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Body Size and Nutritional Status of Children Aged 6-12 Years in Jungkat Village, Jongkat District, Mempawah Regency

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ABSTRACT

The significant impact of stunting in early childhood affects both physical growth and cognitive development. The prevalence of stunting in Jungkat Village highlights the importance of monitoring growth and development during mid-childhood (ages 6-12), as it is a critical period for cognitive, social, and physical development. The study aims to provide insights into the effectiveness of interventions in addressing stunting by describing the body size and nutritional status of children aged 6-12 in Jungkat Village. A cross-sectional method was employed in four primary schools in Jongkat District. Anthropometric measurements of body height and body weight were used to calculate nutritional status indices, including the body height-to-age index and body mass index. In Jungkat Village, children aged 6-12 show varied growth patterns, including high rates of stunting and obesity, with some stunted children maintaining normal BMI for age, indicating complex interactions between nutrition and growth. In addition, there is no significant sexual dimorphism in growth patterns at this age, but differences in weight are evident, with boys generally heavier after age 7. Environmental, socioeconomic, and behavioral factors may significantly influence these patterns, underscoring the need for integrated health and nutrition interventions that target maternal and early childhood support.

1. Introduction

Stunting is a significant issue that can impede physical growth during the first 1,000 days of life. It manifests as a condition where a child's height or length is below the normal range for their age group (Daracantika *et al.* 2021). Poor nutrition and health during the prenatal and postnatal periods, or over an extended period, can lead to growth failure (Grantham-McGregor *et al.* 2007; Fikawati *et al.* 2017). In addition to affecting physical growth, stunting also disrupts a child's cognitive development, which can have long-term implications for their future. Stunted children's Intelligence Quotients (IQ) are typically lower than normal children's (Kementerian Kesehatan Republik Indonesia 2016).

A total of 22 out of 77 cases of stunting in the Jongkat District, Mempawah Regency, West Kalimantan Province, were reported from Jungkat Village (Mempawah.com, 30-08-2019). The number was also confirmed by nutrition staff at the Jongkat District Health Centre during interviews conducted as part of the initial research survey on June 14, 2022. Healthcare facilities in Jongkat District are relatively limited, consisting of only two community health centers (puskesmas) and

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three pharmacies. Community access to hospitals and maternity hospitals is classified as difficult or very difficult. The district experiences high rainfall, with an average of 296 mm, and most residents still rely on rainwater as their primary source of clean water (Badan Pusat Statistik Kabupaten Mempawah 2022). The geographical location, facing the sea to the west, makes Jongkat District—especially Jungkat Village—accustomed to tidal conditions when sea levels rise. During such situations, elementary school-aged children in Jungkat Village often play in the water with their peers, as observed by the research team (unpublished). Survey results from the Indonesian Nutritional Status Study (SSGI) in 2022 also indicate a high prevalence of stunting in Mempawah Regency at 25.1%. Regardless of the calculation of stunting rates from year to year, the probable impact of stunting on children's continued growth also needs to be assessed. Monitoring stunting is crucial for the growth of school-aged children (Best *et al.* 2010; Berhanu *et al.* 2022). Mid-childhood (ages 6-12) is a crucial period for brain development, shaping experiences, and learning (Knudsen 2004), as well as physical and social development (Sugiyanto 1999; Sandberg 2007; Bashash *et al.* 2017). Although children's immune systems become stronger during this period (Papalia *et al.* 2010), behavioral issues can lead to later emotional problems (Timmermans *et al.* 2010). This phase has long-term impacts, enabling rapid brain adaptation (Mah & Ford-Jones 2012).

The growth patterns of children aged 6-12 influence sexual maturation, with puberty typically beginning between ages 10-12. Menarche in girls typically begins around age 10, with variations observed between urban and rural areas (Sudikno & Sandjaja 2020). Meanwhile, the range of spermarche onset also varies between populations, for example, ranging from 11 to 18 years among 11 minority ethnic groups in China between 1995 and 2010 (Song *et al.* 2016), with a median age of 14 years, as referred to by Kuhn *et al.* (1989). Nutritional status is closely linked to the timing and progression of puberty. Adequate nutrition provides the energy and essential resources required for significant physical changes during puberty, including the production of hormones necessary for the development of secondary sexual characteristics (Wickramasinghe *et al.* 2020; Calcaterra *et al.* 2021a, 2021b). Nutritional status, reflected in height, weight, and body fat, significantly impacts the timing of menarche (Mardisentosa *et al.* 2020; Sudikno & Sandjaja 2020). Monitoring children's body size helps prevent and manage nutritional issues. This study focuses on body size and nutritional status among children in Jungkat village to address malnutrition issues, such as stunting.

2. Materials and Methods

2.1. Study Design

This study employs a cross-sectional method conducted in July 2023. Research ethics approval was obtained from the Research Ethics Committee of the Faculty of Medicine, University of Tanjungpura under No. 3479/UN22.9/PG/2023.

2.2. Studied Population

The study population consists of primary school-aged children aged 6-12 years who reside in Jungkat Village, Jongkat District, Mempawah Regency, West Kalimantan Province. Subjects were collected from four primary schools located in Jungkat Village: SDN 01 Jongkat, SDN 03 Jongkat, SDN 04 Jongkat, and SDN 06 Jongkat.

2.3. Sampling Method

Sampling was conducted using a participatory method where participants were recruited after being informed about the study. The researcher explained the objectives and procedures, and if participants agreed, parents or guardians of the children signed the informed consent form.

2.4. Anthropometry

Height measurements for children aged 6-12 years were reported by Sulistyawati (2019), while weight measurements were used by Kementerian Kesehatan Republik Indonesia (2016). Tools included the Kenko stadiometer for height and the Omron HBF-214 digital scale for weight.

2.5. Data Analysis

2.5.1. The Determination of the Age of the Samples

The age of the samples was calculated by subtracting the sample collection date from the child's birthdate. The age was presented in years and full months, with samples taken from children aged 6 years 0 months to 12 years 11 months.

2.5.2. Body Size Curve Construction

The growth curve depicts the distribution of height, weight, and BMI by age, with the age scale divided into 12-month intervals. Data is plotted using the GAMLSS

package in R, which allows for flexible regression and smoothing models. The GAMLSS method handles distributions that may be skewed or have light or heavy tails (Rigby & Stasinopoulos 2005). It analyses the distribution of anthropometric dimensions and predicts the 3rd, 15th, 50th, 85th, and 97th percentiles (WHO 2016) annually by age classes. To model and ensure an optimal fit for each growth feature, the LMS method, implemented within GAMLSS, was used to automatically select the best distribution for the data (Stasinopoulos *et al.* 2017).

2.5.3. Nutritional Status Categorization

2.5.3.1. Height for Age

The subject's height is compared with WHO (2017) height-for-age tables based on standard deviation values. Then, the standard deviation range of each sample is categorized as normal, stunted, or severely stunted (Table 1). The sample count and percentages for each category are calculated.

2.5.3.2. Body Mass Index Categories

BMI is calculated using the formula: BMI = body weight (kg) / height (m^2). The resulting BMI values are then compared to WHO's (2017) standard BMI-for-age tables. Each sample's BMI is categorized according to WHO's nutritional status criteria, and the number and percentage of samples in each category are calculated (Table 2).

Table 1. Height categories according to WHO (2017)

Description	Category
Height-for-age −2 SD and ≥ 3 SD	Normal
Height-for-age −3 SD and ≤−2 SD	Stunted (moderate chronic malnutrition)
Height-for-age <−3 SD	Severely stunted (severe chronic malnutrition)

3. Results

3.1. Subject Distribution and Anthropometry

A total of 626 children participated, comprising 296 girls and 330 boys. Parental informed consent was obtained for all subjects. Table 3 presents the anthropometric data for boys and girls across different age ranges.

Increases in height and weight are observed across all age ranges for both boys and girls. Figures 1, 2, and 3 display growth curves for children aged 6-12 in Jungkat Village, illustrating trends in height, weight, and BMI. Height and weight increase with age for most percentiles, though children at the 3rd percentile gain weight more slowly and may experience a decline by age 12. BMI generally increases with age for children at the 85th and 97th percentiles. Children at the 3rd and 15th percentile have stable but low BMIs (<15), while those at the 50th percentile experience a BMI increase but don't reach 20 by age 12. A BMI decrease is noted for 97th percentile girls between the ages of 9 and 10, although it remains above 20.

3.2. Sex Differences in Growth

Figure 4 shows growth curves for boys and girls aged 6-12 at the 50th percentile. Boys are slightly taller than girls at age 6, but by ages 7-8, heights are similar, with girls being taller until age 12. Boys and girls weigh similarly at age 6, but boys tend to weigh

Table 2. Nutritional status categories for BMI according to WHO (2017)

Baseline (z-score)	Nutritional status category
<-3 SD	Severely thinness
-3 SD and <-2 SD	Thinness
-2 SD and 1 SD	Normal
1 SD and 2 SD	Overweight
>2 SD	Obese

Table 3. Median values and standards of deviation of body size and BMI of children aged 6-12 years in Jungkat Village

Age range (year)	Subject (individuals)		Body weight (kg) ± SD		Body height (cm) ± SD		BMI (kg/m^2) ± SD	
	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
6.0-6.9	43	42	17.40±4.12	17.85±3.72	109.90±5.00	110.40±5.50	14.47±2.42	15.01±2.06
7.0-7.9	56	60	19.90±4.15	19.80±6.29	115.80±4.94	116.15±6.27	14.96±2.18	15.19±2.92
8.0-8.9	36	48	22.60±5.50	21.80±7.40	120.90±5.30	121.15±6.78	15.46±2.86	15.07±3.30
9.0-9.9	59	48	23.50±6.64	23.80±6.26	125.00±6.98	125.15±5.97	15.13±2.58	15.00±2.72
10.0-10.9	55	59	25.80±5.61	27.60±7.83	130.70±6.70	132.50±6.46	15.13±2.52	16.46±3.14
11.0-11.9	41	61	29.80±9.15	33.20±9.66	138.40±7.68	136.40±7.69	15.94±3.06	17.07±4.00
12.0-12.9	6	12	35.95±11.23	33.35±8.94	142.40±12.28	144.20±8.35	17.96±2.19	16.11±3.23

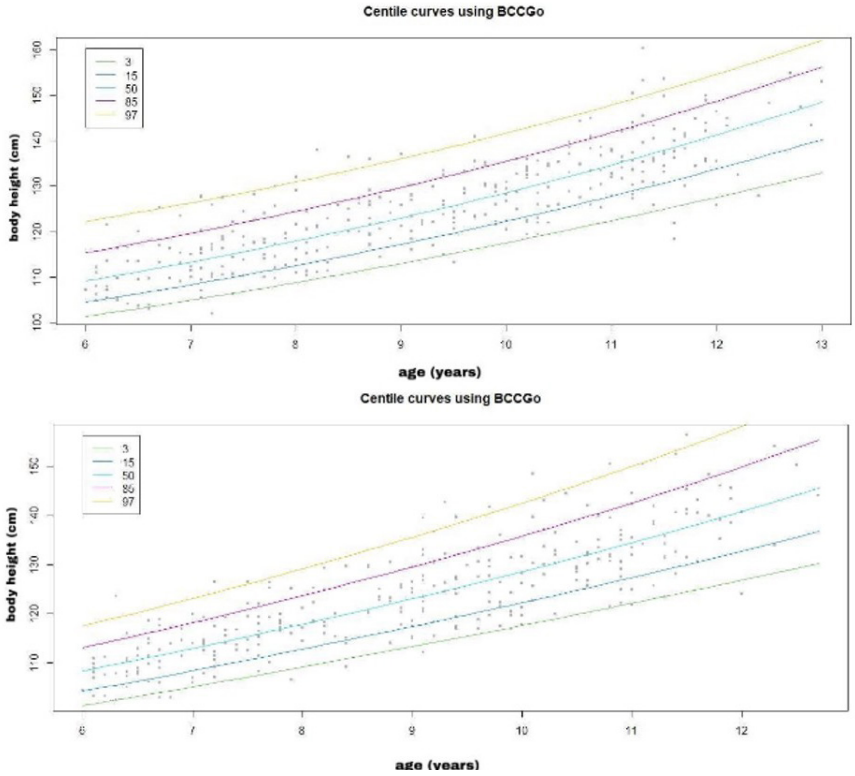

Figure 1. Body height growth curve of boys (♂, left) and girls (♀, right) aged 6-12 years in Jungkat Village

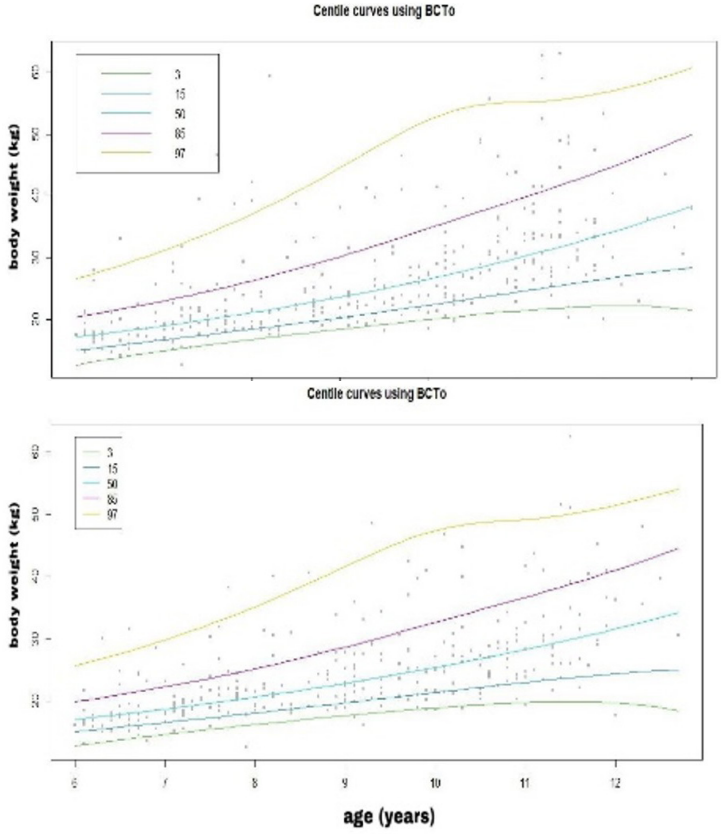

Figure 2. Body weight growth curve of boys (♂, left) and girls (♀, right) aged 6-12 years in Jungkat Village

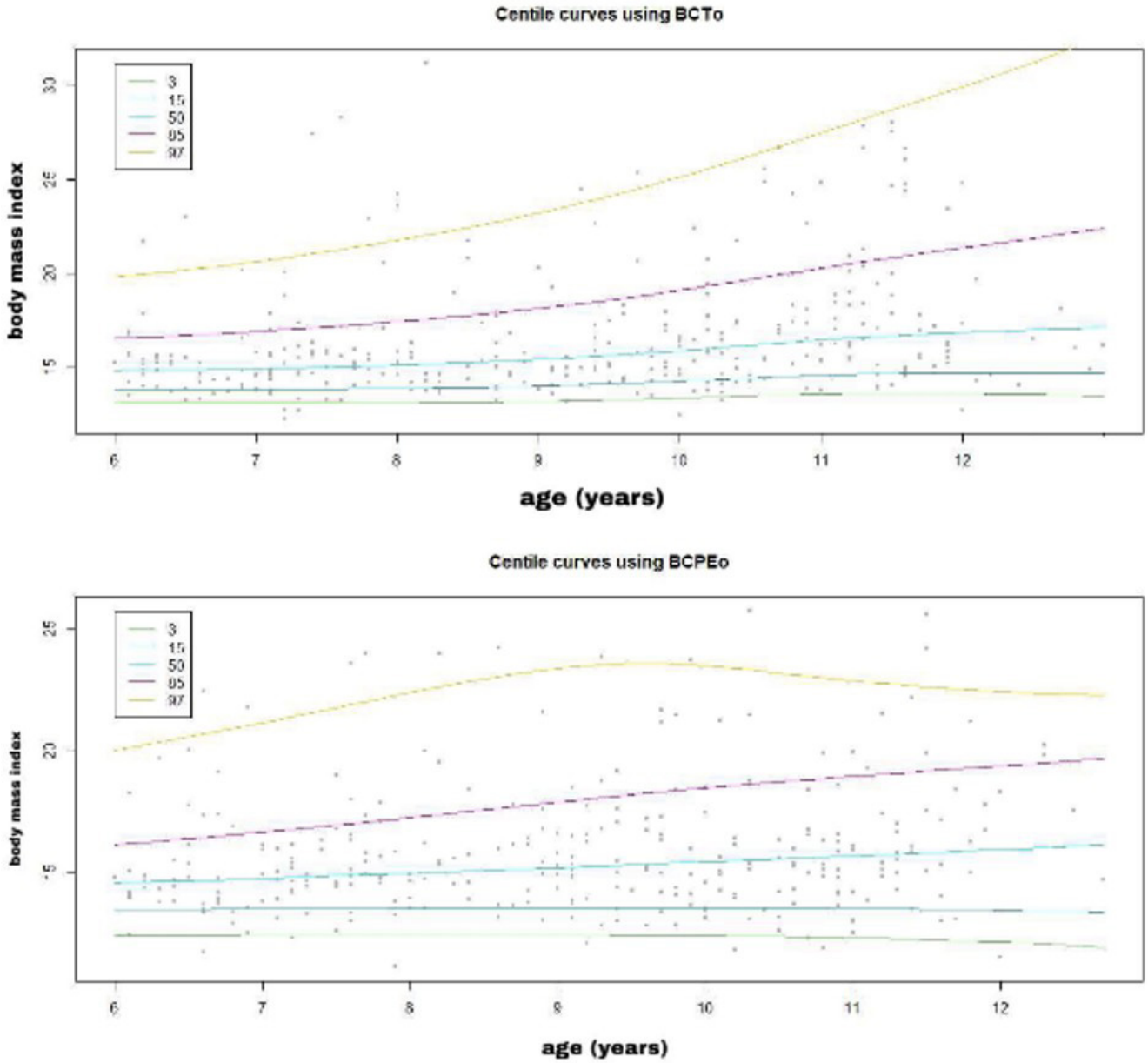

Figure 3. BMI curve of boys (♂, left) and girls (♀, right) aged 6-12 years in Jungkat Village

more from ages 7 to 12. At ages 6-7, boys' BMI is slightly higher, but from ages 7-9, the BMIs of both genders are similar. Between the ages of 9 and 12, boys tend to have a higher BMI. Growth for children in this percentile ranges from approximately 110-140 cm in height and 18-35 kg in weight. Growth continues beyond age 12 in Jungkat Village.

3.3. Nutritional Status

Growth categories are assessed using height-for-age and BMI-for-age indexes. For height-for-age, 78.8% of boys and 79.7% of girls are classified as normal, while 17.9% of boys and 16.2% of girls are stunted, and 3.3% of boys and 4.1% of girls are severely stunted. According to the BMI-for-age index, 78.5% of boys and 78.7% of girls are within the normal range. Thinness affects 3.6% of boys and 6.1% of girls, while severe thinness affects 0.6% of boys and 2.0% of girls. Additionally, 6.7% of boys and 8.8% of girls are overweight, and 10.6% of boys and 4.4% of girls are obese. When combining the data analysis results of height index with age and BMI, it was found that a number of children showing stunted and severely stunted conditions still fell within the

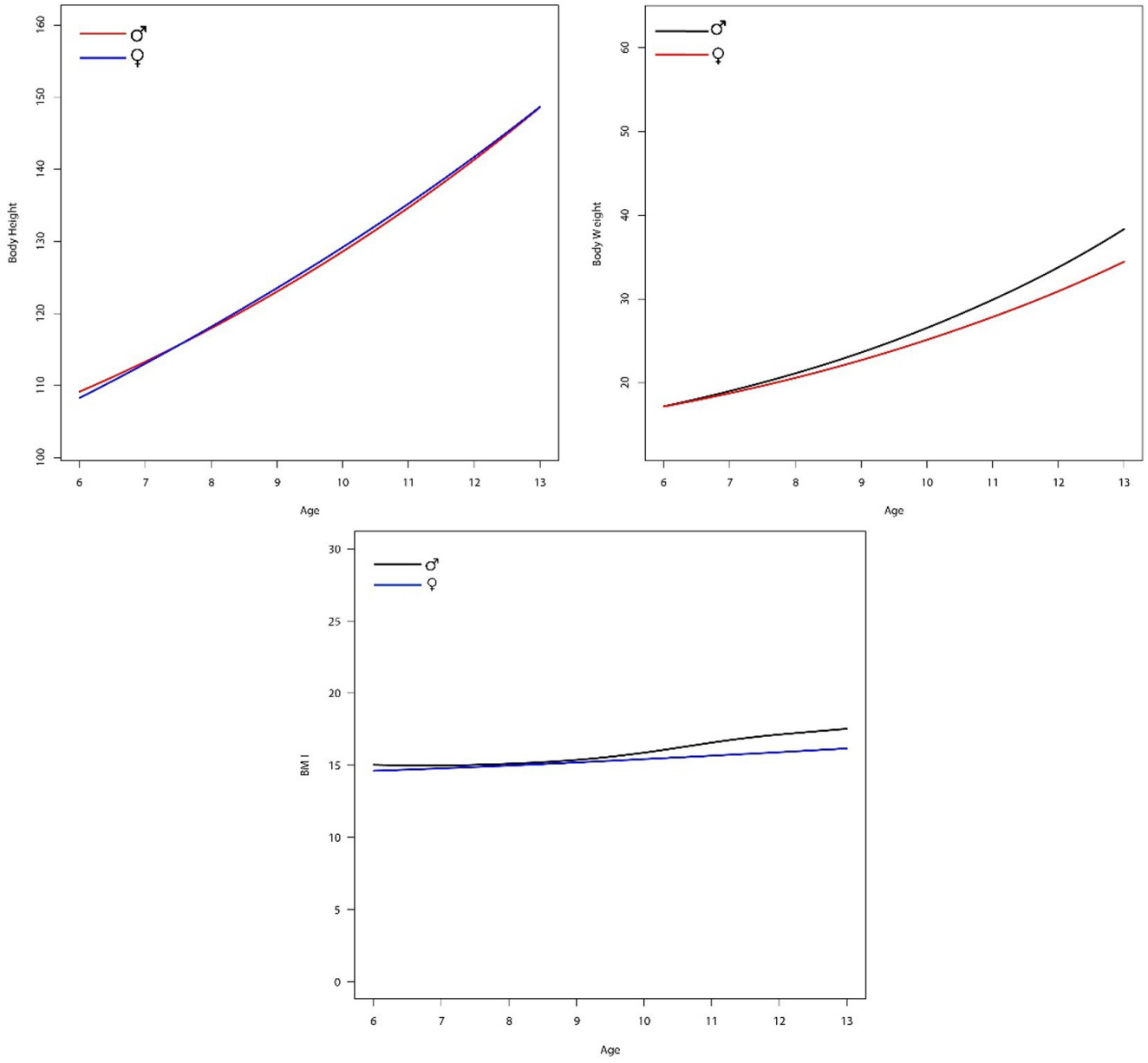

Figure 4. Body height, weight, and BMI growth curve of boys and girls at P50 aged 6-12 years in Jungkat Village

normal BMI range (Figure 5). A total of 15.8% of female children and 2.7% of male children who were categorized as stunted had a normal BMI-for-age index. In comparison, 14.9% of male children and 2.0% of female children classified as stunted were also identified as having normal BMI for age.

4. Discussion

School-aged children (6-12 years) in Jungkat Village exhibit growth in height and weight across all percentiles, with slower growth observed in the lower percentiles. According to WHO Growth Standards (2017), 17.1% of children are stunted, and 3.7% are severely stunted, with no children categorized as tall. Regarding BMI, the rates of overweight (7.7%) and obesity (7.7%) surpass those of thinness (4.8%) and severe thinness (1.3%). Despite this, several children categorized as stunted or severely stunted still exhibited a normal BMI for their age. This observation suggests that a portion of children with growth deficits, as indicated by stunting, still show a normal body mass index, which may point to differing factors influencing growth and nutritional status. The

Figure 5. Combination of height-for-age and BMI-for-age index among children aged 6-12 in Jungkat Village presented in a heatmap for girls (left) and boys (right). The numbers in the boxes indicate the number of individuals and the percentage in a specific index category

occurrence of short stature in children with normal BMI may reflect issues related to chronic undernutrition or suboptimal dietary intake that primarily affect linear growth but not weight gain to the same degree, a phenomenon observed in similar studies on child growth and development (Victora *et al.* 2010). This condition also supports the "small but healthy" hypothesis proposed by Seckler, where individuals with low height-for-age but normal weight-for-height are considered chronically malnourished without acute malnutrition and are deemed "healthy" because they exhibit no functional impairments (Messer 1986; Bogin *et al.* 2007). However, further investigation into the underlying causes and implications of this relationship is necessary for a more comprehensive understanding of child health in diverse populations.

Stunting among children aged 6-12 years is a common occurrence. In Indonesia, Salimar *et al.* (2013) reported a 35.4% stunting rate based on 2010 data. In Sidoarjo, stunting reached 14%, with severe stunting at 4%, and higher rates in rural areas (Sholihah 2021). Stunting remains prevalent globally among school-aged children. In Ethiopia's rural Humbo district, 3.5% of children are severely stunted, 27.3% are moderately stunted, and 26.4% are mildly stunted (Bogale *et al.* 2018). Cambodia has stunting rates of 29.1% and severe stunting at 10.9% (Perignon *et al.* 2014). Sudan reports a 7.1% stunting rate and a 2.3% severe stunting rate (Mohamed & Hussein 2015), while China's rate is 2.6%, with a lower incidence in urban areas (Wu *et al.* 2016). The conditions of stunting and severe stunting, along with BMI below normal, were observed in children aged 6-12 years in Jungkat Village at the following rates: 0.9% and 0.6% for girls and 0.3% and 2.1% for boys, respectively.

Oot *et al.* (2016) found that stunting is associated with poor performance in cognitive tests, including literacy and reasoning. Omar *et al.* (2018) noted that children who are stunted tend to perform worse academically than their peers. Kementerian Kesehatan Republik Indonesia (2016) highlights both short-term effects, such as impaired brain growth and physical development, and long-term effects, including weakened immune systems and increased disease susceptibility. Stunting can persist into adulthood, increasing the risk of low-birth-weight babies (Apriluana & Fikawati 2018). Stunting has a negative impact on cognitive abilities, academic performance, and immune function, thereby increasing the risk of diseases such as diabetes, heart disease, and cancer (Saimu *et al.* 2023).

In Jungkat Village, children with low BMI at an early age tend not to see BMI increases as they grow, while those with high BMI generally maintain it without significant decreases. Lundahl *et al.* (2014) explain that parents often misperceive their children's weight status, believing their children have good nutrition, due to focusing on perceived eating habits rather than actual body shape. In countries with higher obesity rates, parents are more aware of underweight status. Julia *et al.* (2008) noted that overweight or obese children are likely to remain in those categories.

On the other hand, obesity and overweight among children aged 6-12 in Jungkat Village are more prominent. According to Kementerian Kesehatan RI

(2023), overweight prevalence among Indonesian children aged 5-12 was 12.2% for boys and 11.6% for girls, while obesity reached 9.5% for boys and 6% for girls. In Jungkat, boys show higher obesity rates than girls, similar to findings in Greece (Kyriazis *et al.* 2012) and Semende Darat Laut, where boys had a 19.4% obesity rate compared to 18.7% in girls (Maharani & Hernanda 2020). However, no significant link between gender and obesity was found. Sleep duration and physical activity were identified as essential factors in obesity (Maharani & Hernanda 2020).

In Jungkat Village, boys and girls aged 6-12 exhibit similar growth patterns in height, with no sexual dimorphism observed except at the age of 6. This contrasts with other studies (El Mouzan *et al.* 2010; Widiyani *et al.* 2011; Kuiti *et al.* 2017), which generally show that sexual dimorphism appears later. For example, Widiyani *et al.* (2011) found it to be significant after the age of 12, while El Mouzan *et al.* (2010) observed that boys became taller from 7 to 10 years and girls from 10 to 15 years. Factors like genetics, nutrition, and health influence height (Huang *et al.* 2013; Jelenkovic *et al.* 2016; Ayu & Kumaat 2020). The lack of dimorphism in Jungkat may be due to children not yet reaching the age where differences emerge.

The weight growth patterns of boys and girls aged 6-12 in Jungkat Village show sexual dimorphism, with boys becoming heavier than girls after age 7. This difference may relate to puberty and secondary growth factors (Carel 2004; Chen *et al.* 2022). Ahmed *et al.* (2014) also noted that behaviors like sports, stress, and unhealthy food choices contribute to lower body weight in girls. Further research on puberty, behavior, and growth in older children in Jungkat Village is needed to understand this phenomenon better.

Differences in growth patterns among children aged 6-12 in Jungkat Village compared to other populations may result from environmental factors, such as the area's carrying capacity to support life. Ecologically, populations adapt to their environments, leading to unique growth patterns (Pinotti *et al.* 2002). Demirjian *et al.* (1976) also found significant intergroup growth variations across developmental stages, reflecting ethnic differences. Environmental carrying capacity, defined as the number of individuals an ecosystem can support, influences growth rates—faster in resource-rich environments and slower in resource-poor ones (Ruwayari *et al.* 2020). Growth responses are shaped by specific environmental conditions, which affect traits such as future fertility (Benton *et al.* 2006).

Environmental factors, such as climate, significantly impact human development. Populations in extreme temperatures face higher disease risks (Gronlund *et al.* 2018), and public health disruptions can hinder growth (Acolin & Fishman 2023). Socioeconomic factors, including access to healthcare, sanitation, education, and employment, also impact growth. Poor socioeconomic conditions can lead to Malnutrition, disrupting growth patterns (Velasco *et al.* 1982; Dari *et al.* 2017). These factors underscore how natural selection and environmental pressures influence phenotypic diversity and drive evolutionary adaptations.

In Jungkat Village, children (ages 6-12) face short stature, underweight, overweight, and obesity issues. Regular monitoring of weight and height by families and institutions is crucial. Obesity often stems from an imbalance between calorie intake and expenditure, with excessive sugar and low physical activity as key factors (Dehghan *et al.* 2005; Karnik & Kanekar 2012; Ginting & Besral 2020). Avoiding short stature, especially when related to environmental or nutritional factors, can involve several preventive and supportive measures (Sultan *et al.* 2008).

In addition, preventing stunting requires a multisectoral approach, encompassing preconception, prenatal, and postnatal interventions that target women and children (de Onis *et al.* 2013). Integrating nutritional interventions with health, family planning, and sanitation is essential. Addressing underweight involves improving breastfeeding practices, complementary feeding, healthcare, and maternal care. Educational nutrition programs, including counseling and home visits, are necessary to enhance parental awareness of nutrition and health (Septiani & Ardiansyah 2022).

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