The Relationship of Body Mass Index with Disease Activity in Ankylosing Spondylitis

Raouf R. Merza, Kurdistan M. Ali, Dlair M. Mohamad, Sundus A. Wahhab

1Division of rheumatology, Department of medicine, Faculty of Medical sciences, University of Sulaimani. 2Kirkuk directory of health, rheumatology division. 3 Department of Medicine, Faculty of medical sciences, University of Sulaimani. 4Kirkuk directory of health, rheumatology division.

ABSTRACT

Find out the relationship between body mass index (BMI) and W.C with disease activity score in AS patients and its association with clinical characteristics of AS. One hundred and five patients (75 male and 30 female) who visited rheumatology and medical rehabilitation center in Sulaimani city were recorded in this cross-sectional study. Disease activity was measured by ASDAS-ESR in the hand-held calculator. BMI was calculated and waist circumference (W.C.) was measured and both were evaluated with disease activity score and disease characteristics in those with normal BMI and W.C and those with abnormal BMI and W.C. Data of one hundred and five patients were involved in this study with a mean age of 37±9.5 years with the predominance of male gender (71.4%). The mean BMI of the patients was 27.2±4.6 kg/m², 28.6% of them were obese and 35.2% of them were overweight. Patients who were overweight, obese and increased W.C had significantly higher disease activity scores and older compared to those who had normal BMI and W.C.(p value<0.05). There was no statistically significant difference between the two groups in terms of peripheral arthritis, disease duration, clinical characteristics of AS, and gender (P value>0.05). Overweight, obesity and increased W.C are common among AS patients and significantly related to disease activity score and age, but not with disease characteristics and gender.

Keywords: Ankylosing spondylitis. Obesity. BMI. Disease activity

DOI: http://dx.doi.org/10.32441/kjps.03.02.p6
علاقة مؤشر كتلة الجسم مع نشاط المرض لدى مرضى التهاب الفقار اللاصق

أ.روفي رحيم ميرزا، ك.كردستان مصطفى علي

الصفحة 71 - 85

المؤلفون

1-Raofmerza@yahoo.com, 2kudimali@yahoo.com
3-zang4man@yahoo.com, 4-sonawni2000@yahoo.com

الملخص

يتم في الدراسة، درجة نشاط المرض لدى مرضى التهاب الفقار اللاصق وعلاقتها ببعض الخصائص الديموغرافية والسريرية لـ AS، مثل وزن الجسم والطول والمستشعر ونسبة الجليم في السليمانية، المسجلين في هذه الدراسة المستمرة. تم قياس نشاط المرض باستخدام مؤشر كالة الجسم (BMI) وحساب علاقتهما مع درجة نشاط المرض وعلاقتهما مع الأพันธع المفرط من مؤشر الفقار اللاصق. أظهرت النتائج إحصائياً، أن هناك فروق ذات دالالة إحصائية بين أولئك الذين كانوا يعانون من زيادة الوزن، والسمة، وAS، وASDAS-ESR، وASDAS-ESR الطبيعي فيما يتعلق بدرجة نشاط المرض المقصورة وعمري بالمريض. ومع ذلك، لم تكن هناك فروق ذات دالالة إحصائية بين المجموعتين، من حيث التهاب المفصل المحلي، وحالة المرض، والخصائص السيربية للمرض. وظائف الوزن، السمنة، وزيادة محيط الخصر، مريضي التهاب الفقار اللاصق ويرتبط بدرجة كبيرة بنتائج نشاط المرض، ولكن ليس مع خصائص المرض والجنس.

الكلمات الدالة: التهاب الفقار اللاصق، بداية، مؤشر كتلة الجسم، محيط الخصر، نشاط المرض.
1. Introduction

Ankylosing spondylitis (AS) is a chronic, inflammatory disease that affects the sacroiliac joints and the spine and manifests with pain, joint stiffness, and loss of spinal mobility [1]. However, many patients have extra spinal manifestations such as arthritis, enthesitis and ductility’s, and extra-articular manifestations, such as uveitis, psoriasis and inflammatory bowel disease (IBD) [2]. AS makes part of the seronegative spondyloarthropathies (SPA). SPA represents a group of inflammatory arthritis diseases which share some clinical, genetic, and immunologic features [3]. Male are more often affected than females, with a ratio of 3:1 [4].

The prevalence of AS in different populations varies from 0.1 in African and Eskimo populations, 0.5 % to 1 % in the United Kingdom and the United States, to around 6% in the Haida Native Americans in Northern Canada [5]. It has been evaluated that about 90% of the pathogenesis of AS is genetically determined. [6]. HLAB27 gene is strongly linked with AS; 90–95% of patients with AS are positive for HLA-B27 [7]. The chance of developing AS if one is HLA-B27 positive is 1-5%, reach to 15-20% for people with an affected first degree of a family member [8]. An environmental factor triggers AS in an individual who is genetically predisposed [9].

The clinical manifestations of AS usually commence in early adulthood or late adolescence, with arrival after the age of 45 is unusual [10]. There is no diagnostic laboratory study in AS. The studies of Hematology are usually normal. The erythrocyte sedimentation rate and C-reactive protein are elevated in more than half of cases and tend to be associated with peripheral disease activity [11]. The diagnosis of AS is based on a combination of symptoms, physical findings and imaging studies establish the AS. In the absence of specific diagnostic manifestation, we rely on classification criteria. The modified New York Criteria is one of the most widely used classification criteria for AS [12]. Disease activity concept is a reflection of the underlying inflammation, includes a wide range of domains and measures [13]. The most frequently used instrument for disease activity is BASDAI (Bath Ankylosing Spondylitis Disease Activity Index) [14]. Moreover, it is not sensitive to change [15] and does not include objective activity measures [16]. The new composite index to assess disease activity in AS is the ASDAS which is short for (Ankylosing Spondylitis Disease Activity Score) [17]. The ASDAS containing Erythrocyte Sedimentation Rate (ESR in mm/h) is selected as a disease activity measure. The 4 additional self-report items included in this index, aside from the value of ESR, are back pain [visual analog scale (VAS) 0–10 cm, or numerical rating
scale (NRS) 0–10), duration of morning stiffness (VAS/NRS), peripheral pain/swelling (VAS/NRS), and patient global assessment of disease activity (VAS/NRS ;) [17, 18].

The ASAS members discussed and nominated to define 4 disease activity states: inactive disease (<1.3), moderate disease activity (1.3 to <2.1), high disease activity (2.1 to 3.5), and very high disease activity (>3.5 score) [19].

AS patients like patients with other rheumatic diseases that are included rheumatoid arthritis, having an increased risk of metabolic syndrome when compared to the general population [20, 21]. Adipokines dysregulation, which are bioactive substances that are secreted by adipocytes and immune cells occur in individuals that suffer metabolic syndrome [22, 23].

A change in body composition is caused by muscle weakness, decreased muscle function and physical inactivity in AS. Quantity of lean tissue is reduced in AS, which makes total fatty tissue more conspicuous [24]. In AS, the role of excess adipose tissue has not been studied widely, the link between excess adipose tissue and inflammation in AS is suggested by some indirect results [25]. An increase in adipose tissue, which is regarded to be a dynamic endocrine organ, is related to increased production of pro-inflammatory cytokines, coagulation mediators, complement factors, IL1, and TNF [26, 27]. Low-grade inflammation of obese subjects is resulted from the overproduction of adipokines with pro-inflammatory properties and thus contributes to the expansion of metabolic disturbances and intensification of inflammatory responses [28].

2. Patients and Methods

In this cross-sectional study, a total of 105 patients (75 male & 30 females) were enrolled. Diagnosis of patients was made according to the modified New York criteria from those who visited the division of rheumatology in an internal medical teaching hospital in Sulaimani from May to November 2018.

The exclusion criteria were other chronic or autoimmune inflammatory arthritis, infection, CNS disorders, drug and alcoholic abuse.

The demographic data of the patients including age, weight, height, BMI (BMI = Weight/Height², Kg/m²), Waist circumference (W.C, cm), sex, disease duration, enthesitis, and peripheral joint involvement, were noted through direct interview and fulfilling the prepared questionnaire.
According to patients' BMI, their BMI was organized into 3 categories: normal BMI ≤24.9 kg/m², overweight 25.0 -29.9 kg/m², and obesity that was considered with BMI ≥30 kg/m² [29]. Waist Circumference (W.C) is measured with a tape, the subject standing, at the level midway between the lower rib margin and iliac crest [30]. Because the measurement of the visceral fat component is costly; therefore, W.C is used as a marker of abdominal fat mass. W.C cutoffs are (W.C < 80 cm for females and < 94 for males) for those who were not at increased risk of comorbidity, (W.C ≥ 80 cm for females and ≥94 cm for males) for those who were at increased risk of comorbidity [31] Evaluation of disease activity was done by using ASDAS-ESR (ESR, mm/hr), which was measured by hand-held calculator. All patients' data entered using computerized statistical software; Minitab 18 was used. Descriptive statistics are presented as (mean± standard deviation) and frequencies as percentages. Chi-square, and Kruskal Wallis tests were utilized as appropriate to analyze the relationship between BMI categories and patient characteristics and clinical outcomes in a patient with AS. Statistical significance was set as p-value of less than 0.05.

3. Results and Calculations

About one hundred and five AS patients were involved in the present study with the age of 37±9.5 years, 21 % (22) of them were aging 20-29 years. The higher percentages 39 % (41) were for those with age group 30-39 years. Males were more than females with a ratio as 2.5:1. The mean BMI of patients was 27.25±4.6 kg/m², obese patients were about 28.6 % (30), and overweight was 35.2 % (37) and 36.2 % (38) for patients with normal BMI. Mean waist circumference (W.C) of patients was 100±11.2 cm, 31.4 % (33) of them were with normal W.C, while 68.6 % (72) of them with W.C higher than normal (increased risk of comorbidity). The percentage of patients with a disease duration of ≤ 5 years was 41.9 % (44). Thirty nine of patients were presented with peripheral arthritis, while 58 had extraarticular manifestations, 44 had enthesitis and 14 had uveitis. The mean ESR of patients was 22±22.1 mm/hr, 50 (47.6%) of AS patients had high ESR.

Mean ASDAS-ESR of studied patients was (2.4±1.0), 17(16.2%) was inactive, 25(23.8%) of the patients had moderate disease activity, 44(41.9%) had high disease activity and 19 (18.1%) had very high disease activity. Table 1
### Table 1: characteristics of patients

| Characteristics                | Total(n=105) |
|-------------------------------|--------------|
| **Age(year)**                 | 37.25±9.5    |
| 20-29                         | 22(21%)      |
| 30-39                         | 41(39%)      |
| 40-49                         | 33(31.4%)    |
| ≥50                           | 9(8.6%)      |
| **Gender**                    | 75           |
| Male                          |              |
| **BMI(kg/m²**                 | 27.25±4.6    |
| normal                        | 38(36.2%)    |
| overweight                    | 37(35.2%)    |
| obese                         | 30(28.6%)    |
| **W.C(cm)**                   | 100±11.19    |
| normal                        | 33(31.4%)    |
| increased W.C                 | 72(68.6%)    |
| **Disease duration(mean,SD)** | 8.19±6.78    |
| ≤5 years                      | 44(41.9%)    |
| **Peripheral arthritis**      | 39(37.1%)    |
| **Uveitis**                   | 14(13.3%)    |
| **Enthesitis**                | 44(41.9%)    |
| **ESR(mm/hr)**                | 22.02±22.16  |
| **ASDAS-ESR**                 | 2.46±1.01    |
| Inactive                      | 17(16.2%)    |
| Moderate disease activity     | 25(23.8%)    |
| High                          | 44(41.9%)    |
| Very high                     | 19(18.1%)    |

ASDAS-ESR was higher in the overweight and obese category compared with those with normal weight category and this was statistically noteworthy (p-value < 0.05).
The older patients that were overweight and obese, had a longer disease duration; these results were statically significant only for age (p value of less than 0.05) as presented in Table 2.

### Table 2: Distribution of disease activity age, and disease duration according to BMI of AS patients

| Variable               | BMI                        | P-value |
|------------------------|----------------------------|---------|
|                        | Normal N=38                | Overweight N=37 | Obese N=30 |
| ASDAS                  | 2.3±1.0                    | 2.41±1.04     | 2.8±0.92    | 0.01 |
| Age                    | 32.6±7.84                  | 39.27±9.15    | 40.64±10.1  | 0.001 |
| Disease duration       | 6.92±5.7                   | 9.16±6.7      | 8.6±8.16    | 0.29 |

No substantial differences were perceived between AS patients with normal BMI and those with overweight and obese regarding clinical symptoms and gender (p value of less than 0.05) as presented in Table 3.

### Table 3 Distribution of peripheral arthritis, extra particular manifestations and gender according to BMI

| Variable         | BMI                      | Total | P-value |
|------------------|--------------------------|-------|---------|
|                  | Normal N=30              | Overweight N=37 | Obese N=30 |
| Peripheral arthritis | 12                        | 14    | 13      | 39    | 0.6    |
| Yes              | 26                        | 23    | 17      | 66    |  |
| No               |                           |       |         |       |       |
| Uveitis          | 8                         | 4     | 2       | 14    | 0.17  |
| Yes              | 30                        | 35    | 28      | 91    |  |
| No               |                           |       |         |       |       |
| Enthesitis       | 11                        | 14    | 15      | 44    | 0.09  |
| Yes              | 26                        | 23    | 15      | 61    |  |
| No               |                           |       |         |       |       |
AS patients with waist circumference higher than normal were had higher disease activity and older in age compared with those with normal waist circumference and these results were statistically significant (p value of less than 0.05), no significant differences was witnessed between the two groups regarding disease duration (p value greater than 0.05) as presented in Table 4

**Table 4** Disease activity, age, and disease duration according to waist circumference

| Variable                      | Waist Circumference | P-value |
|-------------------------------|---------------------|---------|
|                               | Normal N=33         | Increased Risk N=72 |         |
| ASDAS-ESR                     | 2.07±1              | 2.67±1              | 0.007   |
| Age (years)                   | 32±7.2              | 40±9.5              | < 0.001 |
| disease duration (years)      | 6.97±5.69           | 8.8±7.68            | 0.23    |

4. Conclusion

Overweight, obesity and increased W.C are common among AS patients and significantly related to disease activity score and age.

No significant association had been seen between BMI, some clinical manifestation of AS (peripheral arthritis, uveitis and enthesitis), and gender. Additional longitudinal studies are vital to know the effect of obesity on AS pathophysiology and more studies are required to detect and monitor the response of the disease in normal and obese patients to different types of treatment.
4. Discussion

AS is a seronegative chronic inflammatory disease that involves the sacroiliac joints and the axial skeleton. Back pain and progressive stiffness of the spine characterized the AS. Arthritis of the hips and shoulders, enthesitis, and anterior uveitis are common. \(^{[32]}\)

Obesity and overweight are increasing universally and now approach a third of the world population\(^{[33]}\). The World Health Organization (WHO) defines obesity as an abnormal or excessive fat accumulation that presents a risk to health\(^{[34]}\). In AS the role of excess adipose tissue has not been studied widely; though, the association between excess adipose tissue and inflammation in AS is suggested by some indirect results\(^{[25]}\).

The connection between obesity and its effect on disease activity in AS is investigated by a few studies; therefore; we have investigated its prevalence in AS patients and its relationship with disease activity, clinical and laboratory findings.

This study showed that (63.8%) of AS patients were overweight (35.2%) and obese (28.6%), this finding is close to that of Maas et al\(^{[35]}\) study in which 37% and 22% of cases were overweight and obese respectively and those of Durcan et al\(^{[36]}\) in which the prevalence of overweight and obesity were 37% and 30.5% respectively.

In the present study, we have found a significant association between BMI and disease activity by using ASDAS-ESR in AS patients (p value less than 0.05). This result is close to the results that were concluded by Durcan et al.\(^{[36]}\), Maas et al.\(^{[35]}\), and Zepa et al\(^{[37]}\).

According to the data of Durcan et al\(^{[36]}\), a cohort study of forty six AS patients, (67.5%) that were overweight or obese had worse perception concerning the benefit of exercise and higher disease activity than patients normal BMI.

Those results were supported by Maas et al. study\(^{[35]}\), a study in the population of 465 axial spondyloarthrits patients, which unveiled that obese patients had higher disease activity score than normal BMI patients\(^{[35]}\).

In the study done by Zepa et al\(^{[37]}\), a cross-sectional study carried on 106 patients predicted that The higher levels of disease activity in AS patients that were overweight and
obese were notable (p<0.05). All these results could confirm the recommendation for AS patients to decrease BMI to appropriate level in order to achieve a high level of remission.

In comparison to other researchers who concluded that BMI is not linked with the level of disease activity and patient related outcome {Kim et al. [38] and Vergas et al. [39]}.

Data obtained from Korean study by Kim et al in a population of 789 axial SPA patients detected that increased BMI is suggestively related with the presence of syndesmophyte, but not with the disease activity in SPA patients [38].

According to data from a SPACE cohort study in 428 patients on the effect of BMI on the disease activity in axial SPA, the disease activity score is not affected by BMI in axial SPA patients [39].

These differences in these results might be explained on basis that the overweight and obesity prevalence in the last two studies were less than those of our study, 21.7% & 28.5% in Kim et al. and 18.5% & 11.9% in Vargas et al. study.

In the present study prevalence of peripheral arthritis, uveitis and enthesitis were (36.2%), (13.3%) and (40%) respectively. Our study revealed that the history of peripheral arthritis and extra-articular manifestation had no effect on BMI categories (p>0.05). This result comparable to that of Zepa et al. study [37].

In our study, we found that AS patients with increased W.C were had higher disease activity by ASDAS-ESR and these results were significant (p value less than 0.05), similar results were concluded by Aydin et al. [40], in a study of 26 AS patients, a significant correlation was established between the visceral adipose tissue using W.C and disease activity score.

There are some limitations to our study. Firstly, the relatively small sample size was conducted. Secondly, we used BMI and W.C as a measurement index for obesity and these do not precisely determine the amount of body fat.
6. ACKNOWLEDGEMENT

The authors acknowledge Dr. Chiman Hassan Mahmood in the Slemani Internal Medical Teaching Hospital for her help and support. The authors also acknowledge Dr. Younis Mustafa Alshkane and Dr. Yassen Hamaamin in the University of Sulaimani for their help in the statistical analysis of data.

7. References

-[1] Bodur H, Ataman S, Rezvani A, Buğdaycı DS, Cevik R, Birtane M, et al. Quality of life and related variables in patients with ankylosing spondylitis. Qual Life Res 2011; 20:543-9. doi: 10.1007/s11136-010-9771-9.

-[2] De Winter, J. J., van Mens, L. J., van der Heijde, D., Landewe, R., Baeten, D. L. . Prevalence of peripheral and extra-articular disease in ankylosing spondylitis versus non-radiographic axial spondyloarthritis: A meta-analysis. Arthritis Res. Ther., 2016; 18, 196.

-[3] Zochling J, Smith EU. Seronegative spondyloarthritis. Best Pract Res Clin Rheumatol 2010; 24:747–56.

-[4] Clunie GPR., Ralsan SH. Rheumatology and bone disease. In: Suart H., Ian D., Mark W., Richard P. (Eds).Davidson’s principle and practice of medicine. 23rd Ed.elsevier:2018: 981-1060.

-[5] Van Der Heijde D. Ankylosing spondylitis. In: John H.: Leslie J., Patience H. (EDS). Primer on the Rheumatic Diseases, 13 th Ed. Springer. Newyork; 2008; 193-216.

-[6] Sieper J. Ankylosing spondylitis. In: Richard A., Philip G., Dentan C., Foster H., Isaas J., Lander U. (Eds). Oxford textbook of Rheumatology. 4 th Ed., oxford university press, UK;2013; 879- 889.

-[7] M. A. Brown, “Progress in spondylarthiritis. Progress in studies of the genetics of ankylosing spondylitis,” Arthritis Research & Therapy, vol. 11, no. 5, p. 254, 2009.
[8] Kilts U., Baraliakos X., Borg A. Spondylarthropathies: pathogenesis and clinical features. In: Bilsma J., Hachula E. (eds). Eular Textbook on Rheumatic Diseases. 2nd Ed. BMJ publishing group. UK; 2015; 295-398.

[9] Taurog JD, Chhabra A, Colbert RA. Ankylosing spondylitis and axial spondyloarthritis. N Engl J Med 2016; 374:2563—74.

[10] Robert W. Janson. Ankylosing Spondylitis. In: Sterling G. (Ed).Rheumatology secrets. 3rd Ed. Mosby, 2015: 261—288.

[11] Awni Qubti M., John A. Ankylosing spondylitis&the Arthritis of Inflammatory Bowel Disease. In: John B., David B., John H. (eds). Current Diagnosis&Treatment Rheumatology. 3rd Ed. Mc Graw Hill education LANCE; 2013; 159-166.

[12] Van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. Arthritis Rheum. 27(4), 361—368 (1984).

[13] Machado P, Landewe R, Lie E, et al. Ankylosing Spondylitis Disease Activity Score (ASDAS): defining cut-off values for disease activity states and improvement scores. Ann Rheum Dis 2011; 70:47—53.

[14] A Turkish version of the Bath Ankylosing Spondylitis Disease Activity Index: reliability and validity. Rheumatol Int 2005; 25:280-4.9

[15] Wanders AJ, Gorman JD, Davis JC, Landewe RB, Van der Heijde DM: Responsiveness and discriminative capacity of the assessments in ankylosing spondylitis disease-controlling anti-rheumatic therapy core set and other outcome measures in a trial of etanercept in ankylosing spondylitis. Arthritis Rheum 2004, 51:1–8.

[16] Fernández-Sueiro JL, Willisch A, Pértega-Díaz S, Tasende JA, Fernandez-Lopez JC, Villar ND, Galdo F, Blanco FJ: Validity of the bath ankylosing spondylitis disease activity index for the evaluation of disease activity in axial psoriatic arthritis. Arthritis Care Res 2010, 62:78—85.
[17] Lukas C, Landewé R, Sieper J, Dougados M, Davis J, Braun J, et al. Development of an ASAS-endorsed disease activity score (ASDAS) in patients with ankylosing spondylitis. Ann Rheum Dis 2009;68:18-24.

[18] Van der Heijde DM, Lie E, Kvien TK, Sieper J, Van den Bosch F, Listing J, et al. ASDAS, a highly discriminatory ASAS-endorsed disease activity score in patients with ankylosing spondylitis. Ann Rheum Dis 2009; 68:1811-8.

[19] Machado P, Van der Heijde D. How to measure disease activity in axial spondyloarthritis? curr opin rheumatol 2011,23:000-000:1-7.

[20] Genre F., Lopez-Mejias R., Miranda-filloy J.A., Ubilla B., Carnero-Lopez B., Blanco R., Pina T., Gonzalez-Juanatey C., Llorca J., Gozelaz-Gay M.A. Adipokines, Biomarkers of Endothelial Activation, and Metabolic Syndrome in Patients with Ankylosong Spondylitis. BioMed Research International, vol 2014, article ID860651,11 pages.

[21] S. Mathieu, P. Motreff, and M. Soubrier, “Spondyloarthopathies: an independent cardiovascular risk factor?” Joint Bone Spine, vol. 77, no. 6, pp. 542–545, 2010.

[22] Y. Deng and P. E. Scherer, “Adipokines as novel biomarkers and regulators of the metabolic syndrome,” Annals of the New York Academy of Sciences, vol. 1212, pp. E1–E19, 2010 .

[23] C. Procaccini, V. de Rosa, M. Galgani et al., “Role of adipokines signaling in the modulation of T cells function,” Frontiers in Immunology, vol. 4, Article ID332, 2013.

[24] Toussirot E, Grandclement E, gangler B, et al.serum adipokines and adipose tissue distribution in rheumatoid arthritis and ankylosing spondylitis, a comparative study. Front immunol 2013; 4:453.

[25] Toy S, Ozbag D, Altay Z. The effects of pre-obesity on quality of life, disease activity, and functional status in patients with ankylosing spondylitis. North Clin Istan2017;4(1):52-59.
-[26] Smitka K, Marešová D. Adipose tissue as an endocrine organ: an update on pro-inflammatory and anti-inflammatory microenvironment. Prague Med Rep 2015; 116:87–111.

-[27] Rosas J, Llinares-Tello F, Senbare-Gallego J.M., ET al. Obesity decrease clinical efficacy and levels of adalimumab in patients with ankylosing spondylitis. Clinical and Experimental Rheumatology 2017; 35:145-148.

-[28] Gremese E, Bernardi S, Bonazza S, Nowik M, Peluso G, Massara A, et al. Body weight, gender and response to TNF-α blockers in axial spondyloarthritis. Rheumatology (Oxford). 2014; 53:875-81.

-[29] World Health Organization. Obesity and overweight. http://www.who.int/mediacentre/factsheets/fs311/en/ 2013; Updated January 2015.

-[30] National Institutes of Health. The Practical Guide: Identification, Evaluation and Treatment of Overweight and Obesity in Adults. Bethesda, MD: National Institutes of Health; 2000.

-[31] World Health Organization. Waist circumference and Waist-Hip Ratio.Geneva; World Health Organization; 2008.Page 34.

-[32] Al-Osami MH, Hameed EK, Al-Hamadani AM. Effect of HLA-B27 status and body mass index on the clinical response to infliximab in ankylosing spondylitis patients. Indian J Rheumatol 2018; 13:33-7.

-[33] Daïen CI, Sellam J. Obesity and inflammatory arthritis: Impact on occurrence, disease characteristics and therapeutic response. RMD Open 2015; 1:e000012.

-[34] World health organization. Health topics: obesity. Geneva: world health organization (2011). Available from: http://www.int/topics/obesity/en/.

-[35] Maas, P., Arends, S., van der Veer, E., Wink, F., Efde, M., Bootsma, H., Brouwer, E., Spoorenberg, A. (2016). Obesity is common in axial spondyloarthritis and is associated with poor clinical outcome. J. Rheumatol., 43 (2), 383–387.
-[36] Durcan, L., Wilson, F., Conway, R., Cunnane, G., O'Shea, F.D. (2012). Increase body mass index in ankylosing spondylitis is associated with greater burden of symptoms and poor perceptions of the benefits of exercise. J. Rheumatol., 39 (12), 2310–2314.

-[37] Zepa J., Bulina J., Lavrentjevs V., Vinkalna I., Nikitina-Zake L., Andersone D., Lejnieks A., The impact of body mass index on disease progression in ankylosing spondylitis. Proc, Latvian Acad. Sci., Section B, Vol. 72 (2018), No. 1.

-[38] Kim, S. K., Choe, J. Y., Lee, S. S., Shin, K. (2017). Body mass index is related with the presence of syndesmophyte in axial spondyloarthritis: Data from the Korean College of Rheumatology BIOlogics (KOBIO) registry. Mod. Rheumatol, 13, 1–7.

-[39] Vargas, R. R., van den Berg, R., van Lunteren, M., Ez-Zaitouni, Z., Bakker, P. A. C., Dagfinrud, H., Ramonda, R., Landewe, R., Molenaar, E., van Gaalen, F. A., van der Heijde, D. (2016). Does body mass index (BMI) influence the Ankylosing Spondylitis Disease Activity Score in axial spondyloarthritis? Data from the SPACE cohort. RMD Open, 2, e000283.

-[40] Aydin M, Aydin F, Yuksel M, Yildiz A, Polat N, Akil MA, et al. Visceral fat reflects disease activity in patients with ankylosing spondylitis. Clin Invest Med 2014; 37:E186.