Nicotine metabolites: Biomarkers for tobacco exposure and addiction studies.

Dennis Moebus*

Institute for Urban Public Health (InUPH), University of Duisburg-Essen, Germany

Introduction

Nicotine metabolism plays a critical role in tobacco addiction, smoking behavior, and cessation outcomes. The breakdown of nicotine in the body produces several metabolites, with cotinine being the most widely studied biomarker for tobacco exposure. Nicotine metabolites serve as objective indicators in addiction research, allowing scientists to measure smoking intensity, secondhand smoke exposure, and individual differences in nicotine processing. This article explores the significance of nicotine metabolites as biomarkers in tobacco research, their applications in addiction studies, and how they can inform personalized smoking cessation strategies [1].

Nicotine is primarily metabolized in the liver by the enzyme CYP2A6, converting it into cotinine, which is further broken down into 3′-hydroxycotinine and other metabolites. The main nicotine metabolites used as biomarkers include, accounting for ~70-80% of nicotine metabolism [2].

Has a long half-life (15-20 hours), making it a reliable indicator of recent tobacco use.Found in blood, urine, saliva, and hair, making it useful for different types of tobacco exposure assessment. Formed from cotinine via CYP2A6 enzyme activity. The ratio of 3HC to cotinine (Nicotine Metabolite Ratio, NMR) indicates how quickly an individual metabolizes nicotine [3].

Fast metabolizers have a high 3HC/cotinine ratio and may smoke more or struggle with nicotine replacement therapies. These minor metabolites are found in urine and blood. Less commonly used as biomarkers due to their shorter half-life and lower concentrations in the body. Nicotine, cotinine, and 3HC can be glucuronidated, making them more water-soluble for elimination [4].

Individuals with genetic variations affecting glucuronidation may process nicotine differently, influencing smoking behaviour. Cotinine is the gold standard biomarker for measuring tobacco exposure. It can be used to: Differentiate smokers from non-smokers [5].

Assess secondhand smoke (SHS) exposure, especially in children and non-smokers. Monitor nicotine intake in smokers using e-cigarettes, nicotine patches, or smokeless tobacco. A high NMR (3HC/cotinine ratio) indicates rapid nicotine metabolism, leading to higher smoking rates and stronger dependence [6].

Slow metabolizers tend to smoke fewer cigarettes per day but may retain nicotine longer in their system. Nicotine metabolites help personalize smoking cessation strategies by identifying individuals who may benefit from alternative treatments [7].

Nicotine replacement therapy (NRT) works better in slow metabolizers because nicotine stays in their system longer. Varenicline (Chantix) is more effective in fast metabolizers, as they tend to relapse faster with NRT alone. Cotinine levels can measure treatment adherence, ensuring smokers are correctly using NRT products [8].

Non-smokers exposed to passive smoking (SHS) show elevated cotinine levels in urine or saliva. Thirdhand smoke (THS) exposure—nicotine residues in clothing, furniture, or dust—can be detected through hair or urine cotinine levels [9].

Nicotine metabolites can be detected in various biological samples, each with advantages: High sensitivity, widely used in research and workplace screening. Provides precise measurement of nicotine intake. Non-invasive, commonly used for smoking cessation studies. Detects long-term nicotine exposure, useful for epidemiological studies [10].

Conclusion

Nicotine metabolites, particularly cotinine and 3′-hydroxycotinine, are essential biomarkers for studying tobacco addiction, secondhand smoke exposure, and smoking cessation. Their analysis helps classify smoking intensity, predict treatment responses, and inform public health policies. As nicotine delivery methods evolve, ongoing research into nicotine metabolism will play a key role in shaping future addiction studies and regulatory measures.

References

1. Brady KT, Randall CL. Gender differences in substance use disorders. Psychiat Cli North America. 1999;22(2):241-52.
2. Volkow ND. Personalizing the treatment of substance use disorders. Am J Psychiatry. 2020;177(2):113-6.
3. Hasin DS, O'brien CP, Auriacombe M, Borges G, Bucholz K, Budney A, Compton WM, Crowley T, Ling W, Petry NM, Schuckit M. DSM-5 criteria for substance use disorders: recommendations and rationale. Am J Psychiatry. 2013;170(8):834-51.

***Correspondence to:** Dennis Moebus, Institute for Urban Public Health (InUPH), University of Duisburg-Essen, Germany. E-mail: dennis.m@uk-essen.de

***Received:** 03-Mar-2025, Manuscript No. AARA-25- 163812; **Editor assigned:** 04-Mar-2025, PreQC No. AARA-25- 163812 (PQ); **Reviewed:** 18-Mar-2025, QC No. AARA-25- 163812; **Revised:** 23-Mar-2025, Manuscript No. AARA-25- 163812 (R); **Published:** 30-Mar-2025, DOI: 10.35841/aara-8.2.263*

***Citation:** Moebus D. Nicotine metabolites: Biomarkers for tobacco exposure and addiction studies. Addict Criminol.2025;8(2):263*

4. Ciraulo DA, Piechniczek-Buczek J, Iscan EN. Outcome predictors in substance use disorders. Psychiatr Clin. 2003;26(2):381-409.

5. Rehm J, Marmet S, Anderson P, Gual A, Kraus L, Nutt DJ, Room R, Samokhvalov AV, Scafato E, Trapencieris M, Wiers RW. Defining substance use disorders: do we really need more than heavy use?. Alcohol Alcoholism.2013;48(6):633-40.

6. Vanyukov MM, Tarter RE, Kirisci L, Kirillova GP, Maher BS, Clark DB. Liability to substance use disorders: 1. Common mechanisms and manifestations. Neurosci Biobehav Rev.;27(6):507-15.

7. McGovern MP, Carroll KM. Evidence-based practices for substance use disorders. Psychiatric Clin. 2003;26(4):991-1010.

8. Smith JP, Book SW. Anxiety and substance use disorders: A review. Psychiatr Times. 2008;25(10):19.

9. Robinson SM, Adinoff B. The classification of substance use disorders: Historical, contextual, and conceptual considerations. Behav Sci. 2016;6(3):18.

10. Ball SA. Personality traits, problems, and disorders: Clinical applications to substance use disorders. J Res Pers. 2005;39(1):84-102.

Citation: *Moebus D. Nicotine metabolites: Biomarkers for tobacco exposure and addiction studies. Addict Criminol.2025;8(2):263*