Original Research Article

Relationship between obesity, physical activity, sleeping hours and red blood cell parameters in adult Sudanese population

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Abstract

Ideal body weight with proper physical activity and good sleep are essential parameters for good quality of life. This study is concerned with assessing the association of general obesity, physical activity and sleeping hours with hemoglobin (Hb) concentration and red blood cell (RBC) parameters in healthy adults in Sudan. In this cross sectional study, 1086 healthy adults between 20 and 60 years were included out of which 275 were males and 811 were females. A complete blood count (CBC) was performed for Hb, RBC count, PCV, MCH and MCHC using Sysmex KX-21 automated hematology analyzer. The median and 95 percentile (2.5^{th} to 97.5^{th}) range values for Hb and RBC count in underweight were 13.0 (Range: 9.6-16.7) g/dl and 4.6 (Range: 3.6-5.8) $\times 10^3/\mu L$ respectively, while Hb and RBC count in obese were 13.1 (Range: 10.4-17.0) g/dl and 4.6 (Range: 3.7-5.9) $\times 10^3/\mu L$ respectively, with no significant difference. The RBC count (p=0.004) and Hb (p≤0.001) were significantly high in physically active compared to physically inactive participants; whereas the hemoglobin concentration (p=0.047), red blood cells (p=0.007) and hematocrit (p≤0.001) values were significantly low in long-term sleep compared to normal sleeping hours. In conclusion, there were no significant differences in hemoglobin concentration, RBC count, PCV, MCH and MCHC between under weight, normal weight, overweight and obese persons. Increased physical activity was associated with higher Hb levels and RBC counts, while long-term sleep showed lower Hb and RBCs.

Introduction

Enlarged adipose tissue increases the risk of diabetes, hypertension, cardiovascular disease and respiratory disorders. Furthermore, it effects iron status in the body **[1]**. Obesity is also associated with subclinical inflammation which might contribute to development of anemia. On the contrary, severe weight loss is associated with significant decrease in C-reactive protein (CRP) which is the main acute phase protein and a sensitive marker of systemic inflammation

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indicating that fat mass plays an important role in the production of CRP [2]. Several studies demonstrated that the anemia is directly associated with general obesity and physical inactivity [3,4,5].

It has been reported that exercise exerts physiological stress on the body that leads to hormonal, cellular and physical changes like raised blood pressure, body temperature and increase oxygen intake, which depends on number of factors such as the type and duration of exercise [6]. The effects of exercise and training on the hemopoietic system have been a hot topic in sports medicine. Many recent studies centered on hypothesis of sports anemia induced by endurance training. It is well documented that exercise training can stimulate erythropoiesis and increase red cell mass as well as plasma volume, resulting in increased blood volume [7,8,9,10]. Hematological parameters might be influenced by the type and intensity of the physical activity [11].

Sleep is defined as a state of reversible loss of consciousness [12]. Sleep is a biological process that is very much essential for optimal health and survival. It plays an important role in maintaining functions of brain, metabolism, immune system, hormonal and cardiovascular systems [13,14]. Good quality sleep can be described as sufficient sleep time and regularity with absence of any sleep disorders [15].

This study was concerned with evaluating the association of obesity, physical activity and sleep hours with hemoglobin concentration and RBC parameters in healthy adults in Sudan.

Materials and methods

Ethical approval was obtained from the Sudanese Federal Ministry of Health in Sudan (FMOH) (Reference number: 1-10-2016) and The National Ribat University.

This descriptive cross sectional study was done in Sudan during 2017-2018. 1086 adults were included (275 males and 811 females). Subjects with hematological disorders or chronic diseases like hypertension, diabetes mellitus, liver diseases, renal diseases, cardiac diseases, tuberculosis, asthma, thyroid disorders, or with recent acute diseases (Malaria, typhoid fever, etc.) were excluded. Any subject with recent history of surgery especially splenectomy were also excluded. All healthy Sudanese people between 20 and 60 years were included. All selected subjects answered a structured questionnaire containing personal, clinical and life style information. Written consent was taken from each participant.

Age in years (Date of birth), standing height in cm (without footwear) was recorded on a wall mounted measuring tape and weight in kg (without footwear) was recorded on weighing scale. Body mass index (BMI) in kg/m^2 was calculated. Participants were then grouped into 4 categories: underweight, normal weight, overweight and obese based on BMI. 3 ml of venous blood was collected into K3-EDTA vacutainer and was analyzed using Sysmex KX-21 automated hematology analyzer.

Statistical analysis

Normality of continuous variable data was determined by using the Shapiro-Wilk test and normal Q-Q plot. The parametric continuous variables are presented as a mean±SD while non-parametric continuous variables are presented as a median (interpercentile range) and analyzed by Mann-Whitney U test. One-way, two-way analyses of variance (ANOVA) and Student t-test were applied for normally distributed continuous variables. While Mann-Whitney U test was used for non-pramatric continuos variables.

Firstly three tests were performed (skewness, kurtosis and the Kolmogorov Smirnov) to determine the normality of our data. The test results was significant ($p<0.05$). Therefore, we used non-parametic method to determine the reference range, the reference intervals was calculated by using lower and upper percentile limits with the 95% confidence intervals as the following: Lower percentile limit ws set to the 2.5^{th} and upper percentile limit was set to 97.5^{th} percentile.

Statistical tests were 2-sided, and p value less than 0.05 was considered significant. All statistical analyses were performed using the SPSS version 25 (IBM SPSS Inc., Chicago, USA).

Results

The mean age of the total 1086 participants was 25±9 years. The mean age slightly varied between genders: 28.6 years for males and 24.2 years for females. The mean height, weight and BMI were 162±50, 61±14 and 22.9±4.9 respectively. The red blood cell (RBC) count, hemoglobin (Hb) and hematocrit (HCT) and blood indices showed no significant differences with different body mass index categories (**Table 1** and **Table 2**).

Our result showed that, red blood cells and hemoglobin had significant positive correlation with height and weight (**Table 3**).

In context of physical activity, the mean height, weight and BMI in physically active individuals (Exercise group) were 195±22, 60±13 and 22.6±4.8 respectively, while in physically inactive

group the mean of height was 164±66, weight and BMI were 61±14 and 22.8±4.9 respectively. There are no significant differences in weight, height and BMI between exercise and no exercise group (**Table 4**).

Our result showed significantly higher RBC count (p=0.004) and Hb (p≤0.001) in physically active individuals (Exercise group) compared with physically inactive (No exercise) group (**Figure 1** and **Figure 2**).

Our result showed football players had significantly higher hemoglobin (p≤0.001) and red blood cells levels (p≤0.001) compared with other type of physical activities (**Table 5** and **Figure 3**).

Table 1: RBC count and hemoglobin according to body mass index in adult Sudanese

Parameter	Under weight (N=207)	Normal (N=522)	Over weight (N=201)	Obese (N=85)	p value
RBC count (x10^3/µL)	4.6 (3.6-5.8)	4.6 (3.7-5.9)	4.6 (3.8-5.8)	4.6 (3.7-5.9)	0.384
Hb (g/dl)	13.0 (9.6-16.7)	12.9 (9.3-17.0)	12.9 (9.7-16.3)	13.1 (10.4-17.0)	0.558

Data presented as median (Interpercentile range)

Table 2: Hematocrit and blood indices according to body mass index in adult Sudanese

Parameters	Under weight (N=207)	Normal (N=522)	Over weight (N=201)	Obese (N=85)	p value
HCT (%)	39.5 (36.4-44.0)	39.7 (36.4-44.1)	38.8 (35.5-42.9)	40.5 (36.7-45.4)	0.205
MCH (pg)	28.7 (26.8-30.3)	28.4 (26.3-30.0)	28.3 (26.1-29.6)	29.1 (26.5-30.5)	0.071
MCHC (%)	32.6 (30.3-34.3)	32.4 (30.8-34.2)	32.9 (31.2-34.6)	32.6 (31.1-34.7)	0.366

Data presented as median (Interpercentile range)

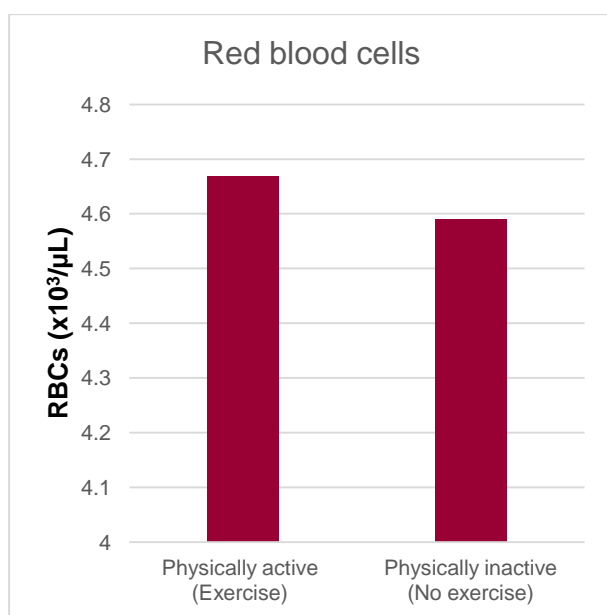**Table 3:** Correlation of RBCs and Hb with height and weight

| Parameter	Height	Weight
RBCs	0.223[**]	0.134[**]
Hb	0.220[**]	0.131[**]

**p value ≤ 0.001

Table 4: Differences between weight, height and BMI in relation to physical activity

Parameter	Exercise (N=491)	No exercise (N=523)	p value
Height (cm)	195±22	164±66	0.761
Weight (kg)	60±13	61±14	0.482
BMI (kg/m^2)	22.6±4.8	22.8±4.9	0.284

Numbers represent mean±SD

Figure 1. Differences in RBC count between physically active and physically inactive
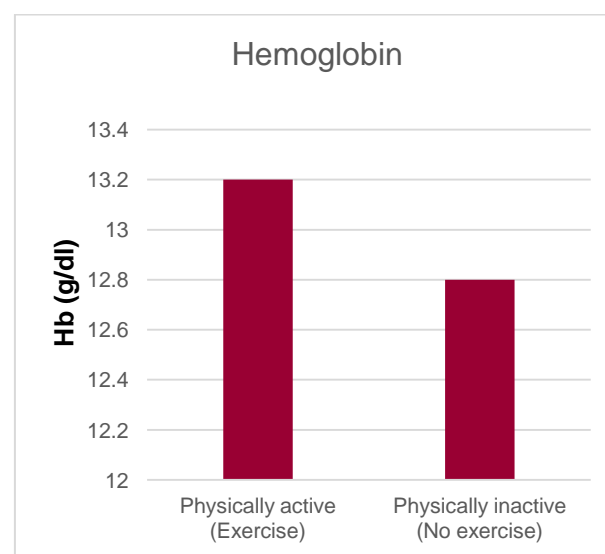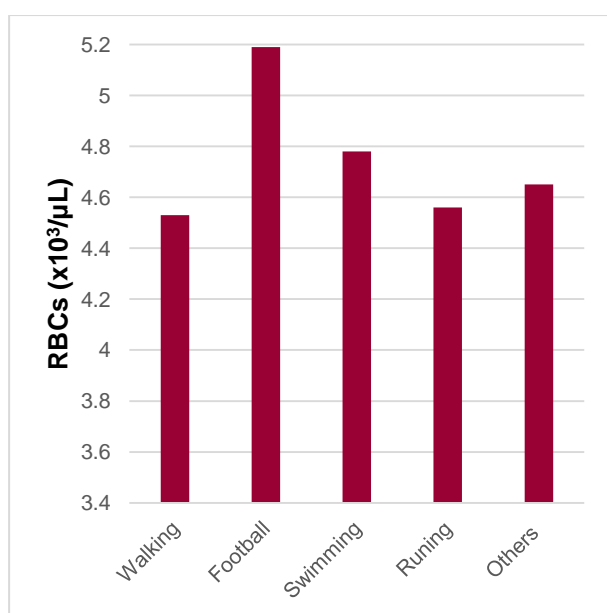

Figure 2. Differences in Hb between physically active and physically inactive

Table 5: Comparison of the median of Hb (g/dl) level with different type of physical activities

Parameter	n	Hb	p value
Walking	249	12.9±1.9	
Football	127	15.7±1.6	
Swimming	74	13.5±1.7	≤0.001
Running	29	13.5±1.7	
Others	12	13.1±1.9	

Numbers represent mean±SD

Figure 3. Comparison of the median of RBCs with different types of physical activities

Our results showed significant variation in weight and BMI with sleeping hours; short sleep duration is associated with more weight and BMI (**Table 6**).

Table 6: The variation in weight and BMI according to sleeping hours

	<6 hours	6-8 hours	>8 hours	p value
Weight	63±14	60±13	59±13	0.034
BMI	23.3±4.4	22.6±4.8	22.8±5.6	0.05

Numbers represent mean±SD

Our results showed that the hemoglobin concentration, red blood cells and hematocrit were significantly low in long-term sleep compared with normal sleeping hours (**Table 7**; **Figure 4** and **Figure 5**).
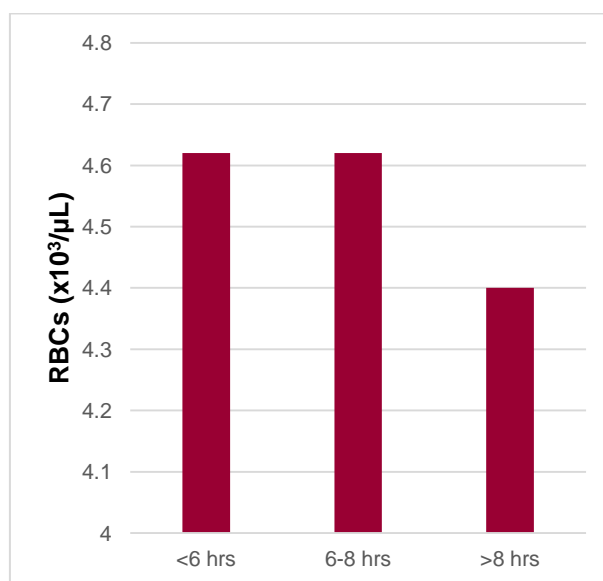
Figure 4. Differences in RBCs in relation to sleep duration
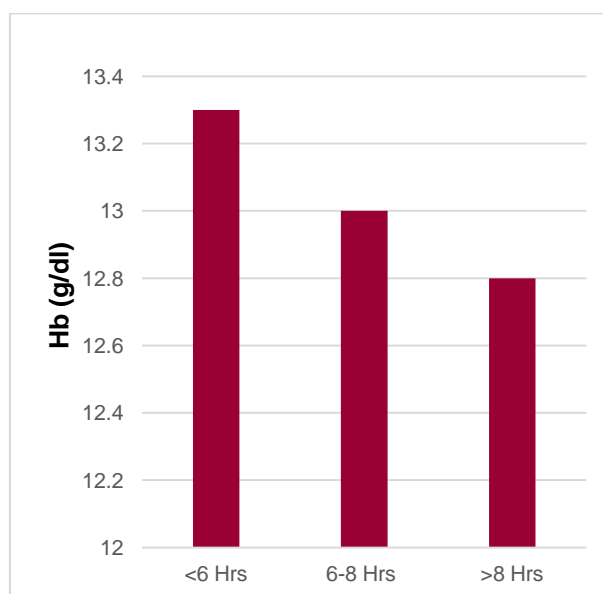
Figure 5. Differences in Hb in relation to sleep duration

Table 7: Differences in blood parameters in relation to sleep hours

Parameter	<6 hours (N=195)	6 to 8 hours (N=646)	>8 hours (N=89)	p value
RBCs (×10^3/µL)	4.62 (3.68-5.78)	4.62 (3.73-5.87)	4.40 (3.48-5.84)	0.007
Hb (g/dl)	13.3 (9.3-16.6)	13.0 (9.6-16.9)	12.8 (9.5-15..2)	0.047
Hematocrit (%)	38.9 (30.4-52.7)	40.0 (31.2-54.2)	37.1 (30.0-52.2)	<0.001

Numbers represent median (interpercentile range)

Discussion

Our study results showed that there is no or weak association between BMI, hemoglobin, hematocrit and red blood cells indices; this is in agreement with many previous studies [16,17,18]. On the other hand many researchers demonstrated that low BMI is one of the reasonable predictors of anemia [3,19]. Furthermore, one study observed that females with central obesity developed anemia less than normal weight women [4]. A study conducted in older Koreans reported that the advancing age, low BMI and the female gender are independent risk factors for anemia [20]. The possible explanation for this inverse association between high BMI and anemia might be well nutritional status of obese people with high intake of iron containing foods.

In our study we found that hemoglobin and red blood cells are significantly high in physically active participants. These findings agree with many studies that examined the effect of aerobic exercise (for 8 to 12 weeks) on the red blood cells and hemoglobin content and found significant increase in red blood cells and hemoglobin levels [21,22,23]. Exercise or training programs less than 8 weeks does not have significant change in red blood cells and hemoglobin level [8,24,25,26] while long training programs more the 12 weeks lead to decrease hemoglobin level [27,28]. Our result showed significant inverse association between BMI and sleep duration, this finding is in accordance with one study [29], other study reported that BMI was effected only by short sleep duration [30]. It is noteworthy that both short and long sleep duration increase chances of future body weight gain in adults [31]. The possible explanation for this finding might be the association of short sleep duration with disturbance in adipokinase secretion that lead to weight gain [32]. Short sleep duration obviously increases awake duration that increases frequency of eating which would add to the total calorie intake. It has also been suggested that daytime tiredness and fatigue in addition to changed eating patterns may result in less physical exercise, which in turn reduces the body's total energy expenditure, and thereby increasing the risk of obesity [33].

Our results showed significant decrease in hemoglobin, red blood cells and hematocrit in long-term sleeping (>8 hours) compared with normal (6-8 hours) sleep duration. This supports the findings of another study which demonstrated high hemoglobin and red blood cells parameters in insomnia patient [34]. On the contrary, one study revealed that anemia was associated with short sleep duration in elderly (>50 years) persons [35]. Other study observed that, there is no significant difference in sleep duration between anemic and non-anemic individuals [36]. One of the possible mechanisms that might link sleep duration with anemia is increased plasma level of inflammatory markers such as C-reactive protein that appear to increase in long sleep duration [37].

Conclusion

There were no statistically significant differences in Hb, RBC count, hematocrit, MCH and MCHC between under weight, normal weight, overweight and obese persons. Increased physical activity was associated with higher Hb levels and RBC counts, while long-term sleep showed lower Hb and RBCs.

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