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Association of dietary intake and physical activity with hypercholesterolemia among prolanis participants

Hubungan asupan makan dan aktivitas fisik dengan hiperkolesterolemia pada peserta prolanis

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Abstract

Cholesterol levels are vital indicators of the risk of metabolic disease. However, data on specific lifestyle determinants contributing to hypercholesterolemia within the Chronic Disease Management Program (Prolanis) population remain limited, despite their enrollment in routine monitoring programs. This study aimed to analyze the association between cholesterol intake, fiber intake, and physical activity with cholesterol levels in Prolanis participants. This cross-sectional study involved 42 Prolanis participants aged 42–76 years at the Kedato Community Health Center in Bandar Lampung. Nutrient intake was measured using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), physical activity was assessed using the Physical Activity Level (PAL) assessment, and cholesterol levels were measured enzymatically. Bivariate analysis indicated significant associations between cholesterol intake (OR=11.000; 95%CI: 2.366–51.141), fiber intake (OR=5.600; 95%CI: 1.218–25.751), and physical activity (OR=4.750; 95%CI: 1.226–18.406) with cholesterol levels. BMI and central obesity were not significantly associated with each other. However, in the multivariate logistic regression model, physical activity emerged as the sole independent correlate (Adjusted OR 4.848; 95% CI: 1.026–22.909), whereas the associations for dietary variables were attenuated and lost statistical significance. Although dietary factors showed initial associations, physical activity was identified as the most robust independent correlate of cholesterol levels among the Prolanis participants in this study. These findings suggest that emphasizing physical activity is a critical component of strategies to address hypercholesterolemia in this population.

Keywords: Cholesterol intake, Cholesterol level, Fiber, Prolanis participants.

Abstrak

Kadar kolesterol merupakan indikator vital risiko penyakit metabolik. Namun, data mengenai determinan gaya hidup spesifik yang berkontribusi terhadap hiperkolesterolemia, khususnya pada populasi Program Pengelolaan Penyakit Kronis (Prolanis), masih terbatas meskipun mereka telah terdaftar dalam pemantauan rutin. Penelitian ini bertujuan untuk menganalisis hubungan antara asupan kolesterol, asupan serat, dan aktivitas fisik dengan kadar kolesterol pada peserta Prolanis. Studi *cross-sectional* ini melibatkan 42 peserta Prolanis berusia 42–76 tahun di Puskesmas Kedaton, Bandar Lampung. Asupan zat gizi diukur menggunakan *Semi-Quantitative Food Frequency Questionnaire* (SQ-FFQ), aktivitas fisik melalui penilaian *Physical Activity Level* (PAL), dan kadar kolesterol menggunakan metode enzimatik. Analisis bivariat menunjukkan adanya hubungan yang signifikan antara asupan kolesterol (OR=11.000; 95%CI: 2.366–51.141),

asupan serat (OR=5.600; 95%CI: 1.218–25.751), dan aktivitas fisik (OR=4.750; 95%CI: 1.226–18.406) dengan kadar kolesterol. IMT dan obesitas sentral tidak menunjukkan hubungan yang signifikan. Namun, dalam model regresi logistik multivariat, aktivitas fisik muncul sebagai satu-satunya faktor independen yang berasosiasi (Adjusted OR=4.848; 95%CI: 1.026–22.909), sementara hubungan pada variabel diet melemah dan kehilangan signifikansi statistik. Meskipun faktor diet menunjukkan hubungan awal, aktivitas fisik teridentifikasi sebagai korelasi independen yang paling kuat terhadap kadar kolesterol di antara peserta Prolanis ini. Temuan ini menyarankan bahwa penekanan pada aktivitas fisik merupakan komponen kritis dalam strategi penanganan hiperkolesterolemia pada kelompok ini.

Kata Kunci: Asupan kolesterol, Kadar kolesterol, Peserta Prolanis, Serat.

Introduction

Cardiovascular disease continues to be a primary driver of illness and death among the elderly, where dyslipidemia, especially high total and low-density lipoprotein (LDL) cholesterol, represents a critical modifiable risk (Abera et al., 2024; Brunham et al., 2024). While large cohort studies emphasize age-related patterns in lipid concentrations (Aggarwal et al., 2022; Lin et al., 2024; Xiao et al., 2024), the management of hypercholesterolemia in elderly populations presents unique challenges due to entrenched lifestyle habits and complex age-related nutritional factors, including sarcopenia, altered lipid absorption, and potential medication–nutrient interactions. In Indonesia, the demographic shift toward an aging population necessitates a robust understanding of these determinants within established healthcare frameworks (Sitohang, 2023).

Dietary behavior and physical activity are recognized as primary modulators of serum lipid profiles. Current evidence distinguishes the metabolic impacts of lipid sources; while high saturated fat intake is established as a potent driver of elevated LDL cholesterol, dietary cholesterol exerts a more modest and variable effect on serum lipids, although both contribute to overall cardiovascular risk (Antoni, 2023; Carson et al., 2020), whereas dietary fiber, particularly soluble fiber, is associated with significant reductions in LDL cholesterol and mortality (Soliman, 2019; Zhang et al., 2022). Synergistically, physical activity enhances HDL functionality, improves insulin sensitivity, and reduces systemic inflammation, which can mediate lipid improvements independent of weight loss (Almuraikhy et al., 2024; Silva et al., 2024; Zhang et al., 2025).

However, a significant gap exists in the literature. Most investigations assess dietary components or physical activity in isolation or rely on controlled clinical trials that do not reflect real-world adherence. There is limited evidence examining the specific associations of dietary intake (fiber vs. cholesterol) and physical activity levels with lipid profiles, specifically within the context of the Chronic Disease Management Program (Prolanis).

Prolanis participants represent a high-risk group managed through a structured club-based model that differs from general elderly care by offering routine, monthly monitoring and group health education. However, standard nutritional counseling within this framework is often delivered as generic group advice rather than as personalized medical nutrition therapy. This approach predominantly focuses on pharmacological adherence, potentially overlooking the optimization of specific lifestyle variables that are critical for controlling dyslipidemia in community settings (Belanger et al., 2022; Khalafi et al., 2023; Muscella et al., 2020). Therefore, this study aimed to evaluate the correlation between specific dietary determinants (cholesterol and fiber intake), physical activity, and baseline cholesterol levels among elderly Prolanis participants at the Kedaton Community Health Center in Bandar Lampung. Unlike general population studies, this study specifically targeted the Prolanis cohort to identify modifiable behavioral targets.

The findings aim to identify specific dietary and physical activity patterns associated with cholesterol levels, offering preliminary insights that can help tailor nutritional counseling topics within the Prolanis program for this vulnerable group of patients. Based on

established physiological mechanisms, it is hypothesized that higher dietary cholesterol intake, lower fiber consumption, and reduced physical activity levels are significantly associated with elevated total cholesterol concentrations among these elderly Prolanis participants.

Methods

Study Design and Participants

This observational analytic study utilized a cross-sectional design and was conducted at the Kedaton Community Health Center in Bandar Lampung, Indonesia. This design was selected to facilitate the simultaneous assessment of exposure variables (nutrient intake, nutritional status, and physical activity) and the outcome variable (cholesterol levels) at a single point in time, thereby providing a temporal snapshot of the associations within the Chronic Disease Management Program (Prolanis).

The target population comprised all registered Prolanis members at the study facility. To maximize data representativeness and statistical robustness within the constraints of a finite population, a total sampling (census) technique was employed. This approach involved recruiting the entire accessible population (n=42) that met the inclusion criteria during the study period. While the sample size is determined by the population limit, this exhaustive recruitment strategy eliminates sampling errors associated with random selection and captures the complete variability of the specific cohort, ensuring sufficient data adequacy to detect relevant trends in this community setting.

The inclusion criteria were as follows: (1) active registered Prolanis members, (2) aged ≥ 40 years, (3) provision of written informed consent, and (4) availability of cholesterol measurements concurrent with dietary and physical activity assessments. The exclusion criteria included incomplete medical records regarding current cholesterol levels or cognitive/communication impairments that precluded reliable dietary interviews.

Data Collection Tools and Technique

Data were collected using a combination of validated dietary, anthropometric, physical activity, and biochemical assessment tools to comprehensively evaluate the nutritional and health status of the participants.

Dietary intake was assessed using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) adapted from a validated Indonesian food list to ensure cultural relevance and instrument reliability. The SQ-FFQ captured habitual food consumption over the previous month to reflect the usual dietary patterns. Nutrient intake data, specifically dietary fiber and cholesterol, were analyzed using the NutriSurvey software.

Nutritional status was evaluated through anthropometric measurements, including Body Mass Index (BMI) and abdominal circumference as indicators of general and central obesity. Body weight was measured using the InnoQ Digital Flatscale 100, and height was measured using the InnoQ Digital Stadiometer 100 (InnoQ, Indonesia). Abdominal circumference was measured using a standard non-elastic measuring tape following standardized procedures.

Physical activity levels were assessed using the Physical Activity Level (PAL) form based on a 24-hour physical activity recall. To overcome the limitations of single-day recall and better represent habitual activity, participants were instructed to recall a “typical” day that reflected their usual routines. Trained enumerators conducted face-to-face interviews to document the type and duration of all activities performed over a 24-hour period, ranging from sleep to vigorous physical activity. The validity of this approach is supported by the standardized Physical Activity Ratio (PAR) values established by the FAO/WHO/UNU (2001) expert consultation on human energy requirements. Total Energy Expenditure (TEE) was calculated as the sum of the energy expenditure for each activity (duration × PAR), and PAL was derived using the formula PAL = TEE/Basal Metabolic Rate (BMR). This method is widely used in nutritional epidemiology to classify physical activity intensity, such as light/sedentary (PAL 1.40–1.69) and active (PAL ≥ 1.70) lifestyles. To enhance reliability and minimize recall bias, the interviews followed a standardized activity probe list.

Biochemical assessment was performed using biomarker analysis of fasting blood samples. Approximately 8 mL of venous blood was collected in the morning between 07:00 and 09:00 AM after a standardized 10-hour overnight fast to reduce physiological variability in the results. Total cholesterol levels were analyzed using the CHOD-PAP method (Roche

Diagnostics). All laboratory analyses were performed at Pramitra Biolab Laboratory, Indonesia, an accredited facility for biochemical testing.

Operational Definitions and Variable Categorization

To ensure study reproducibility and clarity of interpretation, the variables were categorized based on established clinical standards. Hypercholesterolemia (the dependent variable) was defined as a total cholesterol level of ≥ 200 mg/dL, following the NCEP ATP III guidelines. Nutritional status was categorized using Asia-Pacific BMI cut-offs, where obesity was defined as BMI ≥ 25 kg/m^2 (or use ≥ 27 kg/m^2 if using Kemenkes RI standard), and Central Obesity was defined as abdominal circumference ≥ 90 cm for men and ≥ 80 cm for women.

Regarding Nutrient Intake, participants were categorized into "High" or "Low/Normal" groups based on the Recommended Dietary Allowances (AKG 2019) standards relevant to their age group. Specifically, low fiber intake was defined as consumption below [for example, 25 g/day], and High Cholesterol Intake was defined as exceeding [e.g., 200-300 mg/day]. Physical Activity was dichotomized based on PAL values, where participants with a PAL <1.70 were classified as "Inactive/ Sedentary," and those with PAL ≥1.70 were classified as "Active."

Data Analysis

Univariate Analysis: Descriptive statistics (frequency and percentage) were used to characterize the distribution of respondent demographics, physical activity levels, nutritional status (BMI and abdominal circumference), and nutrient intake. Bivariate Analysis: The Chi-square test (or Fisher's exact test, where expected cell counts were low) was employed to determine the crude association between independent variables and cholesterol levels.

Multivariate Analysis: To control for confounding factors and identify independent determinants, Multiple Logistic Regression analysis was performed. Potential confounders, including age, sex, and nutritional status, were statistically adjusted for within the model. Variables showing potential associations in the bivariate analysis ($p < 0.25$) were selected as candidates. Prior to final modeling, multicollinearity was assessed using the Variance Inflation Factor (VIF) to ensure independence among predictors. Subsequently, a backward stepwise method was applied to retain only the significant variables. The model's calibration and robustness were evaluated using the Hosmer-Lemeshow Goodness of Fit test. The final model presents the Adjusted Odds Ratio (aOR) with a 95% Confidence Interval (CI), estimating the strength of association after adjusting for covariates.

Ethical Statement

This study was approved by the Tanjungkarang Health Polytechnic of the Indonesian Ministry of Health (registration number: 423/KEPK-TJK/V/2024). The participants provided informed consent prior to participation, ensuring their voluntary involvement in the study. Strict privacy protocols were implemented, including the anonymization of all datasets using coding systems and restricting data access to authorized investigators, thereby guaranteeing participant anonymity and data confidentiality throughout the study.

Result and Discussion

Respondent Characteristics

Table 1 presents the demographic profiles of the 42 Prolanis participants. The cohort was predominantly elderly, with 76.2% of the patients aged ≥ 60 years. The majority were female (69%) and possessed a relatively high educational background, with 71.4% having completed at least senior high school or college-level education. Regarding health literacy exposure, 66.7% of respondents reported never receiving specific nutritional counseling.

Table 1. Characteristics of Respondents

Characteristics	n	%
Age (Year)		
<60	10	23.8
60 - 69	26	61.9
>70	6	14.3
Sex		
Male	13	31
Female	29	69
Education		
Basic Education (≤	12	28.6
Junior High School)	14	33.3
Senior High School	16	38.1

Higher Education (College/University)		
Nutrional counseling		
Never Received	28	66.7
Ever Received	14	33.3

Distribution of Health and Lifestyle Risks

As detailed in Tables 2 and 3, the distribution of metabolic and behavioral characteristics showed that 85.7% of the participants were classified as obese by BMI, and 66.7% presented with central obesity. Regarding physical activity, 64.3% of the participants were categorized as inactive. Dietary data indicated that 66.7% of the participants had high cholesterol intake, whereas 73.8% had low fiber consumption. In terms of the primary outcome, 57.1% of the participants were identified as having hypercholesterolemia.

Table 2. Distribution of health status, lifestyle, and clinical characteristics of respondents

Characteristics	Category	n	%
Nutritional Status (Anthropometry):			
Body Mass Index (BMI)	Obese	36	85.7
	Normal	6	14.3
Central Obesity (Abdominal Circumference)	Obese	28	66.7
	Normal	14	33.3
Lifestyle Factors:			
Physical Activity	Inactive	27	64.3
	Active	15	35.7
Cholesterol Intake	High Intake	28	66.7
	Good/Normal Intake	14	33.3
Fiber Intake	Low Intake	31	73.8
	High Intake	11	26.2
Clinical Outcome:			
Total Cholesterol Level	High (Hypercholesterolemia)	24	57.1
	Normal	18	42.9

Determinants of Cholesterol

Table 3 presents the bivariate analysis of potential determinants, identifying significant associations between the three lifestyle factors and cholesterol levels. High cholesterol intake showed the strongest association (P =0.002) with a Crude Odds Ratio (cOR) of 11.000; however, the wide 95% Confidence Interval (2.366–51.141) suggests substantial variability in this point estimate. Similarly, low fiber intake (p=0.020; cOR=5.600) and physical inactivity (p=0.016; cOR=4.750) were identified as significant risk factors. The broad confidence intervals observed across these variables reflect limitations in estimation precision, emphasizing the direction of the association rather than the precise magnitude of the odds. Conversely, anthropometric indicators (BMI and central obesity) did not show a statistically significant association with cholesterol levels

Table 3. Relationship of cholesterol intake, fiber, and physical activity on cholesterol levels

Variable	Category	Cholesterol Level				Total		p-value	OR
		High		Normal					
		n	%	n	%	n	**%**		
Cholesterol intake	High	21	87.5	7	38.9	27	66.7	0.002*	11.000 (2.366 – 51.141)
	Normal	3	12.5	11	61.1	15	33.3		
	Total	24	100	18	100	42	100		
Fiber	Normal	21	87.5	10	55.6	31	73.8	0.020*	5.600 (1.218 – 25.751)
	Low	3	12.5	8	44.4	11	26.2		
	Total	24	100	18	100	42	100		
Physical Activity	High	19	79.2	8	44.4	27	64.3	0.016*	4.750 (1.226 – 18.406)
	Normal	5	20.8	10	55.6	15	35.7		
	Total	24	100	18	100	42	100		

BMI	Obese	16	66.7	12	66.7	28	66.7	1.000	1.000 (0.274 – 3.656)
	Normal	8	33.3	6	33.3	14	33.3		
	Total	24	100	18	100	42	100		
Central Obesity	Obese	20	83.3	16	88.9	36	85.7	0.685	0.625 (0.101 – 3.858)
	Normal	4	16.7	2	11.1	6	14.3		
	Total	24	100	18	100	42	100		

** indicates significant differences (p < 0.05).*

Multivariate logistic regression was performed to identify independent predictors and control for confounding factors (Table 4). Variables with p<0.25 in the bivariate analysis (cholesterol intake, fiber intake, and physical activity) were entered into the model. The final model revealed that Physical Activity was the only independent associated factor (p=0.046). The Adjusted Odds Ratio (aOR) was 4.848 (95% CI: 1.026–22.909), indicating that physically inactive older adults had nearly five-fold higher odds of elevated cholesterol than active individuals, even after adjusting for dietary habits. Conversely, dietary variables (cholesterol and fiber intake) were not statistically significant in this multivariate adjustment.

Table 4. Factors that influence cholesterol levels (Final Model)

Variable	B	p-value	aOR
Constant	-5.172		
Physical Activity	1.578	0.046*	4.848 (1.026 – 22.909)

*Note: * indicates a significant difference (p < 0.05); Nagelkerke R^2 = 0.215; Hosmer-Lemeshow Test, p=0.678.*

The most significant finding of this study was that physical activity emerged as the sole factor independently associated with cholesterol levels in the multivariate model (p=0.046), surpassing the observed influence of dietary intake and adiposity. Specifically, older adults with low physical activity were nearly five times more likely to experience hypercholesterolemia than active individuals (aOR=4.85). This finding is critical given the clinical profile of our respondents, where 57.1% were classified as having hypercholesterolemia a prevalence consistent with that reported by (Bittner et al., 2025), who identified elevated cholesterol as a persistent and major modifiable risk factor in geriatric populations. Although dietary factors showed significant unadjusted associations, physical activity emerged as the only significant variable in the final model. This finding suggests that within this specific Prolanis cohort, physical inactivity is more consistently associated with hypercholesterolemia than dietary intake when controlling for other covariates.

The protective effect of physical activity observed in this study aligns with a robust body of evidence, including recent findings by (Yun et al., 2023) and (Braga et al., 2023), who reported that regular exercise significantly improves lipid profiles. Biologically, this dominance can be explained by the immediate impact of muscle contraction on lipid metabolism, which appears more potent than dietary restrictions in the aging body. Physical exertion upregulates Lipoprotein Lipase (LPL) activity in skeletal muscles. Increased LPL production accelerates the hydrolysis of triglyceride-rich lipoproteins and facilitates the transfer of cholesterol to HDL particles, a process known as Reverse Cholesterol Transport (Franczyk et al., 2023).

Furthermore, aerobic exercise stimulates insulin sensitivity and reduces hepatic synthesis of VLDL cholesterol (Syeda et al., 2023). In the context of aging, where the basal metabolic rate naturally declines, physical activity acts as a crucial compensatory mechanism to maintain lipid homeostasis.

Regarding dietary factors, our study revealed a high prevalence of poor dietary habits, with 66.7% of respondents consuming high-cholesterol diets and 73.8% having low fiber intake. These factors showed significant associations in the bivariate analysis, supporting established literature that high saturated fat (Carson et al., 2020; Zheng et al., 2023) and low fiber intake (Pandey et al., 2024), exacerbate cardiovascular risk. However, the attenuation of the statistical significance of dietary variables in the multivariate model should be interpreted with caution. Rather than implying a lack of biological effect, this finding may reflect measurement error inherent in self-reported dietary assessment or residual confounding, where the robust statistical signal of physical

activity masks the more variable impact of dietary intake in this sample size.

This likely reflects specific local and methodological contexts rather than the lack of importance of diet. This finding may also be contextualized by local dietary habits. Previous studies have indicated that dietary habits among the elderly in this region are often characterized by the pervasive consumption of coconut milk-based dishes and suboptimal vegetable intake. This potential homogeneity creates a variance constraint, limiting the statistical power to detect dietary differences compared with the more distinct separation observed in physical activity levels. Additionally, methodologically, the reliance on recall memory (SQ-FFQ) in elderly populations is prone to bias, whereas physical activity categorization (e.g., participation in Senam Prolanis) is more objective and distinct.

In terms of anthropometric indicators, we observed a high prevalence of obesity (85.7%) and central obesity (66.7%) in our cohort. While Liu et al. (2023) suggested that central obesity is a strong predictor of morbidity, our study found no significant relationship between BMI or central obesity and cholesterol levels. These null findings regarding anthropometry might ostensibly align with the 'Obesity Paradox. However, given the limited sample size and the absence of precise body composition data (e.g., muscle mass vs. fat mass), these results likely reflect the limitations of BMI as a marker of metabolic risk in the elderly rather than confirming a protective effect of obesity. As noted by (Moraes et al., 2025), body composition changes in the elderly, such as sarcopenia (loss of muscle mass), mean that BMI often fails to accurately distinguish between lean mass and adipose tissue. Crucially, metabolic health in the elderly is often determined more by fat functionality and ectopic fat deposition than by general subcutaneous fat measurements. This reinforces that for patients with PL, "being thin" does not guarantee metabolic health; a thin but sedentary patient remains at high risk for dyslipidemia due to poor lipid clearance mechanisms (Markovič et al., 2022).

This study had several strengths, particularly its focus on the Prolanis high-risk cohort and the use of multivariate analysis to control for confounding variables. However, limitations include the cross-sectional design, which prevents causal inference, and the sample size (n=42), which, while representative of the specific unit via total sampling, warrants caution in broader generalization.

Despite these limitations, the findings provide urgent evidence-based recommendations for health policies in Indonesia. Based on the robust association identified between physical activity and cholesterol control, our findings suggest that optimizing participation in Senam Prolanis could be a valuable component of hypercholesterolemia management. Rather than viewing it solely as a social activity, integrating structured attendance monitoring may enhance its clinical utility. Furthermore, educational strategies might benefit from shifting the focus towards behavioral activation, such as encouraging non-exercise physical activity (NEPA), such as walking or gardening, which appears to be a feasible approach for this population.

Conclusion

This study identified physical inactivity as the most robust independent correlate of hypercholesterolemia among elderly Prolanis participants, showing a stronger statistical association than dietary intake or adiposity in this specific cohort. The multivariate analysis suggested that maintaining physical activity plays a pivotal role in metabolic regulation in the elderly, where sedentary behavior poses a nearly five-fold increase in the odds of dyslipidemia (aOR= 4.85). Consequently, these findings support the reprioritization of lifestyle interventions within the Prolanis framework.

Healthcare providers should integrate structured physical activity, ranging from monitored Senam Prolanis attendance to simple daily movements such as walking, as a core, non-negotiable component of cholesterol management, rather than treating it as secondary to dietary advice.

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