OPEN ACCESS
Scholars International Journal of Biochemistry
Abbreviated Key Title: Sch Int J Biochem
ISSN 2616-8650 (Print) |ISSN 2617-3476 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Review Article

Adverse Effect of Tobacco Smoking (*Nicotiana tabacum*) on the Bone Health

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DOI: 10.36348/sijb.2021.v04i10.001 | **Received:** 03.11.2021 | **Accepted:** 08.12.2021 | **Published:** 14.12.2021

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Abstract

Tobacco smoke is complex mixture, which is major source of toxic chemicals. Smoking is a risk factor for osteoporosis and osteoporotic fractures. According to WHO estimations, 5.4 million premature deaths are derivative to tobacco smoking. The most frequent causes of tobacco-related death are chronic obstructive pulmonary disease, heart disease and several types of cancer. Smoking negatively associated with the bone mineral density of the entire hip and femoral neck, and the exposure time was negatively associated with the bone mineral density of the total hip, femoral neck, spine, lumbar and the whole body. Smoking decreases the mechanical strength of the regenerating bone and postpones the mineralization, Indirect actions on adrenocortical hormones, sex, intestinal calcium absorption, vessels, oxygen supply, vitamin D, increased incidence of fractures and the loss of bone mineral content.

Keywords: Tobacco Smoking Bone Health.

INTRODUCTION

Tobacco is an agricultural product made from the leaves of the genus Nicotiana [1]. Tobacco smoke *Nicotiana tabacum* is a reactive, complex and dynamic mixture that comprises nearly 5,000 chemicals [2]. Smoking is the major source of exposure to toxic chemicals and intermediary chemical diseases in individuals [3, 4].

Smoking is a risk factor for osteoporosis and osteoporotic fractures through variety of pathophysiological methods [5] and its yields ought to a adverse result on the skeleton as per they are linked with osteoporosis [6, 7] come loose of osseous implants [8], decreased fracture healing [9, 10] changes bone quality [11] and bone healing, also increasing the threat of perioperative injuries, decreases bone mineral density, diseases and problems such as wound problems and fracture healing problems[12].

Nicotine causes a decrease in body mass index and weight [13]. According to WHO estimations, 5.4 million premature deaths are derivative to tobacco smoking throughout the world [14]. The current surgeon general report confirmed the relationship between smoking and rheumatoid arthritis, periodontitis, and hip fracture [15]. An estimated 10 million smokers will die each year by 2025 [16]. The most frequent causes of tobacco-related death are chronic obstructive pulmonary disease, heart disease and several types of cancer, especially lung cancer [17].

Smoking increases the risk of bone loss, affects dental implantations and peri-implant failure [18], lumbar disc herniation [19], damaging postoperative effects on knee ligaments [20], higher rate of complication after anterior cruciate ligament (ACL) reconstruction [16] and slows down healing of rotator cuff repair [21]. Smoking is related with rotator cuff tears and other shoulder indications [7].

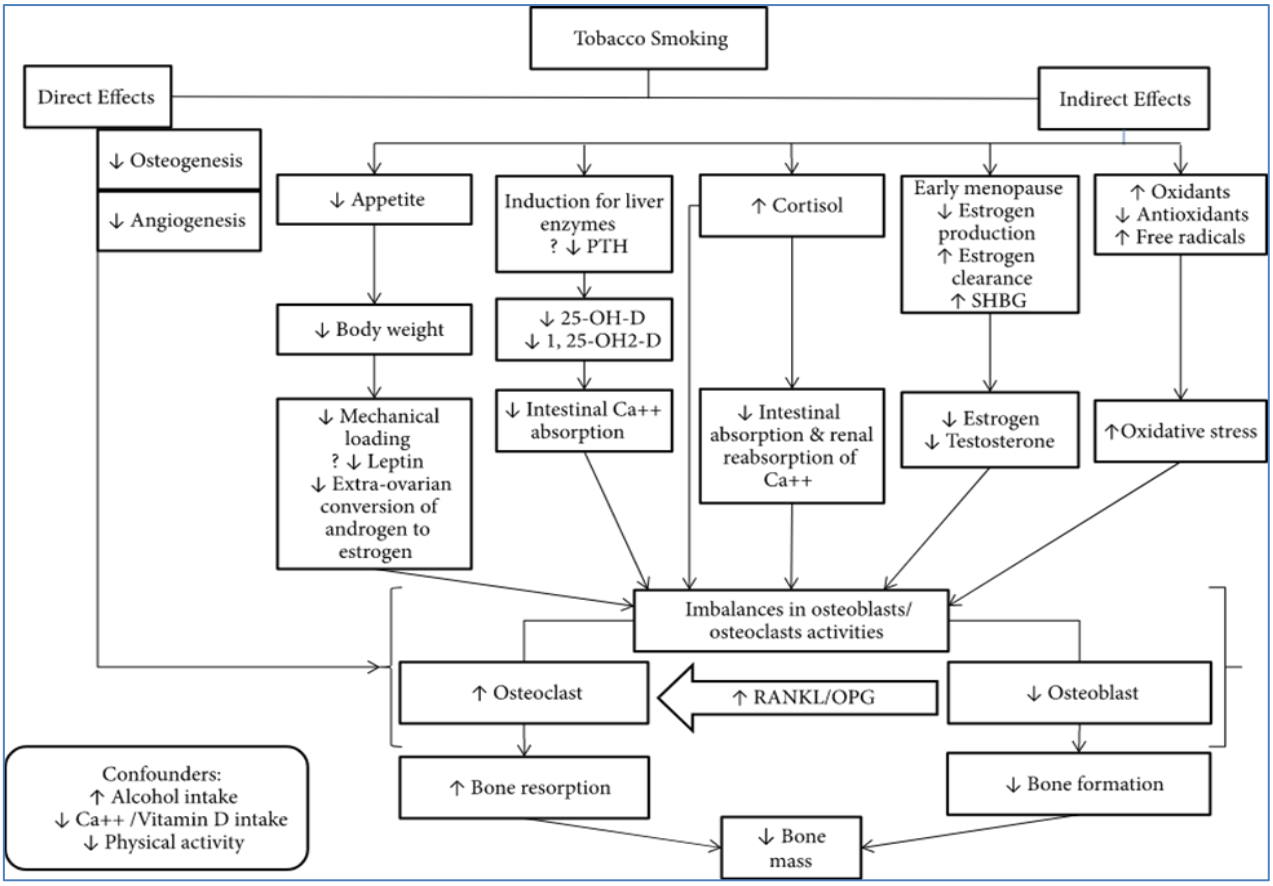

Fig-1: Prospective Pathophysiologic Mechanisms of Reduced Bone Mass in Tobacco Smoke. [22]

Composition of Tobacco Smoking

Main components of smoking are nicotine, carbon monoxide, hydrogen cyanide, benzene, formaldehyde, phenol, polycyclic aromatic hydrocarbons (PAHs) tobacco-specific nitrosamines (TSNAs) and tar [23].

Table-1: Estimated Chemical Composition of fused Cigarette Tobacco [24]

Component	Wet weight fused cigarette tobacco (%)	Dry weight tobacco (%)
Carbohydrates		
Sugars	12.5	15.15
Celluloses	10.0	12.12
Pectic substances	8.5	10.36
Water	2.5	3.03
Proteins and Amino acids	12.0	0.00
Proteins		
Free Amino Acids	6.0	7.27
Bases	2.5	3.03
Volatile bases	2.0	2.42
Nicotine	1.5	1.81
Waxes and resins	8.0	9.69
Metals	5.0	6.06
Phenols	6.5	7.87
Acids	9.0	10.90
Lignin	3.5	4.24
Humectants	3.0	0.00
Flavorants	2.5	0.00
Inorganic ions	1.5	1.81
Others	3.5	4.24

Table-2: Estimated number of Chemical Components in Tobacco and Tobacco Smoke [25]

Component	Tobacco	Tobacco smoke
Hydrocarbons		
Alkanes	20	31
Alkenes and alkynes	16	320
Alicyclics	42	76
Monocyclic aromatic	8	58
Polycyclic aromatic	12	570
Oxygen-containing components		
Alcohols		
Phytosterols and derivatives	875	542
Aldehydes	63	9
Ketones	119	62
Carboxylic acids	418	514
Lipids (waxes) and resins **Amino acids**	368	275
Esters	69	1
Lactones		
Anhydrides	388	123
Carbohydrates	133	118
Phenols	6	7
Quinones	230	6
Ethers	107	363
	14	26
	466	392

Metals present in Tobacco Smoke

Tobacco smoke contains Lead (Pb), Cadmium (Cd), Aluminum (Al), Arsenic (As), Nickel (Ni) and Mercury (Hg) [26]

Effects of Tobacco Smoking on Bones in Animals

Model	Findings	Reference
Rat	Harmful effects on bone growth were detected 41.8% reduction in alkaline phosphatase levels decrease of 11.25% in tibia length 41.5% decrease in bone mineral density 42.8% reduction in maximum strength bones were weaker, deforming bone was shorter,	[27]
Rat	Rats exposed to tobacco smoke showed delayed fracture healing and callus that was characterized by decreased maturity, density, and mechanical resistance.	[10]
Rat	Tobacco Smoke exposure can reduce bone mass and impair bone architecture and exacerbate multiple features of osteoporosis exhibited.	[28]
Chick	Nicotine suppressing the development of femur bone by stopping the process of bone matrix Formation.	[28]
Mice	Cigarette smoking causes osteoporosis and undesirably effects on immune system.	[29]
Mice	**Mid-shaft femur** Load 8%, stiffness 13 %, stresses 10%, and modulus 14% was lower. **Femoral neck** Load 9% and stiffness 12% lower The ash-to-dry bone weight ratio was smaller. Distal femoral bone volume/total volume (%) and trabecular thickness showed decreasing trends.	[30]
Rats	Smoking decreases bone mineral density. Fewer marrow cells were present in the smoke-exposed rats and a black carbon dust-like substance was observed.	[33]
Rabbit	Decreases the mechanical strength of the regenerating bone and postpone the mineralization.	[34]
Wistar rats	Present important negative effect on bone to- implant contact and Bone Area	[35]

Smoking during puberty was found to be negatively associated with the bone mineral density of the entire hip and femoral neck, and the exposure time was negatively associated with the bone mineral density of the total hip, femoral neck, spine, lumbar and the whole body, In premenopausal women [31]. Smoking can cause an imbalance in bone turnover, resulting in decreased bone mass and making bones prone to osteoporosis and fractures. Tobacco smoke indirectly affects bone mass by changing body weight, the parathyroid hormone-vitamin D axis, adrenal hormones, sex hormones, and increased oxidative stress in bone tissue [22]. Negative consequences of tobacco smoking include Indirect actions on adrenocortical hormones, sex, intestinal calcium absorption, vessels, oxygen supply, vitamin D, increased incidence of fractures and the loss of bone mineral content [32].

CONCLUSION

Tobacco smoke is complex mixture contains Lead (Pb), Cadmium (Cd), Aluminum (Al), Arsenic (As), Nickel (Ni) and Mercury (Hg), which is a major source of toxicity. Tobacco smoking is a risk factor for osteoporosis and osteoporotic fractures through variety of pathophysiological methods and its yields ought to adverse result on the skeleton as per they are linked with osteoporosis. Smoking decreases the mechanical strength of the regenerating bone and postpone the mineralization. Smoking during puberty was found to be negatively associated with the bone mineral density of the entire hip and femoral neck.

REFERENCE

1. Yeasmeen, T., Parvin, R., & Khan, M. A. H. (2014). Tobacco: the silent killer. *Journal of Enam Medical College*, *4*(2), 72-74.
2. Talhout, R., Schulz, T., Florek, E., Van Benthem, J., Wester, P., & Opperhuizen, A. (2011). Hazardous compounds in tobacco smoke. *International Journal of environmental research and public health*, 8(2), 613-628.
3. Fowles, J., & Dybing, E. (2003). Application of toxicological risk assessment principles to the chemical constituents of cigarette smoke. *Tobacco control*, 12(4), 424-430.
4. Ezzati, M., & Lopez, A. D. (2003). Estimates of global mortality attributable to smoking in 2000. *The lancet*, 362(9387), 847-852.
5. Yoon, V., Maalouf, N. M., & Sakhaee, K. (2012). The effects of smoking on bone metabolism. *Osteoporosis International*, 23(8), 2081-2092.
6. Tarantino, U., Cariati, I., Greggi, C., Gasbarra, E., Belluati, A., Ciolli, L., & Brandi, M. L. (2021). Skeletal System Biology and Smoke Damage: From Basic Science to Medical Clinic. *International Journal of Molecular Sciences*, 22(12), 6629.
7. Bishop, J. Y., Santiago-Torres, J. E., Rimmke, N., & Flanigan, D. C. (2015). Smoking predisposes to rotator cuff pathology and shoulder dysfunction: a systematic review. Arthroscopy: *The Journal of Arthroscopic & Related Surgery*, 31(8), 1598-1605.
8. Fini, M., Giavaresi, G., Salamanna, F., Veronesi, F., Martini, L., De Mattei, M., & Tschon, M. (2011). Harmful lifestyles on orthopedic implantation surgery: a descriptive review on alcohol and tobacco use. *Journal of bone and mineral metabolism*, 29(6), 633-644.
9. Hernigou, J., & Schuind, F. (2013). Smoking as a predictor of negative outcome in diaphyseal fracture healing. *International orthopaedics*, 37(5), 883-887.
10. Santiago HA, Zamarioli A, Sousa Neto MD, Volpon JB. Exposure to Secondhand Smoke Impairs Fracture Healing in Rats. Clin Orthop Relat Res. 2017; 475(3):894-902, http://dx.doi.org/10.1007/s11999-016-5217-1.
11. Ajiro, Y., Tokuhashi, Y., Matsuzaki, H., Nakajima, S., & Ogawa, T. (2010). Impact of passive smoking on the bones of rats. *Orthopedic*s, 33(2), 90.
12. Duthon, V. B., Ozturk, M., El-Achachi, S., & Menetrey, J. (2014). Deleterious effects of smoking on the musculoskeletal system. *Revue medicale suisse*, 10(437), 1466-1471.
13. Magnani, K. L., Cataneo, D. C., Capelozzi, V. L., Defaveri, J., Hasimoto, E. N., & Cataneo, A. J. M. (2012). Lung morphology and growth of rats exposed to tobacco smoke and alcohol. *Acta cirurgica brasileira*, 27, 687-693.
14. World Health Organization. (2008). WHO report on the global tobacco epidemic: the MPOWER package? WHO report on the global tobacco epidemic: the MPOWER package.
15. Lushniak, B. D., Samet, J. M., Pechacek, T. F., Norman, L. A., & Taylor, P. A. (2014). The Health consequences of smoking—50 years of progress: A report of the Surgeon General.
16. Novikov, D. A., Swensen, S. J., Buza III, J. A., Gidumal, R. H., & Strauss, E. J. (2016). The effect of smoking on ACL reconstruction: a systematic review. *The Physician and sportsmedicine*, 44(4), 335-341.
17. Santiago-Torres, J., Flanigan, D. C., Butler, R. B., & Bishop, J. Y. (2015). The effect of smoking on rotator cuff and glenoid labrum surgery: a systematic review. *The American journal of sports medicine*, 43(3), 745-751.
18. Moraschini, V. (2016). Success of dental implants in smokers and non-smokers: a systematic review and meta-analysis. *International journal of oral and maxillofacial surgery*, 45(2), 205-215.
19. Huang, W., Qian, Y., Zheng, K., Yu, L., & Yu, X. (2016). Is smoking a risk factor for lumbar disc herniation?. *European Spine Journal*, 25(1), 168-176.
20. Kanneganti, P., Harris, J. D., Brophy, R. H., Carey, J. L., Lattermann, C., & Flanigan, D. C. (2012). The effect of smoking on ligament and cartilage surgery in the knee: a systematic review. *The*

American journal of sports medicine, 40(12), 2872-2878.
21. Santiago-Torres, J., Flanigan, D. C., Butler, R. B., & Bishop, J. Y. (2015). The effect of smoking on rotator cuff and glenoid labrum surgery: a systematic review. *The American journal of sports medicine*, 43(3), 745-751.
22. Al-Bashaireh, A. M., Haddad, L. G., Weaver, M., Chengguo, X., Kelly, D. L., & Yoon, S. (2018). The effect of tobacco smoking on bone mass: an overview of pathophysiologic mechanisms. *Journal of osteoporosis*, 2018.
23. Harris, J. E. (1996). Cigarette smoke components and disease: cigarette smoke is more than a triad of tar, nicotine, and carbon monoxide. *Smoking and tobacco control monograph*, 7, 59-75.
24. Hobbs, M.E: Some physico-chemical aspects of cigarette smoke generation; CORESTA/TCRC Joint Conf., Williamsburg, VA, CORESTA Invited Papers (1972) 53–75.
25. Rodgman, A., and T.A. Perfetti: The chemical components of tobacco and tobacco smoke; CRC Press, Boca Raton, FL (2008).
26. Milnerowicz, H., Ściskalska, M., & Dul, M. (2015). Pro-inflammatory effects of metals in persons and animals exposed to tobacco smoke. *Journal of Trace Elements in Medicine and Biology*, 29, 1-10.
27. Rosa, R. C., Pereira, S. C., Cardoso, F. A. G., Caetano, A. G., Santiago, H. A. R. D., & Volpon, J. B. (2017). Second hand tobacco smoke adversely affects the bone of immature rats. *Clinics*, 72, 785-789.
28. Shan, M., Qamar, K., & Iqbal, I. (2015). Role of nicotine and camellia sinensis on the developing femur of chick. JPMA. *The Journal of the Pakistan Medical Association*, 65(10), 1094-1096.
29. Fusby, J. S., Kassmeier, M. D., Palmer, V. L., Perry, G. A., Anderson, D. K., Hackfort, B. T., ... & Swanson, P. C. (2010). Cigarette smoke-induced effects on bone marrow B-cell subsets and CD4+: CD8+ T-cell ratios are reversed by smoking cessation: influence of bone mass on immune cell response to and recovery from smoke exposure. *Inhalation toxicology*, 22(9), 785-796.
30. Akhter, M. P., Lund, A. D., & Gairola, C. G. (2005). Bone biomechanical property deterioration due to tobacco smoke exposure. *Calcified tissue international*, *77*(5), 319-326.
31. Blum, M., Harris, S. S., Must, A., Phillips, S. M., Rand, W. M., & Dawson-Hughes, B. (2002). Household tobacco smoke exposure is negatively associated with premenopausal bone mass. *Osteoporosis International*, *13*(8), 663-668.
32. Abate, M., Vanni, D., Pantalone, A., & Salini, V. (2013). Cigarette smoking and musculoskeletal disorders. *Muscles, ligaments and tendons journal*, *3*(2), 63.
33. Ajiro, Y., Tokuhashi, Y., Matsuzaki, H., Nakajima, S., & Ogawa, T. (2010). Impact of passive smoking on the bones of rats. *Orthopedics*, *33*(2), 90.
34. Ueng, S. W., Lin, S. S., Wang, C. R., Liu, S. J., Tai, C. L., & Shih, C. H. (1999). Bone healing of tibial lengthening is delayed by cigarette smoking: study of bone mineral density and torsional strength on rabbits. *Journal of Trauma and Acute Care Surgery*, *46*(1), 110-115.
35. César-Neto, J. B., Duarte, P. M., Sallum, E. A., Barbieri, D., Moreno Jr, H., & Nociti Jr, F. H. (2003). A comparative study on the effect of nicotine administration and cigarette smoke inhalation on bone healing around titanium implants. *Journal of periodontology*, *74*(10), 1454-1459.