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Neonates Measurements and Maternal Factors in Sudan 1 2 Abstract: 3

Introduction: Anthropometric measurements of neonates serve as a vital clinical 4 tool for identifying small or large newborns. These measurements also play a crucial role 5 in assessing the potential outcomes of newborns, helping to predict future risks of 6 morbidity or mortality. The purpose of this study was to determine the average 7 anthropometric measurements representative of Sudan's newborn population and to 8 examine the relationship between these measurements and maternal factors. 9 Methodology: This study employed a descriptive prospective design across three hospitals 10 located in Khartoum: Omdurman Maternity Hospital, Bahri Teaching Hospital, and Saad 11 Abo Aila Hospital. The study included 794 mothers and their newborns after meeting the 12 inclusion and exclusion criteria within the first 72 hours postdelivery. 13 Neonatal measurements, including birth weight, crown-heel length, and head and chest 14 circumference, were taken for those who met the criteria. Statistical Package for Social 15 Science (SPSS) version 20 to present means and generate tables and figures. Chi-square 16 test used to assess the significant relationship between different maternal and neonatal 17 variables. All ethical considerations were maintained. Results: newborn Males made up 18 51.5% (409), while females represented 48.5% (385). Maternal age falls within the 20 to 19 under 31 years range, representing 52% of the total. The most prevalent Body Mass Index 20 (BMI) category in the sample was overweight, making up 41.7%, whereas 18.9% of the 21 mothers were classified as obese. Head circumference demonstrated a statistically 22 significant correlation with maternal BMI (P-value = 0.017). Maternal parity showed a 23 statistically significant correlation with both newborn weight (P-value = 0.006) and head 24 circumference (P-value = 0.008). Pregnancy complications were identified in 14% of 25 cases and demonstrated a statistically significant correlation with weight, length, head 26 circumference, and chest circumference (all P-values < 0.05). The most frequent health 27 issue encountered during pregnancy was hypertension, affecting 41% of cases, followed 28 by malaria at 22% and diabetes at 13%. The occurrence of morbidities during pregnancy 29 showed a statistically significant relationship with weight, length, head circumference, 30

and chest circumference, with all P-values being less than 0.05. Conclusion: The study 31 observed that maternal complications in Sudan such as overweight, hypertension, malaria, 32 and diabetes has direct negative impact in relation to neonatal measurements, including 33 height, weight, head circumference, and chest circumference. Urgent intervention needed 34 at the national level. 35 36 Keywords: Anthropometric measurements, neonate, Maternal factors, Sudan. 37 38 1. Introduction: 39 Anthropometric measurements are noninvasive, quantitative methods used to 40 evaluate the physical dimensions, proportions, and composition of the human 41 body (Casadei & Kiel, 2022). These include metrics such as height, weight, Body Mass 42 Index (BMI), and skinfold thickness. Widely employed in pediatrics to monitor growth 43 and in adults for assessing health risks like obesity or informing ergonomic design, these 44

measurements offer essential and cost-efficient data for various applications (Carrión 45 Martínez et al, 2022). 46 Between 1997 and 2003, the World Health Organization (WHO) developed new global 47 standards for evaluating the growth and development of children aged 0 to 5 years. This 48 initiative included approximately 8,500 children from Brazil, Ghana, India, Norway, 49 Oman, and the United States of America (USA) who were raised under optimal 50 conditions. The standards emphasized breastfeeding as the benchmark for healthy growth 51 (WHO, 2026). This is what is nowadays known as Multicenter Growth Reference Study 52 (MGRS). 53 A neonate, or newborn, refers to an infant during the first 28 days of life, a crucial 54 period marked by rapid physiological adjustments, the development of early bonds, and the 55 initiation of feeding. This phase is associated with heightened risks of illness and 56 mortality often necessitating specialized care for preterm or medically compromised 57 infants (Anthony & McKinlay, 2023). Primary concerns during this time include 58 susceptibility to infections, respiratory challenges, and maintaining proper temperature 59 regulation. In 2023, around 2.3 million newborns worldwide lost their lives within the 60 first 28 days, a period known as the neonatal stage. This continues to be the most critical 61 and fragile phase for child survival, representing

47% of all deaths among children under the age of five (Cao et al, 2022). Maternal factors refer to the physical, social, and genetic conditions of a pregnant individual that play a crucial role in shaping pregnancy, childbirth, and the long-term health of the child. Important and manageable aspects include maternal age, prepregnancy weight, existing **7 medical conditions such as diabetes** or hypertension, infections, and **67** mental wellbeing (Muglia et al, 2022). Abnormal maternity conditions considerably **68** heighten the likelihood of disabilities and developmental challenges in children **69** (Alkazalehet al, 2025). **70** Global maternal health and mortality, reflected in a rate of 197 deaths per 100,000 live **71** births in 2023, are largely influenced by stark inequities. Notably, 94% of these deaths **72** occur in low resource settings (Shanto et al, 2023). **73** Sudan, situated in East North Africa, is classified as a developing country (Satti et al, 2026; Abdalrhman et al, 2025). Ongoing conflict has significantly harmed the nation's **75** healthcare system, leaving many pregnant women without access to essential maternal **76** care services (Abdelnour et al, 2026; Satti et al, 2025). Therefore, Maternal mortality **77** remains a significant issue in Sudan, accounting for approximately **78.7%** to **80.25%** of **78** deaths between 2000 and 2019 (Taha et al, 2025). The primary cause is **79** obstetric hemorrhage, responsible for **45.45%** to **45.5%** of fatalities, followed by **80** hypertensive disorders at **16.1%**, and sepsis (Taha et al, 2025). In 2023, the national **81** maternal mortality ratio was estimated at 256 per 100,000 live births (Elhassan et al, **82** 2025). **83** 2. Methodology: **84** The study was a prospective, cross-sectional, hospital-based investigation conducted **85** in Khartoum State across three hospitals: Omdurman Maternity Hospital, Bahri Teaching **86** Hospital, and Saad Abo Ailla Teaching Hospital. The study population comprised **87** Sudanese women who had recently given birth in these hospitals, along with their neonates **88** within the first **72** hours post-delivery. A total of 794 mothers and their newborns **89**

participated. Data for the study were collected using a straightforward questionnaire **90** designed to gather demographic information from the mothers. The author was actively **91** involved in screening all mothers and babies (n=794) and conducted clinical neonatal **92**

examinations to rule out any congenital abnormalities. Additionally, the author performed 93 anthropometric measurements following standard methodologies. The mothers' body 94 weight and height were measured using a stadiometer. Neonatal anthropometric 95 parameters were recorded with measuring tapes, pre-calibrated weighing scales, and an 96 infantometer for length measurements. The collected data was summarized and presented 97 through tables and graphs. Pearson's chi-square test was employed to evaluate the 98 significance of the suggested relationships among various maternal and neonatal variables. 99 Additionally, the chi-square test and the **5 Statistical Package for the Social Sciences (SPSS)** 100 version 20 were utilized for generating tables, figures, and processing the results. All 101 ethical considerations have been maintained. 102 3.

Results: 103 104 105 106 107 108 109 110 Figure 1: Gender (n=794) 111

Males constituted 51.5% (409) of the sample, while females accounted for 48.5% (385), 112 as illustrated in Figure 1. **2** 113 114 115 116 117 118 119 120 121 122 Figure 2:

Maternal ages (n=794) 123

124 125 126 Figure 2: Age (n=794) 127 The maternal age group with the highest frequency, as shown in Figure 2, was 128 between 20 and under 31 years, accounting for 52%. **6** 129 130 131 132 133 134 135 Figure 3: Maternal BMI (n=794) 136

The most common BMI category among the sample was overweight, comprising 41.7%, 137 while obese mothers accounted for 18.9%. On the other hand, 37% had a normal BMI, as 138 depicted in Figure 3. 139 140 Head circumferences showed a significant statistical

association with maternal BMI (P141 value = 0.017) as presented in Table 1. 142 Table

1: Maternal BMI and baby anthropometric measurements 143 Maternal BMI weight length

Head circumference Chest circumference Total normal abnormal | normal abnormal |

normal abnormal | normal | abnormal | Under weight 19 0 16 3 19 0 13 6 19 Normal

weight 284 11 225 70 270 25 230 65 295 Over weight 319 16 281 54 304 31 264 71 335

Obese 139 6 120 25 132 13 125 20 145 Total 761 33 642 152 725 69 632 162 794

p-value 0.087 0.055 0.017 0.129 144 145 146 Figure 4: Distribution of obese mothers (n=145) 147 A total of 145 mothers (18.9%) were categorized as obese; among them, 116 fell under Class 1 148 obesity, while 4 were reclassified as Class 3 with severe obesity, as illustrated in Figure 4. 3 149 150 151 152 153 154 155 156 157 158 159 Figure 5: Maternal parity (n=794) 160 Figure 5 showed that 50% (400) were multiparous and 26% (240) were primigravida, 161 and 24% (190) were grandmultipara. 162 Maternal parity demonstrated a statistically significant association with newborn weight 163 (P-value =0.006) and head circumference (P-value =0.008), as in Table 2. 164 Table 2. Maternal parity and baby anthropometric measurements (n=794) 165

Weight	Length	Head circumference	Total	Normal	abnormal	Normal
abnormal	Normal	abnormal	Primigravida	94.6%	5.4%	79.4%
			Grandmultipara	92.6%	7.4%	81.1%
			Total	95.8%	4.2%	80.9%
				19.1%	91.3%	8.7%
			100% (794)	p-value	0.006	0.824
					0.008	166 167

Figure 6. Medical illness during current pregnancy (n=794) 168 As illustrated in Figure 6, 86% (683) of mothers did not experience any medical illness 169 during pregnancy, while 14% (111) experienced medical conditions during this period. 170 171 Figure 7. Types of disease during current pregnancy (n=111) 172 The most common health issue during pregnancy was hypertension (41%), followed by 173 malaria (22%) and diabetes (13%) as in Figure 7. 174 175

The prevalence of morbidities during pregnancy had statistically significant association 176 with weight, length, head circumference, and chest circumference (all P-values < 0.05), as 177 detailed in Table 3. 178 Table 3. Maternal diseases during current pregnancy and baby anthropometric 179 measurements (n=111) 180 Maternal diseases during current pregnancy weight length Head circumference Chest circumference mean SD mean SD

mean SD mean SD Malaria 2.93 0.41 46.16 2.46 34.39 1.25 31.39 1.82 DM 3.47 0.40
47.82 1.95 35.32 1.07 33.43 1.87 Hypertension 2.82 0.58 46.22 2.79 33.91 1.76 30.48
2.85 Others 3.05 0.38 47.45 1.87 31.70 1.37 31.40 1.53 p-value 0.000 0.045 0.013
0.001 181 4. Discussion: 182 There are a significant gender differences exist in the
prevalence and incidence of 183 conditions affecting newborns. Male infants are
more prone to preterm birth, higher 184 mortality rates, infections, sepsis, and congenital
abnormalities (Gebremeskel et al, 185 2022). This study revealed no significant differences
concerning the gender of the 186 newborns. 187 In this study, the most common
maternal age falls within 20 to 31 years old. This age 188 is aligned to the common
maternal age worldwide and in the USA (Brown et al, 2025). 189 The most mothers BMI
category in this study was overweight. Mothers who are 190 overweight or obese are more
likely to give birth to infants with higher birth 191 weights, which are also associated with
newborn measurements such as head 192 circumference which clearly identified in this
study. The prevalence of overweight and 193 obesity among pregnant women in Sudan is
rising at a concerning pace, especially in 194 urban regions, posing a notable public health
challenge (Eltayeb & 195 Khalifa, 2021). Research reveals a strikingly high occurrence, with
one study reporting that 196 over 35% of pregnant women are overweight and almost 20%
are obese (Eltayeb & 197 Khalifa, 2021). 198 In addition, this study showed correlation
between pregnancy complications and 199 newborn measures regarding weight, length,
head circumference, and chest 200 circumference. Pregnancy complications like diabetes
and hypertension considerably 201 heighten the likelihood of unfavorable outcomes for
newborns, including issues with birth 202 weight. Such complications frequently result in
respiratory difficulties and developmental 203 challenges (Sokouet al, 2025). On the same
issue, the most frequent health issue 204 encountered during pregnancy in this study was
hypertension, malaria, and diabetes. In 205 Sudan, Hypertension during pregnancy is a
significant contributor to maternal morbidity 206

and mortality in Sudan, responsible for around 16.1% of maternal fatalities (Elhassan et

207 al, 2025). Regarding malaria, Prevalence rates are significant, with studies reporting 208 pregnant women infection rates up to 38.5% in some areas (Sulimanet al, 2021). 209 Furthermore, the prevalence of diabetes is notably high among the Sudanese population 210 (Abdelnour et al, 2025). Some studies attribute this to the fact that sugar is one of Sudan's 211 primary products (Abdelnour et al, 2023). Therefore, Effective management of malaria, 212 diabetes, and hypertension among pregnant women in Sudan necessitates a 213 comprehensive approach to antenatal care (Adam et al, 2011). This involves promoting 214 the use of insecticide-treated nets, ensuring timely malaria treatment with Artemisinin 215 Based Combination Therapies, and closely monitoring and controlling blood pressure and 216 blood sugar levels (Aliet al, 2011). 217 The occurrence of morbidities during pregnancy in this study showed significant 218 relationship with weight, length, head circumference, and chest circumference. It is well 219 documented in the literature that Maternal health issues, such as obesity and diabetes, 220 have a direct impact on neonatal outcomes specifically towards weights, head 221 circumferences, and chest circumferences (Shoji et al, 2022). 222 Finally, enhancing maternal and neonatal health in Sudan demands immediate, multi-223 dimensional efforts aimed at rebuilding health systems affected by conflict (Elhassan et al, 224 2025; Olaleye et al, 2023). This involves establishing well-equipped neonatal intensive care 225 units and reinforcing primary healthcare services (Elhassan et al, 2025). Priority actions 226 include providing midwives with emergency care training, expanding antenatal care 227 coverage, ensuring access to critical medical supplies, and raising 228 community awareness about safe childbirth practices (Olaleye et al, 2023). 229 230 5. Conclusion: 231 The study emphasized that maternal health issues in Sudan such as overweight, 232 hypertension, malaria, and diabetes significantly affect neonatal measurements, including 233 height, weight, head circumference, and chest circumference. This underscores the 234 pressing need for nationwide interventions aimed at enhancing primary healthcare services 235 to improve the health of both mothers and newborns. 236 237 References: 238 239 1. Abdalrhman, S., Elyas, U., Abdelnour, H., Abdulmagid, T., Almalty, T., Adam, 240 M. (2025). Medical Staff

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