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Correlation between Nicotine Dependence and Cardiorespiratory Fitness within the Wellness Matrix Framework among University Students

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Abstract

Background: The increasing use of tobacco and electronic nicotine delivery systems (ENDS) among youth represents a significant public health concern. In Indonesia, nicotine use among university students may contribute to long-term health risks. This study evaluated the correlation between nicotine dependence, measured using the Hooked-on Nicotine Checklist (HONC), and cardiorespiratory fitness assessed through maximal oxygen uptake (VO_2max) within the Wellness Matrix Framework.

Methods: A cross-sectional study was conducted among 40 male undergraduate students aged 18–24 years at Universitas Padjadjaran who actively used cigarettes, e-cigarettes, or vape products. Participants were selected using purposive sampling. Nicotine dependence was assessed using a modified HONC questionnaire, whereas VO_2max was estimated using the YMCA 3-Minute Step Test. Descriptive statistics, the Shapiro-Wilk tests, and Pearson correlations analysis were applied (α=0.10).

Results: Participants showed moderate nicotine dependence (mean HONC score: 5.6 ± 2.37) and moderate fitness (mean VO_2max: 44.31±3.86 mL/kg/min). A weak inverse correlation was found between HONC scores and VO_2max (r=-0.275, p=0.085). Body mass index showed a strong negative correlation with VO_2max (r=-0.824, p<0.001). Subgroup analysis showed consistent negative trends between nicotine dependence and VO_2max across single, dual, and triple product users. Duration of nicotine use showed negligible correlation with VO_2max (r=0.041, p=0.802).

Conclusion: Higher nicotine dependence is associated with lower cardiorespiratory fitness and affects multiple wellness dimensions. These findings underscore the importance of holistic interventions targeting physical and psychosocial wellness among young adults.

Keywords: Cardiorespiratory fitness, nicotine dependence, university students, wellness, young adults

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Introduction

Tobacco use remains a major global health challenge, with approximately 1.25 billion adult tobacco users worldwide.[1] Although a decline in tobacco use among individuals aged 15–24 years is projected, from more than 20% in 2000 to approximately 12% by 2030, these estimates often exclude electronic nicotine delivery systems (ENDS), such as e-cigarettes and vape products.[2] A recent study indicates a rising global trend in e-cigarette use among youth, with considerable regional variation in prevalence and dual use (e-cigarettes and conventional cigarettes). Data suggest that approximately 56.7% of young people are aware of e-cigarettes, and 10.9% report active use within the preceding 30 days.[3]

In Indonesia, youth smoking represents a significant public health concern, with an estimated 70 million active smokers nationwide, including 7.4% aged 10–18 years.[4] Initiation of smoking during early adolescence (10–19 years) carries heightened risks due to ongoing

brain development, increasing susceptibility to nicotine and potential progression to other nicotine products.[5] Compared with adults, adolescents are more likely to engage in risk-taking behaviors such as smoking, as reward-related brain regions are more active, whereas impulse control systems are still developing.[6] Early nicotine exposure impacts critical brain regions involved in emotion regulation, including the nucleus accumbens, medial prefrontal cortex, and amygdala, leading to altered neural connectivity.[7] Adolescents also exhibit increased sensitivity to nicotine's rewarding effects and were more prone to nicotine-induced synaptic changes, increasing their risk of addiction and future affective disorders.[8] The addictive cycle, driven by withdrawal symptoms such as cravings and cognitive impairment, further complicated cessationefforts.[9]

Both conventional cigarettes and e-cigarettes, despite often being perceived as safer alternatives, exert harmful effects due to nicotine's addictive properties, inflammatory responses, and vascular impacts.[10] Although e-cigarettes might contain lower levels of certain toxic substances compared with conventional cigarettes, dual users were exposed to higher overall toxic burden.[11] A strong negative association has been reported between smoking habits and physical fitness. Smokers consistently demonstrated lower cardiorespiratory fitness (CRF) compared with non-smokers. Cardiorespiratory fitness was commonly assessed using maximal oxygen consumption (VO_2max), reflecting the body's capacity to utilize oxygen during intense physical activity.[12] A previous study has reported an inverse correlation between VO_2max and nicotine dependence levels,with higher dependence linked to lower VO_2max and reduced physical activity levels, irrespective of age, gender, body mass index (BMI), and alcohol consumption.[13]

Physical fitness is a key component of the six-dimensional wellness matrix,[14] playing a critical role in the overall health of university students by influencing physical condition, mental well-being, and academic performance.[15,16] Cardiorespiratory fitness, in particular, depends on the coordinated function of the cardiovascular, respiratory, and muscular systems to deliver oxygen to tissues during physical activity.[17] Understanding the relationship between nicotine dependence and physical fitness within a wellness framework provides insight into how unhealthy behaviors may affect broader aspects of student well-being.

This research supports targeted interventions and anti-smoking campaigns that address physical effects and promote healthier coping strategies ultimately aiming to enhance student health and quality of life.

Although the physiological effects of nicotine are well established, few studies have examined these effects within a holistic health framework. The Wellness Matrix, which includes physical, emotional, social, intellectual, occupational, and spiritual domains, offers a comprehensive perspective on how physical decline may contribute to broader deficits in overall wellness.

Therefore, this study aimed to identify the correlation of nicotine dependence with physical fitness status among undergraduate students at Universitas Padjadjaran, to describe respondent characteristics based on nicotine product use patterns, and to analyze the relationship between HONC scores and VO_2Max within the framework of the Physical Wellness dimension of the Wellness Matrix.

Methods

This study employed a quantitative cross-sectional design to evaluate cardiorespiratory fitness and nicotine dependence at a single time point. The study population consisted of 40 male undergraduate students aged 18–24 years at Universitas Padjadjaran, Indonesia, who were active users of conventional cigarettes, e-cigarettes, or vape products. A non-probability purposive sampling technique was used to obtain a homogeneous sample of male participants, thereby minimizing potential confounding due to sex-related differences in cardiorespiratory responses, nicotine metabolism, and patterns of nicotine use. There was conflicting evidence for gender differences in smoking cessation, and there has been little research on gender differences in smoking cessation medication.[18] The sample size was determined based on feasibility and the availability of eligible participants.

Eligible participants were active undergraduate students aged 18–24 years who were current users of nicotine product, including conventional cigarettes, e-cigarettes, or vapes devices. All participants provided written informed consent and were physically capable of completing the YMCA 3-Minute Step Test. Exclusion criteria included a history of cardiovascular disease, respiratory disorders such as asthma or chronic obstructive pulmonary disease, musculoskeletal disorders,

or other medical conditiosn that could limit physical performance, as determined by the Physical Activity Readiness Questionnaire (PAR-Q).

Data collection was conducted from May to July 2025 at the Faculty of Medicine, Universitas Padjadjaran, Jatinangor Campus, Indonesia. Data were obtained through an online questionnaire and a direct physical fitness test. The questionnaire, administered via Google Forms in Bahasa Indonesia, collected demographic information and detailed data on nicotine product use. Consumption was recorded using product-specific units, including number of cigarettes per day for conventional cigarettes and number of puffs per day or cartridges per week for e-cigarettes and vape products.[19,20] All questionnaire items were close-ended.

Nicotine dependence was assessed using a modified version of the Hooked on Nicotine Checklist (HONC), a validated instrument measuring loss of autonomy over nicotine use and served as an early indicator of addiction in adolescents and young adults.[21] Compared with instruments developed for adult populations, such as the Fagerström Test for Nicotine Dependence (FTND), the HONC demonstrated greater sensitivity in younger populations.[21] The instrument consisted of 10 dichotomous (yes/no) items evaluating loss of autonomy over nicotine use. The items assessed: (1) unsuccessful attempts to quit, (2) continued use due to difficulty stopping, (3) self-perceived addiction, (4) strong cravings for nicotine, (5) a strong need to use nicotine, (6) difficulty refraining from use in restricted places, and withdrawal-related symptoms when attempting to stop or abstain, including (7) difficulty concentrating, (8) irritability, (9) strong urges to use nicotine, and (10) feelings of nervousness, restlessness, or anxiety. Each "yes" response was scored as 1 and each "no" response as 0, resulting in a total score ranging from 0 to 10, with higher scores indicating greater nicotine dependence. The instruments was adapted from materials distributed under the Creative Commons Attribution 4.0 International License (CC BY 4.0) and has demonstrated good internal consistency (Cronbach's alpha=0.89 among all tobacco users and 0.86 among exclusive e-cigarette users).[21]

Cardiorespiratory fitness (VO_2max) was estimated indirectly using the YMCA 3-Minute Step Test (YMCA 3MST).[22] This method was widely used due to its practicality, safety, and cost-effectiveness. A previous study had demonstrated a strong correlation ($r \approx 0.80$) between VO_2max estimated using the YMCA 3MST and values obtained using the treadmill-based Bruce protocol.[22] Although direct measurement using maximal exercise testing (e.g., Bruce protocol) was considered the gold standard,[23] the YMCA 3MST provides a a feasible alternative in field settings.

Participants who completed the questionnaire and agreed to undergo physical testing were scheduled for individual appointments. Fitness assessments were conducted in a designated room in the C5 building at the Faculty of Medicine, Universitas Padjadjaran. Baseline vital signs, including blood pressure, resting pulse, respiratory rate, and oxygen saturation were recorded prior to testing to ensure participant safety.

Table 1 Characteristics of Respondents (n=40)

Characteristics	Category	n	%
Age (years)	18–20	18	45.0
	21–24	22	55.0
Product use*	Conventional cigarette	35	87.5
	E-cigarette	33	82.5
	Vape	8	20.0
Nicotine use pattern	Single-product use	20	50.0
	Dual-product use	13	32.5
	Triple-product use	7	17.5
Combination pattern	Cigarette + E-cigarette	23	57.5
	Cigarette only	5	12.5
	Cigarette + E-cigarette + vape	5	12.5
	E-Ccgarette only	4	10.0
	Conventional cigarette + vape	2	5.0
	E-cigarette + vape	1	2.5

Note: *Participants may report more than one product.

Table 2 Product Usage Patterns among Respondents (n=40)

Product Type	Typical Usage Intensity	Distribution Pattern
Conventional cigarette	6–10 cigarettes/day (moderate consumption)	Predominantly moderate daily use
E-Cigarette	<50 puffs/session (majority); >300 puffs/session (minority))	Highly variable usage intensity
Vape	251–300 puffs/session (most common range)	Concentrated within higher puff range

Variables assessed in this study included nicotine dependence (HONC score), cardiorespiratory fitness (VO_2max), body mass index (BMI), duration of nicotine use, age, and type of nicotine product used (conventional cigarettes, e-cigarettes, vape devices, or combinations). BMI was calculated from measured height and weight and expressed as kg/m^2. Duration of nicotine use was recorded in months, and the type of nicotine product was categorized based on participant self-report.

The Wellness Matrix Framework was used as a conceptual model to interpret the findings. This framework conceptualizes health as comprising six interconnected domains: physical, emotional, social, intellectual, occupational, and spiritual wellness.[14] In this study, only the Physical Wellness domain was operationalized using objective measures of cardiorespiratory fitness (VO_2max) and BMI, whereas the other domains were not directly assessed and were used solely for interpretative purposes.

Statistical analysis was performed using IBM SPSS Statistics version 29.0. Descriptive statistics were used to summarize participant characteristics. Data normality was assessed using the Shapiro–Wilk test. Pearson correlation analysis was performed to examine the relationships between HONC scores, BMI, duration of nicotine use, and VO_2max. Subgroup analysis were performed to compare VO_2max across categories of nicotine dependence. A p-value <0.05 was considered statistically significant.

Ethical approval was obtained from the Health Research Ethics Committee of Universitas Padjadjaran (No. 493/UN6.KEP/EC/2025). All participants provided written informed consent prior to participation.

Results

A total of 40 male participants were included in this study. More than half of the participants were aged 21–24 years (55.0%), while 45.0% were aged 18–20 years. Based on product use, most participants reported using conventional cigarettes (87.5%) and e-cigarettes (82.5%), whereas vape use was less common (20.0%). Regarding nicotine use patterns, 50.0% of participants were single-product users, 32.5% were dual users, and 17.5% were triple users.

Table 3 Nicotine Dependence Level Based on HONC Score (n=40)

Dependence Level	Score Range	n	%
Low	1–3	9	22.5
Moderate	4–6	19	47.5
High	7–10	12	30.0
Mean (SD)		5.6 (2.37)	

Note: HONC= Hooked on Nicotine Checklist; SD = standard deviation

Table 4 VO_2max Categories based on YMCA 3-Minute Step Test (n=40)

Variable	Category/Range	n	%
VO_2max (mL/kg/min)	Low (<41)	9	22.5
	Moderate (41–47)	25	62.5
	High (>47)	6	15.0
Body mass index	Underweight	7	17.5
	Normal	24	60.0
	Overweight	9	22.5

Table 5 Correlation Between Nicotine Dependence, Product Use Pattern, Smoking Duration, and VO_2max

Variable / Group	Shapiro–Wilk p-value	r	p-value
HONC score	0.139	-0.275	0.085
VO_2max	0.211	—	—
Single-product users	—	-0.784	0.012*
Dual-product users	—	-0.861	<0.001
Triple-product users	—	-0.833	0.080
Smoking duration (years)	0.054	0.041	0.802

Note: *Statistically significant (p<0.05)

The most common combination pattern was the concurrent use of conventional cigarettes and e-cigarettes (57.5%) (Table 1).

Analysis of product usage intensity showed that conventional cigarette users predominantly reported moderate consumption (6–10 cigarettes/day). E-cigarette use demonstrated considerable variability, with most participants reporting fewer than 50 puffs per session, although some reported more than 300 puffs. Vape use tended to be concentrated in the higher range, most commonly between 251–300 puffs per session (Table 2).

The mean nicotine dependence score, assessed using the Hooked on Nicotine Checklist (HONC), was 5.6 (SD=2.37), with a range of 1–10. Based on classification, 22.5% of participants had low dependence, 47.5% moderate dependence, and 30.0% high dependence (Table 3).

Cardiorespiratory fitness assessment using the YMCA 3-Minute Step Test showed a mean VO_2max of 44.31 mL/kg/min (SD=3.86). Most participants (62.5%) were classified as having moderate fitness, while 22.5% had low fitness and 15.0% had high fitness levels. The mean body mass index (BMI) was 22.14 kg/m^2 (SD=3.56), with the majority of participants categorized as having normal BMI (60.0%). A strong negative correlation was observed between BMI and VO_2max ($r=-0.824$, $p<0.001$), indicating that higher BMI was associated with lower cardiorespiratory fitness (Table 4).

Normality testing using the Shapiro–Wilk test showed that both HONC scores and VO_2max were normally distributed. Pearson correlation analysis demonstrated a weak negative correlation between nicotine dependence (HONC score) and VO_2max ($r=-0.275$, $p=0.085$), which was not statistically significant. Subgroup analysis revealed stronger negative correlations among dual-product users ($r=-0.861$, $p<0.001$) and single-product users ($r=-0.784$, $p=0.012$), while the correlation among triple-product users was not statistically significant ($r=-0.833$, $p=0.080$). Smoking duration was not significantly associated with VO_2max ($r=0.041$, $p=0.802$) (Table 5).

Discussion

This study demonstrated that higher nicotine dependence was associated with lower aerobic capacity, and that students who used multiple nicotine products exhibited poorer cardiorespiratory fitness. These findings suggest that combined exposure to different nicotine delivery systems may exert an additive adverse effect on physiological endurance, consistent with reports on dual and poly-tobacco use.[12,13]

The observed inverse relationship between nicotine dependence and cardiorespiratory fitness supports existing evidence that nicotine impairs oxygen utilization and cardiovascular efficiency.[12,13] In addition, higher BMI was strongly associated with lower aerobic fitness, reinforcing the contribution of metabolic status and physical activity to cardiorespiratory performance.[12]

The Hooked on Nicotine Checklist (HONC) effectively captured behavioral dependence across different nicotine products and has been shown to correlate with objective biomarkers of nicotine exposure.[21] The YMCA 3-Minute Step Test also provided a valid estimation of maximal oxygen uptake (VO_2max), as supported by previous validation studies in healthy adult populations.[22]

Within the Wellness Matrix framework, which comprises six interconnected domains, namely physical, emotional, social, intellectual, occupational, and spiritual wellness, this study primarily addressed the Physical Wellness domain.[14] The inverse relationship between VO_2max and nicotine dependence supports evidence that nicotine impairs cardiovascular and pulmonary function. Furthermore, the

strong negative correlation between BMI and VO_2max indicates that reduced physical activity and metabolic imbalance contribute to decreased fitness.[18]

Beyond the physical domain, nicotine use may have broader implications for overall well-being. From an emotional perspective, nicotine dependence is often associated with psychological distress and mental health comorbidities among young adults.[24] National data indicate that nicotine use frequently co-occurs with other substance use and psychological problems.[19] In terms of social wellness, peer influence and social norms play a significant role in e-cigarette use, potentially reinforcing continued nicotine consumption.[25] Although not directly assessed in this study, nicotine exposure may also affect cognitive function, including concentration and memory, which could negatively impact academic performance and intellectual wellness.[20]

Several limitations should be acknowledged. First, the cross-sectional design precludes causal inference between nicotine dependence and cardiorespiratory fitness. Second, the relatively small sample size and unequal distribution among single-, dual-, and triple-product users may have affected subgroup analyses. Third, variations in nicotine concentration and device type were not controlled, and nicotine exposure was based on self-reported data, which may introduce recall bias. In addition, physical activity levels were not quantitatively assessed using standardized instruments such as the International Physical Activity Questionnaire (IPAQ), limiting the ability to control for baseline fitness differences. Furthermore, biochemical verification of nicotine exposure, including cotinine levels, was not performed, and other lifestyle factors, including diet and sleep, were not evaluated.

In conclusion, nicotine dependence among university students is associated with lower cardiorespiratory fitness, particularly among individuals using multiple nicotine products. Greater dependence and higher body mass index were consistently linked to reduced aerobic capacity, reflecting impaired physical wellness. Within the Wellness Matrix framework, these findings suggest the nicotine-related physiological impairment may extend beyond the physical domain and influence overall student well-being.

Future studies should employ longitudinal designs to clarify the temporal relationship between nicotine dependence and cardiorespiratory fitness. The inclusion of objective biomarkers, such as salivary cotinine or exhaled carbon monoxide, may improve the accuracy of nicotine exposure assessment. Additionally, broader evaluations incorporating physical activity, dietary patterns, sleep, and other fitness parameters are needed to better understand the contribution of nicotine use to overall student health.

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Authors' Contributions
MIGG contributed to the initial conception of the study, conducted an extensive literature review to identify the research gap, developed the research design and protocol, performed data collection and statistical analysis, and prepared the initial manuscript draft. RL contributed to the conceptual development of the study, including refinement of the research focus and integration of the Wellness Matrix framework and nicotine dependence variables. RL also provided methodological supervision, guided the interpretation of study results, and provided important intellectual input throughout the research process. SS contributed to methodological guidance, including recommendation and supervision of the cardiorespiratory fitness assessment protocol using the YMCA 3-minute step test. SS also provided academic supervision, methodological input, and oversight regarding ethical and research procedures. All authors read and approved the final manuscript.

Conflict of Interest
The authors declare no conflict of interest.

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