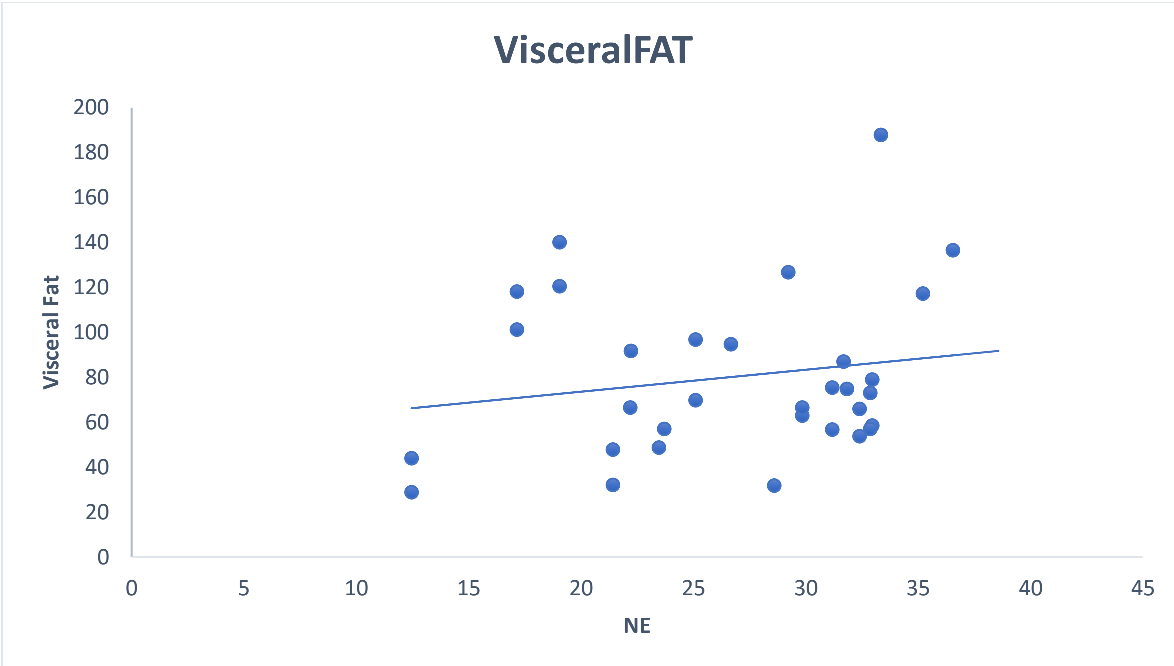

Figure 5: Graph showing the relationship between the NE and visceral fat

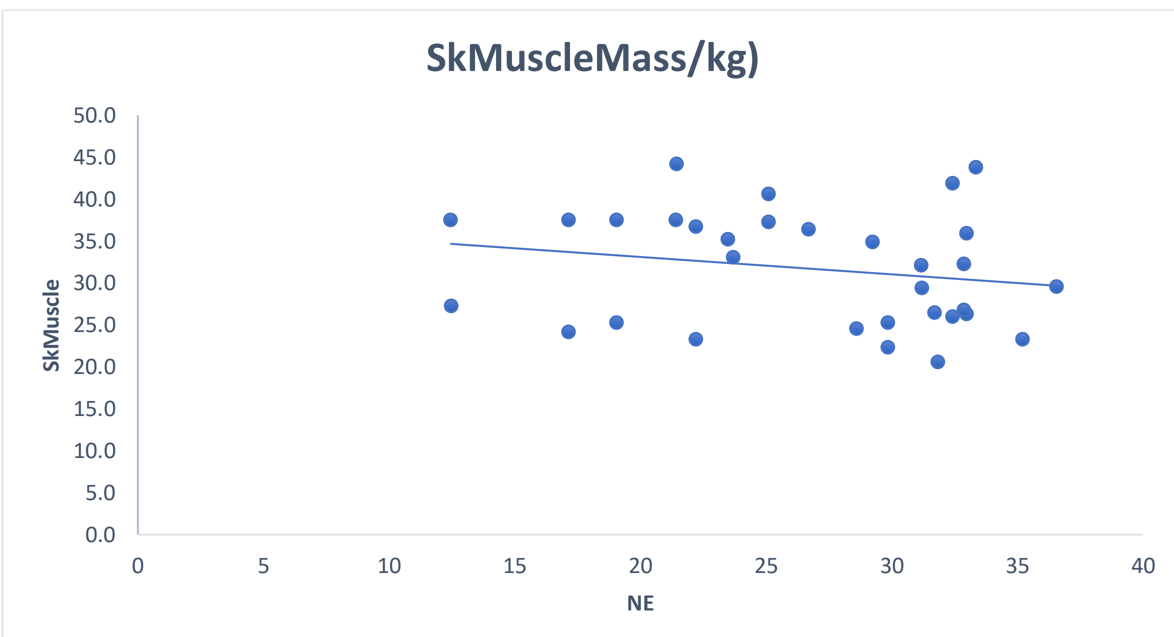

Figure 6: Graph showing the relationship between the NE and skeletal muscles

5.0. Discussion

Globally, BMI is the most common predictor of body composition due to its simplicity and easy to use formula (Nuttall, 2015). According to the findings of this study, it can also be said to be a relatively good predictor of body fat percentage because it has a positive correlation with the body fat percentage assessed with BIA. However, the correlation is weak with a coefficient of 0.3. Böhm & Heitmann (2013) reported that BIA-estimated BF% is directly and closely related to various health outcomes such as CVDs, whereas BMI is not, and the reason might be due to the weak correlation. Both high and low BMIs are not associated with an increased risk of developing chronic diseases, these disparities can also be side to agree with the finding of this study which shows a weak correlation of 0.3 between BIA FAT% and BMI. As a result, BMI might be said not to be very a good predictor of body fat composition in individuals with chronic diseases and spondylarthritis, especially in clinical settings. However, BMI estimation can vary among populations and conditions, Ranasinghe, *et al.* (2013) reported BMI to be strongly correlated with BIA BF % in a population of South Asian adults and this relationship was said to be curvilinear and significantly affected by sex and age.

Nickerson equation (NE) is an equation that aims to improve the BMI estimation by the inclusion of relative handgrip strength. It considers the variation in muscular strength via relative handgrip strength which is often significant in SpA prognosis. It has been reported to improve the accuracy of BMI and significantly reduce the individual error in BF% estimation (Nickerson *et al.* 2020) for variation which includes BMI, sex, and hand grip strength variables was compared with the BIA in this population of individuals with spondylarthritis and the NE has a moderate correlation to the BIA fat percentage, unlike BMI which has a weaker correlation to BIA fat percentage. This agrees with the position of Gamage *et al.* 2013, who reported that other body anthropometry parameters could be included in its calculation to increase the sensitivity of BMI.

In contrast, BMI has a better correlation of 0.6. to the body visceral fat percentage than that of the NE which correlates with $0.4r^s$. High visceral body fat has been reported to be associated with an increased risk of type II Diabetic Mellitus diagnosis (Nusrianto *et al.* 2019) which itself (Diabetes Mellitus) is strongly associated with the prognosis of spinal degenerative diseases (Park et al. 2021) which include spondylarthritis. This can suggest that BMI will be associated with type II diabetes Mellitus diagnosis in both male and female people with spondylarthritis however the sample size is a limiting factor in this report therefore further study will be necessary to reach a conclusion.

Muscle mass is one of the main prognostic factors (predictors) of chronic conditions including spondylarthritis and cardiovascular diseases, increase or decrease of muscle mass is of great importance which was reported by Kim *et. al.* (2022) to be associated with reduction and incremental risk respectively of cardiovascular diseases. Cardiovascular disease is one of the major co-morbidities in spondylarthritis and its presence or absence is associated with an increased or decreased risk of fatality (Toussirot, 2021) which makes its assessment a good prognosis. In this study, it was discovered that BMI has a positive weak correlation (coefficient of 0.5) with the BIA body skeletal muscle percentage. This suggested that higher BMI is not only referring to fat % but also to higher body muscle percentage. This is one of the reasons why a BMI might not be a good prognosis of SpA because higher skeletal muscle implicates a lower risk of this SpA, but a higher BMI often suggests the risk of developing a chronic condition or bad prognosis of a chronic condition which also includes spondylarthritis. However, NE has a negative correlation (coefficient of -.61) with the BIA body skeletal muscle percentage. The NE is positively correlated to body fat while it negatively correlates with skeletal muscle and vice a visa. It implies that lower NE scores mean lower fat mass and higher skeletal muscle mass while higher NE score means higher fat mass and lower skeletal muscle mass. In contrast with BMI which means lower BMI means lower fat mass and lower muscle mass while higher BMI means higher fat mass and higher BMI. It can be suggested from this result that NE makes a better predictor of body composition in people living with spondylarthritis and a good outcome measure among these individuals because increased skeletal muscle mass and decreased fat mass were associated with a reduced risk of acquiring cardiovascular disease and chronic diseases while decreased skeletal muscle mass and increased fat mass were associated with an increased risk of developing the disease. (Kim *et al*. 2022)

5.1. Conclusion

Nickerson equation (NE) is a better assessment equation to predict body fat and skeletal muscle mass because it has a better correlation than BMI, its positive correlation to the fat percentage, and inversely relationship with the lean muscle composition. However, this study's sample size is limited, and the result needs to be validated with a larger sample size.

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Master´s thesis

Exercise Biomedicine – Health and performance, 60 credits

Association of Height, Weight, and Hand Grip Strength with Body Composition in Individuals with Spondylarthritis

Exercise Biomedicine – 60 credits

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