Obesity Indicators and C-Reactive Protein in Indonesian Adults (More than Equal to 40 Years Old): The Indonesian Family Life Survey 5

Yeni Mahwati1*, Dieta Nurrika2,3

1Study Program of Public Health, Sekolah Tinggi Ilmu Kesehatan Dharma Husada, Indonesia
2Department of Public Health, School of Health Science Banten, Indonesia
3Department of Health Informatics and Public Health, Faculty of Epidemiology, Tohoku University School of Public Health, Japan

Abstract
C-reactive protein (CRP) is the best clinical marker for systemic inflammation. Obesity is associated with increased CRP levels. Systemic inflammation is present before morbidity occurs. This study revealed that the identification of obesity indicators and CRP levels is limited among Indonesians. The present study investigated the associations among obesity indicators (body mass index/BMI, waist circumference/WC, waist-to-hip ratio/WHR, waist-to-height ratio/WHtR, and CRP levels) among Indonesian adults. This cross-sectional study based on Indonesian Family Life Survey 5 in 2014–2015 was conducted among 3,386 adults (≥40 years) living in 13 provinces in Indonesia during the study period. All data were collected in 2014. Multiple logistic regression was used to estimate the odds ratio (ORs) and 95% CI for hs-CRP levels on obesity indicators by using underweight (BMI) and normal (WC, WHR, and WHtR) as references. Our multivariable logistic regression analysis indicated that respondents with increased WHR (OR: 1.278, 95% CI: 1.005–1.625, p-value < 0.001) were more likely to have high-risk hs-CRP levels than those with normal WHR. Compared to respondents with normal WHR, those with increased WHtR were found associated with high-risk hs-CRP levels (OR: 1.980, 95% CI: 1.544–2.541, p-value < 0.001). Therefore, WHR and WHtR can predict central obesity, which is associated with hs-CRP levels.

Keywords: adult, c-reactive protein, obesity

Introduction
Acute-phase C-reactive protein (CRP) is well known as a sensitive marker for systemic inflammation, which is synthesized in the liver; the process is predominately regulated by interleukin-6 (IL-6).1,2 Previous prospective studies reported that CRP levels are associated with future coronary heart disease risks.3 Another previous study showed that elevated CRP levels significantly correlate with metabolic abnormality features,4 such as insulin resistance,5 and low high-density lipoprotein cholesterol.6,7 Thus, CRP levels that can assist in predicting future morbidity risks are important.

Obesity is a major public health problem in the world, affecting people in developed and developing countries.2,8,9 In 2016, 39% of adults aged 18 years and above (39% of men and 40% of women) were overweight; overall, approximately 13% of the world’s adult population (11% of men and 15% of women) were obese.10 Obesity is associated with metabolic syndrome, development of type II diabetes,11 and coronary heart disease.12 Inflammation is recently understood as a key pathogenic mechanism in the initiation and progression of cardiovascular disease.13 Adipose tissue is a passive storage repository for fat, but this tissue also plays an active role in metabolism by producing pro-inflammatory cytokine and IL-6. Given that IL-6 has inflammatory properties and stimulates acute phase protein production in the liver, the release of IL-6 from adipose tissue may induce low-grade systemic inflammation in person with the excess body.1 Therefore, identifying obesity markers and CRP levels to predict future morbidity risks becomes a great concern in public health.

In Indonesia, the prevalence of obese adults (18 years and older) was 21.8% in 2018, higher than that in 2007 (10.5%) and 2013 (14.8%).14 In addition, the prevalence of overweight girls (15–18 years) in rural and urban areas was 10%.15 Moreover, the prevalence of obesity in Indonesia from 1993 to 1997 raised remarkably.16

Indonesia has developed a community-based non-communicable disease control model through Integrated Health Post for Elderly-Chronic Disease for controlling
risk factors of non-communicable diseases, such as obesity measurement, body fat analysis, blood pressure, and simple lung function (peak flow meter). From the public health perspective, a further understanding of chronic conditions, such as inflammation and obesity, is needed for the effective interventions and optimal predictions for future health care costs. Investigating obesity markers and CRP levels among Indonesian adults are informative for early intervention in future morbidity risks.

However, to our knowledge, only a few studies on obesity markers and CRP levels among Indonesians use the national scale. Azizah and Sulchan,\textsuperscript{17} conducted a study on stunted obesity female adolescents in Rural Jepara, Indonesia. They found that the female adolescent inflammation in stunted obesity is not provable. Hastuti, \textit{et al.},\textsuperscript{18} also found increased levels of IL-6 and CRP in the obese group compared with the controls among people/residents of Western Indonesia. These studies did not focus on the relationship between obesity indicators and CRP levels. Therefore, the present study investigated the associations among obesity markers (body mass index/BMI), waist circumference/WC, waist-to-hip ratio/WHR, waist-to-height ratio/WHtR, and CRP levels) among Indonesian adults.

\section*{Method}

This study used secondary data from the fifth wave of the Indonesian Family Life Survey (IFLS5). The IFLS is an ongoing longitudinal socioeconomic and health survey. It is based on a sample of households representing approximately 83\% of Indonesians living in 13 of the nation’s 26 provinces. The survey collects data on individual respondents, their families, their households, the communities in which they live, and the health and education facilities they use. The first wave (IFLS1) was administered in 1993 among individuals living in 7,224 households. The IFLS2 sought to re-interview the same respondents four years later. A follow-up survey (IFLS2+) with 25\% of the sample was conducted in 1998 to measure the immediate impact of the economic and political crisis in Indonesia. The third wave, IFLS3, was fielded on the full sample in 2000. The IFLS4 was conducted in late 2007 and early 2008 on the same 1993 households and their split-offs. The IFLS5 was fielded in late 2014 and early 2015 on the same set of IFLS households and split-offs: 16,204 households and 50,148 individuals were interviewed.\textsuperscript{19} Data from IFLS are publicly available from the Rand Corporation website.

In the present study, respondents were adults aged 40 years and older were interviewed. We excluded those with missing data on height, body weight, waist circumference, hip circumference or high-sensitivity CRP (hs-CRP) level, and other covariates (sex, age, marital status, education, residence, and multimorbidity). The final sample comprised of 3,386 individuals.

The study was based on publicly available de-identified data. All IFLS and procedures are reviewed and approved by the Institutional Review Boards in the United States (at RAND) and in Indonesia at the Universitas Gadjah Mada. Written informed consent was obtained from all respondents prior to data collection.\textsuperscript{20}

The BMI, WC, WHR, and WHtR were used as overweight and obesity indicators.\textsuperscript{2} Body mass index was computed by dividing weight (kg) by height squared (m\textsuperscript{2}). Weights were measured to the nearest tenth of a kilogram by using a Camry model EB1003 scale. Heights were assessed to the nearest millimeter by using a Seca plastic height board, Model 213. According to Asian standards by the World Health Organization (WHO), BMI is divided into four categories: underweight (BMI less than 18.50 kg/m\textsuperscript{2}), normal weight (BMI 18.50–22.99 kg/m\textsuperscript{2}), overweight (BMI 22.99–24.99 kg/m\textsuperscript{2}), and obese (BMI 25.00 kg/m\textsuperscript{2} and above).\textsuperscript{21} The WC was measured in a horizontal plane midway between lowest rib and the iliac crest, and then classified into two groups: normal (WC less than 90 cm for men and WC less than 80 cm for women) and increased (WC 90 cm and above for men and WC 80 cm and above for women).\textsuperscript{22} The WHR was calculated as waist circumference divided by hip circumference, and then categorized as: normal (WHR less than 0.9 for men and WHR less than 0.85 for women) and increased (WHR 0.9 and above for men and WHR 0.85 and above for women).\textsuperscript{22} The WHtR was calculated as waist circumference divided by hip circumference, and then categorized as: normal (WHR less than 0.9 for men and WHR less than 0.85 for women) and increased (WHR 0.9 and above for men and WHR 0.85 and above for women).\textsuperscript{22} The CRP concentrations in dried blood spot (DBS) specimens, as the dependent variable, were measured using a hs-CRP ELISA method. Details of the CRP data collection and validation in IFLS 2014 are explained in the IFLS Wave 5 Dried Blood Spot Data User Guide. Concentration values higher than 5 mg/L are considered at high risk.\textsuperscript{19,23}

Age was divided into three categories (40–49, 50–59, and 60 years and older). Household location was classified as urban and rural areas. Marital status was categorized as single, married, divorced, or widowed, whereas education level was classified into primary school, secondary school, college, and above. Multimorbidity was based on the number of respondents self-reported diagnoses of chronic non-communicable diseases (NCDs) that were previously made by health professionals. Examples of such NCDs are diabetes, hypertension, heart disease, stroke, lung diseases, asthma, cancer, arthritis, and depression. Multimorbidity was defined as two or more chronic NCDs.\textsuperscript{24}

Simple logistic regression was used to compare categorical variables. Those found significant in the bivariate
obtained college or above education, 54.5% were living in urban areas, and 60.1% had multimorbidity. Measurements using WC and WHR indicators revealed the same characteristic pattern in obese/overweight participants: 63.4% and 80.6% were female, 51.9% and 74.5% were aged 50–59 years old, 56.3 and 78.3% had high-risk CRP, 51.8% and 75.1 were divorced or widowed, 47.9% and 70.5% obtained college or above education, 51.3% and 74.1% were living in urban areas, and 61.2% and 82.3% had multimorbidity, respectively. Measurements using WHtR showed that participants identified as overweight or obese were 33.6% female, 32.2% aged ≥ 60 years old, 28.2% had high-risk CRP, 39.5% were single, 30% either had no education or only reached primary school, 52.0% were living in urban areas, and 56.8% reported multimorbidity.

Table 2 shows the associations among obesity indicators, other covariates, and hs-CRP levels. In the association between BMI and hs-CRP, overweight/obese respondents were likely to be young female (40–49 years old), to have high-risk hs-CRP, to be married, to obtain higher education level (college and above), to live in urban areas, and to have multimorbidity (p-value < 0.001 for all variables). In the association between WC and hs-CRP, respondents with increased WC were likely to have multimorbidity. However, they were less likely to be male, old (age ≥ 60 years), to have normal hs-CRP, to be single, to obtain lower education (no education), and to live in rural areas (p-value < 0.001 for all variables). In the

### Results

A total of 3,386 participants aged 40 years and over were initially included in this study. Table 1 presents the characteristics of the study population, particularly the overall baseline characteristics of participants according to obesity indicators. Measurements using BMI showed that participants identified as overweight or obese were more than 50% female, aged 40–49 years old, and had high-risk CRP. Moreover, 50.4% were married, 68.3% obtained college or above education, and 60.1% had multimorbidity. Measurements using WC and WHR indicators revealed the same characteristic pattern in obese/overweight participants: 63.4% and 80.6% were female, 51.9% and 74.5% were aged 50–59 years old, 56.3 and 78.3% had high-risk CRP, 51.8% and 75.1 were divorced or widowed, 47.9% and 70.5% obtained college or above education, 51.3% and 74.1% were living in urban areas, and 61.2% and 82.3% had multimorbidity, respectively. Measurements using WHtR showed that participants identified as overweight or obese were 33.6% female, 32.2% aged ≥ 60 years old, 28.2% had high-risk CRP, 39.5% were single, 30% either had no education or only reached primary school, 52.0% were living in urban areas, and 56.8% reported multimorbidity.

Table 2 shows the associations among obesity indicators, other covariates, and hs-CRP levels. In the association between BMI and hs-CRP, overweight/obese respondents were likely to be young female (40–49 years old), to have high-risk hs-CRP, to be married, to obtain higher education level (college and above), to live in urban areas, and to have multimorbidity (p-value < 0.001 for all variables). In the association between WC and hs-CRP, respondents with increased WC were likely to have multimorbidity. However, they were less likely to be male, old (age ≥ 60 years), to have normal hs-CRP, to be single, to obtain lower education (no education), and to live in rural areas (p-value < 0.001 for all variables). In the

### Table 1. Characteristics of Participants (n = 3,386) by Obesity Indicators in Indonesian Family Life Survey-5 2014–2015

| Characteristic | Category | Underweight (%) | Normal (%) | Overweight/Obese (%) | Normal (%) | Increased (%) | Normal (%) | Increased (%) | Normal (%) | Increased (%) |
|---------------|----------|----------------|------------|----------------------|------------|---------------|------------|---------------|------------|---------------|
|               |          | (n = 1,275) | (n = 1,529) |                      | (n = 1,002) |               | (n = 2,348) |               | (n = 2,666) |               |
| Sex           | Male     | 15.8 | 46.2 | 38.0 | 79.9 | 21.0 | 43.1 | 36.9 | 73.5 | 26.5 |
| Age (years)   |          | 12.8 | 51.2 | 36.0 | 36.6 | 63.4 | 19.4 | 80.6 | 66.4 | 33.6 |
|              | 40–49    | 7.1  | 54.9 | 37.2 | 54.3 | 45.7 | 33.4 | 66.6 | 72.8 | 27.2 |
|              | 50–59    | 9.7  | 55.5 | 35.5 | 48.1 | 51.9 | 25.5 | 74.5 | 69.2 | 30.8 |
|              | ≥ 60     | 20.6 | 40.6 | 38.7 | 59.3 | 40.7 | 30.0 | 70.0 | 67.8 | 32.2 |
| CRP           | Normal   | 14.2 | 59.9 | 34.2 | 57.5 | 42.5 | 31.5 | 68.5 | 86.0 | 14.0 |
|              | High risk| 13.5 | 28.2 | 58.4 | 43.7 | 56.3 | 21.7 | 78.3 | 71.8 | 28.2 |
| Marital status| Single   | 21.1 | 46.1 | 32.9 | 71.1 | 28.9 | 43.4 | 56.6 | 60.5 | 39.5 |
|              | Married  | 12.3 | 37.3 | 47.7 | 36.6 | 45.4 | 30.7 | 69.3 | 70.7 | 29.3 |
|              | Divorced or widowed | 18.9 | 38.0 | 31.3 | 48.2 | 51.8 | 24.9 | 75.1 | 66.3 | 33.3 |
| Education    | No education | 23.8 | 42.6 | 35.6 | 59.1 | 40.9 | 31.3 | 68.7 | 68.9 | 31.1 |
|              | Primary school | 15.2 | 39.9 | 44.8 | 56.5 | 43.5 | 30.5 | 69.5 | 68.2 | 31.8 |
|              | Secondary school | 9.1  | 53.9 | 37.0 | 52.1 | 47.9 | 29.5 | 70.5 | 71.0 | 29.0 |
| Residence    | Rural     | 18.4 | 41.0 | 40.6 | 62.5 | 37.5 | 34.2 | 65.8 | 71.2 | 28.8 |
|              | Urban     | 10.6 | 34.9 | 54.5 | 48.7 | 51.3 | 25.9 | 74.1 | 68.0 | 32.0 |
| Multimorbidity| No        | 14.6 | 40.0 | 45.3 | 58.6 | 41.4 | 32.4 | 67.6 | 71.0 | 29.0 |
|              | Yes       | 12.0 | 27.9 | 60.1 | 38.8 | 61.2 | 17.7 | 82.3 | 63.2 | 36.8 |

Notes: BMI: Body Mass Index; WC: Waist Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio; CRP: C-Reactive Protein.

- Underweight (BMI < 18.50 kg/m²), normal weight (BMI 18.50–22.99 kg/m²), overweight (BMI 22.99–24.99 kg/m²), and obese (≥ 25.00 kg/m²).
- Normal (WC < 90 cm for men, < 80 cm for women) and increased (WC ≥ 90 cm for men, ≥ 80 cm for women).
- Normal (WHR ≥ 0.46 to 0.42) and increased (WHR > 0.46).
- Normal (hs-CRP ≥ 3) and high risk (hs-CRP < 3).
The multiple logistic regression analysis showed significant associations among WHR, WHtR, and high-risk hs-CRP levels after adjusting for age, sex, education, marital status, residence, and multimorbidity; these findings were in accordance with previous studies. Our findings showed that all obesity indicators were associated with high-risk hs-CRP levels after adjusting for age, sex, education, marital status, residence, and multimorbidity; these findings were in accordance with previous studies.25-27

Association between WHR and hs-CRP, respondents with increased WHR were likely to be female, aged 50–59 years old, to have high-risk hs-CRP, to be divorced or widowed, to live in urban area, and to have multimorbidity. Furthermore, respondents with increased WHtR were less likely to be male, young (aged 40–49 years old), to have normal hs-CRP, to be married, and to not have multimorbidity.

The multiple logistic regression analysis showed significant associations among WHR, WHtR, and hs-CRP (Table 3). Compared with respondents with normal WHR, the multivariate-adjusted OR (95% CI) of the high-risk hs-CRP level was 1.278 (1.005–1.625) for those with increased WHR. With regard to the association between WHtR and hs-CRP, in comparison with respondents with normal WHtR, the multivariate-adjusted OR (95% CI) was 1.980 (1.544–2.541) for those with increased WHtR; Model 1: p-values were < 0.05 and < 0.01 for WHR and WHtR, respectively. However, no association was observed among BMI, WC, and hs-CRP.

**Discussion**

This study determined the association between obesity indicators and CRP levels among Indonesian adults. The study found that approximately 50% Indonesian adults were overweight or obese, as measured by BMI. All obesity indicators (e.g., BMI, WC, WHR, and WHtR) were associated with hs-CRP levels. WHR and WHtR also associated with high-risk hs-CRP levels after adjusting for age, sex, education, marital status, residence, and multi-morbidity; these findings were in accordance with previous studies.25-27

Our findings showed that all obesity indicators were associated with hs-CRP levels. A previous study suggested a positive correlation among BMI, WC, and hs-CRP, whereas WHR is moderately and significantly correlated with hs-CRP.27 Another study also indicated that CRP increases as WHtR increases.28 We observed that over-
weight/obese respondents with increased WC and WHR likely have high-risk CRP. Ikeoka, et al., 29 revealed that cytokines and other inflammatory mediators (IL-6-soluble receptors, IL-6 and C-reactive protein) may be involved in the formation of systolic and diastolic ventricular dysfunction, as shown by echocardiography in obese individuals normotensive.

After adjusting for covariates, compared with BMI and WC, the current study indicated that WHR and WHtR are associated with high-risk hs-CRP levels. A previous study suggested that abdominal obesity indicators are better compared to the one with BMI, WHR, and WHtR, which play substantial roles in mortality due to cardio-metabolic diseases.29 Another study reported that WHR is a reflection of fat distribution in different parts of the body and a good indicator of central obesity that is significantly carried with cardiovascular risk factors.26 Lee, et al., 30 conducted a meta-analysis among more than 88,000 adults who are mostly from Asian countries. The study suggested that WHtR is the best discriminator for hypertension, diabetes, and dyslipidemia; 30 whereas BMI is the poorest differentiator for cardiovascular risk factors. 31 Another meta-analysis that includes more than 500,000 adults indicates that compared to BMI and WC, WHtR identifies cardio-metabolic risks better. 32 A previous Korean study reported that compared with BMI, WHR better predicts the presence of metabolic syndrome. 33 A prospective study among the Mongolian men in China indicates that WHtR is a robust predictor of ischemic stroke. 34 Thus, the present study suggests that WHR and WHtR may be used to predict hs-CRP levels related to future morbidity risks.

The association between WHtR and hs-CRP levels have been identified both in Indonesia and other countries. It might be because WHtR is a proxy for central (visceral) adipose tissue, which has recently received attention as a marker of ‘early health risk’. Furthermore, abdominal obesity which is defined by WHtR is more effective than BMI to reflects the visceral fat. The WHtR also has been viewed as a simple primary risk assessment tool that identifies more subjects at “cardiometabolic risk” than the combination of BMI and WC. It is suggested that WHtR predicts central obesity, which is associated with hs-CRP levels, is also applied in Indonesia.

The strength of the present study is it used national survey data; hence, the study results are quite representative. However, several limitations are observed, such as 1) the study is cross-sectional; thus, the causal relationships among the observed variables cannot be inferred, 2) Only one hs-CRP measurement was used and thus might not perfectly indicate the long-term inflammatory status of participants.

In summary, BMI, WC, WHR, and WHtR as obesity markers are associated with hs-CRP levels. However, only WHR and WHtR are associated with the high-risk hs-CRP levels. Therefore, WHR and WHtR can predict central obesity associated with hs-CRP levels, which can be used to initiate early prevention for future morbidity risks among Indonesian adults. Furthermore, a longitudinal study is needed to establish the relationship between obesity markers and CRP levels.

Abbreviations
CRP: C-reactive Protein; BMI: Body Mass Index; WC: Waist Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio; IL-6: Interlukin-6; IFLS: Indonesian Family Life Survey; hs-CRP: High-Sensitivity-C-Reactive Protein; NCDs: Non-communicable Diseases.

Ethics Approval and Consent to Participate
The analyses used secondary data that is publicly available. Ethics approval was obtained by RAND Corporation and Survey Meter who fielded the survey.

Competing Interest
Author declares that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials
The dataset is publicly available and can be obtained free of cost upon registration from RAND Corporation’s website.

Authors’ Contribution
Yeni Mahwati conceived the study, participated in its design and acquired the dataset. Dieta Nurikka contributed to the interpretation of the data. Both authors were involved in the drafting of the manuscript and intellectual content. Both authors have read and approved the final draft.

Acknowledgment
We would like to thank Rand Corporation for providing access to IFLS datasets and ethics information.

References
1. Ramdas I, Jella V. Elevated C reactive protein levels in obese individuals with metabolic syndromes. International Journal of Advances in Medicine. 2016; 3 (2): 162-5.
2. Štepić M, Štepić A, Wiaz RN, Paradowski M, Banach M, Rysz J. Obesity indices and inflammatory markers in obese non-diabetic normo- and hypertensive patients: a comparative pilot study. Lipids in Health and Disease. 2014; 13: 1–10.
3. Shrivastava AK, Singh HV, Raizada A, Singh SK. C-reactive protein, inflammation and coronary heart disease. The Egyptian Hearth Journal. 2015; 67 (2): 89–97.
4. Sun M, Zhang L, Chen S, Liu X, Shao X, Zou H. Association of C-re-
active protein and metabolic disorder in a Chinese population. International Journal of Environmental Research and Public Health. 2015; 12 (7): 8228–42.
5. Yang JS, Gerber JN, You HJ. Association between fasting insulin and high-sensitivity C reactive protein in Korean adults. BMJ Open Sport & Exercise Medicine. 2017; 3 (1): 1–7.
6. Bilhorn KR, Yanting L, Brian LT, Wong ND. High-density lipoprotein cholesterol, high-sensitivity C-reactive protein, and cardiovascular disease in United States adults. American Journal of Cardiology. 2012; 110 (10): 1464–7.
7. Avci E, Kiris T, Demirtas AO, Kadi H. Relationship between high-density lipoprotein cholesterol and the red cell distribution width in patients with coronary artery disease. Lipids in Health and Disease. 2018;17 (1): 53.
8. Lin C, Kardia SLR, Li C, Liu C, Lai M, Lin W, et al. The relationship of high sensitivity c-reactive protein to percent body fat mass, body mass index, waist-to-ratio, and waist circumference in a Taiwanese population. BMC Public Health. 2010; 10: 579 (1–8).
9. Mravović T, Radaković S, Medić DR, Đinđić D, Ostojević VT, Cairović A, et al. The relationship between adiposity parameters and C-reactive protein values in overweight and obese women [Odnos Između parametara gojaznosti i vrednosti C-reaktivnog proteina kod pregojaznih i gojaznih žena]. Vojn Pregl. 2018; 75 (2): 185–90.
10. World Health Organization. Obesity and overweight; 2018.
11. Al-Goblan AS, Al-Alfi MA, Khan MZ. Mechanism linking diabetes mellitus and obesity. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy. 2014; 7: 587–91.
12. Khan RJ, Harvey DJ, Leistikow BN, Haque KS. Relationship between obesity and coronary heart disease among urban Bangladeshi men and women Rumana. Diabetes Journal: Integrative Obesity & Diabetes. 2015; 1 (3): 49–55.
13. J Choi, Joseph L, Pilote L. Etiology and pathophysiology/obesity comorbidities obesity and c-reactive protein in various populations: a systematic review and meta-analysis. Obesity Reviews. 2013; 14: 232–44.
14. Kemenkes RI. Risksdas 2018. Jakarta; 2018.
15. Pengpid S, Pelitzer K. The prevalence of overweight, obesity/weight and their related lifestyle factors in Indonesia, 2014–15. AIMS Public Health. 2017; 4 (6): 633–49.
16. Roemling C, Qaim M. Obesity trends and determinants in Indonesia. Appetite. 2012; 58 (3): 1005–13.
17. Nur Azizah A, Sulchan M. Kadar C-reactive protein (CRP) pada remaja putri stunted obesity di pedesaan Jepara. Journal of Nutrition College. 2016; 5 (2): 71–6.
18. Hastuti P, Martantiningtyas DC, Karita D, Tasmimi, Sadewa AH. Association of -174 G>C Interleukin-6 gene polymorphism with interleukin-6 and c-reactive protein levels and obesity: a case–control study among people/residents of western Indonesia. Medical Journal of Malaysia. 2019; 74 (5): 400–4.
19. Strauss J, Witcofar Fi, Sikoki B. The fifth wave of the Indonesia family life survey: overview and field report volume 1. Santa Monica, Calif: RAND Cooperation; 2016.
20. Hussain MA, Al Mamun A, Reid C, Huxley RR. Prevalence, awareness, treatment and control of hypertension in Indonesian adults aged ≥40 years: findings from the Indonesia family life survey (IFLS). PLoS One. 2016; 11 (8): 1–16.
21. Aveyard P, Lewis A, Tearne S, Hood K, Christian-Brown A, Adab P, et al. Screening and brief intervention for obesity in primary care: a parallel, two-arm, randomised trial. Lancet. 2016; 388 (10059): 2492-500.
22. World Health Organization. Waist circumference and waist–hip ratio: report of a WHO expert consultation. 2009; pp.14.
23. Hu P, Herningtyas EH, Strauss J, Crimmins E, Kim JK. Working paper IFLS C-reactive protein data user guide; October, 2013.
24. Mahwati Y. Determinants of multimorbidity among the elderly determinants multimorbiditas pada populasi usia lanjut di Indonesia. Kesmas: Jurnal Kesehatan Masyarakat Nasional. 2014; 9 (2): 187–93.
25. Firdous S, Lodihi MOK, Siddique K. The trends of CRP levels at different waist-to-hip ratios among normotensive overweight and obese patients: a pilot study. Journal of the College of Physicians and Surgeons Pakistan. 2016; 26 (3): 191–4.
26. Thompson AL, Kochler E, Huxley AA, Paynter L, Du S, Zhang B, et al. Weight gain trajectories associated with elevated C-reactive protein levels in Chinese Adults. Journals of American Heart Association. 2016; 5 (9): e003262.
27. Lavanya K, Ramamoothi K, Acharya R V, Madhystha SP. Association between overweight, obesity in relation to serum hs-CRP levels in adults 20-70 years. Journal of Clinical and Diagnostic Research. 2017; 11 (12): OC32–5.
28. Silva JP da, Lima RPA, Pereira D de C, Silva CS de O, Gonçalves M da CR, Filho MB, et al. Association between waist-to-height ratio, isolated and combined morbidities and C-reactive protein in the elderly: a clinical-epidemiological Study. International Journal of Environmental Research and Public Health. 2014; 11 (June): 9595–606.
29. Ikeoka D, Mader JK, Pieber TR. Adipose tissue, inflammation and cardiovascular disease. Revista da Associação Brasileira de Cardiologia. 2010; 56 (1): 116–21.
30. Gharakhanlou R, Farzad B, Agha-Alinejad H, Steffen LM, Bayati M. Anthropometric measures as predictors of cardiovascular disease risk factors in the urban population of Iran. Arquivos Brasileiros de Cardiologia. 2012; 98 (2): 126–35.
31. Shen S, Lu Y, Qi H, Li F, Shen Z, Wu L, et al. Waist-to-height ratio is an effective indicator for comprehensive cardiovascular health. Scientific Reports. 2017; 7: 43046 (1–7).
32. Anchuelo AC, Martinez-Larrad MT, Serrano-Garcia I, Perez CF, Serrano-Rios M. Body fat anthropometric indexes: which of those identify better high cardiovascular risk subjects? a comparative study in Spanish population. PLoS One. 2019; 14 (5): 1–13.
33. Choi DH, Hur YI, Kang JH, Kim K, Cho YG, Hong SM, et al. Usefulness of the waist circumference-to-height ratio in screening for obesity and metabolic syndrome among Korean children and adolescents: Korea national health and nutrition examination survey, 2010–2014. Nutrients. 2017; 9 (3): 256.
34. Juan Xu, Tian Xu, Xiaoqing Bu, Hao Peng, Hongmei Li, Mingzhi Zhang, et al. The predictive value of waist-to-height ratio for ischemic stroke in a population-based prospective cohort study among Mongolian men in China. PLoS One. 2014; 9 (10): 1–6.