Body Mass Index Has Significant Moderate Positive Correlation with High Sensitivity C-Reactive Protein in Overweight and Obese Thai Adults

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Abstract:

Background: Thailand's population is becoming more sedentary, while obesity, another major health issue, is rising worldwide. This trend increases non-communicable disease risk, especially cardiovascular disease. Chronic low-grade systemic inflammation caused by adipose tissue inflammation can be recognized by a rise in hs-CRP, a biomarker of cardiovascular disease risk. According to earlier studies, hs-CRP is significantly greater in obese people and related to lesser physical activity, but obesity may influence the results.

Objectives: This study aimed to study the association between total physical activity, screen time, and hs-CRP in overweight and obese adults. This study also examines screen time, a sedentary behavior indicator.

Materials and Method: This study was a cross-sectional study conducted in 21 healthy, normal-weight, overweight, and obese Thai adults aged between 20 and 40 years old. Subjects' body weight and height were measured, and they were interviewed to answer the GPAQ questionnaire and screen time questionnaire.

Results: Using the Pearson correlation coefficient, total physical activity and screen time had no significant correlation with hs-CRP ($p > 0.05$), while there was a significant, moderate positive correlation between BMI and hs-CRP ($r = 0.462$, $p = 0.035$).

Conclusion: Total physical activity and screen time had no significant correlation with hs-CRP in overweight and obese adults. However, BMI had a significant moderate positive correlation with hs-CRP.

Keywords: hs-CRP; Physical Activity; Overweight; Obesity

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Introduction

Nowadays, the Thai population is starting to shift to a more sedentary lifestyle. The amount of time spent on physical activity is replaced by sedentary behavior, leading to a more negative health outcome.[1] Being sedentary, such as watching television, playing video games, using computers or tablets, and sitting or lying down, is one of the risk factors of many non-communicable diseases, including obesity.[2] Screen time, one of the measures for sedentary behavior, is also associated with a higher risk of overweight and obesity.[3] Overweight and obesity are conditions with abnormal or excessive fat accumulation that may impair health.[4] Overweight is defined as a BMI greater than or equal to 25 kg/m², and obesity is defined as a BMI greater than or equal to 30 kg/m² by the World Health Organization.[4] There is another classification from the WHO Western Pacific Region (WPRO) standard, which is more appropriate for Asians due to different body fat percentage and body composition from Caucasians. The WPRO criteria classified overweight with a BMI between 23.0 and 24.9 kg/m² and obese with a BMI greater than or equal to 25.0 kg/m².[2,5] While in Thailand, overweight is when the BMI is between 23.0-24.9 kg/m², and obesity is divided into several levels including (a) obesity level 1a BMI is between 25.0-29.9 kg/m², (b) obesity level 1b BMI is between 30.0-34.9 kg/m², (c) obesity level 2 BMI is between 35.0-39.9 kg/m², and (d) obesity level 3 BMI is greater than or equal to 40 kg/m² (National Health Security Office [NHSO], 2010).[6] The criteria used in this research is the WPRO standard, which is widely used in Asians.

An increase in BMI can lead to noncommunicable diseases such as (a) cardiovascular diseases, especially heart disease and stroke, and diabetes type 2; (b) musculoskeletal disorders, especially osteoarthritis;[4] (c) Cancers, including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon;[4] (d) gallstones and gallbladder disease; and (e) breathing difficulties, such as asthma and sleep apnea,[7] respectively. While the BMI increases, the risk for these noncommunicable diseases also increases.[4] Obesity is a serious health problem in Thailand and has been increasing worldwide.[8] About 17.1% and 23.8% of Thai adults aged 19 and over are overweight and obese, respectively, with the 40-59-year-old group found to have the highest prevalence, based on the Western Pacific Region of the World Health Organization (WPRO) criteria for obesity.[5] An increase in BMI can lead to many health consequences, such as cardiovascular disease, musculoskeletal disorders, breathing difficulties, and even cancer.[4,7]

Inflammation of adipose tissue in individuals with overweight and obesity can lead to chronic low-grade systemic inflammation,[9] detectable by elevated levels of high-sensitivity C-reactive protein (hs-CRP), an acute-phase protein synthesized by the liver in response to proinflammatory cytokines.[10] High-sensitivity C-reactive protein (hs-CRP) serves as a biomarker for predicting cardiovascular disease risk and may be raised in various circumstances, including acute infections, inflammation, and trauma.[11] Previous studies revealed that hs-CRP is significantly higher in obese individuals,[12] indicating a higher risk of cardiovascular disease. Another factor that could be affecting the level of hs-CRP is physical activity. Previous studies on the association between hs-CRP and physical activity showed that people with lower physical activity had higher levels of hs-CRP; however, these levels may be affected by the level of adiposity of the participants.[13,14] Moreover, longer television screen time was significantly associated with higher C-reactive protein levels, while computer and reading time had no association.[15] Thus, this study aimed to investigate the association between BMI and total physical activity adequacy in overweight and obese Thai adults.

Materials and Method

Participants:

Healthy Thai males and females, aged 20 to 40 years, with a BMI of 18.5 kg/m² or higher. The study was conducted at Mae Fah Luang University Hospital in Bangkok, Thailand. The number of participants was decided based on data from a similar study, "Disparate Habitual Physical Activity and Dietary Intake Profiles of Elderly Men with Low and Elevated Systemic Inflammation" by Dimitrios Draganidis, because there wasn't enough information about physical activity and hs-CRP from earlier research.[16] We enrolled 21 subjects in this study.

Inclusion Criteria:

(a) Male and female participants were aged between 20 and 40 years old.

(b) BMI equal to or more than 18.5 kg/m²

(c) Non-smokers or those who quit smoking for more than 20 years.

(d) Participants are healthy and not on any supplements or medication.

(e) Willingness to sign the informed consent and follow the instructions given.

Participants agreed to examine blood samples.

Exclusion Criteria:

(a) Pregnant and breastfeeding women

(b) Participants with other inflammatory conditions, such as autoimmune diseases, inflammatory bowel diseases, inflammatory joint diseases, and cancer.

(c) Participants with recent infections (within 2 weeks)

(d) Participants with recent traumas (within 2 weeks)

Discontinuation Criteria:

(a) Participants who want to drop out of the study

(b) Participants who cannot comply with the instructions

(c) Participants who suffer from serious illness during the study

(d) Participants with hs-CRP higher than 10 mg/L.

This study was conducted in strict accordance with Good Clinical Practice (GCP) criteria. This guideline encompasses the protection of human rights in clinical trials, the assurance of subjects' safety and well-being, and the requirements for conducting clinical studies. The Mae Fah Luang University Ethics Committee on Human Research, No. EC 23166-20, gave its consent for this study.

Questionnaires:

GPAQ (Global Physical Activity Questionnaire) includes 16 Questions, 3 Domains (Activity at work, Travel to and from places, Recreational activities). Total Physical Activity (TPA) calculated by the equation: TPA (MET-minutes/week) = summation of the total MET-minutes of activity computed for each domain (days of activity per week * amount of time * intensity of activity) (* = multiplication). MET Value Used for the Calculation of a Person's Overall Energy Expenditure Using GPAQ Data is shown below:

Table 1 MET Value Used for the Calculation of a Person's Overall Energy Expenditure

Domain	MET Value
Work	Moderate MET value = 4.0 Vigorous MET value = 8.0
Transport	Cycling and walking MET value = 4.0
Recreation	Moderate MET value = 4.0 Vigorous MET value = 8.0

Physical Activity cut-off value: Score of less than 600 MET minutes per week do not meet WHO recommendations on physical activity for health

Physical Examination

Weight was measured by digital scale, done in light clothing and without shoes. Height was measured by the stadiometer without shoes. The body mass index (BMI) was calculated by dividing weight in kilograms (kg) by height in centimeters (cm) squared. Blood pressure and heart rate were measured by a digital sphygmomanometer. In Thailand, overweight is defined as a BMI between 23.0 and 24.9 kg/m², with obesity categorized into several levels, including (a) obesity level 1a, where the BMI is between 25.0 and 29.9 kg/m²; (b) obesity level 1b, where the BMI is between 30.0 and 34.9 kg/m²; (c) obesity level 2, where the BMI is between 35.0 and 39.9 kg/m²; and (d) obesity level 3, where the BMI is greater than or equal to 40 kg/m².[6] The criteria used in this research is the WPRO standard, which is widely used in Asians, as shown below:

Table 2 Obesity Classification by WPRO Criteria

Classification	BMI (kg/m²)
Underweight	< 18.5
Normal	18.5 - 22.9
Overweight	23.0 - 24.9
Obesity Class I	25.0 - 29.9
Obesity Class II	≥ 30

Statistical Analysis

The documentation of the medical records and the outcome of this study are recorded and analyzed by Microsoft Excel and SPSS software version 29.0 (IBM Corp., 2023). Qualitative data, such as gender, were analyzed and presented as numeric data and percentages, while other data, such as weight, height, and BMI, were analyzed and presented as the mean, median, standard deviation, and interquartile range. The chi-square test was used to assess the association between the classification of body mass index and total physical activity adequacy, calculating the odds ratio (OR) and 95% confidence intervals (CI). A two-sided P-value less than 0.05 is considered statistically significant.

Results

We conducted this study to investigate the relationship between hs-CRP, total physical activity, and screen time in adults who are overweight or obese. It was conducted on 21 healthy volunteers aged between 20 and 40 with a BMI of more than 18.5 kg/m² and no underlying diseases and concurrent use of any medication or supplements. General characteristics, total physical activity, and screen time were collected by a questionnaire, and the participants' body weight, height, and serum hs-CRP were measured. We found that 15 individuals were female and 6 were male. The mean age was 34.90 ± 5.34 years old, the mean height was 162.43 ± 7.86 cm, and the mean weight was 60.41 ± 11.51 kg. The mean body mass index (BMI) was 22.77 ± 3.20 kg/m². 10 subjects were normal weight, followed by 6 subjects who were obese and 5 overweight subjects. Most of the participants were office workers (16 subjects), followed by medical personnel (4 subjects) and one housekeeper. Total physical activity had a median value of 1,120 (IQR 200, 1,615) MET-minutes/week. A total of 14 subjects, accounting for 66.7%, demonstrated adequate physical activity. The mean screen time score was 11.42 ± 2.50. The median hs-CRP level was 0.92 (IQR 0.41, 1.86) mg/L. The majority had a low risk of cardiovascular disease (13 subjects), followed by intermediate risk (7 subjects) and high risk (1 subject) (Table 3).

Table 3 Demographic data

Demographic data	n = 21
Sex, n (%)	
Male	6 (28.6)
Female	15 (71.4)
Age, n (%)	
21-30	5 (23.8)
31-40	16 (76.2)
Height (cm), mean ± SD (min-max)	162.43 ± 7.86 (150-183)
Weight (kg), mean ± SD (min-max)	60.41 ± 11.51 (45-83)
Body mass index (kg/m2), mean ± SD (min-max)	22.77 ± 3.20 (18.73-27.48)
Total physical activity (MET-minutes/week), median (IQR)	1,120 (200, 1,615)
Total physical activity level, n (%)	
Adequate physical activity	14 (66.7)
Inadequate physical activity	7 (33.3)

It was found that 70% of the participants with normal weight had adequate physical activity and 30% had inadequate physical activity, while 63.6% of those who were overweight or obese had adequate physical activity and 36.4% had inadequate physical activity. The relationship between BMI classification and total physical activity adequacy was not statistically significant ($p = 0.758$). However, considering the odds ratio value of 0.75 (95% CI 0.12, 4.66), it can be said that the odds of overweight or obese participants who had adequate physical activity are 0.75 times lower than normal-weight participants (Table 4).

Table 4 The Association Between BMI and Total Physical Activity Adequacy

BMI classification	Total Physical Activity Adequacy		Odds ratio (95%CI)	*p*-value
	Adequate (n = 14)	Inadequate (n = 7)		
Normal	7 (70.0)	3 (30.0)	Reference	0.757
Overweight/ Obese I	7 (63.6)	4 (36.4)	0.75 (0.12, 4.66)	

Note: Data were analyzed with Chi-square test.

Discussion

This study intended to investigate the correlation between BMI and overall physical activity in overweight and obese people. The study involved 21 healthy adults aged 20 to 40 years, with a BMI of 18.5 kg/m^2 or more. Total physical activity was collected by questionnaires. Low physical activity and high screen time usage represent a sedentary lifestyle, which could lead to a higher risk of non-communicable diseases, including obesity and cardiovascular diseases.[2] The benefits of this study were to identify the increased risk of developing cardiovascular disease in overweight and obese adults and to use it as reference data for future studies. Previous studies demonstrated that BMI was moderately positively correlated with hs-CRP in children and adults.[17-19] A recent study indicated that those with elevated physical activity exhibited lower hs-CRP levels compared to those with diminished physical activity; however, these findings may be influenced by a higher prevalence of overweight and obese participants in the low physical activity cohort.[14]

Obesity is more prevalent in people from lower socioeconomic classes in developing countries without food scarcity, presumably from high-fat diets, which are more affordable. On the other hand, in low-income countries with food scarcity, the rich are more susceptible to obesity because of more accessibility to excess food and less involvement in labor work.[20] A study in Ghana and Nigeria, which are low-to-middle-income countries, showed that older adults in urban areas with higher income and education were associated with a higher chance of obesity.[21] The prevalence of overweight and obesity has been increasing worldwide.[8] It is also considered a serious health problem in Thailand. From a study in 2018, the prevalence of overweight and obesity in Thai adults aged 19 and over was 17.1% and 23.8%, respectively, based on the WRPO criteria, but only 19.0% and 4.8% based on the WHO criteria. According to the WPRO criteria, adults in the 40–59-year-old group were found to have the highest prevalence, and the population in Bangkok had the highest prevalence of obesity.[5] The main cause of obesity and being overweight is when there is an energy imbalance between calories taken in and calories expended, leading to excess weight gain and abnormal accumulation of fat in the body.[4,20] Many factors contribute to obesity, including genetics, individual factors, and environmental factors.[20] Different genetic contributing mechanisms can classify obesity into three groups: monogenic, polygenic, or syndromic. Monogenic obesity, which involves chromosomal deletion or single gene defects, contributes to rare and early-onset obesity; for example, gene defects that are related to leptin deficiency, proopiomelanocortin (POMC) deficiency, and melanocortin-4 receptor (MC4R) deficiency.[22]

Polygenic obesity, which involves hundreds of polymorphisms with small effects, is more common.[22] Individuals possessing a genetic predisposition are at an elevated risk of developing obesity. Genome-wide association studies (GWAS) have identified over 300 single nucleotide polymorphisms (SNPs) linked to obesity-related traits, such as BMI and waist-to-hip ratio, along with more than 500 genetic loci associated with obesity.[24] SNPs in FTO (fat mass and obesity-associated gene) are found in multiple populations, and studies indicated that FTO is associated with appetite and feeding behavior; however, the mechanism is not well understood.[25] The FTO gene can cause an increase in hunger level, caloric intake, body fat storage, and tendency to a sedentary lifestyle. Moreover, it can reduce satiety and lead to overeating.[26] Syndromic obesity is a rare genetic condition that is present from birth and often comes with other health issues, like problems with thinking, unusual physical features, or organ problems. This includes Prader-Willi syndrome, Bardet-Biedl syndrome, and Cohen syndrome.[26]

An imbalance between caloric intake and energy expenditure causes body bodyweight change. When caloric consumption surpasses energy expenditure, a positive energy balance results in an increase in body mass, typically in the form of body fat. Conversely, when energy expenditure surpasses energy intake, a negative energy balance results in a reduction of body mass.[27] Individuals with obesity face a heightened risk of numerous diseases and health complications in comparison to those of normal weight.[7] Obesity affects many dimensions, including physical health, mental health, and social factors, among others.[18] Individual factors that can affect obesity are the factors that play an important role in energy expenditure. These include the basal metabolic rate (BMR), the energy used in breaking down food, and the energy used in physical activity.[20] Also, excessive energy from calorie intake can contribute to fat accumulation, especially from high-energy-dense food.[28] High energy-dense diets, which are high in energy and fat but low in fruits, vegetables, and fiber,[29] are positively correlated with increased weight gain and excess adiposity.[30] Obesity elevates the likelihood of impairments and age-associated ailments, including cardiovascular disease, diabetes, osteoarthritis, and cancer. Furthermore, research suggests that obesity shortens life expectancy and influences the aging process in cells. According to previous studies, obesity is negatively associated with telomere length, which may be due to oxidative stress and inflammation.[31] Some diseases or endocrine disorders are related to obesity, for example, Cushing's disease, hypothyroidism, and polycystic ovary syndrome.[20] A study on medication-induced weight gain revealed that antipsychotics, antidepressants, antihyperglycemics, antihypertensives, and corticosteroids include drugs significantly linked to weight increase.[32] Being obese may create stigma, and obesity discrimination may lead to some mental disorders.[18] Previous studies have linked obesity to depression, eating disorders, anxiety, substance abuse, sexual abuse, and other issues. They also affect an individual's self-esteem, their body image dissatisfaction, and a decreased quality of life.[33] Obesity in childhood and adolescence is associated with an increased risk of premature morbidity and mortality, specifically cardio-metabolic morbidity.[18] They also have an increased risk of fractures, metabolic syndrome, and breathing problems in the future.[4]

Workplace environments can also affect obesity. Long working hours can lead to increased sitting time and reduced time for exercise and other physical activities, resulting in an increase in BMI. Also, it can affect the meal by processed food or fast food instead of healthier homemade food.[20] Nowadays, the improvement in labor-saving technology, such as communication devices and internet media platforms, is related to a decrease in work-related energy expenditure and weight gain.[34] Neighborhoods also have an effect on obesity. A study in Canada found that high neighborhood walkability is associated with decreased prevalence of overweight and obesity.[35] Neighborhood deprivation or a neighborhood with crime is associated with an increased probability of being overweight.[34] Recently, an improvement in socioeconomic status leads to a more sedentary lifestyle, which contributes to an increase in noncommunicable diseases, including obesity. Studies indicate that physical inactivity is associated with weight gain and sedentary behavior is associated with abdominal obesity. However, the association between screen time and obesity is still inconclusive.[36]

According to this study, there was no significant association between BMI and physical activity. However, there are still some other sedentary behaviors that could bestudied including hs-CRP, screen time, and time spent sitting or lying down. The amount and intensity of physical activity might have an influence on hs-CRP, while too little physical activity could not affect hs-CRP. Apart from hs-CRP, there are other markers related to inflammation and cardiovascular diseases that could be studied, for example, arterial stiffness, and inflammatory markers like erythrocyte sedimentation rate (ESR), fibrinogen, and interleukin-6 (IL-6). The limitation of this study was the data collection method. Questionnaires were used to record total physical activity. Therefore, the participants need to recall their memory of their daily physical activity throughout the week, which could possibly lead to inaccurate answers and results.

Conclusion

There was no significant connection between total physical activity and screen time with hs-CRP levels in overweight and obese subjects. Nonetheless, BMI exhibited a notable moderate positive connection with hs-CRP. The quantity and intensity of physical exercise may affect hs-CRP, but insufficient physical activity may not impact hs-CRP.

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Vitoon Julalarattanaporn; data curation: Suchanart Tangchitnob; writing—original draft preparation: Phakkharawat Sittiprapaporn; writing—review and editing: Phakkharawat Sittiprapaporn; visualization: Vitoon Julalarattanaporn; supervision: Vitoon Julalarattanaporn; project administration: Vitoon Julalarattanaporn; funding acquisition: Suchanart Tangchitnob. All authors have read and agreed to the published version of the manuscript.

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