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EDITORIAL

Exercise as microbial medicine: A physical therapy-led strategy to target the gut–vascular axis in metabolic hypertension

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Hypertension has traditionally been considered to involve only blood vessels, kidneys, and an autonomic nervous system. With its co-existence with obesity, Type-II Diabetes Mellitus, dyslipidemia and chronic inflammation, it is referred as Metabolic Hypertension (1) hence requires a broad conceptual framework to understand. Despite, advances in Hypertensive treatment approaches, it is still believed to cause death and disability-adjusted life-years lost globally as a leading factor, as South Asia represents one of the fastest growing epicenters as well developing countries like Pakistan since rapid urbanization, sedentary occupations, tobacco consumption, high-salt ultra-processed diets, and limited access to structured physical activity programs have created an ideal substrate for metabolic dysfunction and tremendously affects health as a silent killer.(2,3) Younger populations are increasingly presenting with hypertension accompanied by central obesity, impaired glucose tolerance, and dyslipidemia features that reflect metabolic, rather than purely vascular, pathology.(4)

Now emerging evidences from gut microbiome science have challenged the classical hemodynamic paradigm, by positioning hypertension as a disorder of the gut–vascular–metabolic axis as it severely affects the gut health beyond merely affecting the vascular health, because the pathogenicity of Hypertension is very complex and includes genetic, environmental, hormonal, hemodynamic and inflammatory mechanisms. Therefore, it is suggested through growing evidences that the gut microbiome plays a pivotal role in development of hypertension because gastrointestinal tract stocks immune cells and trillions of microorganisms that regulate immunity, glucose metabolism, lipid handling, and endothelial integrity as the largest compartment. Any imbalance in microbial diversity leads to reduced production of short-chain fatty acids (SCFAs) such as butyrate and propionate, essential for vascular relaxation and insulin sensitivity, Increased generation of pro-hypertensive metabolites, including trimethylamine N-oxide (TMAO), increased intestinal permeability and systemic inflammation, precipitates endothelial dysfunction which cumulatively develops and progresses Hypertension. So, in accordance to lifestyle factors such as increased structured and regular physical activity shapes and modulates the microbiomes, hence, modify the risks for hypertensive disease.(5-9)

Regardless of pharmacological advances, Hypertension control has still remained inadequate. This evidence therefore emphasizes that metabolic hypertension is not merely a disease of arteries, but also of the microbial ecosystem that latently affects vascular health and highlights the need for rehabilitation-driven preventive models that target the biological roots of metabolic hypertension. Hence, within this framework, physical therapy and rehabilitation science hold an idiosyncratic role in operationalizing an economical, sustainable, and innovative approach: the use of exercise as microbial medicine.(10)

Continuing the context, Physical activity stands alone as a most potent non-pharmacological regulator for healthy gut microbial dynamics. Aerobic and resistance trainings have proven to escalate the microbial richness by enhancing SCFA-producing bacterial populations, and suppressing the inflammatory taxa. These adaptations resultantly improve endothelial nitric oxide bioavailability, reduce systemic inflammation, improved insulin sensitivity with enhanced rate of lipid metabolism.(11-13) Furthermore, from physical therapy aspect, exercise no longer merely serves as a perfunctory intervention yet reshapes the internal microbial ambiance as a biological therapy. And, Physical therapists occupy a pivotal role at the crossroads of preventive care, long-term disease management, and lifestyle-based rehabilitation. Incorporating gut-targeted exercise protocols into hypertensive care pathways can transform outcomes through structured

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aerobic training (moderate-intensity walking, cycling, aquatic therapy) for enhancing microbial diversity, Progressive resistive exercise training that increases metabolic flexibility and insulin action within the body, yoga-based breathing techniques, diaphragmatic control modulate autonomic tone and gut permeability within Hypertensive population, education-focused rehabilitation addresses sedentary behavior, smoking cessation, and adherence to protocol-based physical activity.(14,15) These strategies can be delivered within outpatient physiotherapy departments, community-based rehabilitation centers, and home-based models making them highly pertinent to resource-limited settings such as Pakistan.

The conjunction of frequent tobacco use, screen-dependent behavior, sedentary lifestyles, and absence of structured rehabilitation protocols have formed a perfect tempest. If urgent action will not be taken, metabolic hypertension will evolve as dominant cardiovascular phenotype for the next decades. Therefore, an exercise-centered gut rehabilitation offers a timely predisposing factor grounded in physiological principles, reinforced by microbiome research, and translated into practical physical therapy interventions.(16)

In conclusion, it has been emphasized that the rehabilitation sciences must be shifted merely from symptom-oriented blood pressure control to cause-oriented metabolic restoration. Viewing exercise as a microbial medicine redefines physical therapy not only as a discipline of movement, but as a science of internal healing. By targeting the gut–vascular axis, physical therapists can play a decisive role in preventing, delaying, and reversing metabolic hypertension both in Pakistan and across the globe.

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