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Hand Grip Strength in Pregnant and Non-Pregnant Females

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Background: Hand Grip Strength (HGS) is a predictor of upper extremity function, and changes in muscles strength and physical function and capabilities to undertake activities of daily living. Despite toll of pregnancy on musculoskeletal system, assessment of HGS in antenatal care is not a routine practice yet.
Objectives: The current study aimed to compare HGS in pregnant and non-pregnant females and also investigated the correlation of HGS among the groups.
Patients and Methods: The current case control study included 174 females (87 pregnant and age-matched non-pregnant controls respectively). HGS was assessed using a hand held Jamar dynamometer. Body adiposity was assessed by a Bioelectric Impedance Analysis machine. Data were analyzed using descriptive and inferential statistics at $P < 0.05$.
Results: The results showed that the pregnant and non-pregnant subjects could be compared regarding the age (29.7 ± 5.3 vs. 28.2 ± 5.8 years; $P = 0.440$). There was significant difference in dominant HGS (26.8 ± 8.9 vs. 29.3 ± 7.1 kgf; $P = 0.044$) and non-dominant HGS (24.7 ± 8.5 vs. 28.6 ± 8.4 kgf; $P = 0.002$) between pregnant and non-pregnant subjects, respectively. Physical characteristics weakly correlated with HGS for both dominant and non-dominant hands [correlation (r) ranges from 0.00 - 0.250]. Measures of adiposity significantly correlated with HGS in pregnant and non-pregnant females, respectively ($P < 0.05$). However, there were significant increases in the measures of adiposity with high parity, gravidity, and advances in stage of pregnancy ($P < 0.05$).
Conclusions: The current study revealed that pregnant females had significantly lower HGS compared with non-pregnant ones. High parity and gravidity and later stage of pregnancy led to significantly lower HGS. Higher level of adiposity led to poorer performance of HGS in females. It is recommended to evaluate HGS in antenatal care, which may have diagnostic and prognostic benefits.

Keywords: Hand Grip Strength; Pregnancy; Body Adiposity; Bioelectric Impedance Analysis

1. Background

Hand Grip Strength (HGS) is reported as an indicator of the total body strength (1, 2), an objective test for physical capability (3), and a valid predictor of work capacity (4, 5), degree of disease/injury, and rehabilitation outcomes (6-8). A better performance on the HGS is associated with high functional index of nutritional status (9, 10), reduced risk of a series of ill health outcomes (6-8, 11) and decreased functional limitations (3-5, 12), disability (13, 14), and morbidity and mortality rates especially among older populations (15, 16).

HGS, as a physiological variable, is influenced by a gamut of factors not limited to socio-demographic (17, 18), anthropometric and morphologic (19-21), and pathophysiologic (22, 23) variables. There is substantial evidence in the literature indicating higher preponderance of poor HGS among females compared with males (24-28). However, the determinants and predictors of the higher predilection for poor HGS among females seem to have been inadequately explored.

Pregnancy, parity, and menopause are peculiar physiologic events in a female's life. Pregnancy is typified by a series of physiological, psychological and physical alterations. Particularly, musculoskeletal changes resulting from pregnancy are widely acknowledged, though, its magnitude is scarcely quantified (29). However, menopause and pregnancy are implicated in reduced HGS in females. Some available studies showed that pregnant females had lower upper extremity strength than non-pregnant ones (30). Similarly, decreases in the strength are noticed in postpartum females (31). Whereas, some other studies showed no significant difference in HGS between pregnant and non-pregnant females (32, 33). Therefore, the outcomes of the available few studies are inconclusive. However, inclusion of HGS assessment in antenatal care may have diagnostic and prognostic benefits, since it is not a routine practice in most settings yet.

2. Objectives

The current study aimed to compare HGS between pregnant and non-pregnant females. In addition, the study sought to investigate the correlation between HGS and anthropometric and obstetric characteristics among the two groups.

3. Patients and Methods

A total of 174 (87 pregnant and age-matched non-pregnant controls respectively) females participated in this case control study. The pregnant group was recruited from females attending antenatal clinic of the Obafemi Awolowo University Teaching Hospital Complex (OAUTHC), Ile-Ife, Nigeria, and Health Centre of the Obafemi Awolowo University (OAU), Ile-Ife, Nigeria, respectively. The non-pregnant subjects comprised of age-matched staff of the OAUTHC and OAU, respectively. The participants were consecutively recruited into the study. Inclusion criteria were being within the reproductive age of less than 45 years, having neither movement restriction nor positive history of neurological disorder, hand joint disease or injury to upper extremity, and having no cognitive deficit. Based on the data from clinical records, the pregnant females recruited into the current study had no related disease.

The Ethical Committee of the OAUTHC, Ile-Ife, Nigeria, approved the study. The heads of the antenatal clinics of the OAUTHC and Health Centre of the OAU, Ile-Ife, Nigeria, respectively gave permission for the study. All participants signed informed consent letters to participate in the study.

3.1. Procedures and Measurements

3.1.1. Assessment of Hand Grip Strength

HGS was measured using a Jamar dynamometer (Model 84466; Takei Kiki Kogyo, Tokyo, Japan). Participants held the test arm of the dynamometer at a 90°C elbow flexion with the forearm in neutral position and the hand parallel to the forearm. Participants were instructed to squeeze the dynamometer maximally three times for both hands (right and left). This procedure was repeated in sitting position and all the measures were recorded (34, 35).

3.1.2. Assessment of Percent Body Fat

Percent Body Fat (PBF) was assessed using an Omron BF306 (Mod. HBF-306-E. CC, Japan) Bioelectrical Impedance Analysis (BIA) machine. Participants were instructed to take away all metal objects (such as earrings, chains, wrist watches etc.), stand erect with the feet together and also hold the BIA machine in both hands in such a way that the hands cover the metal surfaces of the machine. The participants were then instructed to hold the arms straight at 90° of shoulder flexion. Dryness of the palms was ensured by using a dry towel to clean the palmar surface of each participant's hand. The height, weight, gender, and age of each of the subjects were fed into the micro data processor of the instrument. The participants stood still until a new set of data were displayed on the meter. This method is based on the behavior of biological structures subjected to a constant low-level alternating current (36). The PBF was rounded.

Lean Body Mass (LBM) (kg): This was calculated from the PBF estimate of the BIA. LBM was calculated by subtracting fat weight (kg) from the total body weight (kg). LBM = Total body weight–Fat weight. Fat weight was calculated from the BIA estimate of the PBF using the following Equation:

1) $$PBF = \left(\frac{fat \quad weight}{total \quad body \quad weight}\right) \times 100$$

Therefore,

2) $$fat \quad weight = \frac{(PBF \times total \quad body \quad weight)}{100}$$

Weight and height were assessed following the standard procedures. A bathroom weighing scale (Inters Ikea BV) calibrated from 0 - 120 kg was used to measure the body weight with the accuracy of 1.0 kg. A height meter (HM210D) was used to assess height in centimeters (cm). Subjects were asked to stand barefoot on the platform of the scale while looking straight. A straight ruler was placed on the vertex of the head and the corresponding value was recorded. Body Mass Index (BMI) was calculated as the ratio of weight to height squared, i.e. BMI (Kg/m^2) = Weight (kg) ÷ height (m^2). Other obstetric variables (such as the stage of pregnancy, number of pregnancies, parity) were collected from the pregnant group's case charts.

3.2. Data Analysis

Data were summarized using descriptive statistics of mean and standard deviation. Inferential statistics of independent t-test was used to compare HGS, anthropometric and socio-demographic variables between pregnant and non-pregnant females. Pearson's product moment correlation analysis was used to test the relationship between HGS and independent variables. Analysis was carried out using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). $P < 0.05$ was considered as the level of significance.

4. Results

Table 1 shows the general characteristics and the HGS of all subjects. The mean age of the pregnant and the non-pregnant groups was 29.7 ± 5.3 years and 28.2 ± 5.8 years, respectively. There was a significant difference in the dominant HGS (26.8 ± 8.9 vs. 29.3 ± 7.1 kgf; P = 0.044) and non-dominant HGS (24.7 ± 8.5 vs. 28.6 ± 8.4 kgf; P = 0.002), respectively. The obstetric characteristics of the participants are shown in Table 2. The majority of the pregnant group subjects were primiparous (71.8%), while most of the non-pregnant subjects were multiparous (61.3%).

The measures of adiposity and HGS of the pregnant females by parity, gravidity, and stage of pregnancy, compared using a One-Way ANOVA and LSD Post-Hoc test, are presented in Table 3. The results showed significant increase in the measures of adiposity with higher number of parity mostly between nulliparous and primiparous (P < 0.05). Significant increase in the measures of adiposity with higher number of gravidity was found between nulligravida and primigravida (P < 0.05). However, some adiposity measures did not show any significant difference between primigravida and multigravida (P > 0.05). Based on the stage of pregnancy, there were significant differences in the dominant and non-dominant HGS, respectively (P < 0.05).

The three different HGS trials for both dominant and non-dominant hand, compared using a One-Way ANOVA and LSD Post-Hoc test, is presented in Table 4. The result indicated significant difference in the dominant and non-dominant HGS trials, respectively (P < 0.05). LSD post-hoc analysis revealed that the second trial scores were significantly higher than those of the 1st trial (P < 0.05). The second and third trials did not follow a definite trend of difference with regards to the changes in the mean scores; however, there were no significant differences between the second and third trials (P > 0.05).

Relationship between HGS and physical characteristics of the pregnant and non-pregnant participants are presented in Table 5. The results showed that the physical characteristics weakly correlated with HGS with correlation co-efficient (r) ranging from 0.00 - 0.250 for both dominant and non-dominant hands.

Table 1. Independent t-test Comparison of General Characteristics and Hand Grip Strength of the Pregnant and Non-Pregnant Females [a]

Variable	Pregnant (n = 87)	Non-pregnant (n = 87)		
	Mean ± SD	Mean ± SD	t-cal	P Value
Age, y	29.7 ± 5.3	28.2 ± 5.8	1.7	0.440
Weight, Kg	73.8 ± 10.2	62.6 ± 9.4	7.5	0.278
Height, m	1.63 ± 5.2	1.61 ± 7.2	2.3	0.002 [b]
BMI, Kg/m²	27.6 ± 4.1	23.9 ± 3.9	5.9	0.201
PBF, %	34.9 ± 6.1	30.3 ± 6.8	4.3	0.621
LBM, kg	48.6 ± 5.4	44.1 ± 7.6	4.5	0.074
BFM, kg	25.2 ± 7.3	18.5 ± 5.6	6.8	0.003 [b]
DHGS	26.8 ± 8.9	29.3 ± 7.1	-2.0	0.044 [b]
NDHGS	24.7 ± 8.5	28.6 ± 8.4	-3.1	0.002 [b]

[a] Abbreviations: BMI, Body Mass Index; PBF, Percentage Body Fat; LBM, Lean Body Mass; BFM, Body Fat Mass; DHGS, Dominant Hand Grip Strength; NDHGS, Non-Dominant Hand Grip Strength.
[b] P < 0.05 was considered as level of significance.

Table 2. Obstetric Characteristics of the Subjects [a]

Variable	All Subjects	Pregnant	Non-Pregnant
Parity			
Nulliparous	80 (46)	40 (50)	40 (50)
Primiparous	39 (22.4)	28 (71.8)	11 (28.2)
Multiparous	44 (25.3)	17 (38.64)	27 (61.36)
Gravidity			
Nulligravida	37 (21.3)	-	37 (42.53)
Primigravida	56 (32.2)	39 (44.82)	17 (19.54)
Multigravida	81 (46.6)	48 (55.17)	33 (37.93)
Stage of pregnancy			
1st Trimester	-	12 (69)	-
2nd trimester	-	27 (15.5)	-
3rd Trimester	-	48 (27.6)	-

[a] Values are presented as No (%)

Table 3. Comparing the Adiposity and Hand Grip Strength of the Pregnant Females by Parity, Gravidity and Stage of Pregnancy, Using One-Way ANOVA and LSD Post-hoc Test [a]

Variable	Mean ± SD	F-Ratio	P Value
Parity			
BMI		9.415	0.001 [b]
Nulliparous	24.37 ± 4.32 [c]		
Primiparous	27.44 ± 4.55 [c]		
Multiparous	27.05 ± 3.71 [c]		
PBF		1.396	0.281
Nulliparous	31.55 ± 5.72		
Primiparous	33.71 ± 7.07		
Multiparous	32.77 ± 8.28		
LBM		8.397	0.001 [b]
Nulliparous	44.18 ± 6.12 [c]		
Primiparous	48.59 ± 6.85 [c]		
Multiparous	48.38 ± 7.57 [c]		
BFM		6.659	0.002 [b]
Nulliparous	19.86 ± 6.02 [c]		
Primiparous	24.51 ± 8.15 [c]		
Multiparous	23.22 ± 7.97 [c]		
Gravidity			
BMI		19.82	0.001 [b]
Nulliparous	22.4 ± 4.02 [c]		
Primiparous	25.6 ± 4.02 [c]		
Multiparous	27.43 ± 3.97 [c]		
PBF		5.79	0.004 [b]
Nulliparous	29.22 ± 4.26 [c]		
Primiparous	32.73 ± 6.09 [c]		
Multiparous	33.63 ± 7.67 [c]		
LBM		14.853	0.001 [b]
Nulliparous	41.49 ± 5.73 [c]		
Primiparous	46.34 ± 6.45 [c]		
Multiparous	48.47 ± 6.76 [c]		
BFM		18.594	0.001 [b]
Nulliparous	16.27 ± 3.07 [c]		
Primiparous	22.02 ± 6.13 [c]		
Multiparous	24.30 ± 8.01 [c]		
Stage of pregnancy			
BMI		0.077	0.926
1st Trimester	27.21 ± 3.25		
2nd Trimester	27.77 ± 5.07		
3rd Trimester	27.57 ± 3.81		
PBF		0.303	0.739
1st Trimester	35.31 ± 6.11		
2nd Trimester	34.72 ± 6.48		
3rd Trimester	34.04 ± 5.94		
LBM		1.339	0.268
1st Trimester	47.00 ± 4.22		
2nd Trimester	47.80 ± 5.89		
3rd Trimester	49.36 ± 5.23		
BFM		0.012	0.988
1st Trimester	25.00 ± 6.51		
2nd Trimester	5.37 ± 7.94		
3rd Trimester	25.17 ± 7.19		
Parity			
DHGS		9.415	0.001 [b]
Nulliparous	26.37 ± 4.32 [c]		
Primiparous	29.44 ± 4.55 [c]		
Multiparous	29.05 ± 3.71 [c]		
NDHGS		6.659	0.002 [b]
Nulliparous	19.86 ± 6.02 [c]		
Primiparous	24.51 ± 8.15 [c]		
Multiparous	23.22 ± 7.97 [c]		
Gravidity			
DHGS		17.82	0.001 [b]
Nulliparous	25.4 ± 5.02 [c]		
Primiparous	27.6 ± 6.03 [c]		
Multiparous	29.43 ± 5.97 [c]		
NDHGS		12.65	0.001 [b]
Nulliparous	18.25 ± 1.05 [c]		
Primiparous	20.04 ± 5.13 [c]		
Multiparous	22.30 ± 6.01 [c]		
Stage of pregnancy			
DHGS		0.067	0.826
First Trimester	27.21 ± 3.25		
Second Trimester	26.35 ± 5.07		
Third Trimester	25.57 ± 3.81		
NDHGS		0.012	0.988
FirstTrimester	25.00 ± 6.51		
Second Trimester	22.37 ± 3.23		
Third Trimester	21.17 ± 2.25		

[a] Abbreviations: BMI, Body Mass Index; PBF, Percentage Body Fat; LBM, Lean Body Mass; BFM, Body Fat Mass; DHGS, Dominant Hand Grip Strength, NDHGS, Non-Dominant Hand Grip Strength.
[b] $P < 0.05$ was considered as level of significance.
[c] For a particular variable, mode means different superscripts are significantly different ($P < 0.05$). Mode means the same superscripts are not significantly different ($P > 0.05$). When only one contrast is significant, one of the cells means no superscript attached.

Table 4. Comparing the Three Trial Assessments of Hand Grip Strength, Using One-Way ANOVA and LSD Post-hoc Test [a, b]

Variable	First Trial	Second Trial	Third Trial	F-Ratio	P Value
	Mean ± SD	Mean ± SD	Mean ± SD		
All participants					
DHGS	26.7 ± 9.1 [d]	28.8 ± 9.3 [d]	28.6 ± 9.2 [d]	9.79	0.002 [c]
NDHGS	27.5 ± 10.0 [d]	26.4 ± 9.4 [d]	25.9 ± 9.8 [d]	6.04	0.015 [c]
Pregnant					
DHGS	25.1 ± 9.7 [d]	26.8 ± 9.7 [d]	28.5 ± 9.8 [d]	15.13	0.001 [c]
NDHGS	25.1 ± 9.2 [d]	24.9 ± 9.6	23.9 ± 9.1 [d]	2.054	0.155
Non-pregnant					
DHGS	28.2 ± 8.3 [d]	30.8 ± 8.6 [d]	28.8 ± 8.9 [d]	0.389	0.534
NDHGS	29.9 ± 10.3 [d]	27.9 ± 9.1 [d]	27.9 ± 10.1 [d]	4.000	0.049 [c]

[a] N = 174
[b] Abbreviations: DHGS, Dominant Hand Grip Strength; NDHGS, Non-Dominant Hand Grip Strength.
[d] For a particular variable, mode means different superscripts are significantly different ($P < 0.05$). Mode means the same superscripts are not significantly different ($P > 0.05$). When only one contrast is significant, one of the cells means no superscript attached.
[c] $P < 0.05$ was considered as level of significance.

Table 5. Pearson's Product Moment Correlation Test of Relationship Between Hand Grip Strength and Physical Characteristics of the Pregnant and Non-Pregnant Females [a]

Variable	Pregnant Group		Non-pregnant Group	
	DHGS	NDHGS	DHGS	NDHGS
	r (p)	r (p)	r (p)	r (p)
Age	0.086 (0.427) [b]	0.034 (0.752) [b]	0.067 (0.537) [b]	-0.099 (0.361)
Weight	0.080 (0.463) [b]	0.073(0.502)	0.047 (0.666) [b]	0.028 (0.799) [b]
Height	0.203 (0.059) [b]	0.241 (0.025) [b]	-0.028(0.800)	-0.113 (0.296)
BMI	-0.021 (0.844)	0.080 (0.460)	0.071 (0.516) [b]	0.147 (0.175) [b]
PBF	0.211 (0.030) [b]	0.030 (0.785) [b]	0.006 (0.953) [b]	-0.023 (0.832)
LBM	-0.080 (0.459)	0.024 (0.823) [b]	-0.063 (0.561)	0.026 (0.814) [b]
BFM	0.171 (0.113) [b]	0.048 (0.659) [b]	-0.036 (0.740)	0.012 (0.916) [b]
Pregnancy stage	0.185 (0.85) [b]	0.078 (0.645) [b]		

[a] Abbreviations: BMI, Body Mass Index; PBF, Percentage Body Fat; LBM, Lean Body Mass; BFM, Body Fat Mass.
[b] Indicates significant co-efficient (r) ranging from 0.00 - 0.250.

5. Discussion

The study subjects were relatively young. A majority of the pregnant females were primiparous and were also in the first trimester stage of pregnancy while most of the non-pregnant participants were multiparous. A majority of the pregnant subjects were multigravida while most of the non-pregnant participants were nulligravida. The groups were largely comparable in their anthropometric parameters except for height and body fat mass values, which were higher in the pregnant group. Comparability of the anthropometric and morphologic parameters between the groups of the study may help to eliminate co-founding factors for the difference between the groups. This is because anthropometric and morphological parameters are important indicators and determinants of physical performance test results (37-39) including HGS performance (19-21).

The comparison of the measures of adiposity of the groups based on parity, gravidity, and stage of pregnancy showed that females with higher parity had significantly higher measures of adiposity. In addition, higher gravidity led to increase in measures of adiposity. Koch et al. (40) observed that parity modestly influenced BMI in their study and concluded that parity causes increase in body adiposity but not necessarily following an abdominal pattern. The child bearing years are described as important life stages for females that may result in substantial weight gain, leading to the development of obesity (41). Resultant increase in weight gain and body fat associated with parity is linked with excessive gestational weight gain (42). Akbarzade et al. (43) reported that maternal weight gain has consequences including a decrease in non-reactive parameters of non-stress test (non-stress test is the most common way to evaluate the fetus during pregnancy) and the number of accelerations of the fetal heart rate, which is the most important index for fetal health.

The current study tested the reliability of one trial versus three HGS trials in pregnant and non-pregnant females. Current recommendations state that taking the mean of three repeated grip trials provides more reliable results than only one trial (44). However, some others advocate for the best of three trials (45, 46) while others investigators prefer a single trial (47, 48). However, the repeated measure analysis used in the current study showed significant difference in the HGS trials for the dominant and non-dominant hand, respectively. Post-hoc analysis revealed that the second trial scores were significantly higher than those of the first trial. However, there were no significant differences between mean scores of the second and third trials. The findings of the study were in tandem with the study indicating that maximum HGS readings occur most frequently with the first or second attempt of a series of successive trials (49). However, the American Society of Hand Therapist recommended that the mean of the three successive trials be used as a measure of hand grip strength (34). In line with the above, the current study used the mean value of the three trials of HGS assessment for both dominant and non-dominant hand in the final analysis.

The non-pregnant group in the current study had significantly higher HGS than the pregnant group. Morrissey (32) carried out a comparative study on HGS between pregnant and non-pregnant females and found no significant difference between the groups. Comparison of the HGS of the pregnant females by parity, gravidity, and stage of pregnancy was also carried out in this study, and significant differences were found in the dominant hand grip strength and non-dominant hand grip strength among the pregnant females. It indicates that the obstetric characteristics such as parity, gravidity, and stage of pregnancy have significant effect on the HGS in females. Pregnancy-related alteration in musculoskeletal system may account for the significantly lower HGS observed among the pregnant group in the current study. Pregnancy leads to alteration in collagen metabolism and increased connective tissue pliability and extensibility, which result from altered levels of relaxin, estrogen, and progesterone. Their ligamentous tissues are predisposed to laxity with resultant reduced joint stability. To allow the birth of the baby the symphysis pubis, sacroiliac joints, and the tensile strengths of muscles are particularly affected and this ligamentous laxity may continue for six months postpartum (50). Comparison of the pattern of HGS in this population showed significant differences between the dominant and non-dominant HGS of the pregnant and non-pregnant groups, respectively. Similarly, studies among other populations showed consistent trend of higher HGS in the dominant upper extremity compared with the non-dominant limb. Results of the current study showed that HGS weakly correlated with physical characteristics among pregnant and non-pregnant groups.

A potential limitation of this study was unevenly matched groups. Since the control group could not be matched by trimester, gravidity, and parity, age was the major matching criterion in the current study. However, the physiological and physical changes in pregnancy (51, 52) coupled with reduced physical activity and energy expenditure (53) put the pregnant females at disadvantage of having poorer HGS assessment results. In addition, further studies should validate the use of BIA and BMI as the measures of body composition in pregnancy. Although, BIA is reported as an easy, fast, non-invasive, and accurate method to estimate the body water composition during pregnancy (54, 55), however, it may have high frequency of errors (56, 57); while BMI may not represent a true body composition status since it does not consider significant parameters such as total lean body mass and fat content (58).

It was concluded that pregnant females had significantly lower HGS compared with non-pregnant ones. High parity and gravidity, and the later stage of pregnancy led to significantly lower HGS. Level of adiposity significantly influences the performance of HGS in females.

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Authors' Contributions

Chidozie Emmanuel Mbada: study conception, design, data analysis and writing the manuscript; Adebanjo Babalola Adeyemi: study design, conception, and writing the manuscript; Olalekan Omosebi: study conception, data collection, and writing the manuscript; Adekemi Eunice Olowokere and Funmilola Adenike Faremi: study conception and writing the manuscript.

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