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The Impact of IQOS® on Health and Physical Performance: Myths vs. Facts - literature review

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Abstract
Tobacco harm reduction (THR) strategies aim to minimize the adverse health effects of smoking while allowing nicotine consumption. Heated tobacco products (HTPs) such as IQOS® have been marketed as a less harmful alternative to conventional cigarettes. This literature review examines the chemical composition of IQOS® emissions compared to traditional cigarettes, dispels common myths, and evaluates its impact on the human physiological system, including the respiratory and cardiovascular systems, long-term carcinogenic risks, and physical performance. Studies indicate that IQOS® emissions contain lower levels of harmful and potentially harmful constituents (HPHCs) than conventional cigarettes, but concerns remain regarding certain toxicants, including formaldehyde, acetaldehyde, and acrolein. The product is often perceived as a safer alternative; however, research suggests that its health risks may not be significantly reduced. IQOS® has been linked to pulmonary and cardiovascular effects, oxidative stress, and potential carcinogenic risks. Additionally, its impact on physical performance and metabolism remains unclear. While IQOS® may provide some advantages over traditional cigarettes, misinformation and its appeal to young users raise public health concerns. Further long-term research is necessary to assess its full impact on human health and athletic performance.

Keywords: IQOS®, heated tobacco products, health effects, physical performance, tobacco harm reduction

Introduction and objective

The tobacco harm reduction (THR) approaches are designed to lower the negative health impacts of smoking while still allowing the consumption of nicotine (1). Considering the current estimations that a billion people might die from smoking-related illnesses this century, it has become crucial to practice THR (2). Non-combustible tobacco alternatives like heated tobacco products (HTPs) have also been effective in reducing the toxic chemicals exposure of smokers (3). IQOS®, a prominent HTP product developed by Philip Morris International, functions as a substitute for conventional cigarettes by heating tobacco to around 350°C without burning it, thereby claiming to reduce the emission of pollutants (4).

Studies have demonstrated that IQOS® delivers nicotine in amounts comparable to combustible cigarettes, while the levels of acute respiratory distress syndrome-inducing reactive oxygen species and carbonyls are significantly lower. However, concerning reactive gaseous emissions released by IQOS® use, these emissions remain elevated and could pose health risks (5). The product has been widely rolled out across nations with varying levels of awareness and usage among young adults. However, any industry assertion of lower risk has proved untrue with many current users of IQOS® still smoking cigarettes and e-cigarettes (6). While IQOS® may be a less detrimental substitute for conventional smoking, more research is necessary to completely clarify its long-term consequences for both human and environmental health (7).

The aim of this study is to conduct a comprehensive analysis of scientific studies and meta-analyses that examine the chemical composition of IQOS® emissions, compare it to the composition of conventional cigarettes, dispel myths about it, and their impact on the human physiological system, including the respiratory system, cardiovascular system, long-term carcinogenic risks and effects on physical performance.

Review methods

A comprehensive literature review was performed utilizing the National Library of Medicine database (PubMed: https://pubmed.ncbi.nlm.nih.gov) and Google Scholar. The search employed the following keywords: IQOS®, heated tobacco products, myths, health effects, physical performance. A total of 44 scientific studies and meta-analyses were examined, and the data extracted from these studies informed the conclusions drawn.

Comparison of IQOS® and conventional cigarettes emissions

A comparative analysis of the chemical profiles between conventional cigarettes and emissions from IQOS® heated tobacco products demonstrates significant differences. The findings indicate that the emissions from IQOS® are typically 1 to 2 orders of magnitude lower than those of traditional cigarettes and produce a reduced number of harmful chemicals overall. (8) The smoke from conventional cigarettes contains a higher concentration of Aromatic Hydrocarbons, Alkadienes, and Terpenes compared to Heated Tobacco Products (HTP), but fewer Alcohols and Esters. IQOS® emissions differ from conventional cigarettes, showing distinct profiles with seven unique Aromatic Hydrocarbons, seven Alcohols, one Acid, and several other compounds, including Alkadienes, Esters, Aldehydes, and Terpenes. (9) Particulate matter from IQOS® is primarily composed of semi-volatile organic compounds, unlike the solid particles found in cigarette smoke. In both conventional cigarettes and IQOS®, water constituted a significant portion of the particulate matter, with a substantially higher presence in the IQOS® aerosol. The smoke from traditional cigarettes contained combustion-related solid particles, including elements such as carbon, oxygen, potassium, calcium, and silicon. In contrast, the particulate matter in the IQOS® aerosol consisted of semi-volatile organic compounds, with only minor traces of oxygen and silicon.(10) Furthermore, metal emissions from IQOS® are lower than those from both e-cigarettes and traditional cigarettes and generally align with ambient background levels. However, IQOS® does generate certain carcinogenic aldehydes, including formaldehyde, acetaldehyde, and acrolein, though these are present at significantly reduced concentrations compared to conventional cigarettes. (11). Table 1 shows a comparison of IQOS® emissions and traditional cigarettes emissions. Research on IQOS® indicates a reduction in the levels of harmful and potentially harmful constituents (HPHCs) relative to conventional cigarettes. Data from Philip Morris International demonstrate decreased exposure to certain HPHCs (12), while independent studies corroborate significant reductions in aldehydes (by 80-95%) and volatile organic compounds (by 97-99%) (13) Certain studies propose that the yields of harmful and potentially harmful constituents (HPHCs) may be underestimated and could be higher when measured relative to the tobacco content. Moreover, IQOS® emissions contain carbon particles and compounds generated through pyrolysis, which raises concerns regarding possible health implications (14).

Although IQOS® emits lower levels of indoor air pollutants compared to conventional cigarettes, its impact remains significant, with acrolein concentrations potentially reaching concerning levels in certain indoor environments. The estimated average daily intake for users of benzene, formaldehyde, acetaldehyde, and acrolein was 39 μg, 32 μg, 2.2 mg, and 71 μg, respectively. Indoor air concentrations were predicted for typical scenarios, revealing that acrolein levels of concern (exceeding 0.35 $\mu g/m^3$) could result from IQOS® usage in both residential and public spaces. Heated tobacco products are less potent sources of indoor pollution than conventional cigarettes, yet their impact is neither negligible nor fully understood (15). Overall, while HTPs appear to be less detrimental to indoor air quality than conventional cigarettes, their effects are still significant and warrant further investigation and potential regulatory action.

Table 1. Comparison of IQOS® emissions vs traditional cigarettes

Component	**IQOS®**	Traditional Cigarettes
Nicotine delivery	Comparable to cigarettes	High nicotine levels
CO	Significantly lower	High levels
ROS	Significantly lower	High levels
Acetaldehyde	Reduced by 80-95%, but still present	High levels
Formaldehyde	Reduced by 80-95%, but still present	High levels
Acrolein	Present but at lower levels	High levels
Aromatic Hydrocarbons	Present but at lower levels	High levels
Alkadienes and Terpenes	Present but at lower levels	High levels
Particulate Matter	Semi-volatile organic compounds	Solid particles, combustion-related
Water Content	Higher water content in aerosol	Lower water content
Heavy Metals	Lower emissions than both e-cigarettes and traditional cigarettes	Present

*CO- carbon monoxide; ROS- reactive oxygen species

Myths Surrounding IQOS®

The first myth surrounding IQOS® is its name, which is not an acronym. PMI has never publicly used any acronym to describe or market IQOS® and has repeatedly denied that IQOS® is an acronym. However, this acronym, which implicitly suggests a cessation claim, has appeared in numerous peer-reviewed publications (16). The second myth is that the product has no health risks. IQOS® has been promoted in the US as a potentially reduced-risk tobacco option, but regulatory agencies such as the FDA require substantial evidence before endorsing such claims. The implications for human health remain ambiguous, and PMI's own data do not substantiate its claims that IQOS® is less hazardous than traditional cigarettes. Moreover, IQOS® exposes users to varying levels of different toxicants-both lower and higher-compared to conventional cigarettes. Additionally, the reduced exposure claims associated with IQOS® are misleading and are likely to be misinterpreted as indicating
a reduced health risk (17). The third myth is that the product is a safer alternative to smoking. IQOS® and other heat-not-burn tobacco products are often perceived as less harmful than conventional cigarettes, but research indicates that the aerosol they produce contains the same harmful substances, albeit in lower concentrations. The toxicological impact of aerosol from these devices is comparable to that of traditional cigarette smoke. Moreover, the repeated reheating of tar deposits within the IQOS® device during use can result in the generation of higher concentrations of harmful compounds and particulate matter (18). Furthermore, IQOS® may not serve as an effective substitute for traditional smoking, as many users either continue to smoke conventional cigarettes or begin using IQOS® without any prior history of smoking (19). Research indicates that there is no statistically significant difference between IQOS® and conventional cigarettes for 23 out of 24 biomarkers of potential harm in American adults. Similarly, in Japan, no significant differences were observed for 10 out of 13 biomarkers of potential harm between users of IQOS® and traditional cigarettes. These findings suggest that the health risks associated with IQOS® are comparable to those of conventional smoking, challenging claims that IQOS® is a safer alternative [20]. Philip Morris International's (PMI) research on IQOS®, a heated tobacco product, raises questions regarding possible disinformation and misunderstanding of its claimed health benefits. Research indicates that consumers - especially young people - may misunderstand PMI's claims of lower risk and less exposure, which could result in the commencement of tobacco use. Furthermore, only 3–15% of individuals were able to use IQOS® exclusively, according to PMI's data, indicating that complete conversion from cigarettes to IQOS® is uncommon. PMI has not provided evidence that consumers will understand the necessity to "switch completely" from cigarettes to IQOS® in order to obtain the claimed health benefits. Furthermore, these suggested assertions may actually lessen smokers' intentions to stop smoking, despite PMI's promises to the contrary.(21)(22) IQOS® heated tobacco products are likely to appeal to and be misused by adolescents and young adults. PMI has failed to provide sufficient evidence that IQOS® will not attract or be used by this age group, including those who are either non-users or former users of tobacco products. Additionally, PMI did not take into account independent research on adolescents and young adults, which could have influenced their conclusions, and their own studies had notable methodological shortcomings.

According to both PMI's data and independent research, the introduction of IQOS® is likely to result in the initiation of tobacco use among non-smoking adolescents and young adults. (23) Point-of-sale marketing of IQOS® in Israel raises concerns about potential misinformation and its appeal to youth. IQOS® and HEETS were displayed in prominent locations, making them easily visible to young people, despite the absence of free samples or promotions. The packaging used colours to denote flavours and strength, while retailers described IQOS® as less harmful, a cessation device, and as not producing smoke. These marketing strategies are troubling because they may foster incorrect perceptions of the product and potentially increase tobacco use, particularly among adolescents. These results highlight the significance of communicating and interpreting IQOS®-related health claims with caution (24).

Impact on Respiratory system

Recent studies have raised concerns about the pulmonary health effects of heated tobacco products like IQOS®. Research indicates that chronic exposure to IQOS® aerosol in animal models is associated with pulmonary emphysema, inflammation, oxidative stress, and impaired lung function (25,26). These pathological changes are similar to those observed with traditional tobacco smoke. Specifically, Arano Nitta et al. reported that IQOS® exposure in mice activated apoptosis-mediated pathways in lung tissue, suggesting potential long-term damage (26). Human trials have also demonstrated acute pulmonary effects, including reduced oxygen saturation and airflow parameters, occurring shortly after IQOS® use (27). Furthermore, Moazed et al. reviewed data from Philip Morris International and found no evidence that former cigarette smokers who transitioned to IQOS® experienced reduced harm or improved pulmonary inflammation. These findings suggest that IQOS® may not be a safe alternative to conventional cigarettes and underscore the need for further research into its long-term effects on respiratory health (28).

Impact on Cardiovascular system

Recent research has investigated the effects of IQOS®, a heat-not-burn tobacco product, on cardiovascular health. While IQOS® may emit fewer toxic substances than traditional cigarettes, it still poses potential risks to cardiovascular health (29). Some studies suggest that transitioning from continuous cigarette smoking to IQOS® may improve certain cardiovascular risk markers (30). For instance, a one-month study reported that switching to IQOS® improved coronary microcirculatory function, aortic flexibility, and left ventricular performance (31). However, other findings by Znyk et al. associate IQOS® use with increased oxidative stress and potential exacerbation of airway inflammation. Furthermore, it was discovered that the acute effects of IQOS® and conventional cigarettes were comparable in terms of heart rate, blood pressure, and arterial stiffness. To completely comprehend the long-term cardiovascular implications of using IQOS®, more research is required (30).

Long-term carcinogenic risks

Recent investigations have focused on the long-term carcinogenic risks associated with using IQOS® and other electronic nicotine delivery systems. Although IQOS® is marketed as a lower-risk alternative, there is a lack of long-term data on its effectiveness and safety in reducing harm (32). Ongoing postmarket surveillance studies aim to assess the health effects associated with IQOS® use, user perceptions of risk, and patterns of tobacco consumption (33). Research indicates that the likelihood of users fully transitioning to IQOS® is significantly influenced by their perception of reduced harm (34). Concerns about the carcinogenic risks associated with these products persist. Studies on e-cigarettes have raised questions about the long-term urological safety of electronic nicotine delivery systems, as users have been found to have higher concentrations of urinary biomarkers linked to bladder cancer compared to non-users. Further research is necessary to fully understand the carcinogenic risks associated with prolonged IQOS® use (35).

Impact on Physical Performance

Recent studies have explored the impact of IQOS, a heated tobacco product, on physical performance and health outcomes. Sharman & Nurmagambetov (2020)(1) found that IQOS users demonstrated better respiratory function and physical capacity compared to conventional cigarette smokers after one year. However, Yaman et al. (2021) (2) observed that acute IQOS use impaired myocardial systolic and diastolic functions similarly to conventional cigarettes. Factors influencing IQOS initiation and use include perceived health benefits, financial considerations, and sensory experiences (3). Interestingly, lower IQOS risk perceptions were associated with decreased IQOS use. While IQOS emits significantly lower levels of reactive oxygen species and carbonyl compounds than combustible cigarettes, it still produces harmful constituents linked to cancer, pulmonary disease, and addiction (4). The impact of nicotine on athletic performance remains inconclusive, with studies reporting mixed results ranging from ergogenic to ergolytic effects (5). Further research is needed to address limitations in existing studies and determine the long-term effects of IQOS use on cardiovascular health and athletic performance. While IQOS may offer some advantages over conventional cigarettes, its long-term effects on physical performance and health remain unclear, warranting further research to fully understand its impact on athletes and general users.

Effects on Muscles and Metabolism

Nicotine, the primary bioactive component in tobacco, has significant effects on metabolism and muscle function. It induces metabolic disruptions, particularly in lipid and amino acid metabolism, which can be partially mitigated by resveratrol (6). While heated tobacco products may pose reduced health risks compared to traditional smoking, they can still alter mitochondrial function and increase oxidative stress (7). Nicotine administration has been shown to reduce cortical excitability, though without significant impact on physical performance (8). It exerts anorectic effects and modulates energy expenditure by regulating thermogenic activity in brown adipose tissue and glucose homeostasis. These actions occur both centrally, through hypothalamic neuropeptide systems, and directly on metabolic tissues (9).

Despite its potential for weight management, nicotine's overall health impacts remain complex, necessitating further research to fully understand its effects on muscles and metabolism in sports contexts.

Conclusions

Although IQOS® and similar heated tobacco products may provide a lower exposure to certain harmful substances than traditional cigarettes, there are still potential risks associated with their use. Misinformation in marketing and public belief that IQOS® is a safer option has caused misuse, especially among teenagers and young people. The existing evidence indicates that IQOS® does not offer a notable reduction in health risks when compared to conventional smoking, highlighting the importance of continuous research and regulatory supervision to safeguard

public health. The available evidence suggests that while IQOS® may present certain advantages over conventional cigarettes, its overall impact on physical performance and health remains uncertain. Nicotine, as the primary active compound in IQOS®, has complex effects on metabolism and muscle function. The interaction between nicotine-induced metabolic changes and physical performance requires deeper exploration to assess both potential advantages and long-term risks.

Given the mixed findings and the limitations of current studies, future research should focus on long-term investigations of IQOS® users, particularly in sports and physically active populations. Understanding the chronic effects of heated tobacco products on cardiovascular, muscular, and metabolic health is essential to provide clearer recommendations for athletes and general consumers. Until more definitive conclusions can be drawn, caution is advised in considering IQOS® as a safer alternative to conventional cigarettes, especially for individuals engaged in regular physical activity.

Disclosure:

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